2025 Conference on Implantable Auditory Prostheses

Lake Tahoe sits on the traditional ancestral lands of the Washoe Tribe. The Washoe – the aboriginal stewards of the land in and around the Lake Tahoe Basin since the beginning of time, continue to protect and preserve the Washoe peoples' homelands. We offer gratitude for the land itself, and for the opportunity to learn, work, and be in community with this land.

13 to 18 July 2025

Granlibakken Conference Center

Lake Tahoe, CA

V0.4

2025 CONFERENCE ON IMPLANTABLE AUDITORY PROSTHESES

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Conference Co-chair:  **Olivier Macherey**

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Administrative Coordinator: Wendy James

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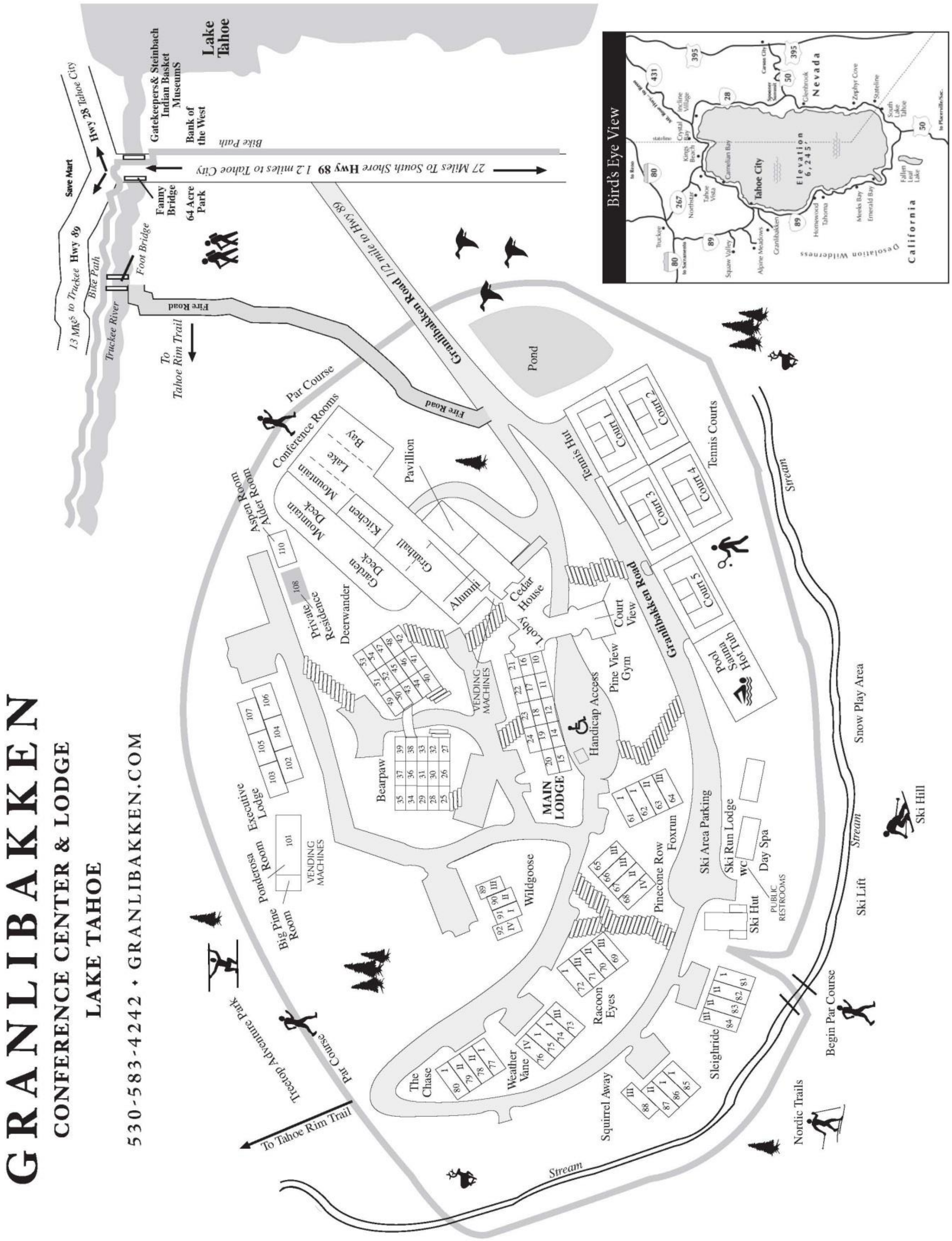
Kara Leyzac	**Medical University of South Carolina, Charleston, SC, USA**
Melissa Polonenko	**University of Minnesota, Minneapolis, MN, USA**

INDUSTRY REPRESENTATIVES

Jane Opie	**MED-EL, Innsbruck, Austria**
Tony Spahr	**Advanced Bionics, Valencia, CA, USA**
Christopher (Stoph) Long	**Cochlear Americas, Lone Tree, CO, USA**



GRANLIBAKKEN
CONFERENCE CENTER & LODGE
LAKE TAHOE
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Bird's Eye View
Lake Tahoe
Gatekeepers& Steinbach Indian Basket MuseumS
Bank of the West
Fanny Bridge
64 Acre Park
Foot Bridge
Truckee River
Bike Path
13 Miles to Truckee Hwy 89
Hwy 28 Tahoe City
Save Mart
27 Miles To South Shore Hwy 89 1.2 miles to Tahoe City
Granlibakken Road 1/2 mile to Hwy 89
To Tahoe Rim Trail
Fire Road
Pond
Par Course
Conference Rooms
Lake
Bay
Mountain
Mountain Deck
Kitchen
Grahall
Garden Deck
Pavillion
Alumni
Cedar House
Lobby
Court View
Pine View Gym
Handicap Access
MAIN LODGE
Tennis Hut
Tennis Courts
Court 1
Court 2
Court 3
Court 4
Court 5
Granlibakken Road
Pool Sauna Hot Tub
Aspen Room
Alder Room
Private Residence
Deerwander
VENDING MACHINES
Bearpaw
Executive Lodge
Ponderosa Room
Big Pine Room
Wildgoose
Pinecone Row
Foxrun
Ski Area Parking
Ski Run Lodge
WC
Day Spa
Ski Hut
PUBLIC RESTROOMS
Snow Play Area
Ski Hill
Ski Lift
Racoon Eyes
Weather Vane
The Chase
Squirrel Away
Sleighride
Begin Par Course
Nordic Trails
Treetop Adventure Park
Stream

CIAP 2025 SPONSORS

Table of Contents

CIAP 2025 Program Overview

Sunday July 13		
15:00-19:00	**Registration**	
18:00-19:00	**Dinner**	
19:00-20:15	**Student Meet-up/Trivia Event**	
19:00-00:00	**Welcome Reception**	
Monday July 14		
7:00	**Breakfast opens**	
8:15-8:30	**Welcome and introductions / code of conduct policy**	
Session 1a: Device and electrode insertion - David Friedmann, Craig Buchman (session chairs)		
08:30-08:50	Implantable Microphone for Totally Implantable Cochlear Implant	Hideko Heidi Nakajima
08:50-09:10	Novel Functionality for Cochlear Implants: Electrochemical in Vivo Sensing After Chronic Implantation	Stefan Reinelt, Aline Xavier, Susan Arndt, Stefan J. Rupitsch, Andreas Weltin, Jochen Kieninger, Nicole Rosskothen-Kuhl
09:10-09:30	Significant Cochlear Implant Insertion Trauma Is Associated with Apical Spiral Ganglion Neuron Loss in the Human	Julie Arenberg, Abbie Hall, Christopher Giardina, Anbuselvan Dharmarajan, Jennifer O'Mally, Alicia Quesnel
09:30-9:50	A Combined Model for Intracochlear Electrocochleography Simulations in Healthy and Impaired Ears	Aristeidis Choustoulakis, Margriet J. Van Gendt, Jeroen J. Briaire, Johan H. M. Frijns
9:50-10:05	Safety and efficacy of DB-OTO gene therapy in children with profound deafness due to otoferlin variants: Data from the CHORD phase 1/2 open-label trial and the importance of minimally traumatic surgery, a case study	Manuel Manrique
10:05-10:40	**Break**	

Session 1b: Signal processing and sound coding - Xin Luo, John Hansen (session chairs)		
10:40-11:20	Advancements and Challenges in Signal Processing and Sound Coding for Cochlear Implants	Waldo Nogueira
11:20-11:40	The Effect of Reverberation and Artificial-Intelligence-Based Dereverberation Algorithms on Speech Intelligibility for Cochlear Implant Users	Nienke C. Langerak, H. Christiaan Stronks, Esther F. Van Marrewijk, Jeroen J. Briaire, Shaliza Merchant, Daphne L. Geijsen, Jean-Marie Lemercier, Timo Gerkmann, Johan H. M. Frijns
11:40-12:00	Towards a Closed Loop Brain Computer Interface to Make Music More Accessible for Cochlear Implant Users	Jonas Althoff, Waldo Nogueira
12:00-13:00	**Lunch**	
16:00-18:00	**Poster Viewing**	
18:00-19:00	**Dinner**	
Session 2: Peripheral mechanisms underlying perception - Bernhard Laback, Ian Bruce (session chairs)		
19:00-19:40	Learning from the Central Nervous System About Peripheral Coding of Complex Sounds	Laurel Carney
19:40-20:00	Investigating Neural Encoding of Vowel Formants: Comparing Rate-Place and Neural-Fluctuation Contrast Theories in Cochlear-Implant Users	Benjamin Palatnik, Marcus Milani, Braden N. Maxwell, Heather A. Kreft, Andrew J. Oxenham
20:00-20:20	**Break**	
20:20-20:40	Dynamic Range Adaptation in Cochlear Implants	Coline Marché, Sabine Meunier, Stéphane Roman, Charlotte Garcia, Olivier Macherey
20:40-21:00	Weighting of Place and Temporal Envelope Cues for Pitch, Music, and Emotion Perception with Cochlear Implants	Lina A. J. Reiss, Holden Sanders, Nicole Dean, Clementine McTaggart, Qian-jie Fu, David M. Landsberger, John J. Galvin 3rd, Monita Chatterjee
21:00-23:00	**Poster viewing and socializing**	

Tuesday July 15		
7:00	**Breakfast opens**	
Session 3a: Genetic factors		
08:30-09:10	The Value Genetic Testing Adds to a Cochlear Implant Evaluation	Richard Smith
Session 3b: Memorial for Paul Abbas – Michelle Hughes (session chair)		
09:10-09:50	Memorial for Paul Abbas	
09:50-10:20	**Break**	
Session 3c: Temporal coding - Monita Chatterjee, Jan Wouters (session chairs)		
10:20-10:35	Introduction	Robert P. Carlyon, Ray Goldsworthy
10:35-10:45	Plasticity, Experience and Signal Processing as Determinants for Binaural Hearing Abilities in Cochlear Implant Users	Ruth Y. Litovsky
10:45-10:55	Neural Limitations Lead to Reduced Temporal and Binaural Sensitivity in Cochlear Implant Listening	Yoojin Chung, Bertrand Delgutte
10:55-11:05	Enhancing ITD Sensitivity and Rate Discrimination in Electric Hearing Through Behavioral Training and Optimized Stimulation Designs	Maike Vollmer, Frank W. Ohl
11:05-11:15	Physiology and Limitations of Temporal Processing	Andrej Kral
11:15-11:25	Changing Perspectives on Temporal Coding for Binaural Cues in Cochlear Implants	Jan W. H. Schnupp, Nicole Rosskothen-Kuhl
11:25-11:35	Learning to Hear Stimulation Timing Cues for Pitch Perception and Sound Localization	Ray Goldsworthy
11:35-11:45	Temporal Coding: Overview, Plasticity, and the (Lack of) Effect of Experience and Training on Pitch Perception by Cochlear Implant Users	Robert P. Carlyon
11:45-12:00	Discussion	
12:00-13:30	CCi-Mobile workshop (Alumni room)	John H. L. Hansen
12:00-13:00	**Lunch**	

Industry and funding agency presentations		
13:30-13:50	Cochlear – Improving Real-word Outcomes – Christopher Long	
13:50-14:10	Advanced Bionics – Science-driven performance improvements – Paddy Boyle	
14:10-14:30	MED-EL- Bridging the Translational Gap: The Integration of Research into System Design and Clinical Practice – Katelyn Glassman	
14:30-14:45	CCi-Mobile – John H. L. Hansen	
14:45-15:00	**Break**	
15:00-15:15	Rinri – Rincell-1: A Cell-Based Therapy for Neural Hearing Loss – Doug Hartley	
15:15-15:30	NIRx - Functional Near-Infrared Spectroscopy (fNIRS) Applications in Cochlear Implant Research – Samantha O'Connell	
15:30-15:45	NIDCD - Roger Miller	
15:45-16:00	ARPA-H - Cal Roberts	
16:00-18:00	**Poster viewing**	
18:00-19:00	**Dinner**	
Session 4: Tonotopic coding - Joshua Bernstein, Maragaret Dillon (session chairs)		
19:00-19:20	Unlocking the Cochlea with Synchrotron Phase-Contrast Imaging	Sumit Agrawal
19:20-19:40	Tonotopic Coding in the Human Cochlea	Amit Walia, Matthew Shew, Jacques Herzog, Amanda Ortmann, Shannon Lefler, Jordan Varghese, Matthew Wu, Craig A. Buchman
19:40-20:00	Targeting Individualized Frequency Maps in Cochlear Implant Users with a Computational Model and Behavioral Genetic Algorithm	Elad Sagi, Nicole H. Capach, Megan Eitel, Maya Hatley
20:00-20:20	**Break**	
20:20-20:40	Frequency Coding in Cochlear Implants	Benoît Godey
20:40-21:00	Anatomy-Based Fitting Versus Standard Mapping of CI-Processors: Preliminary Results of a Crossover Randomized Control Intervention Study	Uwe Baumann, Marten Geisen, Silke Helbig, Timo Stöver, Tobias Weissgerber
21:00-23:00	**Poster viewing & socializing**	

Wednesday July 16		
7:00	**Breakfast opens**	
Session 5: Neural health - Kara Leyzac, Shuman He (session chairs)		
08:30-09:10	Unraveling Auditory Nerve Condition: Key to Cochlear Implant Efficacy	Niyazi O. Arslan, Xin Luo
09:10-09:30	What Can the ABR Tell Us About Auditory Nerve Function	Kelly C. Harris
09:30-9:50	The Failure Index: An ECAP Marker for Neuronal Health	Wiebke Konerding, Peter Baumhoff, Julie Arenberg, Cornelia Batsoulis, Heval Benav, Anette Günther, Andreas Büchner, Andrej Kral
9:50-10:10	Riding the Slopes: From Modeling the IPG Effect to a Potential Clinical Application	Josh S. Stohl, Marko Takanen
10:10-10:40	**Break**	
10:40-11:00	Cochlear Health in DFNA9 CI Users	Julie Moyaert, Dyan Ramekers, Vincent Van Rompaey, Griet Mertens, Annick Gilles, Emilie Cardon, Lana Biot, Marc Lammers
11:00-11:20	Characterising the Electrode-Neuron Interface Using the Panoramic ECAP Method	Charlotte Garcia
11:20-11:40	The Electrically Evoked Compound Action Potential as Predictor of Hearing Performance in Cochlear Implant Users	Dyan Ramekers, Tinne Vandenbroeke, Marko Takanen, Vincent Van Rompaey, Marc Lammers
11:40-12:00	Towards Individualized CI Care Using Holistic and Longitudinal Big Data Networks	Yue Zhang, Michel Hoen
12:00-13:00	**Lunch**	
13:30-15:30	**Mentoring session**	
16:00-18:00	**Poster viewing**	
18:00-19:00	**Dinner**	
20:00-00:00	**CIAP social, music, dance party and poster viewing**	

Thursday July 17		
7:00	**Breakfast opens**	
Session 6a: Factors affecting performance - Etienne Gaudrain, Katelynn Berg (session chairs)		
08:50-09:10	Misperception of Talker Prosody as a Core Component of Cochlear Implant Patient's Difficulty Hearing Speech in Noise	Harley J. Wheeler, Matthew B. Winn
9:10-9:30	Topographic Maps of Temporal Envelope Modulation Processing in Cochlear Implant Users	Brent Sterckx, Marc Moonen, Jan Wouters
9:30-9:50	Effects of Personality Traits on Speech-Perception Performance in Adult CI Users	Eric R. Rodriguez, Douglas Samuel, Maureen J. Shader
9:50-10:10	Neural Correlates of Target Detection in Cochlear Implant Users During Speech-in-Noise Processing and Auditory Object Formation	Phillip E. Gander, Nour Alsabbagh, Francis Smith, Joel I. Berger, Bob McMurray, Timothy D. Griffiths, Inyong Choi
10:10-10:40	**Break**	
10:40-11:00	Using Visual World Eye Tracking to Characterize Attention to Auditory Targets	Lukas Suveg, Ruth Y. Litovsky
11:00-11:20	Sequential Versus Simultaneous Across-Ear Loudness Balancing for Single-Sided Deafness Cochlear-Implant Users	Sandeep A. Phatak, Michael A. Johns, Matthew J. Goupell, Joshua G. W. Bernstein
11:20-11:40	Recordings from the brain: A review of direct CAEP measurements in Cochlear Implant Users	Chen Chen
Session 6b: Memorial for Bertrand Delgutte – Andrew Oxenham (session chair)		
11:40-12:00	Memorial for Bertrand Delgutte	
12:00-12:15	**Group picture / student picture**	
12:15-13:00	**Lunch**	
13:30-15:00	**Company research interface presentations**	
13:30-14:00	**MED-EL**	
14:00-14:30	**Advanced Bionics**	
14:30-15:00	**Cochlear**	

16:00-18:00	**Poster viewing**	
18:00-19:00	**Dinner**	
Session 7: Alternative strategies - Maike Vollmer, Johan Frijns (session chairs)		
19:00-19:20	Transcription Factor Cocktails for Hair Cell Regeneration in Mature Cochleae	Averyt Matthew, Lin Yang, Valeria Mas, Sunita Singh, Lisa Beyer, Diane Prieskorn, Andrew Groves, Yehoash Raphael
19:20-19:40	Better Temporal Acuity for Cochlear Implants	John C. Middlebrooks, Matthew L. Richardson, Robert P. Carlyon, Harrison W. Lin
19:40-20:00	Low-Threshold Activation and Cross-Modal Optimization for Optogenetic Hearing Restoration in Rodents	Anna Vavakou, Victoria Hunniford, Fadhel El May, Niels Albrecht, Bettina Wolf, Eric Klein, Patrick Ruther, Alexander Ecker, Thomas Mager, Tobias Moser
20:00-20:20	**Break**	
20:20-20:40	Cortical Implants for Hearing Restoration	Tania Rinaldi Barkat
20:40-21:00	Targeted Neuromodulation to Improve Cochlear Implant Use in Rodents	Robert C. Froemke
21:00-23:00	**Poster viewing and socializing**	

Friday July 18		
7:00	**Breakfast opens**	
Session 8:	**Plasticity, development, and training - Mario Svirsky, Justin Aronoff (session chairs)**	
08:30-08:50	Longitudinal Studies of Early Cochlear Implant Use	Ariel Edward Hight, Rohit Makol, Nicole Capach, Jonathan Neukam, Mario A. Svirsky, Robert C. Froemke
08:50-09:10	Between- and Within-Recipient Neural Correlates of Loudness Growth with Cochlear Implant Stimulation Levels	Dorothée Arzounian, François Guérit, John M. Deeks, Charlotte Garcia, Evelien De Groote, Manohar Bance, Robert P. Carlyon

09:10-09:30	Examining Effects of Left Versus Right Pre-Lingual Unilateral Deafness on Cortical Responses to Sound	Hanne Bartels, Melissa J. Polonenko, Hyo-jeong Lee, Jaina Negandhi, Sharon L. Cushing, Blake C. Papsin, Karen A. Gordon
09:30-09:50	Aural Preference Reorganization Following Congenital Single-Sided Deafness Is More Pronounced in Secondary Than in Primary Auditory Cortex	Yusuf Prasandhya Astagiri, E. Firdaus, Peter Hubka, Jochen Tillein, Andrej Kral
09:50-10:10	Plasticity Limits Cochlear Implant Outcomes: Evidence from Machine Learning Models of Perception	Annesya Banerjee, Mark R. Saddler, Josh McDermott
10:10-10:40	**Break**	
10:40-11:00	AI-enabled Prediction to Improve Language After Pediatric Cochlear Implantation	Nancy M. Young, Yanlin Wang, Di Yuan, Shani Dettman, Dawn Choo, Emily Shimeng Xu, Denise Thomas, Maura Ryan, Patrick C. M. Wong
11:00-11:20	Effects of Maturation and Image-Guided Cochlear Implant Programming on Spectral and Temporal Resolution in Children with Cochlear Implants	Andrea Defreese, Katelyn Berg, Jourdan Holder, Linsey Sunderhaus, Stephen Camarata, René Gifford
11:20-11:40	The Effect of Voice Training on Speech-On-Speech Intelligibility and Listening Effort in Cochlear Implant Users	Ada Biçer, Thomas Koelewijn, Deniz Başkent
11:40-12:00	A Novel Naturalistic Dual-Task Ear Training Paradigm with Real-Time Gamified Neurofeedback for Cochlear Implant Users	Filip Miscevic, Bowen Xiu, Andrew Dimitrijevic
12:00-13:00	**Lunch**	
13:00	**Conference ends**	

PODIUM SESSION SCHEDULE

Monday

1A. Device and electrode insertion - David Friedmann, Craig Buchman (session chairs)

08:30 - 08:50. Implantable Microphone for Totally Implantable Cochlear Implant Hideko Heidi Nakajima

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9:50 - 10:05. Safety and Efficacy of DB-OTO Gene Therapy in Children with Profound Deafness Due to Otoferlin Variants: Data from the CHORD Phase 1/2 Open-Label Trial and the Importance of Minimally Traumatic Surgery, a Case Study Manuel Manrique

1B. Signal processing and sound coding - Xin Luo, John Hansen (session chairs)

10:40 - 11:20. Advancements and Challenges in Signal Processing and Sound Coding for Cochlear Implants Waldo Nogueira

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Tuesday

3A. Genetic factors

08:30 - 09:10. The Value Genetic Testing Adds to a Cochlear Implant Evaluation Richard Smith

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Industry and regulatory presentations

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The Integration of Research into System Design and Clinical Practice Katelynn Glassman

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15:00 – 15:15. Rinri - Rincell-1: A Cell-Based Therapy for Neural Hearing Loss Doug Hartley

15:15 – 15:30. NIRx - Functional Near-Infrared Spectroscopy (fNIRS) Applications in Cochlear Implant Research Samantha O’Connell

15:30 – 15:45. NIDCD Roger Miller

15:45 – 16:00. ARPA-H Cal Roberts

4. Tonotopic coding - Joshua Bernstein, Maragaret Dillon (session chairs)

19:00 - 19:20. Unlocking the Cochlea with Synchrotron Phase-Contrast Imaging Sumit Agrawal

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Mentoring session

13:30 – 15:30. Ruth Y. Litovsky, Matthew J. Goupell

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11:20 - 11:40. Recordings from the brain: A review of direct CAEP measurements in Cochlear Implant Users Chen Chen

6B. Memorial for Bertrand Delgutte – Andrew Oxenham, session chair

11:40 - 12:00. Memorial for Bertrand Delgutte

Company research interface presentations

13:30 - 14:00. MED-EL

14:00 - 14:30. Advanced Bionics

14:30 - 15:30. Cochlear

7. Alternative strategies - Maike Vollmer, Johan Frijns (session chairs)

19:00 - 19:20. Transcription Factor Cocktails for Hair Cell Regeneration in Mature Cochleae Averyt Matthew, Lin Yang, Valeria Mas, Sunita Singh, Lisa Beyer, Diane Prieskorn, Andrew Groves, Yehoash Raphael

19:20 - 19:40. Better Temporal Acuity for Cochlear Implants John C. Middlebrooks, Matthew L. Richardson, Robert P. Carlyon, Harrison W. Lin

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20:20 - 20:40. Cortical Implants for Hearing Restoration Tania Rinaldi Barkat

20:40 - 21:00. Targeted Neuromodulation to Improve Cochlear Implant Use in Rodents Robert C. Froemke

Friday

8. Plasticity, development, and training - Mario Svirsky, Justin Aronoff (session chairs)

08:30 - 08:50. Longitudinal Studies of Early Cochlear Implant Use Ariel Edward Hight, Rohit Makol, Nicole Capach, Jonathan Neukam, Mario A. Svirsky, Robert C. Froemke

08:50 - 09:10. Between- and Within-Recipient Neural Correlates of Loudness Growth with Cochlear Implant Stimulation Levels Dorothée Arzounian, François Guérit, John M. Deeks, Charlotte Garcia, Evelien De Groote, Manohar Bance, Robert P. Carlyon

09:10 - 09:30. Examining Effects of Left Versus Right Pre-Lingual Unilateral Deafness on Cortical Responses to Sound Hanne Bartels, Melissa J. Polonenko, Hyo-jeong Lee, Jaina Negandhi, Sharon L. Cushing, Blake C. Papsin, Karen A. Gordon

09:30 - 09:50. Aural Preference Reorganization Following Congenital Single-Sided Deafness Is More Pronounced in Secondary Than in Primary Auditory Cortex Yusuf Prasandhya Astagiri, E. Firdaus, Peter Hubka, Jochen Tillein, Andrej Kral

09:50 - 10:10. Plasticity Limits Cochlear Implant Outcomes: Evidence from Machine Learning Models of Perception Annesya Banerjee, Mark R. Saddler, Josh McDermott

10:40 - 11:00. AI-enabled Prediction to Improve Language After Pediatric Cochlear Implantation Nancy M. Young, Yanlin Wang, Di Yuan, Shani Dettman, Dawn Choo, Emily Shimeng Xu, Denise Thomas, Maura Ryan, Patrick C. M. Wong

11:00 - 11:20. Effects of Maturation and Image-Guided Cochlear Implant Programming on Spectral and Temporal Resolution in Children with Cochlear Implants Andrea Defreese, Katelyn Berg, Jourdan Holder, Linsey Sunderhaus, Stephen Camarata, René Gifford

11:20 - 11:40. The Effect of Voice Training on Speech-On-Speech Intelligibility and Listening Effort in Cochlear Implant Users Ada Biçer, Thomas Koelewijn, Deniz Başkent

11:40 - 12:00. A Novel Naturalistic Dual-Task Ear Training Paradigm with Real-Time Gamified Neurofeedback for Cochlear Implant Users Filip Miscevic, Bowen Xiu, Andrew Dimitrijevic

POSTER SCHEDULE

Monday 8:00 -Tuesday 12:30

M-T 1: Comparing Hearing Aids and Cochlear Implants in Realistic Listening Environments Lisa Maggs, Brett Swanson, Ronny Ibrahim, Kelly Miles, Zachary Smith, Megan Gradden, Joerg M. Buchholz

M-T 2: Characterizing the Electrode-Neural Interface in Auditory Brainstem Implants Mahan Azadpour, Rahul Sinha, Maya Hatley, Nicole Capach, Megan Eitel, William Shapiro, J. Thomas Roland Jr., Mario Svirsky

M-T 3: Effect of Speech Material on the Pupil Response During Effortful Listening for Cochlear Implant Users and Typical Hearing Listeners H. Christiaan Stronks, Robin Van Deurzen, Paula L. Jansen, Jeroen J. Briaire, Johan H. M. Frijns

M-T 4: The Speech Perception in Quiet and Noisy Environments in Mandarin-Speaking Cochlear Implant Users with Low Frequency Residual Hearing Ruijie Wang, Lei Xu, Jianfen Luo, Xiuhua Chao, Haibo Wang

M-T 5: Cochlear Implant Users' Perceptual Test Scores Match Self-Assessed Music Perception, but Not Self-Assessed Music Enjoyment Eleanor E. Harding, Burcu Deniz, Etienne Gaudrain, Robert Harris, Barbara Tillmann, Bert Maat, Rolien H. Free, Deniz Başkent

M-T 6: Longitudinal Changes in Somatosensory P300 Responses in Single-Sided Deaf Patients Following Cochlear Implantation Ghislain Sofack, Kotaiba Raouafi, Sven P. Heinrich, Antje Aschendorff, Maria Michael, Thomas Wesarg, Susan Arndt, Pascale Sandmann, Iva Speck

M-T 7: Outcomes of Cochlear Implantation in Adults with Asymmetric Sensorineural Hearing Loss Eung-Kyung Cho, Myung-Whan Suh, Sang-Yeon Lee, Moo-Kyun Park, Jun Ho Lee, Seung-Ha Oh, Heonjeong Oh

M-T 9: Understanding Bilateral Speech Interference in Single-Sided Deafness Cochlear Implant Users Julianna R. Voelker, Sandeep A. Phatak, Matthew J. Goupell, Joshua G. W. Bernstein

M-T 10: Developing a Paradigm to Assess the Impact of Cognitive Status on Cochlear-Implant Audio-Visual Benefit Marina Salorio-Corbetto, Edwin Koubeh, Marta Fernández Ledesma, Nicholas Haywood, Deborah A. Vickers

M-T 11: Systematic Comparisons of eCAP Measurements Between Adult and Pediatric Cochlear Implant Users I: Cochlear Nerve Responsiveness and Electrode-Neuron Interface Index Zi Gao, Yi Yuan, Christopher R. Mueller, Shuman He

M-T 12: A Computationally Efficient Algorithm for Music Complexity Reduction in Cochlear Implants Using an Auditory Adaptation Model Anil Nagathil, Benjamin Lentz, Giselle Mojica, Ian C. Bruce, Christiane Völter, Rainer Martin

M-T 13: Self-Optimized Acoustic Models of Cochlear Implant Sound Quality Vary Across Single-Sided Deaf Cochlear Implant Users. Ariel Edward Hight, Rohit Makol, Maya Hatley, Megan Eitel, Nicole Capach, Jonathan Neukam, Sean K. Lineaweaver, Robert C. Froemke, Mario A. Svirsky

M-T 14: Click and Toneburst Electrocochleography to Assess Cochlear and Neural Function—an Extension of the Total Response Jonathan D. Neukam, Terrin N. Tamati, Aaron C. Moberly, René H. Gifford

M-T 15: Quantifying Longitudinal Objective and Subjective Changes in Speech Perception Performance in Adult CI Users in Experimental Processing Strategies Caylin McCallick, Julie G. Arenberg, Charles Hem, Faten Awwad

M-T 16: The Effect of Different Simulated Reverberant Environments on Cochlear Implant Users' and Normal Hearing Listeners' Binaural Fusion Justin M. Aronoff, Prajna Bk, Natalie Gustafson, Itunu M. Oyebamiji

M-T 17: Charge Injection Comparison Across Different Return Electrodes and Electrode Configurations for Neural Stimulation Christopher K. Nguyen, Stuart F. Cogan

M-T 18: The Role of Selective Attention in Bilateral Speech Interference for Single-Sided Deafness Cochlear-Implant Users Michael A. Johns, Sandeep A. Phatak, Matthew J. Goupell, Joshua G. W. Bernstein

M-T 19: Objective Measures of Binaural Hearing in Simulated Bilateral CI Users Juan-Daniel Galeano-Otálvaro, Bejamin Dieudonné, Jan Wouters

M-T 20: Effects of Contralateral Acoustic Masking on Speech Recognition as a Function of Age for Pediatric and Adult Cochlear Implant Users with Asymmetric Hearing Loss Margaret T. Dillon, Margaret E. Richter, Lisa R. Park, Amanda D. Sloop, Samantha P. Scharf, Nicholas J. Thompson, Kevin D. Brown, Emily Buss

M-T 21: A Neural Perspective on Temporal Envelope Modulation Encoding and Speech Perception Variability in CI Users Elise Verwaerde, Wouter David, Julian Schott, Robin Gransier, Nicolas Verhaert, Jan Wouters

M-T 22: Estimating Electrode Array Placement Using Tim and Validation Christopher J. Bennett, Ryan O. Melman, Zachary Smith, Joerg Pesch

M-T 23: Spatial Acuity Under Reverberation by Pediatrically Implanted Children and Adults with Bilateral Cochlear Implants Z. Ellen Peng, Victoria Sweeney, Darby Durbin

M-T 24: Cortical Effects of Chronic Cochlear Implant Stimulation in Children with Left and Right Sided Unilateral Deafness Hanne Bartels, Melissa J. Polonenko, Hyo-jeong Lee, Jaina Negandhi, Sharon L. Cushing, Blake C. Papsin, Karen A. Gordon

M-T 25: A Comprehensive Study on Temporal Loudness Integration in Cochlear Implant Users Carmen Marie Castañeda González, Linda Hu, Deyang Jiang, Sonja Karg, Anna Dietze, Daniela Schwanda, Miguel Obando Leitón, Werner Hemmert

M-T 26: Evaluation of Subjective Quality/enjoyment of Music and Speech in a Group of CI Subjects with Single-Sided Deafness Tobias Weissgerber, Sophia Kreuz, Uwe Baumann

M-T 27: Speaker-in-the-Loop: The Role of Recognizable Voices in Cochlear Implant Speech Intelligibility Hazem Younis, John H. L. Hansen

M-T 29: Characterizing Variability in Modiolar Proximity and Its Influence on Cochlear Implant Speech Recognition Outcomes with Precurved Electrode Arrays Michael W. Canfarotta, Aaron C. Moberly, Andrea J. Defreese, Ankita Patro, Jourdan T. Holder, René H. Gifford, David S. Haynes, Jack Noble

M-T 31: User-Mediated Adjustment of the CI and CROS Signal Mixing Ratio Improves Speech Intelligibility in Noise at Various Talker Locations. Anne Van Alphen, H. Christiaan Stronks, Jeroen J. Briaire, Johan H. M. Frijns

M-T 32: Probing Discrepancies Between Perceived Loudness and eCAP Amplitudes Along the Electrode Array in Cochlear Implant Users Charlotte Garcia, Dorothée Arzounian, François Guérit, Robert P Carlyon

M-T 33: Neural Adaptations to New Cochlear Implants: A Longitudinal Electroencephalogram Study Shimin Mo, Claude Alain, Andrew Dimitrijevic

M-T 34: Effect of Contralateral Stimuli on Perceptual Learning of Vocoded Speech Marine Jambois, Alexis Hervais-Adelman, Olivier Macherey

M-T 35: Focused Ultrasound Stimulation of Spiral Ganglion Neurons Elena Brunet, Vinay Parameshwarappa, Eric Debieu, Aziz Moqrich, Damir Kovacic, Emilie Franceschini, Olivier Macherey

M-T 37: Neurons in the Cochlea Versus Neurons in the Cochlear Nucleus – Refractory Periods and Polarity Effects in Humans with Different Auditory Prostheses Lutz Gaertner, Marko Takanen, Konrad Schwarz, Thomas Lenarz, Andreas Buechner

M-T 38: The Relationship Between Neural-Health Asymmetry and Interaural Loudness Mismatch for Bilateral Cochlear-Implant Users Obada J. Alqasem, Joshua G. W. Bernstein, Matthew J. Goupell

M-T 40: Facial Nerve Stimulation in a Computational Model of the Implanted Cochlea Randy Kalkman, Jeroen Briaire, Johan Frijns

M-T 41: Pulse Rate and Pulse Amplitude Modulation Sensitivity in the Inferior Colliculus of Cochlear Implant Rats Qinjie Zhang, Pui Chung Wong, Fei Peng, Shiyi Fang, Muhammad Zeeshan, Huan Jia, Jan W. H. Schnupp

M-T 42: How to Measure Binaural Hearing is a Clinical Setting, Towards a Unified Testing Framework for Single-Sided Deafness (SSD) Martijn Agterberg

M-T 43: Cochlear Microphonic Potentials in Front of the Intact and Behind the Opened Round Window Membrane: Is there a Difference? Ioana T. Brill, Stefan M. Brill, Stefan Hans, Stefan Dazert

M-T 45: Spiral Ganglion Neuron Path Tracing in High-Resolution muCT Scans Albert Croner, Johannes Ségur-Eltz, Siwei Bai, Mahdi Fallahtaherpazir, Alissa Breit, Johannes Melcher, Martin Dierolf, Rudolf Glueckert, Anneliese Schrott-Fischer, Werner Hemmert

M-T 46: Temporal Pitch Processing by Cochlear-Implant Recipients: Insights from Frequency-Following Responses and Behavioural Pitch Ranking Evelien De Groote, Wouter David, Charlotte Garcia, Robin Gransier, Jan Wouters, Robert P. Carlyon

M-T 47: A Transcanal Catheter for Delivery of Therapeutic Hypothermia to the Inner Ear: Experimental and Numerical Analysis Maria Fernanda Yepes, Pavan S. Krishnan, Curtis S. King, Suhrud M. Rajguru

M-T 48: Long-Term Use of Cochlear Implants in Older Adults Maya G. Hatley, Emily R. Spitzer, Susan B. Waltzman

M-T 50: High-Resolution Models of Human Cochlea for Studying Neural Activation Siwei Bai, Albert Croner, Carmen M. Castañeda González, Mahdi Fallahtaherpazir, Rudolf Glueckert, Anneliese Schrott-Fischer, Werner Hemmert

M-T 51: Impact of Central Auditory Attention on Listening Effort and Speech Performance in Cochlear Implant Users Yue Zhang, Amparo Callejón-Leblic, Ana Picazo-Reina, Sergio Trejo,Serafín Sánchez-Gómez

M-T 52: The Effect of Broadband and Frequency-Specific Delay Compensation in Bimodal CI Users Stefan Zirn, Franz-Ullrich Mueller, Sebastian Roth, Julian Angermeier, Werner Hemmert

M-T 54: Focused Threshold Profiles Relate to Vowel Identification Confusions in Adult Cochlear Implant Listeners Andrew Burleson, Charles Hem, Caylin McCallick, Julie G Arenberg

M-T 55: Outcomes of Cochlear Implantation in Children with Single-Sided Deafness in a Multicenter Clinical Trial Jill Firszt, Laura Holden, Noel Dwyer, Tim Holden, Ruth Reeder, Craig Buchman

M-T 56: Predicting Auditory Nerve Fiber Activation Threshold in Image-Based Cochlear Implants Models Using MLP Minh Vu, Erin L. Bratu, Jack H. Noble

M-T 58: Binaural Fusion in Single-Sided Deaf Cochlear Implant Users Lucrèce de Villars, John Galvin, Qian-Jie Fu, Faustine Legrand, Mathieu Robier, David Bakhos

M-T 59: Perceptual Cues Underlying Cochlear Implant Users' and Normal Hearing Listeners' Ability to Distinguish Reverberant Rooms B. K. Prajna, Justin M. Aronoff

M-T 60: The Effect of Electrode Length, Number of Electrodes, and Frequency Range on Both Spectral Representation and Spectral Resolution Emily R. Spitzer, David R. Friedmann, Madeleine M. Beyer, David M. Landsberger

M-T 62: Explaining Binaural Speech Benefits for Cochlear-Implant Listeners Using Monaural Measures of Asymmetry Matthew J. Goupell, Kylie Kelleher, Erin Catob, Michael A. Johns, Sandeep A. Phatak, Julianna R. Voelker, Joshua G. W. Bernstein

M-T 63: The Interaction Between Listening Effort and Rollover in Older Adults with Hearing Loss for Degraded Sustained Speech Natalie Field, Matthew J. Goupell, Chengjie G. Huang

M-T 64: Links Between Music Intervention, Informal Music Activities, Singing Pitch Accuracy, and Semantic Verbal Fluency Ritva Torppa, Li Xu, Lotta Keitilä, Valerie Looi

M-T 65: Behavioral and Neural Processing of Pitch Relations within Spectrally Sparse Musical Chords in Cochlear Implant Listeners Marie-Luise Augsten, Martin J. Lindenbeck, Bernhard Laback

M-T 66: Novel Method for Precise In-Situ Intracochlear Therapeutic Delivery Analysis Peter Baumhoff, Per Cayé-Thomasen, Peter Erfurt, Wiebke Konerding, Andrej Kral, Charlotte Amalie Navntoft

M-T 67: Anatomical and Cochlear Implant Placement Analysis Using Nautilus: An Automatic Image Analysis Tool Raabid Hussain, Reda Kamraoui, Jan Margeta, Roger Calixto

M-T 68: Reconstructing Perceptually Integrated Consonants by Cochlear Implant Users with Contralateral Hearing Aid (Bimodal Hearing) Caroline Grady, Magdeline Schwarz, Corinne Cancila, Allison Leach, Benjamin Estell, Yang-Soo Yoon

M-T 69: Meet Me Halfway – Connecting Objective Bottom-Up and Behavioural Top-Down Approaches to Speech Perception Based on Temporal Envelope Modulations Brent Sterckx, Marc Moonen, Jan Wouters

M-T 70: Measuring Auditory Awareness by Cochlear Implant Listeners Clément Gaultier, Paul Avan, Tobias Goehring

M-T 71: The Opto-Electrical Cochlear Implant Joaquín Cury, Maaz Shakur Haji, Xiaodong Tan, Claus-Peter Richter

M-T 72: Phonological Processing and Talker Discrimination in Adult Cochlear Implant Users Gizem Babaoglu, Aaron C. Moberly, Terrin N. Tamati

M-T 73: Stream Segregation for Cochlear Implant Listeners Nicholas R. Haywood, Ben Williges, Marina Salorio-Corbetto, Deborah Vickers

M-T 74: Binaural and Monaural Pulse Rate Discrimination: Does a Second Ear Help? Tanvi Thakkar, Serena Fincher, Stephen R. Dennison, Josh Stohl

M-T 75: Hearing Loss, Not Speech Recognition, Impacts Cognitive Function in Cochlear-Implanted Children Angelika Illg, Melina Schipper, William Kronenberger, Andrej Kral

M-T 76: Acoustic Cues for Emotional Prosody Perception Used by School-Age Children and Prelingually Deaf Young Adults with Cochlear Implants Aditya M. Kulkarni, Abby Pitts, Parker Hagemann, Jessica Combs, Dawna Lewis, Denis Fitzpatrick, John Galvin, Xin Luo, Monita Chatterjee

M-T 77: Evaluating Tonotopic Heterogeneity in Electrophysiological and Psychoacoustic Measures in Cochlear Implant Users Leanne Sijgers, Marlies Geys, Patrick Boyle, Josef Chalupper, Alex Huber, Flurin Pfiffner

Tuesday 13:00 – Wednesday 23:30

T-W 1: A Novel CI Coding Strategy Based on a Cochlear Model and Deep Neural Network Maryam Hosseini, Tim Brochier, Brett Swanson, Alan Kan, Richard F. Lyon

T-W 2: Novel Approaches to Investigating Binaural Processing in Bilateral Cochlear Implants Using Neural Processing and Psychophysical Measures Aditi Gargeshwari, G. Nike Gnanateja, Karen Gordon, Lulia Snan, Mohammad Maarefvand, Ruth Y. Litovsky

T-W 3: Auditory Sequence Learning in Children with Cochlear Implants Compared to Normal Hearing: What Did We Learn from Comparing Speech Versus Non-Speech Stimuli? Liat Kishon-Rabin, Shira Cohen, Ronen Perez

T-W 5: UmboMic: Design and Fabrication of an Implantable Microphone John Z. Zhang, Emma F. Wawrzynek, Julie G. Arenberg, D. Bradley Welling, Ioannis Kymissis, Elizabeth S. Olson, Jeffrey H. Lang, Hideko Heidi Nakajima

T-W 6: Investigating Inter-Brain Synchrony in Children with Cochlear Implants and their Mothers: A Comparative fNIRS Analysis with Normally Hearing Dyads Hilal Dogan, Efstratia Papoutselou, Guangting Mai, Samantha C. Harrison, Douglas E. H. Hartley, Derek Hoare

T-W 7: Frequency Range Preferences, Perceptual Abilities, and Music-Related Quality of Life in Adult Cochlear Implant Users Katelyn Berg, Barak Spector, Emily Spitzer, Terrin Tamati, Aaron Moberly, David Haynes, David Landsberger

T-W 8: The Danceability of Music Through a CI for Single-Side Deaf Listeners Gabriel McDerment, Natalia Stupak, David Landsberger

T-W 9: SOE Miller Sums Add Up to Channel Crosstalk? Chris J. James, Joerg Pesch

T-W 10: The Role of Talker Variability and Visual Cues on Emotion Identification Tasks Devon P. Major, Abby Pitts, Kaylah Lalonde, Monita Chatterjee

T-W 12: Scoring Speech Perception Tests Using Artificial Intelligence Rohit Makol, Maya Hatley, Sofiya Yusina, Megan Eitel, Mahan Azadpour, Mario A. Svirsky, Ariel E. Hight

T-W 13: Reliability of Using CBCT Scans to Derive the Parameters of the Dimensions of the Facial Canal Shavana Govender, Tania Hanekom, Rene Human-Baron

T-W 14: Investigation of Intracochlear Electrical Fields with Spread of Excitation and Volt-Age Matrix and their Link to Speech Perception Tobias Rader, Pascal Nachtigäller

T-W 15: New Insights on Focused Analog Stimulation in a Guinea Pig Model of the Cochlear Implant Victor Adenis, Ryan Bartholomew, Jae-Ik Lee, Andrew Jung, M. Christian Brown, Daniel J. Lee, Shelley I. Fried, Julie G. Arenberg

T-W 16: Electrophysiological Differences Between Lateral Wall and Perimodiolar Electrode Arrays Viral Tejani

T-W 18: How Frequency-Based Testing May Enhance our Understanding of Cochlear Implant Adaptation to Frequency-To-Place Factors? Louis Villejoubert, Deborah Anne Vickers

T-W 19: The Interaction Between Processing Strategy and Masker Type on Speech Perception in Noise with Simulated Cochlear Implants Lidea Shahidi, Caleb Lee, Robert P. Carlyon, Tobias Goehring

T-W 20: Comparison of the Effect on the Auditory Nerve Response of Ace and Fidelity 120 in a Computational Model Ilja M. Venema, Savine S. M. Martens, Jeroen J. Briaire, Johan H. M. Frijns

T-W 21: A Novel Method to Assess Contributions of Spectral and Temporal Pitch Cues in Realistic Speech Stimuli Floris Rotteveel, Bert Maat, Chris James, Damir Kovačić, Lina A. J. Reiss, Deniz Başkent, Etienne P. C. Gaudrain

T-W 22: Development of a Machine Learning System for Predicting Cochlear Implant Performance: A Comparative Analysis with Expert Predictions and a Web-Based Demonstration Alexey Demyanchuk, Eugen Kludt, Thomas Lenarz, Andreas Buechner

T-W 23: Auditory and Cognitive Contributions to Gated Word Recognition in Cochlear Implant Users Ariana Bennaim, Nirmal Srinivasan, Chhayakant Patro

T-W 26: CI Adults' Neural Encoding of Emotion and Gender Discrimination in Speech Xinyi Yao, Emily Graber, Andrew Dimitrijevic

T-W 27: When to Consider Aided Thresholds and Time on Air Abnormal: Insights from Big Data Saji Maruthurkkara, Quang Thai, Griet Goovaerts, Yue Zhang

T-W 28: Insights from Monopolar and 3-Point Impedances Collected Daily for Three Months from the Day of Surgery Patrick Boyle, Faizah Mushtaq, Efstratia Papoutselou, Doug Hartley

T-W 29: Outcomes for Single-Sided-Deafness Cochlear-Implant Users with Shifted Frequency Assignments to Reduce Interaural Frequency Mismatch Joshua G. W. Bernstein, Julianna R. Voelker, Sandeep A. Phatak, Elicia M. Pillion, Kenneth Kragh Jensen, Megan M. Eitel, Matthew J. Goupell

T-W 30: Towards Closed Loop Cochlear Implant Fitting Based on Intracochlear Cortically Auditory Evoked Potentials Jonas Althof, Nina Aldag, Waldo Nogueira

T-W 31: Naturalistic Cochlear Implant Field Testing with Ecological Momentary Assessment Taylor Lawson, John H. L. Hansen

T-W 32: Impact of Cochlear Implant Processing on Acoustic Cues Critical for Room Adaptation B. K. Prajna, Justin M. Aronoff

T-W 33: A Deformable Convolution GAN for Reverberation Suppression in Cochlear Implant Users Hsin-Tien Chiang, John H. L. Hansen

T-W 34: Examining the Relationship Between Language, Phonological Processing, and Literacy Skills Among Children with Cochlear Implants Mackenzie A. Lighterink, René H. Gifford, Stephen Camarata

T-W 35: Near-Infrared Light Protects Residual Hearing and Preserves Spiral Ganglion Neurons in an Animal Model of CI Surgery Dietmar Basta, Max Meuser, Moritz Gröschel, Sivan Faraj, Susanne Schwitzer, Patrick Boyle, Arne Ernst

T-W 36: Semantic Cues in CI Speech Processing: Effects of "neural Context Gain" in Anomalous and Meaningful Speech Perception Abigail Mollison, Sandy Snyder, Maureen J. Shader

T-W 38: Restoring Multi-Electrode Interaural-Time-Difference Sensitivity by Adjusting Inter-Electrode Pulse Timing Paul G. Mayo, Matthew J. Goupell

T-W 39: Benefit of Learning Systems for the Situation-Specific Optimization of Hearing Systems in Everyday Life Josef Chalupper, Manuel Kohl, Sven Kliesch, Andreas Buechner

T-W 40: Envelope-Following Responses in Cochlear Implant Users: Effects of Temporal Envelope Modulation Complexity Julian Schott, Robin Gransier, Marc Moonen, Jan Wouters

T-W 41: CI Select: An iPhone App for Patient-Driven Frequency Allocation Table Selection Megan Eitel, Victor Treaba, Dan Jethanamest, Nicole Capach, Mario Svirsky

T-W 42: Exploring the Impact of Noise Exposure and Cochlear Implantation on Hearing Preservation Kayla Minesinger, Rachele Sangaletti, Maria Camilla Salazar, Maria Fernanda Yepes, Federica Raciti, Suhrud M. Rajguru

T-W 43: Impedance Subcomponent for Different Type of Electrode Arrays. A Glimpse into the Implanted Cochlea. Seba Ausili, Federico Dilella

T-W 44: A Prospective, Multi-Centre Case-Control Trial Examining Factors that Predict Variable Clinical Performance in Post Lingual Adult CI Recipients Pam W. Dawson, Amanda Fullerton, Harish Krishnamoorthi, Kerrie Plant, Robert Cown, Nadine Buczak, Christopher J. Long, Chris J. James, Fergio Sismono, Andreas Büchner

T-W 45: The Physiological Mechanism Underlying the Polarity Effect on the Electrically Evoked Compound Action Potential Measured Using Symmetric, Biphasic Pulses in Human Cochlear Implant Users Shuman He, Jacob Oleson, Xiuhua Chao, Lei Xu, Ruijie Wang, Jianfen Luo, Yi Yuan

T-W 46: Spectro-Temporal Processing Using the Spectral-Temporally Modulated Ripple Test (SMRT) and its Relation to Hearing Loss and Cognition in Adults Aaron C. Moberly, Katelyn Berg, Andrea J. Defreese, Terrin N. Tamati

T-W 47: Effects of Electrode Position and T-NRT Measurement on Neural Health Estimates in CI Users Nadine Buczak, Eugen Kludt, Fergio Sismono, Thomas Lenarz, Andreas Büchner

T-W 48: Piano Training Does Not Improve Cochlear Implant Users' Vocal or Musical Emotion Categorization Eleanor E. Harding, Etienne Gaudrain, Robert Harris, Barbara Tillmann, Bert Maat, Steven De Rooij, Rolien H. Free, Deniz Başkent

T-W 49: Piano Training Improves Cochlear Implant Users' Speech-on-Speech Perception Eleanor E. Harding, Etienne Gaudrain, Robert Harris, Barbara Tillmann, Bert Maat, Steven De Rooij, Rolien H. Free, Deniz Başkent

T-W 50: The Role of Cochlear Implant-Hearing Aid Performance Disparity in Bimodal Benefit: A Controlled SNR Study Abigail Proctor, Priyanka Jaisinghani

T-W 51: The Role of Cochlear Implant-Hearing Aid Performance Disparity in Bimodal Benefit: A Controlled Spectral Resolution Parameters Study Rebecca M. Jones, Priyanka Jaisinghani

T-W 52: Impact of Consistent Device Usage on Self-Perceived Listening Fatigue in Adults with Cochlear Implants Swarali D. Joshi, Kelly N. Jahn

T-W 53: Impact of Interaural Level Difference on Binaural Fusion in the Presence of Interaural Place Mismatch in Normal Hearing Listeners Using Vocoders Itunu M. Oyebamiji, Justin M. Aronoff

T-W 54: Examining Asymmetry, Selective Attention, and Binaural Fusion as Predictors of Binaural Unmasking (or Interference) in Cochlear Implant Users Emily Burg, Matthew Fitzgerald, Duane Watson, René Gifford

T-W 55: Investigating the Responsiveness of the Auditory Nerve with Focused Perceptual Thresholds, eCAPs, and the Failure Index (FI) Across Cochlear Implant Electrodes Dietmar M. Wohlbauer, Charles Hem, Wiebke Konerding, Andrej Kral, Julie G. Arenberg

T-W 56: Exploring the Impact of Artifact Removal on Electrically Evoked Compound Action Potentials and Derived Metrics: A Comparison of New and Established Techniques Rachel A. Scheperle, Jeffrey A. Skidmore, Logan L. Flom, Brian J. Mostaert, Ibrahim Razu, Marlan R. Hansen

T-W 58: Development of Music Perception with a CI in an Orchestra Musician with Single-Sided Deafness Ritva Torppa, Jussi Jaatinen, Viljami Salmela, Tapio Lokki, Jussi Valtonen, Diamond Brown, David M. Landsberger

T-W 59: Stimulating the Cochlear Apex without Longer Electrode Arrays – Study Update Natalia Stupak, Emily R. Spitzer, Mariana Mejia Turnbull, Mary Shannon Carroll, Lisa Goldin, Alison Rigby, Catherine Flynn, Madeleine M. Beyer, Sarah Mantione, Justin Cotrell

T-W 60: SMRT for Kids: Validation of a Pediatric Spectral-Temporally Modulated Ripple Test Jun Zhang, Madeleine M. Beyer, Natalia Stupak, David Landsberger

T-W 61: Longitudinal Analysis of Intracochlear Electrocochleographic Response Patterns Marlies Geys, Adrian Dalbert, Christof Röösli, Alexander Huber, Flurin Pfiffner, Leanne Sijgers

T-W 62: Evaluating the Impact of Listener-Selected Frequency Allocation Tables on Sound Quality and Speech Perception in Single-Sided Deaf CI Users Nicole Hope Capach, Allison Biever, Camille Dunn, Megan Eitel, Elad Sagi, Mahan Azadpour, Ariel Hight, William H. Shapiro, Mario A. Svirsky

T-W 63: Evaluating Greenwood's Function for Tonotopic Mapping in Single-Sided Deaf Cochlear Implant Users Andreas Buechner, Tobias Weller, Thomas Lenarz, Richard Penninger, Daniel Schurzig

T-W 64: The Effects of Deafness Onset on Spatial Hearing and Music Perception in Young Adults with Bilateral Cochlear Implants W. S. Liu, N. R. Haywood, M. Salorio-Corbetto, F. Guerit, D. A. Vickers

T-W 67: Advancing Hearing Diagnostics and Devices Through Extracochlear Electric-Acoustic Stimulation Waldo Nogueria, Daniel Kipping, Yixuan Zhang, Benjamin Krueger

T-W 68: Effects of Semantic Context on Speech Recognition and Spatial Release from Masking in Children Using Bilateral Cochlear Implants and Age-Matched Typical Hearing Children Nimesha Didulani Dantanarayana, Shelly P. Godar, Margaret A. Koeritzer, Sara M. Misurelli, Ruth Y. Litovsky

T-W 69: Consumer Perceptions of Auditory Prosthetic Devices: Evaluating Performance, Privacy, Security, and Usability Sohini Saha, Leslie M. Collins, Sherri L. Smith, Boyla O. Mainsah

T-W 70: Investigating Age and Biological Sex Interactions on Temporal Processing Deficits in Cochlear-Implant Users Anhelina Bilokon, Miranda Cleary, Maureen J. Shader, Matthew J. Goupell

T-W 71: Developments and Barrier for Surgical Robots for Cochlear Implantation Huan Jia, Haoyue Tan, Jia Guo, Hao Wu

T-W 72: Stimulation Rate Variability in Cochlear Implants: A Novel Approach to Improving Speech Intelligibility Samuel Okei, John Hansen

T-W 73: Monitoring of the Inner Ear Function During and After Cochlear Implant Insertion Using Electrocochleography Sabine Haumann, Max E. Timm, Andreas Büchner, Thomas Lenarz, Rolf B. Salcher

T-W 74: Examining the Impact of Income and Minority Status on Access to Hearing Health Support Among Cochlear Implant Users Tanvi Thakkar, Serena Fincher

T-W 75: Improving SSD-CI Outcomes by Reducing Interaural Frequency and Loudness Mismatches Through Device Programming Laura Holden, Rosalie Uchanski, Noel Dwyer, Ruth Reeder, Tim Holden, Jill Firszt

T-W 76: Cortical Encoding of Tones vs. Acute Intracochlear Stimulation in Normal Hearing and Adult-Deafened Rats: A Comparative Study Using High-Density Micro-Electrocorticography. Ariel Edward Hight, Michele Insanally, Julia Scarpa, Yew-Song Cheng, Mario A. Svirsky, Robert C. Froemke

T-W 78: Bilinguals' Speech Perception of Noise-Vocoded Speech Deena Wechsler-Kashi

Thursday 8:00 – Friday 12:30

Th-F 1: A Biologically Plausible Vocoder for Auditory Perception Modeling Jacob de Nobel, Thomas Bäck, Jeroen Briaire, Anna Kononova, Johan Frijns

Th-F 2: The Impact of Active Communication and Device Use on Speech Outcomes in Adult CI Users Griet Goovaerts, Obaid Qazi, Birgit Philips, Tom Bertens, Andreas Büchner, Filiep Vanpoucke

Th-F 4: Establishing a Reliable Test Procedure for Measuring the Association of Spectro-Temporal Processing with Speech Acquisition for Paediatric Cochlear Implant Users Carolina Leal, Elizabeth Buchanan-Worster, Deborah Vickers

Th-F 5: Use of Adjectives in Narrative Discourse in School-Aged Children with Hearing Loss Deena Wechsler-Kashi, Galit Ben-Zvi

Th-F 6: Relating Individual Binaural Cues to Free-Field Localization Performance with the CCi-MOBILE Research Platform Using a Real-Time Mixed Rate Coding Strategy Stephen R. Dennison, Agudemu Borjigin, Ruth Y. Litovsky

Th-F 8: Combining Dexamethasone with Diclofenac or Immunophilin Inhibitor Mm284 in Cochlear Implants: Evaluating Electrically Evoked Action Potentials in Guinea Pig Onhintz de Olano Dieterich, Wiebke Behrends, Stefan Strahl, Gerrit Paasche

Th-F 9: Health-Related Quality of Life Among Cochlear Implant Users in Chinese Adults: A Nationwide, Cross-Sectional, Web-Based Survey Huan Jia, Jiayu Sun, Guo Jia, Hao Wu

Th-F 10: Speech Perception and Acoustic Cue Transmission in Quiet and Noise in Cochlear Implant Users: Prelingually-Implanted Children Versus Post-Lingually Implanted Adults Destinee Halverson, Olga Peskova, Mariette Broncheau, David Horn

Th-F 11: Can Neural Health Estimates Explain the Variability in Place-Pitch Sensitivity Improvement from Current Focusing Among Cochlear Implant Users? Niyazi O. Arslan, Xin Luo

Th-F 12: Machine Learning Models of Hearing Demonstrate the Limits of Attentional Selection of Speech Heard Through Cochlear Implants Annesya Banerjee, Ian Griffith, Josh McDermott

Th-F 13: FilterSTRIPES: A Frequency-Specific Version of the Spectro-Temporal Ripple for Investigating Processor Effectiveness Evelien De Groote, Deborah A. Vickers, Manohar Bance, Robert P. Carlyon

Th-F 14: Predicting the Acoustic Underpinnings of Phonemic Confusions in Noise Based on Spread of Excitation Bobby E. Gibbs Li, Erika D. Rodriguez, Sam M. Herkert

Th-F 15: "Look Over Here!": Using Visual Cues to Support Spatial Hearing in Children with Hearing Loss Anna Ishchuk, Jaina Negandhi, Emily Jesin, Rachel Lim, Nicholas Bridi, Robel Alemu, Sharon Cushing, Blake Papsin, Karen Gordon

Th-F 16: Pitch Perception Limitations with a Cochlear Implant as Revealed by Vocal Mimicry of Prosodic Stimuli by Single-Sided Deaf Listeners David M. Landsberger, Natalia Stupak, Benjamin Gordon, Sean Lang, John J. Galvin III

Th-F 17: Validating Reconstructed Consonants Perceptually Integrated Across Ears by Listeners with Normal Hearing and Hearing Loss Allison Leach, Corinne Cancila, Caroline Grady, Magdeline Schwarz, Benjamin Estell, Yang-Soo Yoon

Th-F 18: Audiovisual Speech-Evoked Oscillatory Dynamics in Aging Cochlear Implant Users James W. Dias, Kara C. Schvartz-Leyzac, Kelly C. Harris

Th-F 19: Advancing Optical Cochlear Implants: Insights from Acoustic and Led-Evoked Inferior Colliculus Responses Niels Albrecht, Fadhel El May, Elisabeth Koert, Anna Vavakou, Eric Klein, Bettina Wolf, Patrick Ruther, Tobias Moser

Th-F 20: Development of a Neural Health Test Battery for Trials of Advanced Therapies for Hearing Loss Eleni Genitsaridi, Andrew Soulby, Efstratia Papoutselou, Patrick Boyle, Charlotte Garcia, François Guérit, Faizah Mushtaq, Huib Versnel, Robert P. Carlyon, Douglas E. H. Hartley

Th-F 21: Comparison of Methods to Assign the Maximum Comfortable Loudness Levels on the Speech Recognition for Cochlear Implant Users with Asymmetric Hearing Loss Margaret E. Richter, Margaret T Dillon

Th-F 22: Comparison of Speech in Noise Processing in Hearing Impaired Populations Using [15 O]Water PET Phillip E. Gander, Joel I. Berger, Bob McMurray, Inyong Choi, Laura L. Ponto, Timothy D. Griffiths

Th-F 23: What Is the Source of the Binaural Advantage for Music Sound Quality in Single-Sided Deaf Cochlear Implant Users? Sean Lang, David M. Landsberger, Natalia Stupak, John J. Galvin III

Th-F 24: Behavioral and Physiological Responses to Emotionally Evocative Sounds in Adults with Cochlear Implants Prabuddha Bhatarai, Kelly N. Jahn

Th-F 25: Pitch Processing of Electrical Stimulation at the Apex of the Cochlea Robert P. Carlyon, Evelien De Groote, Dorothee Arzounian, John M. Deeks, Olivier Macherey

Th-F 26: Using Electrophysiology to Assess Language Processing in Cochlear Implant Using Children David P. Corina, Elizabeth Perotti, Sharon Coffey-Corina, Lee M. Miller

Th-F 27: Principal Component-Based Reconstruction of Cochlear Implant Maps Griet Goovaerts, Sean R. Anderson, Amir Ansari, Tom Bertens

Th-F 28: A Vocoder-Based Study on the Effects of Simulated Current Spread on Binaural Fusion Justin M. Aronoff, Josephine R. Lapapa, Jordan Deutsch, Karla Rodriguez

Th-F 29: Electroacoustic Pitch Matching in Cochlear Implant Users with Single-Sided Deafness Maya G. Hatley, Nicole Capach, René Gifford, Ariel Hight, Annette Lavender, Artur Lorens, Jonathan Neukam, Elad Sagi, Mario Svirsky, Mahan Azadpour

Th-F 30: The Contribution of Frequency-Specific Interaural Level Differences to Spatial Selective Attention Benjamin N. Richardson, Jana M. Kainerstorfer, Barbara G. Shinn-Cunningham, Christopher A. Brown

Th-F 32: Performance of Recipients of Cochlear Implants at Adolescence Rosalie M. Uchanski, Lisa S. Davidson, Ann E. Geers, Brent Spehar

Th-F 33: Improving ITD Sensitivity of Cochlear Implanted Rats: Microsecond Precise Versus Binaurally Jittered ITD Information Tim Fleiner, Christian Wirtz, Reinhold Schatzer, Peter Nopp, Susan Arndt, Jan W. Schnupp, Nicole Rosskothen-Kuhl

Th-F 34: Contributions of Low Frequency Acoustic Hearing to Binaural Sensitivity and Speech Unmasking in Individuals with Electric-Acoustic Stimulation and Normal Hearing Mohammad Maarefvand, René H. Gifford, Spencer Smith, Shelly Godar, Sara Misurelli, Roya Abdi, Jonathan D. Neukam, Fan-Yin Cheng, Olaedo Obinna, Ruth Y. Litovsky

Th-F 35: Evaluating Electrophysiological and Behavioral Measures of Neural Health in Cochlear Implant Users: A Computational Simulation Study Yixuan Zhang, Daniel Kipping, Waldo Nogueira

Th-F 36: Age-Related Temporal Processing Deficits Assessed Via Forward Masking in Cochlear-Implant Users Chengjie G. Huang, Natalie A. Field, Gianna Delucca, Rebecca Scheerer, Samira Anderson, Matthew J. Goupell

Th-F 37: Co-Production with the South Asian Community to Increase Inclusion and Engagement with Hearing Research Jane Gallacher, Bhavisha Parmar, Deborah Vickers

Th-F 38: Focussed, but Broad Enough: Towards Psychophysically Relevant Current Focussing with Cochlear Implants François Guérit, Robert P. Carlyon

Th-F 39: Comparing Physiological and Psychophysical Spread of Excitation: eCAP Versus Electric and Bluetooth PTCs Charles B Hem, Dietmar M. Wohlbauer, Caylin R. Mccallick, Julie G. Arenberg

Th-F 40: Measuring Speech in Noise Perception During Infancy with HD-DOT Addison D. N. Billing, Robert J. Cooper, Deborah A. Vickers

Th-F 41: Using SCINSEVs for Intraoperative Detection of Partial Insertion and Tip Fold-Over in a Tertiary Care Centre Marina Salorio-Corbetto, Rei Chin, Susan T. Eitutis, Yu C. Tam, Noah Havers, Matthew E. Smith, Neil P. Donnelly, James Tysome, Patrick Axon, Manohar L. Bance

Th-F 42: Evaluation of the Reliability of the Cochlear Implants Using Large Animal Model Doo-Hee Kim, Dong-Min Kang, Soo-Won Shin, Gwang-Jin Choi, Jun-Woo Hyun, Yoon-Hee Ha, Sang-Woo Kim, Ho-Seung Lee, Kyou-Sik Min, Myung-Hwan Suh

Th-F 43: Predicting Post-Operative Cochlear Implant Outcomes with Pre-Operative Psychophysics Emily R. Spitzer, David R. Friedmann, Madeleine M. Beyer, David M. Landsberger

Th-F 44: The Contribution of Vestibular and Balance Function on Developmental Outcomes of Children with Bilateral Cochlear Implants Melissa Hazen, Sharon L. Cushing, Karen A. Gordon

Th-F 45: Impact of Linked Sound Processing on the Encoding of Binaural Cues in Bilateral Cochlear Implants Gianpaolo Palo, Obaid Qazi, Tom Bertens, Filiep Vanpoucke, Jan Wouters

Th-F 46: Stimulating and Recording Cortical Potentials Directly Via Advanced Bionics' Cochlear Implant System Chen Chen, Don Bell-Souder, Tony Spahr, Anu Sharma

Th-F 47: A Behavioral Measure of Neural Adaptation Olivier Macherey, Jacques Chatron, Stéphane Roman, Robert P. Carlyon

Th-F 48: Accounting for Age Differences in Spectral and Temporal Modulation Perception with a Cochlear Implant David L. Horn, Destinee M. Halverson, Olga Peskova, Mariette S. Broncheau, Lynne A. Werner, Jay T. Rubinstein

Th-F 49: Dynamic Selection of Electrode Firing Sequences from Model-Based Estimates of Neural Responses Erin L. Bratu, Andrea J. Defreese, Katelyn A. Berg, René H. Gifford, Jack H. Noble

Th-F 50: Electrophysiology Based Surgical Sensitivity Comparison Between Manual and Robot-Assisted CI Sidharta Gupta, Dyan Ramekers, Tinne Vandenbroeke, Emilie Heuninck, Griet Mertens, Vincent Van Rompaey, Marc Lammers

Th-F 51: Sensitivity Analysis of Speech Enhancement for Cochlear Implant (CI) Users in Noisy Reverberant Environments Sohini Saha, Leslie M. Collins, Boyla O. Mainsah

Th-F 52: Delay Compensation Between Acoustic and Electric Inputs Can Partially Restore Degraded ITD Coding to Binaural-Bimodal (Acoustic-Electric) Stimulation Maike Vollmer, Merle Berents, Andreas Schulz, Frank W. Ohl

Th-F 53: Visual Amplitude Envelope Benefits Speech Perception in Cochlear Implant Users: A Pilot fNIRS and eCAP Study Yi Yuan, Zi Gao, Yingying Wang, Shuman He

Th-F 55: Electrical Model of the Guinea Pig Head for In-Silico Analysis of Neural Stimulation by Cochlear Implants Michael Handler, Peter Baumhoff, Wiebke Konerding, Björn Michael Vey, Andrej Kral, Daniel Baumgarten

Th-F 56: Investigating the Effect of Envelope Sampling at Low Stimulation Rates on Speech Perception and Power Consumption with Cochlear Implants Lidea Shahidi, Robert P. Carlyon, Deborah A. Vickers, Tobias Goehring

Th-F 57: Focused Stimulation Enhances Music Sound Quality in Cochlear Implant Recipients: Findings from a Feasibility Study Naomi B. H. Croghan, Zachary M. Smith, Jennifer H. Torres, Sara I. Duran, Wendy B. Potts, David C. Kelsall, Allison Biever, Richard K. Gurgel, Kate Johnson, Christopher J. Long

Th-F 58: Psychophysical Tuning Curves for Children and Adults with and without Cochlear Implants Scott C. Aker, Charles Hem, Caylin R. McCallick, Julie G. Arenberg

Th-F 59: Analyzing Electroanatomical Modeling Techniques for Image-Guided Cochlear Implant Programming Jared A. Rybarczyk, Erin L. Bratu, Jack H. Noble

Th-F 60: Optical Detection of Basilar Membrane Damage Joaquín Cury, Olivia Griffith, Jordan Villa, Xiaodong Tan, Claus-Peter Richter

Th-F 61: A Combinational Approach Using Lombard Effect Perturbation and Enhancement as a Front-End Solution for Speech Intelligibility in Noise Juliana N. Saba, Nursadul Mamun, John H. L. Hansen

Th-F 62: Monitoring of Daily Impedance Fluctuations in Experienced CI Users Joerg Pesch, Marc Leblans, Loes Beckers, Filiep Vanpoucke, Andrzej Zarowski, Karyn Galvin, Weyi Wang, Tom Bertens

Th-F 64: Factors Influencing Hearing Preservation and Speech Understanding: A Predictive Modelling Approach Annette Günther, Thomas Lenarz, Andreas Büchner

Th-F 65: Anatomical Frequency Maps Strictly Based on the Greenwood Function May Be Suboptimal for Bimodal CI Users Nicole Hope Capach, Elad Sagi, René H. Gifford, Mario A. Svirsky

Th-F 66: Loudness Growth with Pulse Phase Duration: Effect of Stimulation Mode Emily Spitzer, David Landsberger, David Bakhos, Matthew Robier, Bradford Bacchus, John Galvin

Th-F 69: Take-Home Cochlear Implant Processor with Spectral and Temporal Enhanced Processing (Step) Damir Kovačić, Chris J. James

Th-F 70: Resting-State Functional Connectivity in Cochlear Implant Users: A fNIRS Study Yingying Wang, Yi Yuan, Shuman He, Michelle Hughes, Hongying Dai

Th-F 71: Electrophysiological Assessment of Temporal Envelope Modulation Encoding for the Fitting of Cochlear Implants Elise Verwaerde, Julian Schott, Wouter David, Robin Gransier, Marc Moonen, Jan Wouters

Th-F 72: The Use of Micro-Computed Tomography Images to Investigate the Relationship Between the Internal Auditory Canal Shape and the Class of the Cochlea. Nandipha Mntungwa, Tania Hanekom, Rene Human-Baron

Th-F 74: The Evolving Contribution of Early and Later Gestures to Subsequent Vocabulary Outcomes in Mandarin-Speaking Children with Cochlear Implants Jianfen Luo, Lei Xu, Min Wang, Jinming Li, Linda J. Spencer, Shuman He, Ling-Yu Guo

Th-F 75: Clinical Evaluation of Frequency Allocation for Bimodal Cochlear Implant Users Megan Eitel, Nicole Capach, Maya Hatley, Mario Svirsky

Th-F 76: Cochlear Malformations Impact the Relationship Between Current Spread and Neural Response at the Electrode-Interface in Children with Cochlear Implants Carina J. Sabourin, Stephen G. Lomber, Jaina Negandhi, Sharon L. Cushing, Blake C. Papsin, Karen A. Gordon

Th-F 77: Semi-Objective Cochlear Implant Fitting with Electrically Evoked Auditory Steady-State Responses Results in Good Speech Perception Julian Schott, Elise Verwaerde, Robin Gransier, Marc Moonen, Jan Wouters

Th-F 78: Leveraging Interaural Time Differences for Improved Speech Localization in Cochlear Implant Users Using CCi-MOBILE Samuel Okei, John Hansen

PODIUM ABSTRACTS

Monday: 08:30 - 08:50

IMPLANTABLE MICROPHONE FOR TOTALLY IMPLANTABLE COCHLEAR IMPLANT

Hideko Heidi Nakajima

Harvard Medical School; Eaton-Peabody Laboratories, Mass Eye and Ear

A totally-implantable cochlear implant (TICI) has the potential to offer significant advantages over a conventional cochlear implant (CI) with external hardware. Obstacles to internalizing all hardware for a TICI, such as power consumption, battery life, charging, and miniaturization have been overcome through recent technical advances. However, to enable widespread adoption of a TICI, an implantable microphone having performance on par with that of conventional external microphones is still needed. Although TICIs are not currently available on the market, several clinical studies have been performed or are underway.

We have developed a prototype implantable microphone suitable for a TICI that can take advantage of the external ear's acoustic pressure enhancement and benefit from sound localization cues that improve hearing in the face of challenging environmental noise. This microphone, called the UmboMic, senses the motion of the umbo (the distal tip of the manubrium) within the middle ear cavity. Due to its novel design and fabrication, the UmboMic's performance rivals that of a conventional external cochlear implant microphone in terms of sensitivity, bandwidth, linearity, dynamic range, signal-to-noise ratio, and ability to reject and shield from electrical noise (such as cochlear implant signals). The UmboMic was developed through iterations of analytical modeling, finite-element analysis, bench testing and implanted testing in human cadaveric ears. Its exceptional performance derives from its architecture: a triangular cantilever sensor comprised of two layers of piezoelectric polymer polyvinylidene fluoride (PVDF) providing a differential output to a custom low-noise low-power differential amplifier for excellent signal-to-noise.

Monday: 08:50 - 09:10

NOVEL FUNCTIONALITY FOR COCHLEAR IMPLANTS: ELECTROCHEMICAL IN VIVO SENSING AFTER CHRONIC IMPLANTATION

S. Reinelt[1], A. Xavier[2], S. Arndt[2], S. J. Rupitsch[1], A. Weltin[1], J. Kieninger[1], N. Rosskothen-Kuhl[2]

[1]University of Freiburg, Germany, IMTEK – Department of Microsystems Engineering
[2]Department of Otorhinolaryngology, Section of Experimental and Clinical Otology,
Medical Center – University of Freiburg, Faculty of Medicine, Germany

Cochlear implants (CIs) are the most successful neural implants with more than 1 million implanted hearing prostheses worldwide. They compensate for hearing loss in patients by directly stimulating the auditory nerve electrically. In acute experiments, we were able to show for the first time that CI electrodes can be turned into in vivo sensors by applying suitable electrochemical methods [1]. This novel sensor function enables monitoring of the implant's microenvironment, e.g. by measuring intracochlear oxygen level and monitoring of the implant's electrode condition. This approach promises viable in-sights into the development of inflammation reactions and foreign body response after cochlear im-plantation, as well as additional monitoring functionality besides impedance measurements of existing implants without the need for adaptations. Here, we investigate if CI electrodes are stable in vivo sensors after chronic CI supply in rats.

Deaf rats were bilaterally implanted with CIs and underwent binaural sound lateralization training for up to six months, with all animals showing excellent hearing performance [2]. For the measurements in anesthetized rats, CIs were connected to a potentiostatic measurement setup with an additionally placed Ag/AgCl reference electrode. We used combined amperometric and potentiometric sensor methods to sense the dissolved oxygen in the cochlea in real time. The rats were repeatedly supplied with pure oxygen as a breathing gas via a nasal mask.

After months of chronic implantation, it was possible to recover the sensor signal and reproducibly sense intracochlear oxygen levels with all CI electrodes. Figure 1 illustrates a sample in vivo experiment, in which a CI rat was either breathing normal air or pure oxygen via the mask. Both oxygen re-duction reaction (ORR) current and open circuit potential (OCP) extracted from electrochemical measurements showed stable and repeatable responses to oxygen supply.

We have successfully demonstrated that chronically implanted CI electrodes can be converted into functional electrochemical oxygen sensors. This novel functionality of CI electrodes offers great potential for long-term investigation of the biochemical microenvironment and monitoring of the condition and stability of implant electrodes.

Monday: 09:10 - 09:30

SIGNIFICANT COCHLEAR IMPLANT INSERTION TRAUMA IS ASSOCIATED WITH APICAL SPIRAL GANGLION NEURON LOSS IN THE HUMAN

Julie Arenberg, Abbie Hall, Christopher Giardina, Anbuselvan Dharmarajan, Jennifer O'Mally, Alicia Quesnel

Harvard, Mass Eye and Ear, Eaton Peabody Laboratory;
Mass Eye And Ear, Otopathology Laboratory;
Harvard, Mass Eye and Ear, Otopathology Laboratory

Hearing and structure preservation approaches to cochlear implant (CI) insertion aim to minimize trauma and preserve residual spiral ganglion neurons (SGNs). In cases of significant insertion trauma, peripheral axons running through the bony osseous spiral lamina (OSL) inherently become damaged if the OSL is fractured. The current investigation sought to determine if the relative location of OSL fracture was associated with focal areas of SGN loss. Eight adult ears from the Mass Eye and Ear Otopathology Laboratory were identified with OSL fractures due to CI insertion trauma. Digitized e-Slides were used to create 3D cochlear reconstructions, and a coordinate system relative to the round window allowed for angular assignment of SGNs and OSL fracture locations. When available, contralateral ears were also analyzed for comparison, with particular emphasis on peripheral axon density. OSL fracture lengths ranged from 30 degrees to 109 degrees about the modiolus, with a median fracture length of 71 degrees. Six of the 8 fractures were associated with CI scalar translocation, while in 2 cases the fracture occurred without translocation. Total SGN counts ranged from 11,540 to 27,960. Abrupt and focal drops of >50% in SGN density within 30 degrees about the modiolus occurred in 7 of 8 temporal bones with OSL fracture, and when analyzing SGN density by length along Rosenthal's Canal (RC) 6 out of 8 had SGN drops greater than 15% apical to the site of fracture. The case with the longest fracture demonstrated nearly a complete loss of neurons apical to the deepest fracture location. Interestingly, the areas of localized "dead zones" were typically apical to the fracture site itself and not perfectly overlapping, which may be due to the twisting of the cochlea and where the fractured axons ultimately innervate the RC. In temporal bones from CI patients, the angular location of OSL fracture explains some (but not all) of the SGN drops seen in traumatic CI insertions. Variation in local SGN density was observed across the length of these cochleae, indicating multiple processes likely contribute to SGN dead zones.

Monday: 09:30 - 9:50

A COMBINED MODEL FOR INTRACOCHLEAR ELECTROCOCHLEOGRAPHY SIMULATIONS IN HEALTHY AND IMPAIRED EARS

Aristeidis Choustoulakis, **Margriet J. Van Gendt, Jeroen J. Briaire, Johannes H. M. Frijns**

Leiden University Medical Center

A combined model for intracochlear electrocochleography simulations in healthy and impaired ears Aristeidis Choustoulakis (1), M.J. van Gendt (1), J.J. Briaire (1), J.H.M. Frijns (1) (1) Leiden University Medical Center, Albinusdreef 2, 2333 ZA Leiden, The Netherlands Objective: Intracochlear electrocochleography (ECochG) is a novel method for monitoring residual hearing intra- and postoperatively. The variation in hearing loss pathologies of the CI recipients introduces additional variation in the recordings. A computational model was developed to improve the interpretation of these measurements. With the model the effect of different pathologies on the ECochG response can be evaluated. To validate the model, the simulations are compared to experimental data and recordings from actual CI-recipients.

Methods: The proposed model consists of the middle-ear filter and the basilar membrane filters, the inner and outer hair cells in the form of a circuit representation and the auditory nerve in the form of a synapse and a spike generator. Model parameters are adjusted to simulate different hearing loss etiologies. Outputs of each aforementioned stage are simulated and compared to experimental animal data. The electrocochleography model (van Gendt et al. 2020) is added to the output of the hair cells via the volume conduction stage (Kalkman et al. 2014). The electrocochleography simulations are compared to recordings in actual CI-patients. Intracochlear ECochG is recorded using the Active Insertion Monitoring (AIM) system by Advanced Bionics. Subjective thresholds are predicted both intra- and postoperatively. These thresholds are compared to audiogram thresholds up to 6 months after surgery.

Results: Validation shows that with the model typical ECochG recordings can be simulated. Patient data showed a wide variety in responses. Intra-operative data show that the electrocochleography thresholds are overall higher than pre-operative thresholds. Post-operatively, a correlation was found between post-operative audiometric thresholds and ECochG thresholds in CI-recipients at 125 and 250 Hz, this was not found for the higher frequencies. Based on the model simulations, variations in ECochG responses can be explained by different numbers of contributing hair cells, changes in Endocochlear Potential or tip link sensitivity.

Conclusions: The model is applicable to study the mechanisms underlying the functions of the auditory system in healthy and impaired ears and the intracochlear ECochG recordings. Various etiologies affect the ECochG response in distinct manners, which can explain differences in patient recordings.

References:
[1] van Gendt MJ, Koka K, Kalkman RK, Stronks HC, Briaire JJ, Litvak L, Frijns JHM. Simulating intracochlear electrocochleography with a combined model of acoustic hearing and electric current spread in the cochlea. J Acoust Soc Am. 2020 Mar;147(3):2049.
2] Kalkman RK, Briaire JJ, Dekker DM, Frijns JH. Place pitch versus electrode location in a realistic computational model of the implanted human cochlea. Hear Res. 2014 Sep;315:10-24.

Monday: 9:50 - 10:05

SAFETY AND EFFICACY OF DB-OTO GENE THERAPY IN CHILDREN WITH PROFOUND DEAFNESS DUE TO OTOFERLIN VARIANTS: DATA FROM THE CHORD PHASE 1/2 OPEN-LABEL TRIAL AND THE IMPORTANCE OF MINIMALLY TRAUMATIC SURGERY, A CASE STUDY

Manuel Manrique

Regeneron

Monday: 10:40 - 11:20

ADVANCEMENTS AND CHALLENGES IN SIGNAL PROCESSING AND SOUND CODING FOR COCHLEAR IMPLANTS

Waldo Nogueira[1,2]

[1]Hannover Medical School and Cluster of Excellence "Hearing4all", Germany
[2]Institute of Neuroscience and Department of Microlectronics and Systems Electronics, Universitat Autonoma de Barcelona, Spain

Sound coding is a critical component of cochlear implant systems, responsible for transforming acoustic signals into electrical stimulation patterns that activate the auditory nerve. This process begins with sound capture via an external microphone, followed by digitization, noise reduction, and the computation of stimulation patterns delivered through intracochlear electrodes. While various sound coding strategies have been developed to enhance speech perception, progress has plateaued, and cochlear implant users still experience limited performance compared to normal hearing individuals.

These limitations stem from both biological and technological constraints, including the coarse electrode-nerve interface, current spread in the cochlear fluids, neural health variability, and hardware restrictions such as limited number of electrodes, stimulation flexibility and binaural processing. Additionally, the nature of artificial electric stimulation of the auditory nerve limits temporal neural processing constraining pitch perception and binaural processing.

Recent advances in medical imaging, novel impedance measurements and electrophysiological measurements with the cochlear implant electrodes enable more precise characterization of the electrode-nerve interface, paving the way for future individualized sound coding strategies. Furthermore, the integration of artificial intelligence in the sound coding strategy and the emergence of next generation implanted electronics including integrated digital signal processors, memory, and adaptive stimulation—promise to revolutionize cochlear implants. The next-generation of cochlear implant systems will be able to dynamically interpret neural responses and deliver personalized stimulation, offering new opportunities to improve speech understanding, sound localization, and music appreciation cochlear implant users.

Monday: 11:20 - 11:40

THE EFFECT OF REVERBERATION AND ARTIFICIAL-INTELLIGENCE-BASED DEREVERBERATION ALGORITHMS ON SPEECH INTELLIGIBILITY FOR COCHLEAR IMPLANT USERS

Nienke C. Langerak[1], H. Christiaan Stronks[1,2], Esther F. Van Marrewijk[1], Jeroen J. Briaire[1], Shaliza Merchant[1], Daphne L. Geijsen[1], Jean-Marie Lemercier[3], Timo Gerkmann[3], Johan H. M. Frijns[1,2,4]

[1]Department of Otorhinolaryngology and Head & Neck Surgery, Leiden University Medical Center, Leiden, The Netherlands
[2]Leiden Institute for Brain and Cognition, Leiden University, Leiden, The Netherlands
[3]Signal Processing, Universität Hamburg, Hamburg, Germany
[4]Department of Bioelectronics, Delft University of Technology, Delft, The Netherlands

Objective: Cochlear implants (CIs) generally perform well in quiet conditions, but speech understanding in an environment with reverberations remains difficult. This study aimed to quantify the detrimental effects of reverberation on speech intelligibility for CI users and to minimize the reverberations in speech signal by using novel artificial intelligence-based algorithms created for use in CIs.

Methods: A prospective crossover study was performed that included 15 CI users, with each participant being their own control. The study consisted of two parts: in the first part, the effect of reverberation on speech intelligibility was investigated by creating psychometric functions using different reverberation times. Speech tests were streamed directly to the speech processor, and reverberation was added by a simulated room of 7 x 6 x 3.5 m with varying reverberation times. With these psychometric functions we could determine the reverberation threshold where 50% was repeated correctly (SRT) and use this as starting point for the second part of the study where two dereverberation algorithms were tested. The first was trained to minimize late reverberations (DNN-WPE) and another version with an additional post-filter was trained to minimize early and late reverberations (DNN-WPEPF). These two algorithms were tested by performing speech intelligibility tests in six conditions: clean speech (no reverberation), clean speech processed with both algorithms, reverberated speech, and reverberated speech processed by both algorithms. Additionally, subjective ratings were performed to assess how the participant perceived the processed sound. To this end, a graphical user interface was designed where pairwise comparisons of the aforementioned conditions could be compared in terms of three outcomes: listening effort, naturalness, and perceived speech intelligibility.

Results: The psychometric functions with reverberation yielded a median reverberation time of 1.1 s at the SRT for CI users (within a range of 0.8 s and 3 s) and a much longer reverberation time of 7.5 s for typical hearing participants. When reverberated speech was processed with DNN-WPE at the participants' SRT, an improvement of 11% was observed ($p < 0.001$) and when processed with DNN-WPEPF an improvement of 17% was observed ($p < 0.001$). The benefit of DNN-WPEPF was significantly larger than the benefit of DNN-WPE ($p = 0.018$). Both algorithms did not significantly affect speech intelligibility of clean speech ($p = 1.00$). Speech dereverberated with either algorithm was significantly preferred over reverberated speech for all three outcomes. Moreover, speech dereverberated with DNN-WPEPF was significantly preferred over speech dereverberated with DNN-WPE.

Conclusion: This study revealed that reverberation affects speech intelligibility for CI users more profoundly than for normal hearing participants. The DNN-WPE and DNN-WPEPF dereverberation algorithms resulted in substantial benefits for CI users regarding speech intelligibility and subjective ratings. These algorithms did not affect the clean speech, showing that they can be switched on permanently, even in the absence of reverberations. Further developments are required to implement the algorithms in real time on the CI processor and more research is needed to assess them under more realistic listening conditions.

Monday: 11:40 - 12:00

TOWARDS A CLOSED LOOP BRAIN COMPUTER INTERFACE TO MAKE MUSIC MORE ACCESSIBLE FOR COCHLEAR IMPLANT USERS

Jonas Althoff, Waldo Nogueira

Hannover Medical School and Cluster of Excellence "Hearing4all"

For individuals with profound hearing loss, cochlear implants (CIs) provide access to sounds that support speech perception. However, many CI users still face challenges when listening to music. Our project aims to enhance music perception through an innovative brain-computer interface (BCI). This BCI concept involves using brain signals to control a deep neural network within the CI sound processor, emphasizing specific music components. To achieve this goal, we conducted three studies: The first study aimed at unveiling beneficial musical components in music remixing for CI users. 10 Bilateral CI users and 10 normal hearing listeners were asked to remix multitracks grouped into melody, bass, accompaniment, and percussion. The remixes were conducted in the amplitude, spatial, and spectral domains. In the second study, we addressed the task of selective auditory attention decoding (SAAD), to retrieve a powerful neural feature which can be used for the sound processing stage. Results showed that CI users preferred tracks being panned toward the right side, especially the percussion component. When CI users were grouped into frequent or occasional music listeners, significant differences in remixing preferences in all domains were observed. These results suggest that user-dependent music remixing system is desirable. The second study focused on using EEG to assess if it is possible to decode the attended source in a music piece. Previous studies showed the possibility of decoding an attended music source from electroencephalography (EEG) via reconstruction of the sound envelope in normal hearing (NH) listeners. This work investigated if SAAD is also possible in CI users when listening to music, especially for two instruments arising from the same piece. Experiments were conducted in 8 bilateral CI users and 8 NH listeners as controls. Results demonstrate that is indeed possible to perform SAAD in CI users in a dichotic music listening scenario. While the correlation coefficients of NH and CI users differed strongly, the decoding accuracy was not significantly different between the two groups. These results suggest that EEG can potentially be used as a neural measure of attention when CI users listen to music. The third study aimed to combine the previous two studies into one, using the neural responses recorded from EEG as feedback to the sound processing stage. Here, an end-to-end deep neural network trained for source separation has been designed with neural feedback from EEG to further improve separation quality and sound perception. Pilot results show benefits of including brain signals to improve the separation of music instruments. The three studies represent initial steps towards developing a brain-computer interface to enhance music accessibility for CI users. However, they also underscore several challenges that need to be addressed. The experiments were conducted under highly controlled laboratory conditions. Technical challenges include removing CI electrical artifacts and movement artifacts in real auditory scenes. While benefits have been observed with simple music pieces, music itself is much richer and more complex.

Acknowledgements: This work is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation)—Project ID: 446611346 (PI: Waldo Nogueira).

Monday: 19:00 - 19:40

LEARNING FROM THE CENTRAL NERVOUS SYSTEM ABOUT PERIPHERAL CODING OF COMPLEX SOUNDS

Laurel H. Carney

University of Rochester, Rochester, New York, USA

The responses of auditory-nerve (AN) fibers have traditionally been described in terms of average discharge rates versus characteristic frequency (CF), i.e. rate-place representations, or in terms of the detailed timing of discharges over the time course of a stimulus. The temporal representations focus on either temporal fine structure (TFS), dominated by phase-locking to tones or to individual frequency components in complex sounds, or on phase-locking to the envelope of complex sounds (ENV). There are several well-known limitations of rate-place codes – average discharge rates are not simply related to sound energy (Carney, 2018). For example, the saturation of the synapse between the inner-hair-cell (IHC) and AN, which occurs for the high-spontaneous-rate majority of AN fibers at all CFS, and for all spontaneous rate groups at frequencies below about 1500 Hz (Winter and Palmer, 1991), is a serious challenge for rate-based coding, especially for complex sounds and in noisy backgrounds. Additionally, adaptation of the dynamic-range of AN fibers based on each fiber's response history complicates the interpretation of average rates. There is also considerable variation of spontaneous activity over time, so the baseline reference for rate-based coding is not stable. Thus, although a rate-based code for complex sounds seems to be a simple strategy, decoding rates is not a simple exercise. Temporal codes are an attractive solution to these limitations, but they present their own challenges for decoding mechanisms. For example, there is no physiological evidence for neurons, or neural mechanisms, that could decode phase-locking to TFS, for example, with a neural implementation of auto-correlation.

Clues to alternative coding strategies are provided by the physiology of neurons at higher levels of the auditory pathway. The inferior colliculus (IC) is a particularly interesting spot to examine neural coding, as it is a bottleneck in the ascending pathway. The sensitivity of IC neurons to a variety of sounds suggests specific acoustic "structures" that excite or suppress midbrain neurons. This talk will review response properties of neurons in the IC and examine the implications for coding mechanisms in the periphery. In particular, IC sensitivity to amplitude modulations suggests a mechanism for translating temporal cues in the periphery into rate profiles in the midbrain. For example, in response to harmonic speech sounds, temporal responses of AN fibers are dominated by either voice pitch or by harmonics near CF, depending upon the locations of spectral peaks with respect to CF. Accordingly, the amplitudes of pitch-related neural fluctuations vary across CF, and IC neurons are sensitive to the amplitude of NFs (Carney, 2024). NFs also vary in response to unvoiced speech sounds, such as fricative consonants (Hamza et al., 2023). We are still learning new things about IC physiology. Recent investigations of IC responses suggest that modulation tuning is more complex than previously thought, with qualitatively different types of modulation tuning occurring in single neurons depending upon stimulus frequency. Also, a recently described sensitivity of IC neurons to very fast (within-pitch-period) frequency sweeps shapes responses to voiced speech (Mitchell & Carney, 2025). Overall, the properties of IC neurons suggest that the across-CF temporal structure of AN population responses convey a rich set of cues about complex sounds that shape the responses of central neurons.

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Monday: 19:40 - 20:00

INVESTIGATING NEURAL ENCODING OF VOWEL FORMANTS: COMPARING RATE-PLACE AND NEURAL-FLUCTUATION CONTRAST THEORIES IN COCHLEAR-IMPLANT USERS

Benjamin Palatnik, Marcus Milani, Braden N. Maxwell, Heather A. Kreft, Andrew J. Oxenham

University of Minnesota Medical School, Minneapolis, Minnesota, USA; Department of Psychology, University of Minnesota, Minneapolis, Minnesota, USD

Recent work in modeling and physiology has challenged conventional views of how vowel formants are encoded in the auditory system. The traditional rate-place (RP) theory suggests that magnitude increases at vowel formants are encoded as increases in neural firing rate. A more recent theory, known as the neural-fluctuation contrast (NFC) theory suggests instead that these magnitude increases may be encoded through contrast between smaller neural fluctuations (temporal modulation of the neural signal) that occur at formants, and larger neural fluctuations that occur between formants (NFC, or neural-fluctuation contrast theory). Because CI processing routinely separates the temporal from spectral envelope information, CI users' perception may provide a window into the relative importance of rate and fluctuation cues. CI users may also benefit from novel algorithms that enhance fluctuation cues, should the NFC theory provide a more compelling account of the available data. If CI users rely on NFC cues, then presenting vowel stimuli with reduced NFC cues should lead to poorer performance. Conversely, presenting stimuli with original or enhanced NFC cues should maintain or im-prove performance, respectively, even if RP cues are diminished by reducing the spectral contrast of the stimuli. To test these predictions, 30 CI users will be recruited. Single vowel stimuli, taken from a closed set of five vowels, will be presented to participants over a loudspeaker at 0° azimuth in a sound-attenuated booth, and participants will be asked to identify which vowel was presented on each trial. The vowels will be presented in each of the following conditions to control for the presence of RP and NFC cues: 1) Control (no processing); 2) tone vocoded (channels matched to individual CI maps; should be transparent in terms of performance); 3) vocoded – no fluctuations (NFC cues replaced with flat temporal envelope in each channel; RP cues present); 4) vocoded – flat spectrum (RP cues removed by imposing a simple sloping spectrum on the vocoder channels, while maintaining original envelope fluctuation cues); 5) enhanced fluctuation cues (flat spectrum but magnified differences in temporal-envelope fluctuations to enhance NFC cues). If CI listeners use RP information to decode vowel formants, performance should be similar for conditions 1, 2, and 3, but be degraded in conditions 4 and 5. In contrast, if CI listeners use NFC cues, performance should be poorest in condition 3, and may be enhanced, relative to the control, in condition 5. The results will be compared with that in normal-hearing listeners presented with the same stimuli to test for any differences in the use of cues for vowel identification.

This work was supported by NIDCD R01 DC012262 grant, awarded to AJO.

Monday: 20:20 - 20:40

DYNAMIC RANGE ADAPTATION IN COCHLEAR IMPLANTS

Coline Marché[1], Sabine Meunier[1], Stéphane Roman[2], Charlotte Garcia[3], Olivier Macherey[1]

[1]Aix-Marseille University, CNRS, Centrale Méditerranée, LMA, Marseille, France
[2]Dept. Of Pediatric Otolaryngology and Neck Surgery, Aix-Marseille University, France
[3]Cambridge Hearing Group, MRC Cognition and Brain Sciences Unit, University of Cambridge, UK

Dynamic range adaptation (DRA) has been measured by presenting short concatenated segments of noises or tones having a particular level distribution (with some levels being presented much more often than others) and recording the firing rate of different types of auditory neurons to each of these sound segments. DRA manifests as a shift of the rate-level function of the neurons towards the most frequently presented levels (Dean et al., 2005). Therefore, DRA produces a change in sensitivity across the dynamic range, enhancing the coding of the most probable levels. This feat may be particularly important in complex listening environments such as when listening to speech in a noisy background. DRA has been observed at the level of the auditory nerve, implying that either the hair cells, the hair cell-auditory nerve (AN) synapse and/or the AN contribute to this phenomenon. Here we test the hypothesis that the AN is a direct contributor by measuring the effect of modifying the current level distribution on the shape of the electrically-evoked compound action potential response (eCAP) amplitude growth function (AGF). Eleven participants implanted with a device manufactured by Cochlear Corporation took part. eCAPs were measured using a CP910 speech processor connected to a programming POD and the experimental software used NIC4.3 software library functions. Stimuli were trains of biphasic pulses presented at rates of 30, 100 and 300 pulses per second (pps) on a single monopolar channel. The alternating polarity protocol was used for artefact reduction. At each rate, eCAPs were measured in response to 12 current levels (L1-L12 in ascending order) spanning each participant's eCAP dynamic range. These AGFs were obtained in five different conditions (CLASSIC, RANDOM, HPR1, HPR2, HPR3). For CLASSIC, the eCAP responses to each level were collected separately (all sweeps for L1, all sweeps for L2…). For RANDOM, the 12 levels were presented randomly with the same probability of presentation. For HPR1 (High-probability region 1), there was a probability of 80% of presenting L2 or L3 and a probability of 20% of presenting the other levels. HPR2 and HPR3 were similar except that the most presented levels were L6-L7 and L10-L11, respectively. A comparison of the three AGFs collected in the HPR conditions showed a horizontal shift consistent with DRA: the AGF shifts towards higher current levels when the most probable levels get higher. The magnitude of this shift as a function of the HPR level was significantly larger at 300 pps (mean=0.23 dB/dB, 95% C.I.=0.04 dB/dB) than at 100 pps (0.10 +/- 0.04 dB/dB) or 30 pps (0.08 +/- 0.08 dB/dB), consistent with increased adaptation at high rates. Further analyses revealed that the AGF slope was steeper for the HPR than for the RANDOM condition when compared at the most probable levels, suggesting improved intensity coding for HPR. Finally, the time constants of adaptation were found to be similar to those reported in physiological studies of DRA. Although these results do not reflect the activity of single fibers, they suggest that collectively, electrically stimulated auditory nerve fibers exhibit a behavior consistent with DRA and that the AN is a direct contributor to this phenomenon. Implications for cochlear implant coding strategies will be discussed.

Dean, I., Harper, N. S., & McAlpine, D. (2005). Neural population coding of sound level adapts to stimulus statistics. Nature neuroscience, 8(12), 1684–1689.

Monday: 20:40 - 21:00

WEIGHTING OF PLACE AND TEMPORAL ENVELOPE CUES FOR PITCH, MUSIC, AND EMOTION PERCEPTION WITH COCHLEAR IMPLANTS

Lina A. J. Reiss[1], Holden Sanders[1], Nicole Dean[1], Clementine McTaggart[1], Qian-jie Fu[2], David M. Landsberger[3,4], John J. Galvin III[4], Monita Chatterjee[5]

[1]Oregon Health And Science University
[2]University of California - Los Angeles
[3]New York University Grossman School of Medicine
[4]House Institute Foundation
[5]Boys Town National Research Hospital

Pitch cues for spoken emotion and musical melody recognition are often poorly perceived in cochlear implant (CI) users. Two cues for pitch perception available to CI users are cochlear place of stimulation and temporal cues; temporal cues can be encoded either by pulse rate or by amplitude modulation (AM) of the pulse train. Previous pitch ranking studies have shown place of stimulation to be weighted more strongly than pulse rate for pitch perception. However, the relative weighting of place and AM rate for pitch perception in CI users has not yet been directly investigated. The goal of this study was to measure the relative weighting of these cues in bilateral CI users for pitch perception, and the effect of removing each cue on musical contour and spoken emotion identification. Fifteen bilateral CI users (9 females; age range 14-40 years) were recruited. Electrode discrimination (place cue) and AM rate discrimination (temporal envelope cue) were measured using direct stimulation in a 3-alternative forced choice, 2-down, 1-up adaptive procedure. Relative weighting of the two pitch cues was measured using a single-interval pitch scaling magnitude estimation procedure on a scale of 1 to 10. Stimuli were biphasic pulse trains presented to an apical, middle, or basal electrode at a 0, 75, 100, 150, 200, or 300 Hz AM rate. Musical contour and spoken emotion identification were assessed with loudspeaker presentation to the subjects' CI processors under three conditions: unprocessed, place-only, and temporal-only, and two F0 conditions: low-F0 and high-F0. Place- and temporal-only stimuli were created by use of a sine wave vocoder, specifically low-pass filtering temporal envelope cues to below 20 Hz for the place-only condition, and sending the output only to a single middle electrode frequency range for the temporal-only condition. For music, the low and high F0 ranges were 110-220 Hz and 440-880 Hz, respectively. For spoken emotion, the low and high F0 stimuli were male and female voices. Discrimination limens were relatively constant across the electrodes and AM rates tested. Thirteen of fifteen participants showed better pitch discrimination with AM rate than electrode place. In the pitch scaling task, weighting for AM rate was stronger than place in 12/15 participants. Two participants showed no effect of AM rate on pitch scaling, and one participant showed no change in pitch scaling with place or AM rate. Musical contour and spoken emotion identification performance were best in the unprocessed condition, with poorer performance for the temporal-only and place-only conditions. For musical contours, performance was better in the place-only condition for high F0 stimuli, and better in the temporal-only condition for low F0 stimuli. For spoken emotion, performance was better with the place-only condition for female talkers, but similar for both conditions for male talkers. The findings suggest that weighting of temporal envelope cues can sometimes be stronger than place cues, especially for low AM rates and F0s, which has implications for processing strategies to improve pitch perception. However, the relative weighting varies across subjects. Future work is ongoing to investigate the factors that contribute to the relative weightings.

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Tuesday: 08:30 - 09:10

THE VALUE GENETIC TESTING ADDS TO A COCHLEAR IMPLANT EVALUATION

Richard Smith

Department of Otolaryngology–Head & Neck Surgery,
University of Iowa Carver College of Medicine, Iowa City, Iowa, USA

Massively parallel sequencing was first validated for genetic testing for deafness in 2010. It was shown to have an analytical sensitivity and specificity of >99% for single-nucleotide variant detection making it suitable for clinical genetic testing. As such, it is now recommended by the American College of Medical Genetics and Genomics and the International Pediatric Otolaryngology Working Group as standard of care in the evaluation of deafness. By integrating comprehensive genetic testing into the diagnostic algorithm, an underlying genetic basis for hearing loss can be identified in ~40% of persons, although in well studied populations the diagnostic rate is over 70%. In this talk, we review the wet lab and bioinformatic components of comprehensive genetic testing for deafness and then consider its role in the evaluation of patients for cochlear implantation. In children, determining the genetic etiology of hearing loss can help to prognostic outcomes in CI recipients by identifying patients who are predicted to do better than average (i.e., *GJB2*-related hearing loss) and well as those who may have specific difficulties not only in the domains of hearing but also in spoken language and in the subdomains of cognition and mental health (i.e., *POU3F4*-related hearing loss). In adults, understanding audioprofiles associated with different types of genetic deafness and the gene-specific expected rate and degree of future hearing deterioration, especially in the low frequencies (i.e., *ACTG1*-related hearing loss), may inform implant choice as less invasive surgery and the use of short electrodes are adopted to allow for a high degree of hearing preservation. Occasionally, results also impact pre-operative planning (i.e., *KCNQ1*-related hearing loss or Jervell and Lange-Nielsen Syndrome). In aggregate, identification of the etiology of hearing loss in the evaluation of cochlear implant candidates allows for more personalized (optimized) medical care.

Acknowledgments: This research has been supported in part by NIDCD R01s DC002842, DC012049 and DC017955).

Tuesday: 09:10 - 09:50

MEMORIAL FOR PAUL ABBAS

Michelle Hughes, Session chair

This memorial session for Dr. Paul J. Abbas will recount his most impactful contributions to science and his enduring legacy through those he selflessly mentored. As a gifted scientist, his research involved human subjects and numerous animal species, physiological and perceptual investigations, and acoustic and electrical stimulation of the auditory system. Throughout his very productive 42-year research career, he modeled work-life balance as a baker, musician, husband, father, grandfather, and friend. His kind, humble, and gentle demeanor leaves a lasting impact on those who were fortunate to share his life.

Tuesday: 10:20 – 10:35

INTRODUCTION OF THE TEMPORAL CODING SESSION

Ray Goldsworthy[1], Robert P. Carlyon[2]

[1]Keck School of Medicine, University of Southern California
[2]Cambridge Hearing Group, MRC Cognition & Brain Sciences Unit, University of Cambridge

Tuesday: 10:35 – 10:45

TEMPORAL PROCESSING: PLASTICITY, EXPERIENCE AND SIGNAL PROCESSING AS DETERMINANTS FOR BINAURAL HEARING ABILITIES IN COCHLEAR IMPLANT USERS

Ruth Y. Litovsky

Waisman Center, University of Wisconsin Madison, USA

Although cochlear-implant (CI) listeners are implanted bilaterally at a growing pace, their performance on spatial hearing tasks is significantly worse than normal hearing (NH) listeners, such as poorer ability to segregate speech from noise and significantly degraded sound localize in natural environments. NH listeners rely on interaural differences in time and level (ITD and ILD), which are encoded with great precision in the auditory pathway. While bilateral CI users can use ILDs, these cues are not sufficient for exquisite spatial hearing abilities. Critically, bilateral CI listeners lack access to ITDs that would arise from temporal information in the fine structure of low-frequency sounds. One important consideration is that CI signal processors discard information in the temporal fine structure (TFS) of sounds and instead encode acoustic information by the envelope modulations (ENV) at each frequency. In addition, obligatory synchronization between the left and right CI processors is lacking, meaning that the timing of sampling by the analogue-to-digital converter and the timing of electrically pulsed stimulation delivered to specific electrodes in the right and left ears is not preserved from the acoustic signal, thereby information regarding source locations is inconsistent and unreliable. Studies that bypass CI clinical processors and use research processors to accurately capture and present ITDs to human listeners have shown that binaural sensitivity varies greatly. We hypothesize that neural circuitry involved in binaural processing can fail to develop properly, and that ITD sensitivity is very difficult to recover without access to acoustic hearing early in life. Further, that neural signatures for binaural processing is stronger for ITDs in the ENV than in the TFS.

Our current unpublished studies address the question of whether the neural infrastructure can process binaural signals following variable periods of auditory deprivation in children and adults. Using a combination of electroencephalography (EEG) and psychophysics in which research processors are used to bypass clinical processors (direct electrical stimulation), we investigate responses to ITDs and ILDs. Importantly, we ask if binaural pathways can retain sensitivity to both for ENV and TFS in binaural signals. Parallel studies are also conducted using acoustic signals in NH listeners. Further, we designed studies to overcome limitations in CI speech processors that encode ENV cues at rates that are too high for ITD sensitivity, by employing mixed rates of stimulation across the electrode arrays in the two ears. We aim to identify how to best preserve low rates in some binaural channels while allocating high rates to remaining channels to promote capture of speech envelope cues, with the goal of improving outcomes in bilateral CI users ultimately promoting intervention at young ages. While studies to date only showed that binaural sensitivity can be preserved and enhanced using this approach, our new proof of concept shows that speech understanding is also preserved.

In conclusion, because auditory maturation, and binaural hearing specifically, are vulnerable to acoustic deprivation early in life, it is paramount that considerations be given to (a) provision of appropriate binaural cues early in life to promote maturation of binaural pathways, and (b) developing binaural sound coding strategies that capture and provide ITDs with fidelity, without compromising access to pristine speech cues.

Work supported by NIDCD R01DC020355 and R01DC003083 to RY Litovsky

Tuesday: 10:45 – 10:55

NEURAL LIMITATIONS LEAD TO REDUCED TEMPORAL AND BINAURAL SENSITIVITY IN COCHLEAR IMPLANT LISTENING

Yoojin Chung, Bertrand Delgutte

Eaton-Peabody Laboratories, Massachusetts Eye and Ear Infirmary

Based on the key findings from neurophysiological studies at the single unit level in normal hearing and cochlear implanted animals, we suggest that the deficits in the perception of temporal and binaural cues in cochlear implant (CI) users are due to fundamental neural limitation. This limitation is not caused by the lack of precise temporal coding in the auditory periphery, but rather by abnormal spatio-temporal pattern of activation and excessive across-neuron synchrony that may impair the ability of the central auditory circuit to fully utilize the information. The upper limit of phase locking in the auditory nerve fibers (ANFs) to electrical stimulation is 2-3 fold higher than the limit of phase locking to comparable acoustic stimulation, with a large number of ANFs firing in synchronous pattern along the tonotopic axis due to the broad spread of excitation. In the auditory midbrain and cortex, neural ITD sensitivity and temporal coding are degraded at higher pulse rates with electrical stimulation. We suggest the abnormally broad spatial pattern of excitation and across-fiber synchrony in electrical response may engage inhibitory and other suppressive mechanisms in the brainstem thereby blocking excitatory responses at high pulse rates. In addition, neural ITD sensitivity to bilateral CI stimulation is further degraded in animals that experienced auditory deprivation during development but this degradation can be partially reversed by providing meaningful ITD cues through bilateral CIs. We think technologies that achieve more selective and less synchronized patterns of stimulation should improve temporal pitch perception and ITD sensitivity in CI users. Finally, if the plasticity effects observed in neural recordings prove to have behavioral consequences, then more immersive training protocols in temporal tasks may prove effective in improving performance.

Tuesday: 10:55 – 11:05

TEMPORAL PROCESSING: ENHANCING ITD SENSITIVITY AND RATE DISCRIMINATION IN ELECTRIC HEARING THROUGH BEHAVIORAL TRAINING AND OPTIMIZED STIMULATION DESIGNS

Maike Vollmer[1,2], Frank W. Ohl[2]

[1]Department of Otorhinolaryngology-HNS, University Hospital Magdeburg,
Leipziger Straße 44, 39120 Magdeburg, Germany
[2]Systems Physiology of Learning, Leibniz Institute for Neurobiology,
Brenneckestraße 6, 39118 Magdeburg, Germany

Deafness can alter the temporal accuracy of neural processing along the auditory pathway. Such changes likely disrupt rate discrimination and binaural coincidence detection of interaural time differences (ITDs). The present study investigates whether specific designs of intracochlear electric stimulation (ICES) can modify temporal processing in the deaf inferior colliculus (IC) and auditory cortex. Moreover, we evaluated whether passive stimulation versus behavioral training differentially transforms neural temporal processing.

Passive ICES was initiated in neonatally deafened cats either during development or in adulthood after long durations of deafness (>3.5 years). Some animals also received behavioral training in a temporal detection or discrimination task. The pulse rates of the ICES temporal fine structure (TFS) were selected to be either low (30 or 80 pps), intermediate (300 pps), or high (≥800 pps). When compared to acutely-deafened adult animals, low-rate ICES failed to improve temporal processing, whereas ‘temporally-challenging’ higher-rate stimulation around the maximum rate-following capacity typically found in IC neurons (~300 pps) significantly increased the upper limit of synchronized responses to electric pulse trains, even after long durations of deafness. However, stimulation at even higher rates (≥800 pps) failed to enhance temporal coding, suggesting that improvements in temporal processing (e.g., phase-locking, latency, jitter) only occur within a certain range of stimulation rates. In addition, behavioral training was more effective than passive stimulation in driving neural temporal plasticity in the deaf system, particularly in the auditory cortex.

Our results refute that deafness-induced degradations in the upper limit of rate discrimination and ITD sensitivity represent a permanent ‘hard-wired’ upper limit for temporal processing. Rather, we propose that behavioral training on temporal discrimination tasks could be highly effective in engaging plasticity mechanisms for targeting temporal processing capabilities that may contribute to enhanced rate discrimination and ITD sensitivity at higher rates in CI users.

Beyond the effects of ICES rate on temporal plasticity, we will discuss additional modifications in stimulation designs that could further enhance temporal processing in CI listeners. For instance, refining pulse shapes - such as employing on-ramped pulses – can enhance the selectivity of tonotopic activation and may evoke increased synaptic jitter that more closely approximates the naturally dispersed response patterns observed in acoustic stimulation. This increase in jitter potentially alleviates the artificial hypersynchronicity of CN and MNTB responses to electric stimulation and may impact binaural input integration at the MSO and LSO to the effect of improved ITD sensitivity in CI users at higher rates.

Supported by DFG VO 640/2-2, R01-DC-013067, and Towards Co-Evolution in Human-Technology Interfaces (TACTIC-LIN).

Tuesday: 11:05 – 11:15

PHYSIOLOGY AND LIMITATIONS OF TEMPORAL PROCESSING

Andrej Kral

Institute of AudioNeuroTechnology & Dept. of Experimental Otology, ENT Clinics,
Hannover Medical School, Hannover, Germany
Australian Hearing Hub, School of Medicine and Health Sciences,
Macquarie University, Sydney, Australia

Performance of sequential cochlear implantations in prelingually deaf children shows that the second implanted ear underperforms in speech comprehension (Gordon and Kral, 2019, Hear Res). An inhibition between the ears in such condition has been suggested (Burdo et al., 2016, Eur Ann ORL), but the physiological mechanism remained elusive. In cats with single-sided congenital deafness (SSD) the aural preference shifted towards the hearing ear on both hemispheres (Kral et al., 2013, Brain). Binaural integration was also compromised (Tillein et al., 2016 Cereb Cortex).

In the present study, 9 adult hearing controls (HCs), 9 adult bilaterally congenitally deaf cats (CDC) and 4 adult SSD cats were used. All animals were acutely electrically stimulated by cochlear implants (CI). Cortical responses were evoked by a train of 3 biphasic electric pulses (200 µs/phase, 500 Hz). Intensities up to 12 dB above auditory brainstem response threshold were used, whereas the contralateral ear was kept constant at 6 dB above threshold, and the current level of the ipsilateral ear was varied from -2 to 12 dB above threshold. Multiunit activity was recorded using 16-channels arrays covering all layers of the primary auditory cortex. Responses to binaural stimulation were classified to time-sensitive and to excitation or inhibition, the latter depending on whether the stimulation at the ipsilateral ear significantly increased or reduced the firing rate with increasing level.

In HCs, the ipsilateral ear induced inhibition of the responses to the contralateral ear in ~40% of recording sites, whereas in CDCs this proportion was smaller (~30%). IN CDCs, both sensitivity to interaural time and level differences were reduced. While the sensitivity to interaural time differences was significantly degraded in SSD animals, the deaf ear consistently induced suppression of the responses to the hearing ear in majority of units, whereas vice versa the hearing ear caused excitation and inhibition was exceptionally rare. The data suggest a significant extent of brainstem reorganization in olivary complex affecting temporal processing and excitatory-inhibitory interactions. Early binaural hearing is necessary in preventing these adverse consequences.

Supported by Deutsche Forschungsgemeinschaft (Exc 2177).

Tuesday: 11:15 – 11:25

TEMPORAL CODING: CHANGING PERSPECTIVES ON TEMPORAL CODING FOR BINAURAL CUES IN COCHLEAR IMPLANTS

Jan W. H. Schnupp[1], Nicole Rosskothen-Kuhl[2,3]

[1]Chinese University of Hong Kong, Gerald Choa Neuroscience Institute, Sha Tin, Hong Kong, Hongkong
[2]Neurobiological Research Laboratory, Section for Experimental and Clinical Otology, Dept. of Otolaryngology, Medical Center – University of Freiburg, Faculty of Medicine, Killianstr. 5, 79106 Freiburg, Germany,
[3]Bernstein Center Freiburg and Faculty of Biology, University of Freiburg, Freiburg, Germany

Cochlear implants (CIs) have revolutionized hearing restoration, but CI patients still have limitations, for example, in spatial hearing. While efforts have focused on optimizing the delivery of tonotopic spectral information, relatively little attention has been paid to replicating the temporal firing patterns of the auditory nerve observed in normal hearing. Our research explores factors contributing to the poor spatial hearing with CIs by investigating the sensitivity to interaural time differences (ITDs) in early deafened cochlear implanted rats [1-3]. The use of this animal model allows us to circumvent confounds arising from patient needs and clinical practice that plague research on human volunteers. We trained and tested neonatally deafened rats with bilateral CIs, delivering informative pulse timing ITDs throughout, and found that their ITD discrimination thresholds were as good as those of normally hearing individuals, even at clinical stimulation rates [3]. Furthermore, we observed that delivering ITDs via pulse timing is much more effective than delivering ITDs via pulse train envelopes, and that even small conflicting ITDs can confound sizable interaural level differences (ILDs).

Our findings thus indicate that the uninformative pulse timing delivered by the majority of clinical CI processors may hinder spatial perception in CI patients, and that better binaural outcomes may be achievable if CI patients were consistently provided with useful and accurate pulse timing cues throughout.

This work was funded by the Hong Kong Research Grants Council and MED-EL GmbH, Innsbruck, Austria.

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Tuesday: 11:25 – 11:35

LEARNING TO HEAR STIMULATION TIMING CUES FOR PITCH PERCEPTION AND SOUND LOCALIZATION

Ray Goldsworthy

Keck School of Medicine, University of Southern California

Cochlear implant users have poor pitch perception and poor sound localization compared to their peers with normal hearing. A sense of pitch can be provided by both the place and rate of cochlear-implant stimulation. Similarly, a sense of sound location can be provided by both interaural level and timing differences in bilateral stimulation. However, most clinical devices discard the temporal fine structure of incoming sound to only convey relatively crude temporal envelopes. In addition, bilateral implants are not synchronized, which leads to further loss of timing precision for bilateral stimulation. Consequently, cochlear implant users typically do not have access to precise timing cues in their daily lives. To circumvent this lack of access, many scientists bypass clinical sound processing, using research hardware, to provide synchronized and temporally precise stimulation. While these laboratory-based psychophysical studies provide access to precise timing cues, participants typically only receive four to eight hours of experience with the newly provided stimulation cues. Only a few studies have combined precision stimulation with extended psychophysical training to promote learning for the newly encoded timing cues. This presentation will describe the duration and size of learning for pitch discrimination provided by stimulation pulse rate, and for sound lateralization provided by interaural timing differences. For both pitch perception and sound localization, the duration of learning for precise timing cues extends beyond what is typically observed in studies of psychophysical learning in normal-hearing listeners. This prolonged duration of learning may indicate a relatively naïve physiological state for temporal processing in cochlear implant users with greater potential for long-term learning. However, best outcomes after psychophysical training are comparable to outcomes observed in people with normal hearing when tested with bandpass-filtered, acoustic pulse trains. From this, we conclude that cochlear implant users learn to use newly provided, temporally precise, stimulation cues when provided these cues in a clear and consistent manner. Interpretation of results will consider the limits of experience, learning, and psychophysical training for improving pitch perception and sound localization in cochlear implant users.

Tuesday: 11:35 – 11:45

TEMPORAL CODING: OVERVIEW, PLASTICITY, AND THE (LACK OF) EFFECT OF EXPERIENCE AND TRAINING ON PITCH PERCEPTION BY COCHLEAR IMPLANT USERS

Robert P. Carlyon

Cambridge Hearing Group, MRC Cognition & Brain Sciences Unit,
University of Cambridge

Pitch perception and sound laterallization by cochlear-implant (CI) listeners is much worse than in normal hearing (NH), thereby degrading the perception of both speech and music. One reason for this arises from the CI signal processors, that discard information on both the temporal and spectral fine structure of sounds, instead encoding pitch by the envelope modulations present in each frequency channel. These modulations are often shallow and mis-aligned between channels, and can be distorted by the reverberations present in many acoustic environments. In bilaterally implanted listeners the timing between the pulses presented to the two ears are de-synchronised and do not provide reliable information on the incoming sound's azimuth. However, both pitch and sound lateralization remain poor even when experimenters bypass the processor and present simple idealized stimuli such as single-pulse-per-period pulse trains to one electrode or to a matched bilateral electrode pair. In particular, both pitch perception and lateralization deteriorate markedly as the pulse rate increases above some "upper limit", that varies between listeners but is typically ~ 300 pps. An important question is whether the limitations in these tasks, observed with idealized stimuli in adult CI listeners, are inevitable or, alternatively, can be blamed on the patients' lack of exposure to reliable fine timing cues throughout life. In other words: if we provided newly implanted congenitally deaf infants with processors that accurately conveyed pitch and lateralization using fine timing cues, how good would their perception of those cues be in adulthood, compared to people who had only ever been fitted with conventional processors?

I will first summarise the evidence on temporal processing by CI listeners so as to set the scene for a number of presentations from different laboratories and that address this question from different perspectives, including psychophysical and electrophysiological approaches with both children and adults and from detailed invasive recordings from animals. I will then provide my own viewpoint, focussing on behavioural and electrophysiological experiments on the perception of pitch in adult CI listeners. I will argue that limitations to temporal pitch perception by human CI listeners, and particularly the upper limit, do not depend primarily on the listener's experience. Evidence for this comes from the observations that:

(i) Broadly similar limitations are observed in NH listeners presented with bandpass- filtered pulse trains that provide only envelope cues to pitch

(ii) Substantial variations in performance can exist between electrodes within the same CI ear

(iii) There is no convincing evidence from training studies that it is possible to overcome the "upper limit", even though, as with most tasks, performance generally improves overall with practice

(iv) A meta-analysis of 50 listeners from different studies shows no correlation between the upper limit and either age or duration of deafness.

Tuesday: 11:45 – 12:00

DISCUSSIONS ON TEMPORAL CODING

All speakers of the session

Tuesday: 19:00 - 19:20

UNLOCKING THE COCHLEA WITH SYNCHROTRON PHASE-CONTRAST IMAGING

Sumit Agrawal

Department of Otolaryngology – Head & Neck Surgery, Western University, London, Ontario, Canada

Synchrotron Phase-Contrast Imaging (SR-PCI) has allowed for unparalleled three-dimensional views of the temporal bone. The spiral ganglion, basilar membrane, and peripheral axons were visualized and segmented. Ground truth angle-frequency measurements were made, and using an approach designed to minimize perceptual error in frequency estimation, an individualized frequency function based on Greenwood was calculated to relate angular depth to frequency within the cochlea. Novel artificial intelligence strategies were then employed to automatically segment the cochlea, determine total angular length, and frequency map individual cochlear implant electrode contacts. This patient-specific cochlear implant pitch-mapping has now been translated into patient care through pilot studies and planned randomized controlled trials.

Tuesday: 19:20 - 19:40

TONOTOPIC CODING IN THE HUMAN COCHLEA

Amit Walia, Matthew Shew, Jacques Herzog, Amanda Ortmann, Shannon Lefler, Jordan Varghese, Matthew Wu, Craig A. Buchman

Department of Otolaryngology-Head & Neck Surgery, Washington University, St. Louis, Missouri, USA.

Purpose/Objective: Psychoacoustic (Greenwood, 1961) and animal studies have clearly demonstrated the relationship between stimulus frequency and cochlear location for traveling wave maxima, local cochlear microphonics (Fallah et al., 2021) and neural firing (Robles and Ruggero 2001 for review). While these studies provide fundamental/critical information on cochlear tonotopy, the applicability to cochlear implant (CI) stimulation is yet to be determined due to: (1) the lack of direct intracochlear validation of derived maps in humans; and (2) the use of near threshold stimulation levels in both human psychoacoustic studies and animal model testing. The present studies use intracochlear electrocochleography (ECochG) and postoperative imaging in CI patients to elucidate the tonotopic map and spread of excitation at various stimulation levels. These findings have implications for CI mapping strategies.

Methods/Approach: Fifty adult CI recipients with residual low-frequency hearing and 8 children with auditory neuropathy spectrum disorder and substantially preserved cochlear function were recruited for the studies. Intraoperative ECochG was recorded across all electrodes at a variety of frequencies (250 Hz-4 kHz) and intensities using CI electrodes. Offline analysis identified the best frequency (BF) electrodes and postoperative imaging (CT-based angular insertion depth, AID) localized these. Tonotopic maps were constructed at the various stimulus levels and spread of excitation was characterized.

Results/Findings: Tonotopic maps were similar in shape yet, basally-shifted at high stimulus intensities (~90dB SPL) when compared to Greenwood/Stakhovskaya et al. Lower stimulus intensities shifted the map apically, approaching Greenwood at ~40dB SPL levels. Spread of acoustically-evoked excitation was broad at high stimulation levels and becomes localized to the BF electrode region at lower levels. For adults, the degree of frequency-to-place mismatch showed moderate correlation with 3-month CNC words scores for ECochG generated maps (r = 0.51) but no correlation for Greenwood maps. Exemplar cases of cochlear map manipulation relative to ECochG targets will be shown and the impact on performance.

Conclusions/Implications: Intracochlear ECochG can be used to validate the tonotopic maps generated by Greenwood at low level stimulation. Speech level stimulation however, results in a basally-shifted map and broad spread of excitation across the cochlear spiral. Future mapping strategies should consider dynamic place coding and spread of excitation.

This work was funded by NIH T32DC000022 and R01DC020936

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Fallah, E., Strimbu, C. E., & Olson, E. S. (2021). Nonlinearity of intracochlear motion and local cochlear microphonic: Comparison between guinea pig and gerbil. *Hearing research*, *405*, 108234.

Robles, L., & Ruggero, M. A. (2001). Mechanics of the mammalian cochlea. *Physiological reviews*, *81*(3), 1305–1352.

Tuesday: 19:40 - 20:00

TARGETING INDIVIDUALIZED FREQUENCY MAPS IN COCHLEAR IMPLANT USERS WITH A COMPUTATIONAL MODEL AND BEHAVIORAL GENETIC ALGORITHM

Elad Sagi, Nicole H. Capach, Megan Eitel, Maya Hatley

NYU Grossman School of Medicine

The frequency map is a cochlear implant (CI) speech processor parameter that determines how input acoustic frequency ranges are assigned to electrodes. Whether through clinical software or research interfaces, a great amount of flexibility exists in how to program the frequency map, yet it is typically kept at default settings. This default configuration involves mapping an “ideal” frequency range for speech understanding (e.g., 0.2 to 8 kHz) using a logarithmic-like function where bandwidths increase from the apical to basal ends of the electrode array. This mapping roughly approximates how acoustic frequencies are transduced to cochlear locations in normal hearing, but may introduce some level of tonotopic mismatch in the CI recipient. An ongoing debate is whether CI users may benefit from a more tonotopically matched map, but whose implementation may come at the expense of reduced speech information. Aside from anatomical considerations, it is possible that adjusting bandwidths of individual electrodes away from the standard frequency map may provide additional speech information to a CI user. For example, not all CI users discriminate electrodes equally well and some electrodes may be better suited for encoding speech information than others. Presumably, local frequency map adjustments can direct speech information to electrodes that provide better sensory acuity. However, improving encoding of a single speech feature may not translate to overall improvement in speech perception. In addition, the vast number of possible local frequency map adjustments prohibit any systematic evaluation of potential benefit. For example, consider a fixed frequency range of 0.2 to 8 kHz assigned to 12 electrodes with possible intermediate frequency boundaries spaced 200 Hz apart. In this simple case, the number of possible frequency maps is around 1 billion, well exceeding the realm of testing feasibility. In the present study, a computational modeling approach is employed to systematically narrow the vast space of possible frequency maps to those predicted to improve speech understanding in CI users beyond what is achievable with the standard frequency map. Of these, the top hundred predictions are implemented into a behavioral genetic algorithm that allows CI users to conveniently compare and find preferred frequency maps in an acute setting, using both criteria of intelligibility and sound quality. The CI users are then asked to evaluate their top choice for at least one month of daily use, after which speech understanding and sound quality are assessed with their selected frequency map and compared with their standard-of-care map. Preliminary results will be presented. More generally, this study will evaluate whether an algorithmic search for frequency map selection may yield more optimal user-specific benefit.

Tuesday: 20:20 - 20:40

FREQUENCY CODING IN COCHLEAR IMPLANTS

Benoit Godey

Rennes University hospital, France

Objectives: In the cochlea, frequency coding occurs via the two mechanisms of tonotopy and phase locking. Inner hair cells are stimulated by a specific frequency and activate the corresponding area of the auditory cortex in a tonotopic organization. Fine structure (FS) oscillations cause neuronal discharge decoded by auditory centres through a phase locking process. Both complementary processes coexist throughout the cochlea, with FS being predominant for lower frequencies and tonotopy for higher frequencies.

For implanted patients, good respect for frequency coding is essential for good understanding in quiet and noise, as well as good musical perception. Cochlear implants (CIs) process input signals by assigning each electrode a specific frequency range according to its position on the electrode array and, consequently, within the cochlea, the low-frequency bands are delivered to apical electrodes and the high-frequency bands to basal electrodes. For a classic fitting, the frequencies assigned to each electrode are the same for all patients. Due to the variability of cochlear dimensions and differences in the insertion angle of the electrode array, a mismatch can be introduced between the frequency allocation of a cochlear implant electrode contact and the tonotopic frequency of the neurons stimulated by that contact.

Recently, fitting implementing individualized tonotopic mapping based on precise cochlear imaging and tailored frequency allocations were developed. Most CIs encode temporal envelope on each electrode by modulating stimulation amplitudes based on the recorded signal intensity. To enable frequency coding by phase locking, specific fitting was developed with FS coding on apical electrodes. This strategy is based on stimulation rate, which enables to encode the FS on one or 2 apical channels. The aim of this presentation was to evaluate the benefit of frequency coding by fitting based on tonotopic mapping and fitting encoding FS on speech understanding in quiet, in noise, and on musical perception.

Design: Three different studies were conducted with the same method. Prospective, randomized, cross-over, double-blind studies included new CI users. The first study compared a fitting based on tonotopic mapping (TF) with a classical fitting (CF). The second study compared a FS fitting (FSF) with a CF. The third study compared a TF with a TF with FS coding on basal electrodes. Vocal audiometry in quiet and in noise, music perception tests (Gabrielsson scale, interval test, melodic contour identification), and quality of life (HISQUI) assessments were conducted at the end of each period of the cross-over.

Results: In the first study, speech recognition in noise was significantly better with the TF at all signal-to-noise ratio. The Gabrielsson test, melodic contour identification, and melodic recognition scores were significantly higher with the TF. Among the different dimensions evaluated by the Gabrielsson test, the mean scores for clarity, spaciousness, fullness, nearness, and total impression were significantly higher with TF. Ninety-two percent of the participants kept the TF after the study period.

In the second study, FSF significantly improved speech recognition in quiet, Gabrielsson scale scores and interval perception. No significant difference was found for melodic contour identification or HISQUI. A period effect was observed for speech recognition in quiet. Eighty percent of the participants kept the FSF after the study period.

In the third study, in TF, FS cues significantly improved speech recognition in noise for high signal-to-noise ratio. A period effect was observed beyond +6dB without any interaction effect. Speech recognition and tonal audiometry in quiet were not affected FS strategy, in tonotopic-based fitting. Melodic contour identification and pitch discrimination were enhanced by FS cues. Multidimensional qualitative assessment and melodic recognition test were not affected FS strategy. Over 75% of participants retained the TF with FS processing by the end of the study.

Conclusions: For new CI users, TF appears to be more efficient than the default frequency fitting because it allows for better speech recognition in noise without compromising understanding in quiet, and for better music perception. FSF improved music perception and speech recognition in quiet compared to CF, supporting the benefits of FS processing strategies. FS strategies appear relevant in patients with TF because they improve results in noise, and for complex sound signal perception, without compromising understanding in quiet.

Tuesday: 20:40 - 21:00

ANATOMY-BASED FITTING VERSUS STANDARD MAPPING OF CI-PROCESSORS: PRELIMINARY RESULTS OF A CROSSOVER RANDOMIZED CONTROL INTERVENTION STUDY

Uwe Baumann[1], Marten Geisen[2], Silke Helbig[2], Timo Stöver[2], Tobias Weissgerber[1]

[1]Goethe-Universität Frankfurt, ENT/Audiological Acoustics
[2]Goethe-Universität Frankfurt, ENT Department

Background: Cochlear implants (CIs) improve hearing for deaf patients but often provide moderate sound quality, especially in noisy environments and for music. One issue is the standard, non-individualized frequency mapping, which may significantly distort neural stimulation. A recently proposed method, anatomy-based fitting (ABF), customizes frequency mapping based on electrode position. While ABF is expected to improve hearing, habituation effects complicate comparisons. To address this, a prospective study with a randomized crossover design was conducted.

Material & Methods: Study participants were randomly assigned to either the standard map (SMP) group or the ABF approach group. Following a three-month period of familiarization with the respective mappings, a switch was made to the alternative mapping for a further three-month period. After a six-month interval, all participants received programming with both mapping alternatives for a subsequent three-month period. During this period, patients were permitted to alternate between the two mappings to ascertain their preferred setting. Speech perception in quiet (Freiburg Monosyllables, FMS) and with background noise (Matrix Sentence Test, MST) were evaluated at the different test intervals in order to determine the individual benefit with both maps. Furthermore, subjective hearing quality was assessed using the SSQ questionnaire. Inclusion criteria were adult patient with regular uni- or bilateral first time CI indication, duration of deafness less than 10 years, complete or near complete insertion of CI-electrode, and unilateral or (simultaneous) bilateral provision of CI. All participants were implanted with Synchrony 2 implant devices (MED-EL, Innsbruck, Austria) and used either the Sonnet 2 or Rondo III processor. Currently, 1 Flex24, 8 Flex26, 37 Flex28 and 31 FlexSoft cases have been recruited. In nine cases, the implants were placed in bilateral simultaneous surgery.

Results and observations: Of the 70 subjects currently recruited, 19 patients have been marked as dropouts to date for various reasons. Three of them complained about the sound of the standard map after being accommodated to ABF mapping, while six patients complained vice versa about sound quality after conversion from standard to ABF mapping. Twenty-seven subjects (32 ears) completed the study so far. The results at the end point of the study showed that the median FMS for the STD and ABF groups was 67.5% and 62.5%, respectively, and that the median MST SRT was 0.85 dB SNR and 1.05 dB SNR in the SMP (N = 32) and ABF (N = 32) group respectively. The ABF setting was the preferred option for 14 subjects, while the STD setting was the preferred choice for nine subjects. Four subjects did not express a preference. The median SSQ quality score for the STD preferred group was 4.9 (N = 10) and 5.6 (N = 15) for the ABF preferred group. Overall, the ABF setting was rated by all subjects with a median of 2.0 and the STD setting with 3.0 in (German) school grades (1-excellent, 5-poor), indicating slightly better hearing quality in the ABF group.

Conclusion: The results collected thus far demonstrate an absence of a significant advantage for ABF in terms of speech perception scores when compared to SMP. However, a tendency towards improved sound quality and higher preference scores in the ABF group was observed.

Wednesday: 08:30 - 09:10

UNRAVELING AUDITORY NERVE CONDITION: KEY TO COCHLEAR IMPLANT EFFICACY

Niyazi O. Arslan, **Xin Luo**

Arizona State University

The role of auditory nerve condition in cochlear implant (CI) outcomes has been the subject of ongoing debate. Successful transmission of auditory information requires the presence of functioning auditory nerve fibers that respond to electrical stimulation. Therefore, preserving auditory nerve fibers is crucial for optimizing the platform for electrical stimulation, which should, in turn, improve CI outcomes. However, histopathological studies have shown that CI candidates exhibit varying degrees and patterns of degeneration in auditory nerve fibers, which can manifest in a wide range of conditions, from myelin sheath thinning to loss of peripheral axons to a reduction in overall neuron density. Computational and animal studies have further revealed that such degenerative conditions may affect both the absolute properties and relative changes of psychophysical and electrophysiological responses to electrical stimuli. Analyzing these responses offers an indirect method to infer the degree and type of neural degeneration across different stimulation sites in human CI users. In recent years, researchers have made significant efforts to (1) understand the physiological basis behind these neural degeneration-related response characteristics; (2) validate these measures in human CI users through correlation and comparison studies; and (3) explore how this knowledge can be used to improve CI outcomes. This talk will summarize state-of-the-art approaches to estimating neural degeneration, share key lessons learned in establishing reliable measures, and suggest avenues for future investigations.

Wednesday: 09:10 - 09:30

WHAT CAN THE ABR TELL US ABOUT AUDITORY NERVE FUNCTION

Kelly C. Harris

Medical University of South Carolina, Department of Otolaryngology- Head & Neck Surgery

Auditory nerve function is fundamental to hearing. Auditory nerve function is traditionally assessed with the auditory brainstem response (ABR), either as a measure of threshold, or by examining suprathreshold response size (amplitude). In general, lower thresholds, and bigger responses are associated with better auditory nerve function. First, we will review data on the prevalence of auditory nerve deficits with age and noise in a large scale study and meta-analyses. Second, our laboratory focused on developing novel techniques to more fully characterize these deficits *in vivo,* including the development of methods to assess neural synchrony. We employ a translational approach, validating the specificity of our findings in rodent models and with magnetic resonance imaging in aging participants. Finally, we will examine the extent to which these deficits impact speech recognition and may be applicable to cochlear implantation assessment.

Studies focus on the use of electrophysiologic measures of auditory nerve function, including ABR Wave I and the analogous N1 of the compound action potential (CAP), and magnetic resonance imaging of the auditory nerve.

Prevalence of auditory nerve dysfunction increases with age and contributes to poorer speech recognition. A multi-metric approach, focused on examination across measures of neural function may reveal specific deficits important for speech recognition. The possibility of adapting these procedures to candidates for cochlear implantation or for measuring using the electrically-evoked CAP will be discussed.

This work was funded by NIH/NIDCD

Wednesday: 09:30 - 09:50

THE FAILURE INDEX: AN ECAP MARKER FOR NEURONAL HEALTH

Wiebke Konerding[1], Peter Baumhoff[1], Julie Arenberg[2], Cornelia Batsoulis[3], Heval Benav[3], Anette Günther[4], Andreas Büchner[4], Andrej Kral[1]

[1]Department Of Experimental Otology, Hannover Medical School, Hannover, Germany
[2]Massachusetts Eye and Ear Infirmary, Harvard Medical School, Boston, USA
[3]Med-El Research Center, Hannover, Germany; Med-El R&D, Innsbruck, Austria
[4]Department Of Otolaryngology, Hannover Medical School, Hannover, Germany

Objective: Speech perception in cochlear implant (CI) users is likely affected by heterogeneous degeneration of spiral ganglion neurons (SGN). However, interpreting human psychophysical and electrophysiological remains challenging, as reliable markers of locally restricted SGN damage are still missing. Therefore, we 1) developed an electrophysiological marker in the animal model, where neural health can be manipulated and directly measured and 2) applied the marker to recordings in human CI users to test its translational potential.

Methods: 1) In 13 guinea pigs (six female) we induced focal SGN degeneration by mechanical micro-lesioning. After degeneration (8–12 d post-lesioning) we recorded electrically-evoked compound action potentials (eCAP). These were compared with recordings from controls (N = 8) cochleae. For comparability with human data, we stimulated in monopolar configuration with symmetric, biphasic pulses of alternating polarity using species-adapted 6-contact CIs (MED-EL). 2) We conducted a retrospective analysis selecting clinical eCAP recordings based on quality criteria (e.g., clearly identifiable thresholds) The dataset comprised 42,520 eCAPs from 939 CI implanted ears (MED-EL FLEX 28 implants, full-insertions), recorded intraoperatively at Hanno-ver Medical School) and postoperatively at the German Hearing Center Hannover between Au-gust 2017 and August 2024. To quantify the failure to efficiently transduce the stimulation current into neural activation, we introduced the Failure Index (FI: maximal input/output ratio [1]). It is the ratio between minimal current required for saturation of eCAP amplitudes divided by the saturation amplitude.

Results: 1) In guinea pigs, the FI was significantly elevated in the presence of degenerated SGN. It showed classification accuracies of 80%, correctly identified contacts closest to the lesion (~80% of cases), and was correlated with the lesion size. 2) In human CI users, the FI exhibited stable, individual patterns from 3 months to 1 year post-implantation. At the group level, the FI followed a cochleotopic gradient with highest values at high-frequency regions, known to be more prone to neural degeneration. Higher mean FI values were associated with factors indicative of reduced neural health, such as increasing age and reason of deafness. Correlations with speech recognition scores will be reported.

Conclusion: The FI is a clinically relevant, noninvasive marker that is suitable for clinical datasets without a priori knowledge on lesions.

This work was funded by Deutsche Forschungsgemeinschaft (Exc 2177/1) and MHH-plus foundation.

Reference:

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Wednesday: 09:50 - 10:10

RIDING THE SLOPE: FROM MODELING THE IPG EFFECT TO A POTENTIAL CLINICAL APPLICATION

Joshua S. Stohl[1], Marko Takanen[2]

[1]MED-EL US, 2645 Meridian Parkway, Durham, NC, USA
[2]MED-EL GmbH, Fürstenweg 77a, Innsbruck, Austria

The hearing outcomes of a cochlear implant (CI) user are affected by the functionality of the electrode-neuron interface, which can be assessed by measuring electrically evoked compound action potentials (eCAPs). Research on animal models has shown that the so-called inter-phase gap (IPG) effect on the slope of the eCAP amplitude growth function (AGF) is indicative of the neural survival around the stimulating contact [Ramekers et al. (2014), J Assoc Res Otolaryngol 15(2)]. And, indeed, IPG effect differences between the ears have been shown to reflect differences in speech comprehension between the ears of bilateral CI users [Schwartz-Leyzac and Pfingst (2018), Ear Hear 39(2)]. However, there are non-neural aspects that need to be considered when interpreting eCAP-based metrics [Brochier et al. (2021), J Assoc Res Otolaryngol 22]. Together, this brings motivation for model-based investigation on the basis of the IPG effect and for applying the IPG effect in optimization of CI sound coding.

Here, a computational auditory model [Takanen et al. (2024), J Assoc Res Otolaryngol 25] is used to investigate how eCAP characteristics depend on the neural survival and non-neural effects related to the electrode-neuron distance and choice of recording electrode. In addition, the IPG effect on eCAP AGF slope is measured at CI users' physical and virtual stimulation sites to enable channel selections that maximize or minimize the IPG effect [Stohl et al. (2021), World Intellectual Property Organization, WO2021053045A1]. Finally, speech scores obtained with the max- and min-IPG effect maps are compared against those obtained with the CI users' clinical maps in an acute study.

Results: Predictions of the computational model are in agreement with the data from existing literature: IPG effect on eCAP AGF slope is driven by neural survival, but the non-neural influences must be controlled for to enable reliable use of the metric. Results from speech tests show promising changes upon targeting regions with the largest IPG effects. However, variations in eCAP artefacts were observed between measurement sessions, highlighting problems with current artefact-reduction paradigms.

Conclusions: Modeling results bolster the use of the IPG effect in optimization of CI coding strategies, but further work is needed on the eCAP artefact reduction to increase the reliability and repeatability of the site selection. With such improvements neural populations can be targeted in coding strategies for the benefit of the CI user's hearing outcomes.

Wednesday: 10:40 - 11:00

COCHLEAR HEALTH IN DFNA9 CI USERS

Julie Moyaert, Dyan Ramekers, Vincent Van Rompaey, Griet Mertens, Annick Gilles, Emilie Cardon, Lana Biot, Marc Lammers

Dept. Translational Neurosciences, University of Antwerp, Antwerp University Hospital

Background: DeaFNess Autosomal 9 (DFNA9) is an autosomal dominant hereditary disorder caused by pathogenic variants in the COCH gene. These mutations induce the formation of aggregates that are toxic to the fibrocytes in the extracellular matrix, ultimately leading to degeneration of spiral ganglion neurons (SGNs). An important biomarker for evaluating the health and functioning of the SGNs, is the electrically evoked compound action potential (eCAP). The aim of this study was is to evaluate the health of the SGNs in CI users with DFNA9 by studying their eCAP responses and impedances.

Methods: Fifteen carriers of the p.Pro51Ser variant in the COCH gene who received a cochlear implant (CI) (DFNA9 group) and 15 matched control CI subjects without DFNA9 were included. All subjects used a MED-EL Synchrony implant. Impedances and eCAP threshold, amplitude and slope of the eCAP amplitude growth function (AGF) were compared between both groups. Matching of the two groups was based on sex, age at implantation, duration of deafness, and type of implant.

Results: Analyses of electrode impedances between DFNA9 and non-DFNA9 patients show a significant interaction between time and group in the middle and basal electrodes, indicating that electrode impedances were similar in the early phase after implantation between the two groups, but increased significantly more for the DFNA9 group up to one year after implantation. Secondly, the results show that the success rate (present or absent) to record eCAP responses is lower in the DNFA9 group: eCAPs were detectable in 75.5% of the intraoperative measurements (145/192) in comparison to 96.9% (186/192) in the group without DFNA9. ECAP absence in the DFNA9 group was observed across the entire electrode array, but more pronounced in the basal region (channels 11 and 12). Additionally, comparing the parameters of the AGF, the maximum eCAP amplitude was consistently smaller ($F_{1, 67.5} = 23.95$, $p < 0.0001$) and the AGF slope consistently shallower ($F_{1, 68.3} = 12.43$, $p = 0.0008$) for the DFNA9 group compared to the control group throughout the electrode array. Finally, the eCAP thresholds in patients with DFNA9 were higher compared to those in the control patients for all cochlear locations ($F_{1, 68.3} = 6.80$, $p = 0.0112$).

Conclusion: The results of this study reveal that both impedances and advanced eCAP measures consistently suggest a reduced excitability and neuronal health in our DFNA9 population. The increased impedances are likely to result from intrascalar aggregate and fibrosis formation seen in DNFA9, whereas the DNFA9 eCAP responses point towards the accelerated neural degeneration.

Wednesday: 11:00 - 11:20

CHARACTERISING THE ELECTRODE-NEURON INTERFACE USING THE PANORAMIC ECAP METHOD

Charlotte Garcia

Cambridge Hearing Group, MRC Cognition & Brain Sciences Unit, University of Cambridge, UK

It is generally accepted that the state of the electrode-neuron interface (ENI) has implications for cochlear-implant (CI) outcomes. As it is not possible to assess ENI aspects such as neural health directly in human CI users, multiple behavioral and objective markers have been proposed and evaluated over the last few decades. One of these, the Panoramic ECAP Method (PECAP), uses Electrically Evoked Compound Action Potentials (eCAPs) and provides estimates of the relative contribution of spread of electrical current and responsiveness of neurons along the length of a cochlear-implant electrode array. It has the advantage of being a primarily objective metric that characterizes the electrode-neuron interface in detail, estimating both the current spread and the neural responsiveness at each active electrode within the cochlea of a CI user.

PECAP's neural-responsiveness estimate can detect localized areas of reduced neural responsiveness, temporarily imposed by putting neurons that respond to stimulation of individual electrodes into a refractory state during eCAP measurements[1]. It also correlates with focused thresholds[1], and with the difference between focused and unfocused (monopolar) thresholds[2], both behavioral measures that represent aspects of neural health. It is also more isolated from non-neural aspects of the ENI such as electrode-neuron distances than other eCAP-derived neural-health metrics such as eCAP amplitudes and the recently-proposed 'Failure Index[3].' PECAP's current-spread estimate can detect localized areas of increased current spread, artificially increased by simultaneously stimulating multiple adjacent electrodes[4]. In a large-scale, multi-center assessment, it has also been able to detect differences between different electrode array types in Cochlear © devices, suggesting a location-specific effect of narrower current spread at the apex in pre-curved arrays[5].

We have also taken steps to increase potential clinical translatability of PECAP, developing a procedure called 'SpeedCAP' to reduce the data-collection time required down from ≈ 45 to ≈ 8 minutes in Cochlear devices[6]. Recent work has involved development of a web application for PECAP analysis and some data-collection procedures[7], increasing accessibility of the technique beyond researchers with programming skills.

This talk will provide an overview of the benefits, validations, and limitations of the PECAP Method for characterizing patient-specific neural activation patterns. It will also discuss the potential benefits of optimizing cochlear implant programming based on each patient's unique neural activation patterns, some of the future work required in order to achieve this using PECAP.

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THE ELECTRICALLY EVOKED COMPOUND ACTION POTENTIAL AS PREDICTOR OF HEARING PERFORMANCE IN COCHLEAR IMPLANT USERS

Dyan Ramekers, Tinne Vandenbroeke, Marko Takanen, Vincent Van Rompaey, Marc Lammers

Dept. Of Translational Neurosciences, University of Antwerp & Antwerp University Hospital
Med-El Headquarters, Innsbruck, Austria

The electrically evoked compound action potential (eCAP) reflects the combined responsiveness to electrical stimulation of the spiral ganglion neurons (SGNs) that form the auditory nerve. In animal studies eCAP measures correlate strongly with numerical survival of SGNs, and with the health of the remaining SGNs. These correlations suggest that the eCAP is a potent predictor of hearing performance in human cochlear implant (CI) users, since it reflects the condition of the electrode-neural interface. However, correlations between eCAP measures and measures of hearing outcome are typically weak. Complicating factors in studies with human CI users include heterogeneity of the population (etiology, age, duration of implantation), low numbers, processing of clinically obtained data, and the involvement of cognitive ability in hearing outcome. In the present study we examine the potential of the eCAP as a cochlear health measure in a large population of >100 MED-EL CI users. In this relatively large population the influence of etiology on eCAP measures can be studied. Effects of duration of implantation were assessed by comparing intra-operative with post-operative recordings using autoART in MED-EL's MAESTRO software. The influence of recording parameters was assessed by comparing the alternating polarity paradigm for artifact reduction with a forward-masking paradigm – for the latter, responses to anodic-leading and cathodic-leading stimulation were evaluated separately. Finally, in order to circumvent cognitive factors in the relation between eCAP measures and hearing performance, a spectral ripple discrimination task was used in addition to conventional speech audiometry. Preliminary results show moderate correlations between several eCAP measures and patient characteristics, such as age or duration of hearing loss, and between eCAP measures and speech perception scores. The results furthermore appeared to favor cathodic-leading over anodic-leading stimulation for cochlear health measures. Differences in eCAP responses between the three artifact reduction strategies may additionally reveal mechanistic aspects of electrical excitation of the neuronal population. Ripple discrimination scores correlated with both eCAP measures of cochlear health and with speech scores. eCAP-based cochlear health measures are predictive of hearing performance with a CI. Occasionally reported weak correlations may be strengthened by optimizing both stimulation conditions and the choice for hearing outcome measure, and additionally by accounting for patient characteristics such as etiology and duration of hearing loss.

Wednesday: 11:40 - 12:00

TOWARDS INDIVIDUALIZED CI CARE USING HOLISTIC AND LONGITUDINAL BIG DATA NETWORKS

Yue Zhang, Michel Hoen

Cochlear Ltd.

Objective: Recent advances in data transmission bandwidth and security have transformed healthcare data collection, enabling the rise of large-scale operational tools, international registries, and real-world datasets. These developments are shifting clinical evidence generation from controlled lab environments into patients' daily lives, paving the way for individualized care solutions. Cochlear implants (CIs) are particularly well-positioned to benefit from this shift, given the growing global recipient base (now exceeding 1.5 million), the high variability in outcomes, and increasing demands on healthcare systems, especially in aftercare and rehabilitation.

Over the past three decades, Cochlear Ltd has introduced a suite of medical devices and digital applications. As CI users and clinicians interact with these tools, they generate rich data on device usage, neural health, and real-world hearing outcomes. This talk will present our interconnected ecosystem—anchored by the Cochlear™ Link service and Clinical Cloud—which enables the construction of a holistic, longitudinal big data network. We will showcase how insights from this network are driving innovation, enhancing clinical evidence quality, and supporting data privacy and security compliance.

Methods: Data de-identification removes all personal information that can associate data back to specific recipient to ensure privacy compliance. Data mining of Cochlear™ Connected Care Data (including Cochlear™ Link Custom Sound, Nucleus® Smart App and Cochlear™ Remote Check) and secondary analysis of clinical trial data are conducted to extract scientific and clinical insights.

Results: Device data captured by sound processors and implants (e.g., Time on Air, Own Voice Detection, environmental scenes, accessory usage) reveals how CI users engage with their de-vices in daily communication. Longitudinal CI outcomes are captured by Cochlear™ Remote Check, Custom Sound and Nucleus® Smart App since baseline session. Longitudinal data indicates that cohort-level performance is stable across metrics like impedance, Time on Air, aided thresholds, digit triplet tests, SSQ12, and speech recognition in quiet and noise. The most significant changes occur within the first 12 months post-activation depending on specific metric, then followed by gradual improvements throughout the rest of their CI journeys. However, individual variability remains high. Notably, some CI users exhibit greater difficulty in noisy or real-world environments despite similar performance in quiet and audibility. Differences in cognition, auditory sensitivity and neural health suggest possible existence of specific central and peripheral profiles that may underline this variability.

Conclusions: Our integrated ecosystem of devices and applications is generating a rich tapestry of data that connects neural health to real-world hearing outcomes. This big data network is unlocking scientific and clinical insights previously not possible, enabling more personalized and effective CI care. Future clinical trials are needed to test whether targeted interventions based on these insights can improve hearing outcomes and establish causal relationships.

Thursday: 08:50 - 09:10

MISPERCEPTION OF TALKER PROSODY AS A CORE COMPONENT OF COCHLEAR IMPLANT PATIENTS' DIFFICULTY HEARING SPEECH IN NOISE

Harley J. Wheeler, **Matthew B. Winn**

University of Minnesota

Perception of prosody—expression of a talker's intention, emotion, word emphasis, etc. – is dominated by perception of a talker's fundamental frequency (F0, voice pitch), and cannot be inferred by standard speech repetition scores. Misperception of the emphasized words or underlying meaning could be socially costly and dominate a patient's perception of their own auditory ability. The important role of pitch in prosody perception highlights the need to examine it in people who use cochlear implants. Whereas healthy acoustic pitch perception is robust to severe background noise, cochlear implants (CI) lack access to harmonic pitch perception puts patients at risk for poor perception of prosody when noise is present, even if they appear to perceive pitch adequately in quiet. The current study used a novel prosody perception paradigm to demonstrate 1) the prevalence of misunderstandings of prosody in CI listeners, 2) details of how this pattern is linked with pitch perception deficits, and 3) the extreme fragility of prosody perception in noise. Stimuli were sentences with contrastive focus on a specific word, as if to correct prior information. The sentences were embedded in various levels of speech-shaped noise and presented with accompanying text to test only prosody rather than word identification ability. Participants (CI n = 15; NH n = 18) used a visual analog scale to report perceived degree of focus on words in each sentence. CI users showed lower ratings of perceived emphasis on target words and a greater tendency for perceptions of focus away from the target word (misunderstanding of the talker's intent). Most importantly, background noise exacerbated these misperceptions exclusively for the CI group, even at a favorable SNR of +10 dB, with misidentification of the talker's prosody for half of all trials at 0 dB SNR. Accordingly, examination of prosody perception in noise helps us further understand conversational challenges faced by CI listeners that extend beyond word intelligibility and push toward understanding a talker's intention and goals. We propose a major takeaway message that the common complaint of CI patients' difficulty communicating in noise is not merely due to the errors made on word recognition, but due in large part to persistent misperceptions of a talker's point of emphasis and prosody.

Thursday: 09:10 - 09:30

TOPOGRAPHIC MAPS OF TEMPORAL ENVELOPE MODULATION PROCESSING IN COCHLEAR IMPLANT USERS

Brent Sterckx[1,2], Marc Moonen[1], Jan Wouters[2]

[1]STADIUS, Dep. of Electrical Engineering, KU Leuven, Leuven, Belgium
[2]ExpORL, Dep. of Neurosciences, KU Leuven, Leuven, Belgium

A recently developed artifact removal algorithm was used to enable mapping the processing of temporal envelope modulations (TEMs) across CI users' scalp. TEMs are basic features of a speech signal for accurate speech perception, as they contain important temporal information at several different time scales, i.e. modulation frequencies. For example, the TEMs of speech typically contain components at ~4Hz (250ms) and ~20Hz (50ms), which correspond to the syllable and phoneme rates respectively.

In normal-hearing listeners, the processing of TEMs at specific modulation frequencies can be studied from auditory steady-state responses (ASSRs) in EEG recordings as a result of stimulation with a carrier sound modulated at specific frequencies. Topographic maps showing the response activity across the scalp have led to insights with regards to hemispheric lateralization of cortical TEM processing, supporting theories of hemispheric specialization.

In CI users, stimulation artifacts originating from the CI itself dominate the neural responses. The artifacts overlap the ASSRs in both time and frequency domains, and traditional approaches for artifact removal have proven unsuccessful. It is hence currently unknown whether their TEM processing shows a topographic pattern similar to normal-hearing listeners or whether it is altered - as is the case for the processing of transient stimuli. Yet, as they must rely mainly on TEMs for speech perception, obtaining such maps is crucial as altered activation could interfere with hemispheric specialization and hamper speech perception. More importantly, insight into these patterns and alterations could guide the development of future stimulation strategies and improve speech perception with a CI.

Recently, Schott et al. [1] achieved a breakthrough in extracting the 40 Hz ASSR from individual channels of hyper-rate EEG recordings in CI users while using clinical stimulation settings using a system-identification approach. This contribution demonstrates the application of this method to lower-rate but higher-density EEG to obtain the topographic maps of TEM processing in CI users. As a proof-of-concept for this approach, the results from a group of adult CI users are presented. Topographic maps of the ASSR amplitude, signal-to-noise ratio, and latency are obtained using the method at modulation frequencies important for speech perception, i.e. 4 and 20 Hz, corresponding to the syllable and phoneme rates respectively.

Acknowledgements
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Thursday: 09:30 - 09:50

EFFECTS OF PERSONALITY TRAITS ON SPEECH-PERCEPTION PERFORMANCE IN ADULT CI USERS

Eric R. Rodriguez[1], Douglas Samuel[2], Maureen J. Shader[1]

[1]Purdue University, Dept. Of Speech, Language, And Hearing Sciences
[2]Purdue University, Dept. of Psychological Sciences

Purpose/Objective: Cochlear implants (CIs) are an effective treatment for moderate-to-profound hearing loss, yet outcomes in speech perception vary widely across recipients. While factors like duration of deafness and etiology of hearing loss partially explain this variability, they account for only a small fraction of the variance in outcomes, suggesting the influence of other patient-specific traits on speech-perception performance. This study examines personality traits—specifically neuroticism and conscientiousness—as potential predictors of CI outcomes, while controlling for known influential factors. In a variety of medical contexts, neuroticism and conscientiousness are known predictors of rehabilitative outcomes in multiple clinical populations. These personality traits may shape CI users' adaptability and resilience in challenging listening environments. Neuroticism describes a person's tendency to experience distress, while conscientiousness describes a person's inclination for discipline and organization. We hypothesized that CI users with a combination of lower neuroticism and higher conscientiousness will outperform those with higher neuroticism and lower conscientiousness on demanding speech-perception tasks.

Methods/Approach: Eleven CI users completed the gold standard personality assessment (NEO-FFI-3) to determine their scores in the domains of neuroticism and conscientiousness. Speech perception was assessed using AzBio sentences in quiet and in noise at +10-dB SNR. Functional near-infrared spectroscopy (fNIRS) neuroimaging and full-body physiological measures (heart rate, respiratory rate, skin conductance) assessed real-time listening-induced cortical engagement and physiologic stress responses. Additional measures included self-reported resilience, social engagement, and listening effort (NASA Task Load Index). Additional co-variates were collected, including cognitive ability in the domain of inhibition-control using the Flanker task and an estimate of spectral resolution using the Spectro-Temporal Ripple for Investigating Processor EffectivenesS (STRIPES) task.

Results: Preliminary results revealed that CI users with a combination of high neuroticism and low conscientiousness achieved significantly poorer speech-perception scores in noise compared to those with low neuroticism and high conscientiousness. CI users with high neuroticism and low conscientiousness demonstrated heightened activation of the sympathetic nervous system during challenging listening, evidenced by increases in heart rate and skin conductance. CI users with greater listening-induced stress also demonstrated decreased activity in executive-functioning brain regions during demanding listening, suggesting that activation of the autonomous nervous system (fight-or-flight response) impaired their ability to access higher-level cognitive resources. A reduction in activity within executive-function brain regions that is triggered by a heightened physiologic stress response could explain the limitation in speech-perception ability in individuals with high neuroticism and low conscientiousness.

Conclusions/Implications: Findings from this project add to the current knowledge of the biological factors that influence CI outcomes, while also providing a more holistic understanding of CI individual differences. More directly, these findings will allow clinicians to identify specific personality traits that may put individual CI users at a disadvantage for performing well with their device. Our results could also inform CI candidacy assessments by identifying personality profiles that may contribute to positive outcomes, offering insight into preoperative counseling and post-implantation support strategies.

Thursday: 09:50 - 10:10

NEURAL CORRELATES OF TARGET DETECTION IN COCHLEAR IMPLANT USERS DURING SPEECH-IN-NOISE PROCESSING AND AUDITORY OBJECT FORMATION

Phillip E. Gander[1], Nour Alsabbagh[1], Francis Smith[1], Joel I. Berger[1], Bob McMurray[2], Timothy D. Griffiths[3], Inyong Choi[2]

[1]University Of Iowa Hospitals and Clinics, Iowa, USA
[2]University of Iowa, Iowa, USA
[3]Newcastle University, UK

Background: Understanding the neural correlates of speech in noise processing in cochlear implant (CI) users may help identify key sources of variance that exist in implantation outcomes. We have identified an auditory cognitive mechanism in which cross-frequency grouping ability in both normal hearing and CI populations predicts speech in noise performance beyond the integrity of the peripheral auditory system. This central measure appears to identify a critical mechanism that listeners use to segregate auditory objects from the background, like speech in noise. Here we explore the common neural mechanisms employed by CI users during a speech in noise task and an auditory object formation task.

Methods: For the speech in noise task we report 95 adult CI users who participated in the Iowa Test of Consonant Perception (ITCP). The ITCP is a four-alternative forced choice speech in noise task in which we presented a high SNR (+15 dB) and low SNR (+7.5 dB) target word. For the object formation task we report 53 CI users who performed a stochastic figure-ground (SFG) detection paradigm. The SFG paradigm included a stimulus that is either composed of tone pips randomized across time and frequency, “Ground” condition, or a stimulus consisting of several tone pips that become spectrotemporally coherent halfway through, “Figure” condition. Participants pressed a button to indicate whether or not they heard the “Figure”. 64-channel EEG was measured during each task and time-frequency analyses were performed for each subject for each task to look for common neural signatures.

Results: In the speech in noise data set alpha band (8-13 Hz) activity showed a decrease in activity shortly after the target word onset (event-related desynchronization). The SFG data set revealed a strong alpha-band response that significantly differed when the “Figure” was presented. Alpha desynchronization appeared in the “Figure” condition at about 500 ms following the presentation of the coherent tone pips. There was a substantial amount of variability in the pattern of alpha activity across participants in both tasks. There was no relationship between alpha desynchronization and speech in noise accuracy, but there was a relationship for the SFG task.

Conclusions: These results indicate that alpha desynchronization is a common neural signature of object processing. However, further work is needed to determine if this response reflects object perception or cognitive resource load during challenging listening conditions.

Thursday: 10:40 - 11:00

USING VISUAL WORLD EYE TRACKING TO CHARACTERIZE ATTENTION TO AUDITORY TARGETS

Lukas Suveg, Ruth Y. Litovsky

University Of Wisconsin-Madison

Objectives: Spatial separation of target and competing (masker) speech can improve the accuracy with which listeners, including those with bilateral cochlear implants (BiCIs), can identify the target speech. Even if assessments of this benefit were implemented in routine clinical practice, behavioral measures like percent correct scores are not designed to provide insight into the momentary accumulation of perceptual salience of auditory stimuli that informs the ultimate judgement regarding the target speech. In this study, we adapted the “visual world paradigm,” wherein eye-gaze was monitored as participants selected, on a computer monitor, the image representing a spoken target stimulus. This novel study was designed to investigate the effect of spatial congruence between the auditory target and its visual depiction, and how it varies as a function of target-masker spatial configuration and signal to-noise ratio (SNR). Eye gaze behaviors unfolding over the time course of target determination were measured along with time to decision, and percent correct, to test the hypothesis that audiovisual spatial congruence increases the confidence and accuracy with which targets are identified.

Design: Adult BiCI users and typically hearing (TH) listeners participated. Target and masker stimuli were sentences from the coordinate-response measure (CRM) and produced by male talkers. CRM sentence syntax varies only in the "call sign" (e.g., "Baron", "Hopper"), color, and number spoken. The target call-sign was always “Baron,” but the masker call-sign varied randomly across trials, and target and masker sentences were spoken by different talkers on each trial. Target stimuli were played at 65 dBA via loudspeakers located at +/- 90º azimuth. They were presented in quiet, or with a co-located or spatially separated speech masker at various SNRs. Participants responded by clicking the image depicting the target on a computer monitor containing four images. Each quadrant of the screen contained the target number in the target color (target), the masker number in the masker color (inconsistent foil), or a partially consistent foil (i.e., the target number in the masker color and vice versa). Half of the trials were audio-visually congruent.

Results: Improved percent correct was observed, as expected, for spatially separated target-maskers. Preliminary eye gaze analysis suggests that participants committed to their target determination more quickly and consistently when the target was presented alone or with a spatially separated masker. On trials with co-located maskers, participants were more likely to reconsider visual competitors after looking to the target image, suggesting uncertainty and weaker perceptual salience. Audiovisual congruence also reduced the latency to maximum target looks in the separated target-masker configuration, at each SNR. In the co-located target masker configuration, audiovisual congruence increased the latency to maximum target looks at 0 dB SNR but reduced the latency at -8 dB SNR.

Conclusion: In addition to demonstrating improved speech target intelligibility from spatial separation of target and masker stimuli, participants in this study demonstrated that congruent auditory and visual spatial cues can increase the speed, certainty, and confidence with which a target sound is identified. The results at -8 dB SNR might be explained by a strategy in which listeners exploit the loudness difference and attend to the quieter of the two sounds, improving accuracy at the expense of additional trial time. We will present additional analyses from the completed TH study as well as results investigating these effects among a group of BiCI listeners.

Work was funded by a grant from NIH-NIDCD (R.Y. Litovsky R01DC020355).

Thursday: 11:00 - 11:20

SEQUENTIAL VERSUS SIMULTANEOUS ACROSS-EAR LOUDNESS BALANCING FOR SINGLE-SIDED DEAFNESS COCHLEAR-IMPLANT USERS

Sandeep A. Phatak, Michael A. Johns, Matthew J. Goupell, Joshua G. W. Bernstein

Walter Reed National Military Medical Center, Bethesda, Md, USA
University of Maryland - College Park, College Park, Md, USA

For individuals with single-sided deafness (SSD), the primary purpose of a cochlear implant (CI) is to restore spatial hearing. However, the two ears are rarely loudness-balanced when programmed by an audiologist, which could impair spatial perception. Anecdotal reports suggest that the CI ear is often set quieter than the acoustic ear and it is unclear how to optimally balance interaural levels. For bilateral CI users, sequentially loudness-balanced stimuli often do not generate an intracranially centered sound when presented simultaneously. This study tested the hypothesis that “interaural loudness mismatch” (ILM)—differences in the levels required for loudness balancing with simultaneous (LBSM) versus sequential (LBSQ) stimuli—would be prevalent in SSD-CI users, given the many differences between the acoustic and CI ears. ILM was measured for SSD-CI users and for CI users with asymmetric hearing loss (AHL) by comparing the levels required for LBSQ and LBSM. The stimulus level was fixed in one ear (i.e., reference ear) and the level in the other ear was adjusted adaptively using a two-alternative forced-choice task. On each trial, listeners reported which of two sequential stimuli was louder (LBSQ) or toward which side a bilaterally simultaneous stimulus was heard (LBSM). Stimuli were delivered to the acoustic ear and to the CI sound processor via circumaural headphones. ILM was measured for a range of stimulus types (pure tones, a tonal complex, speech, and noise), two reference levels (45 or 55 dB SPL, depending on absolute threshold, and 65 dB SPL), and with each ear serving as the reference. For a subset of stimulus types, a separate control experiment measured the perceived intracranial locations for simultaneously presented stimuli. Preliminary data from 7 (of 13 planned) subjects showed that loudness-balancing outcomes depended on the study variables, with significant interactions between presentation mode (sequential/simultaneous) and both reference ear ($p=0.005$) and reference level ($p<0.001$), but not stimulus type ($p>0.05$). Post-hoc tests indicated that when the acoustic ear served as the reference at 65 dB SPL, CI-ear LBSQ values were significantly ($p<0.001$) lower than LBSM values, resulting in a mean ILM of 7.1 dB. No significant ILM was observed for the lower reference level or when the CI ear served as the reference. Adaptively tracked LBSM estimates closely matched those based on reported intracranial location ($r=0.86$). These results indicate that SSD-CI and AHL-CI users indeed experience ILM. The most ILM occurs in the condition most akin to a likely clinical loudness-balancing scenario: when stimuli are presented sequentially, with the acoustic-ear level held fixed at a comfortable level and the CI level adjusted to match. In this case, LBSQ failed to generate a perceptually centered image. Other approaches to interaural loudness balancing are more likely to yield a balanced spatial percept, such as simultaneous presentation or a sequential approach with the CI ear serving as the reference.

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Thursday: 11:20 - 11:40

RECORDINGS FROM THE BRAIN: A REVIEW OF DIRECT CAEP MEASUREMENTS IN COCHLEAR IMPLANT USERS

Chen Chen, Tony Spahr, Kanth Koka, Gunnar Geissler, Mehrangiz Ashiri, Volkmar Hamacher

Advanced Bionics, LLC (28515 Westinghouse Pl, Valencia, CA

The use of subjective user feedback makes the process of cochlear implant (CI) assessment challenging in cases where users are not able to actively or accurately report their subjective experience (e.g. pediatrics). The cortical auditory evoked potential (CAEP) has proven to be a physiological biomarker to objectively monitor auditory cortex development in normal hearing children and effectiveness of CI implantation (1 - 5), and has further been shown to correlate strongly with clinical CI programming thresholds (6). Obtaining such signals will be very clinically useful, but has not been widely used, due in large part to the complexity of the required scalp EEG systems. Our goal is to find a clinical pathway where we can faithfully measure cortical responses directly using a fully commercial CI system in a fast and convenient manner.

In this presentation, we will review the motivations for CAEP measurements, previous research on various aspects of obtaining such signals with CI systems (7 – 10), as well as the challenges we face, and how we addressed some of them so as to perform such measurements with an Advanced Bionics research system. We will present recent clinical feasibility studies validating that the CI recorded CAEP signals matches those obtained using scalp EEG system (11 – 14), and discuss clinical relevance and future opportunities.

In summary, we will demonstrate the feasibility of stimulating and recording eCAEPs directly through AB's CI system with a user's existing implant in under 5 minutes. This makes it possible to incorporate cortical potential measurements into future CI clinical practice to guide CI fitting and track auditory cortical development. This will also enable extended research capabilities on CAEPs and other brain signals of interest to study the underlying peripheral and central mechanisms of individual responses.

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Thursday: 11:40 - 12:00

MEMORIAL FOR BERTRAND DELGUTTE

Andrew Oxenham, session chair

This brief memorial session for Dr. Bertrand Delgutte will celebrate his impact on the field, on his colleagues, and on his mentees over the years he led his group at the Eaton Peabody Laboratories with Harvard Medical School and led the Harvard-MIT Graduate Program in Speech and Hearing Bioscience and Technology. At the interface between auditory physiology and auditory and speech perception, his rigorous empirical work and creative insights have left a lasting impression on the field of auditory and speech sciences.

Thursday: 19:00 - 19:20

TRANSCRIPTION FACTOR COCKTAILS FOR HAIR CELL REGENERATION IN MATURE COCHLEAE

Averyt Matthew[1], Lin Yang[1], Valeria Mas[1], Sunita Singh[2], Lisa Beyer[1], Diane Prieskorn[1], Andrew Groves[2], Yehoash Raphael[1]

[1]The University of Michigan, Ann Arbor, MI, USA
[2]Baylor College of Medicine, Houston, TX, USA

Using transgenesis and culture work, several labs have shown that a combination of transcription factors that play a role in hair cell (HC) development is superior to Atoh1 alone in inducing transdifferentiation of supporting cells into new HCs. Here we test the combinatorial approach in vivo in the mature Pou4f3-DTR mouse, where an injection of diphtheria toxin (DT) leads to degeneration of all HCs leaving behind supporting cells that appear morphologically differentiated. Mature Pou4f3-DTR mice (N=20) were deafened by injecting DT (20 ng/g). Adenovirus vectors containing gene inserts for Gfi1, Atoh1, Pou4f3, Six1 (GAPS) (N=10) or Gfi1, Atoh1, Pou4f3 (GAP) (N=10) with a reporter gene were injected into the scala media of the cochlea. The contralateral ear served as a control. Mice were given the vector at the same time as the DT injection. Animals were prepared for analysis one month after adenovirus injection. Cochlear whole-mounts were labeled with antibodies against Myosin VIIa, as a hair cell marker, and phalloidin. Presence of new hair cell-like cells (HCLC) was assessed and quantified using epi-fluorescence or confocal microscopy. Both groups (GAP and GAPS) exhibited HCLCs with large variability in the numbers between animals. All animals from both groups had Myosin VIIa positive cells in the experimental (left) ear. Initial qualitative observation revealed that GAPS group animals included 4 out of 10 animals with a large number of HCLCs. In the GAP group, 5 out of 10 animals had a large number of HCLCs. In both groups, HCLCs were located within the auditory epithelium, in areas of the deaf organ of Corti as well as medial or lateral to this area. In conclusion, the GAP cocktail of transcription factor transgenes appears to convert non-sensory cells to HCLCs in a similar way to the GAPS vector. One important next step is to determine if the presence of new HCLCs enhances survival of auditory neurons, which could positively influence outcomes of cochlear implant therapies.

Supported by the HRP and NIH-NIDCD grant R01-DC014832. Keywords: gene therapy, hair cell regeneration, mature cochlea

Thursday: 19:20 - 19:40

BETTER TEMPORAL ACUITY FOR COCHLEAR IMPLANTS

John C. Middlebrooks[1], Matthew L. Richardson[1], Robert P. Carlyon[2], Harrison W. Lin[1]

[1]University Of California at Irvine, CA, USA
[2]University Of Cambridge, Cambridge, England

Purpose: Most users of today's cochlear implant (CI) show only limited sensitivity to temporal fine structure (TFS), which hampers their use of pitch contours to segregate streams of syllables among multiple talkers. In previous short-term animal studies, we used penetrating intraneural (IN) electrodes to stimulate restricted auditory-nerve populations while recording spike activity from neurons in the central nucleus of the inferior colliculus (ICC). We found that low-frequency pathways originating in the cochlear apex transmit TFS to the ICC at higher rates than do the basal pathways that are stimulated by today's CIs. Hypothetically, stimulation of restricted apical fiber populations with a clinical IN electrode could enhance TFS sensitivity for human CI users. As a step toward such a clinical device, we have tested the efficacy and safety of IN stimulation in chronically implanted cats.

Approach: Deafened cats were implanted with IN electrodes and/or with an animal version of a conventional CI. The IN electrode was a single activated-iridium shank. Scalp recordings were made from sedated animals at 2-3-week intervals. Sensitivity for activation of auditory pathways was measured by the electrically-evoked auditory brainstem response (eABR). Temporal transmission was measured by the frequency-following response elicited by electrical pulse trains at varying rates (eFFR). The phase characteristics of the eFFR provided a measure of synchronized activity at various levels of the auditory pathway.

Results: Thresholds for the eABR were ~13 dB lower for IN than for CI stimulation. The maximum synchronized rates for the eFFR at auditory midbrain latencies averaged ~367 pulses/s for IN compared to only ~240 pulses/s for CI stimulation. eABR thresholds and eFFR cutoff rates were stable out to 6 months after implantation.

Conclusions: In a future clinical device, an IN electrode could augment cochlear implants by enhancing temporal acuity, thereby improving speech reception amid competing sounds.

Thursday: 19:40 - 20:00

LOW-THRESHOLD ACTIVATION AND CROSS-MODAL OPTIMIZATION FOR OPTOGENETIC HEARING RESTORATION IN RODENTS

Anna Vavakou[1], Victoria Hunniford[1], Fadhel El May[1], Niels Albrecht[1], Bettina Wolf[1], Eric Klein[2], Patrick Ruther[2], Alexander Ecker[3], Thomas Mager[1], Tobias Moser[1]

[1]Institute for Auditory Neuroscience and InnerEarLab, University Medical Center Göttingen, Germany [2]University of Freiburg, Department of Microsystems Engineering (Imtek), Freiburg, Germany
[3]Institute of Computer Science and Campus Institute Data Science, University of GÃ¶ttingen

The electrical cochlear implants (eCI) have revolutionized the treatment of profound to severe hearing loss. However, users often report difficulty in understanding speech in noisy environments, highlighting a remaining medical need. As an alternative to electrical pulses, the auditory nerve can be stimulated with light, using an optical cochlear implant (oCI). Since light can better be confined in space than current in conductive fluids, the oCI holds the potential of increasing the number of perceptually distinct frequency channels, ultimately improving the hearing sensation of users. The optogenetic activation of the auditory pathway is achieved by transducing the SGNs with adeno-associated viruses (AAVs) that harbor the genetic information for light sensitive ion channels (Channelrhodopsins, ChR). The properties of the chosen ChR strongly define the optogenetic activation profiles of the transduced SGNs. Optogenetic stimulation of the auditory nerve differs from electrical stimulation in several key aspects, such as desired higher frequency resolution and currently lower temporal fidelity. Consequently, sound coding strategies used to deliver electrical currents in eCIs cannot be directly applied to oCIs. In the current study, we use a novel opsin (ChReef) tailored for low activation thresholds, and propose a framework for development and assessment of optical sound coding strategies operating multichannel oCIs in rodent models. The efficacy of optogenetic activation of the auditory nerve was tested in rodent in-vivo models (mice and Mongolian gerbils), via electrophysiological readouts along the auditory pathway following light presentation (Mice: optical Auditory Brainstem Responses (oABR), single SGN measurements; Gerbil: oABR, Multi-Unit Activity in the Inferior Colliculus – 32 channels NeuroNexus probe). All experiments were performed on anesthetized animals. The virus was delivered early postnatally via round window injection. In summary, the threshold for optogenetic activation in the rodent models is below 250nJ. As expected from the slow opsin closing kinetics, the temporal fidelity of single SGN responses to light pulses decreases after 50Hz. ChReef's favorable low activation thresholds allow for activation of the auditory SGNs using oCIs at low power settings (oCIs based on commercial LEDs (220 x 270 µm, C460TR2227-S2100, Cree, 5-10 channels). To further refine oCI light delivery strategies, we propose a framework of cross modal optimization. Specifically, our approach involves training convolutional neural networks to predict responses in the auditory midbrain (Inferior Colliculus) to both optical and acoustical stimulation. We then leverage these models to optimize optical sound coding strategies, aiming to evoke Inferior Colliculus responses that closely resemble those produced by auditory stimuli.

Thursday: 20:20 - 20:40

CORTICAL IMPLANTS FOR HEARING RESTORATION

Tania Rinaldi Barkat

Department of Biomedicine, University of Basel, Switzerland

Hearing loss affects half a billion people worldwide, significantly impairing communication and quality of life. While hearing aids provide adequate support for mild cases, severe hearing loss often requires cochlear implants. Despite their success, cochlear implants suffer from poor spectral accuracy, low acoustic resolution, and ineffectiveness in patients with auditory nerve damage. This study investigates whether cortical implants offer a more effective alternative for auditory restoration.

We implanted surface electrode arrays with 32 contacts (175 µm spacing) onto the auditory cortex of mice and compared them with cochlear implants featuring 4 electrodes (500 µm spacing). To ensure a direct comparison, we analyzed responses from four cortical electrodes, four cochlear implant electrodes, and four frequency-matched acoustic stimuli in normal-hearing mice. Mice were tested on single- and multi-frequency categorization tasks, amplitude modulation categorization, and amplitude modulation in noise categorization. Across all tasks, cortical implants led to superior auditory performance compared to cochlear implants, although learning took longer and followed distinct learning curves. Notably, mice trained with natural sounds could perform the tasks with cortical stimulation without additional training and vice versa, suggesting that cortical stimulation evokes percepts that closely resemble natural hearing.

To investigate the neural basis of these differences, we recorded in vivo electrophysiological responses in the auditory cortex to cortical stimulation, cochlear stimulation, and natural sounds. Neuronal responses scaled with stimulus strength across all conditions. Dimensionality reduction analyses (PCA, t-SNE) revealed that cortical stimulation responses resembled natural sound-evoked responses more closely than cochlear stimulation responses. Linear decoder analyses trained on natural sounds and tested on cortical and cochlear stimulation showed higher classification accuracy for cortical stimulation. Additionally, three-way decoder analyses confirmed that cortical stimulation responses were more similar to natural sounds than to cochlear stimulation, aligning with behavioral findings.

These results suggest that cortical stimulation not only provides better auditory performance but also more faithfully mimics natural auditory processing. The ability of mice to generalize between natural sound and cortical stimulation further supports this claim. While cortical implants show promise as an alternative for hearing restoration, future studies should further investigate learning dynamics, perceptual fidelity, and translational feasibility for clinical application.

Thursday: 20:40 - 21:00

TARGETED NEUROMODULATION TO IMPROVE COCHLEAR IMPLANT USE IN RODENTS

Robert Froemke

NYU Langone Medical Center

Here I will discuss behavioral, physiological, and optogenetic experiments in bilaterally-deafened rats trained to use a unilateral cochlear implant to perform an auditory task. In human users, cochlear implant outcomes can have variable learning rates and levels of achievable performance. This variability is believed to relate to degrees of functionality and neuroplasticity within the central auditory system. However, there is little known about how mechanisms of neural signaling and plasticity relate to individual behavior. We trained rats on a reward-based auditory detection and recognition task first when normal-hearing and then re-trained after deafening and fitting with a cochlear electrode. We observed a broad range of performance using the implant. Recordings from the rat auditory cortex revealed that responses to implant stimulation reflected behavioral performance, with enhanced responses to rewarded stimuli and decreased distinction between unrewarded stimuli. We found that a major modulatory system- the noradrenergic system of the brainstem locus coeruleus- was activated early in use of the implant, and that locus coeruleus activity predicted when each animal would begin to successfully hear again with the cochlear implant. We used optogenetic stimulation of locus coeruleus to improve cochlear implant performance in trained and deafened rats. Finally, I will discuss newer and unpublished work connecting locus coeruleus stimulation to the potential applicability of vagus nerve stimulation to boost auditory perceptual learning in rodents and humans.

Friday: 08:30 - 08:50

LONGITUDINAL STUDIES OF EARLY COCHLEAR IMPLANT USE

Ariel Edward Hight[1], Rohit Makol[1,2], Nicole Capach[1], Jonathan Neukam[3], Mario A. Svirsky[1], Robert C. Froemke[1]

[1]NYU Langone Medical Center
[2]University Of Connecticut Medical Center
[3]Vanderbilt University Medical Center

Purpose/Objective: Adult-deafened cochlear implant users attain open set speech perception, and outcomes vary. Invariably, however, all users undergo adaptation periods following initial activation. Speech scores are initially poorer and improve over the course of weeks to months, and in some rare cases years [1-3]. This adaptation period is largely attributed to recalibration of central pathways to imposed sensory remapping by cochlear implants. Here, we test the hypothesis that auditory acuity, the ability to discern spectral and temporal cues, improves and parallels improvements in speech perception over the course of early cochlear implant use.

Methods/Approach: Humans: we send newly implanted cochlear implant subjects home with a mobile computer used to test spectral and discrimination, as well as CNC word recognition. Animal studies: Normal-hearing rats are trained on spectral discrimination tasks, then deafened and implanted with 8-channel cochlear implants. Post-implantation performance was tracked until reaching plateau.

Results/Findings: Preliminary data from human cochlear implant users tested over a period of 1 month following activation, revealed significant improvements in spectral discrimination in 2 of 3 tested subjects, and improved temporal discrimination in 1 of 3 subjects. Significant improvements in speech perception were found in 2 of 3 subjects, the same subjects with improved spectral discrimination. In a preliminary set of rat cochlear implant users (N=5), we found significant improvements in spectral discrimination over ~2 weeks of behavioral training with cochlear implants.

Conclusions/Implications: There are likely several and overlapping domains of adaptation & neuroplasticity facilitating a subject’s improvement in speech perception. Our focus on perceptual acuity provides insight into fundamental auditory capabilities and their neural correlates in primary auditory pathways. Understanding the dynamics of perceptual improvement and associated neuroplasticity may reveal therapeutic targets for optimizing auditory rehabilitation in new implant users. This work was funded by Charles H. Revson Senior Biomedical Science Fellowship (A.E.H), NIH TL1 (A.E.H), NIH K99 Award (A.E.H), NIH R01 (Froemke & Svirsky), and NIH R01 (Svirsky).

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Friday: 08:50 - 09:10

BETWEEN-AND WITHIN-RECIPIENT NEURAL CORRELATES OF LOUDNESS GROWTH WITH COCHLEAR IMPLANT STIMULATION LEVELS

Dorothée Arzounian, François Guérit, John M. Deeks, Charlotte Garcia, Evelien De Groote, Manohar Bance, Robert P. Carlyon

Cambridge Hearing Group

Purpose: The level of electrical stimulation current that elicits the most comfortable loudness percept with a cochlear implant (CI) varies between implanted ears and between electrodes, and also varies over time during the first months of CI use. The reasons for this progressive change are unclear, one hypothesis being that central auditory gain changes as a result of chronic electrical stimulation. We tested whether the amplitude of neural responses from different central auditory regions may predict between-recipients variations in loudness, as well as the within-recipient variations that occur over time.

Methods: We measured the behavioral comfortable dynamic ranges and electrophysiological responses to two stimuli in 12 adult CI recipients on the day of implant activation and at 3 later time points: 1, 2, and 4 months post-activation. The same measures were collected at 14 months post-activation for one of these “new” recipients, and from 7 other “experienced” adult users with over 14 months of CI use. The two stimuli were a single-pulse-per period (SPP) stimulus with a pulse rate of ~40 pulses-per-second (pps), and an amplitude-modulated (AM) stimulus with a carrier rate of 500 pps, amplitude modulated at ~40 Hz with the trough of the modulation corresponding to detection threshold. Both stimuli were presented in monopolar mode on a single electrode. We measured electrically-evoked Compound Action Potentials (eCAPs, reflecting auditory nerve response), Auditory Brainstem Responses (eABRs, reflecting subcortical responses) and Auditory Steady-State Responses (eASSR, reflecting thalamo-cortical responses) to the SPP stimulus, as well as eASSRs to the AM stimulus. We collected amplitude growth functions relating response amplitude to stimulus current level at all measurement time points except CI activation (where response was only measured at the most comfortable loudness level). We quantified response amplitude growth using the slope of a least-square linear fit (in dB/dB units), corresponding to the change in response amplitude induced by a 1-dB change in stimulus level. We quantified loudness growth with the inverse of the comfortable dynamic range (in dB), i.e. a quantity proportional to the average change in loudness (on the 11-point scale used for behavioral measurements) induced by a 1-dB change in stimulus level.

Results: When investigating correlations across the 19 recipients at 4 months post-activation or later, the growth of the eASSR with stimulation level was significantly correlated with eCAP growth ($r(11)=0.79$, $p=0.0014$) and with stimulus-specific loudness growth ($r(15)=0.71$, $p=0.0014$). When assessing within-recipient changes over time in the 12 new recipients, we could not evidence any significant change in eABR or eASSR response amplitude when repeating measurements at equal stimulation levels. This occurred despite a significant flattening of loudness growth occurring within one month after activation for both experimental stimuli, and despite sufficient statistical power to detect changes in response amplitude induced by changing stimulation levels. When repeating measurements at equal stimulation levels, we found a significant increase in eCAP amplitudes occurring in the first 3 months of CI use.

Conclusions: eASSR amplitude growth appears to be a good marker of differences in loudness growth between recipients when measured after 4 months of CI use. However, we found no evidence of a central auditory gain decrease induced by chronic CI stimulation. This suggests that the changes in report-ed loudness over time reflect either a change in subjective criterion or a change in central gain to which our electrophysiological measures – which reflect only synchronized responses – are not sensitive. Further work is required to understand the mechanisms underlying the seemingly contradictory changes in eCAP amplitude and in loudness growth that occur in the first months of CI use.

This work was funded by the Royal National Institute for Deaf People (RNID, G108648).

Friday: 09:10 - 09:30

EXAMINING EFFECTS OF LEFT VERSUS RIGHT PRE-LINGUAL UNILATERAL DEAFNESS ON CORTICAL RESPONSES TO SOUND

Hanne Bartels, Melissa J. Polonenko, Hyo-jeong Lee, Jaina Negandhi, Sharon L. Cushing, Blake C. Papsin, Karen A. Gordon

Archie's Cochlear Implant Lab, The Hospital for Sick Children, Toronto, Ontario, Canada

Aims: We asked whether there are effects of left versus right-sided unilateral deafness on the developing brain.

Design: Thirty-one children who received a cochlear implant (CI) for early-onset asymmetric hearing loss were included in this study. Children were recruited shortly after CI-activation (< 2 weeks of CI-use, mean [SD] age = 3.4 [1.8–5.5] years) and were grouped by ear of deafness (18 [58.1%] left and 13 [41.9%] right sided deafness). An age-matched control group of normal hearing children was also included (n=15). Cortical responses were evoked unilaterally from each side by acoustic clicks (100µs) delivered at 250Hz in trains of 36ms via an insert earphone to the acoustic hearing ear and by electric biphasic pulses (57µs pulse-width) delivered at 250 pulses/s from an apical electrode (#20) in the newly implanted deaf ear. Localization of cortical sources of activity underlying immature P1 peak amplitudes was performed using the Time-Restricted Artifact and Coherent Source suppression beamformer. Cortical lateralization (CL) and aural preference (AP) were calculated from peak dipole moments in the temporal auditory cortices (AC), with more positive values indicating stronger right hemispheric dominance and right ear preference, respectively.

Results: P1 peak latencies were similar between groups ($p = 0.37$), but responses were slower in the deaf than hearing ear in children with left sided deafness ($p < 0.01$). Contralateral responses to left and right ear stimulation in normal hearing children were significantly larger than any responses evoked in children with unilateral deafness ($p<0.05$ for all comparisons). As expected, children with normal hearing showed contralateral CL from each ear (left ear: mean [SD] = 23.9 [21.2]%; right ear: -12.9 [25.9]% for right ear stimulation) and each cortex showed contralateral AP (left AC: mean [SD] = 17.7 [21.3]%; right AC: -19.6 [19.6]%). By contrast, variable CL pat-terns (mean [SD] = 6.52 [41.4]%) were found in children with unilateral deafness with no significant effect of side of deafness ($p = 0.97$) or side of stimulated ear (left deafness: $p = 0.66$; right deafness: $p = 1.00$). They also showed variable AP (mean [SD] = -1.86 [35.4]) which was not associated with side of deafness ($p = 0.47$) and was similar for both left and right cortical hemispheres ($p = 0.14$). In children with right-sided deafness, CL was similar when evoked by either the hearing ear or the CI and AP was similar in both cortical hemispheres ($r = 0.77$ and $r = 0.65$, respectively). These correlations were weaker in children with left-sided deafness ($r = 0.31$ and 0.16, respectively). No aspects of hearing history significantly predicted the more strongly active cortex or preferred ear in children with unilateral deafness.

Conclusion: Results confirmed that the dominance of pathways from each ear to contralateral auditory cortices is lost in children with early onset unilateral deafness. They can have a particularly dominant cortical hemisphere and preferred ear (particularly in children with right sided deafness) but the individual patterns are not easily predicted by the side, type, or duration of deafness.

Friday: 09:30 - 09:50

AURAL PREFERENCE REORGANIZATION FOLLOWING CONGENITAL SINGLE-SIDED DEAFNESS IS MORE PRONOUNCED IN SECONDARY THAN IN PRIMARY AUDITORY CORTEX

Yusuf Prasandhya Astagiri[1,2], E. Firdaus[2], Peter Hubka[1,3], Jochen Tillein[1,4], Andrej Kral[1]

[1]Institute of AudioNeuroTechnology & Dept. of Experimental Otology, ENT Clinics, Hannover Medical School, Hannover, Germany
[2]Dept. of Medical Physiology and Biophysics / Medical Technology IMERI, Faculty of Medicine, University of Indonesia, Jakarta, Indonesia
[3]Clinical Research Unit in Audiology, Department of Otorhinolaryngology-Head and Neck Surgery, Faculty of Medicine and University Hospital, Comenius University, Slovakia
[4]Dept. of Otolaryngology, School of Medicine, J. W. Goethe University, Frankfurt am Main, Germany

Objective: Congenital single-sided deafness (SSD) is characterized by an extremely asymmetric auditory input, with only one functioning ear. It leads to an aural preference change in the representation within the primary auditory cortex (Kral et al., 2013, Brain). In this study, we investigated the reorganization of cortical activity in a higher order auditory field (PAF) and compared it to the representations in the primary auditory cortex in SSD cats, bilaterally hearing cats (HCs) and bilaterally congenitally deaf cats (CDCs).

Methods: Fifteen adult cats, four SSD, six HCs, and five CDCs were bilaterally implanted with 8 channel feline electrodes (MED-EL, Innsbruck). Three biphasic charge-balanced electric pulses (200 µs/phase, wide bipolar stimulation) was used for stimulation. All hearing ears were acutely deafened (neomycin) prior implantation to avoid electrophonic responses. Neuronal activity was recorded simultaneously from the primary auditory cortex (A1) and the posterior auditory field (PAF) using Neuronexus 16-channel multielectrode arrays. The recordings were localized to the recorded areas using bipolar derivation. The intergroup analyses compared amplitude and latency of cortical responses of the hearing and deaf ear in SSDs (CI stimulation) with contralateral and ipsilateral stimulation in HCs and CDCs. For quantification of phase-locked (evoked) responses, rectified LFPs were averaged across animals. For non-phase-locked components (induced activity), time-frequency representations (TFRs) were derived using wavelet analysis for each trial and were averaged in time-frequency domain across trials, positions and animals. TFR data were analyzed in dB power relative to the prestimulus period and statistically compared using cluster-based permutations.

Results: Response latencies were significantly shorter in A1 compared to PAF in all animal groups as it was typically found for primary and secondary cortical fields. In most comparisons, LFP amplitudes and discharge rates were significantly higher in AI compared to PAF in all animal groups. In SSD animals, responses to the deaf ear were nearly absent in PAF, while stimulation of the hearing ear evoked PAF responses comparable of those found in hearing controls. This was the case for both the evoked and the induced components. There was a further substantial drop of responsiveness to the deaf ear in the secondary field PAF when compared to A1 in the same animals. This indicates that the preference for the hearing ear in SSDs, as described for AI in previous studies, is further increased in the secondary cortex.

Conclusions: Deprivation leads to deficits which were more extensive in PAF compared to AI as shown by reduced LFPs, TFRs and multi-unit activity (Yusuf et al., 2017, Brain). In SSD, activity evoked by stimulation of the deaf ear is significantly below the one in the bilateral deaf group (CDC), more pronounced in the secondary field PAF than in A1. This demonstrates perceptual weakening of the representation of the previously deaf ear along the cortical hierarchy.

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Friday: 09:50 - 10:10

PLASTICITY LIMITS COCHLEAR IMPLANT OUTCOMES: EVIDENCE FROM MACHINE LEARNING MODELS OF PERCEPTION

Annesya Banerjee[1], Mark R. Saddler[2,3], Josh McDermott[2]

[1]Harvard University
[2]Massachusetts Institute of Technology
[3]Technical University of Denmark

Introduction: Cochlear implants (CI) are a standard treatment for severe sensorineural hearing loss but fail to restore fully normal hearing. These shortcomings could arise from suboptimal stimulation strategies, degeneration in the auditory system, or limits on the brain's ability to adapt to CI input. Computational models that predict auditory behavior from CI input may clarify how these different factors shape CI outcomes. Here, we developed artificial neural network models of hearing with CIs and investigated the effects of these different factors on speech recognition and sound localization performance.

Methods: We modeled normal hearing by training a feedforward convolutional neural network to recognize speech or localize sounds in noise given simulated auditory nerve input from an intact cochlea. We modeled CI hearing by testing this trained network on simulated nerve input from CI stimulation. To simulate learning to hear through a CI, we re-optimized all or part of the network for CI input. To assess the potential consequences of neural degeneration, we silenced different fractions of simulated nerve fibers and network model units (simulating peripheral and central degeneration, respectively).

Results: Models trained with CIs exhibited impaired speech recognition and sound localization relative to the normal hearing model. When the entire neural network was optimized for CI input, speech recognition was substantially better than that of typical CI users, even with substantial simulated peripheral and central degeneration. Performance on par with CI users was achieved when re-optimization was limited to the late stages of the network, consistent with plasticity constraints limiting speech recognition in CI users. By contrast, for the task of sound localization, large deficits remained even after reoptimizing the full model, suggesting device-related factors limiting performance. Results differed only modestly between stimulation strategies currently in use. The results point to central plasticity as limiting CI outcomes while also identifying limitations in existing stimulation strategies.

Conclusion: Our results help clarify the roles of impoverished peripheral information and incomplete central plasticity in limiting performance of realistic auditory tasks via CIs.

Friday: 10:40 - 11:00

AI-ENABLED PREDICTION TO IMPROVE LANGUAGE AFTER PEDIATRIC COCHLEAR IMPLANTATION

Nancy M Young[1,2], Yanlin Wang[3], Di Yuan[3], Shani Dettman[4], Dawn Choo[4], Emily Shimeng Xu[1,2], Denise Thomas[2], Maura Ryan[2], Patrick C.M. Wong[3]

[1]Northwestern University, Evanston, IL, USA
[2]Ann & Robert H Lurie Children's Hospital of Chicago, Chicago, IL, USA
[3]Chinese University of Hong Kong, Hong Kong SAR, China
[4]The University of Melbourne, Victoria, AU

Our research group is investigating prediction of spoken language improvement in implanted children on the individual level using neural predictive modelling and the neural mechanisms that underlie changes during the progressive stages of language development. Accurate prediction is important because significant variability in language post cochlear implantation (CI) occurs, even in early implanted children (1). Factors such as age at CI and residual hearing do not explain the majority of outcome variance or enable individual level prediction. Because both top-down and bottom-up neural processing of sensory information is necessary for speech perception, our research group theorizes that predictive modelling enabled by AI analytics using brain structure gleaned from brain imaging will yield accurate predication on the individual level. This could enable a "predict to prescribe" approach to improve language by providing the optimal type and dose of behavioral therapy. Our early work on neural prediction used pre-surgical MRI and machine learning modelling demonstrated accurate individual level prediction of short term outcome (2). The aims of our recent study were to validate and enhance the predictive model using deep children from multilingual children worldwide and deep learning analytics. The second aim was to examine contributions of various brain regions to spoken language at 6-, 12-, and 24-months post-CI.

Preoperative brain images were obtained from 278 implanted children with bilateral severe to profound sensorineural hearing loss. Progress was tracked up to three years after CI. Deep transfer learning models successfully differentiated children with low versus high post-CI improvement. The MobileNet model demonstrated the best performance (accuracy = 87%). A shift in predictive brain regions from auditory and language-related areas to cognitive and audiovisual integration regions occurred suggesting that the language trajectory of implanted children is similar yet delayed in comparison to normal hearing children.
Our results underscore the potential of preoperative neuroanatomical features to predict post-CI spoken language. Accurate individual level prediction combined with understanding of the dynamic neural processes supporting short- and long-term language development may provide a framework to maximize outcome by tailoring children's language intervention based on brain structure.

This work was supported by the Research Grants Council of Hong Kong Grant GRF14605119, National Institutes of Health R21DC016069 and R01DC019387.

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Friday: 11:00 - 11:20

EFFECTS OF MATURATION AND IMAGE-GUIDED COCHLEAR IMPLANT PROGRAMMING ON SPECTRAL AND TEMPORAL RESOLUTION IN CHILDREN WITH COCHLEAR IMPLANTS

Andrea Defreese[1], Katelyn Berg[1], Jourdan Holder[1], Linsey Sunderhaus1, Stephen Camarata[1], René Gifford[2]

[1]Vanderbilt University, Nashville, TN
[2]Hearts for Hearing, Oklahoma City, OK

Background: Cochlear implants (CIs) significantly enhance auditory function and speech recognition in children, yet substantial variability in outcomes persists, with many children showing suboptimal speech and language development[1]. While auditory deprivation prior to implantation contributes to delayed outcomes, both the fidelity of the CI signal and the immature auditory system also play key roles. Children with CIs often demonstrate poorer spectral resolution compared to adults[2], and the relationship between spectral resolution and speech recognition in pediatric CI users remains unclear[3-5.] In contrast, children with CIs tend to exhibit better temporal resolution than adult CI users6[-7], and this improved temporal resolution has been shown to correlate with speech recognition outcomes[8]. To better understand these complexities, it is crucial to examine how maturation and CI signal fidelity influence spectral and temporal resolution in children. Image-guided cochlear implant programming (IGCIP[9]) aims to optimize the CI signal by improving electrode placement and minimizing channel interaction, potentially enhancing these resolution abilities. This study therefore investigates the effects of maturation and IGCIP on spectral (spectral modulation detection) and temporal resolution (sinusoidal amplitude modulation) over two years, while also exploring how these measures relate to speech recognition outcomes in children with CIs.

Methods: Data were collected from 47 prelingually deafened children with CIs (ages 4.5–13, M=8.33) enrolled in a double-blind, waitlist-deferred randomized trial of IGCIP. At baseline, all participants had standard clinical maps, with half randomized to receive IGCIP programming immediately and the other half deferred for 12 months. Spectral resolution was assessed using a spectral modulation detection (SMD) task at 0.5 and 1.0 cycles/octave, and temporal resolution was measured with a sinusoidal amplitude modulation (SAM) task at 4, 32, and 128 Hz. Speech recognition was evaluated with CNC words, BabyBio sentences, vowel recognition, BKB-SIN, and adaptive HINT in RSPACE.

Results: From baseline to 12 months, both IGCIP groups improved significantly at 0.5 cyc/oct ($t(20)=2.77$, $p=0.012$; $t(20)=4.35$, $p<0.001$), with the immediate group also improving at 1.0 cyc/oct ($t(9)=4.52$, $p=0.001$). No significant changes occurred from 12 to 24 months. From baseline to 24 months, both groups improved at 0.5 cyc/oct ($t(20)=4.54$, $p<0.001$; $t(20)=4.84$, $p<0.001$), and the immediate group improved at 1.0 cyc/oct ($t(9)=4.27$, $p=0.002$). For SAM, both groups improved at 4 Hz from baseline to 12 months ($t(22)=4.18$, $p=0.012$; $t(20)=5.21$, $p<0.001$), and the immediate group also improved at 32 Hz ($t(9)=3.23$, $p=0.010$). From 12 to 24 months, only the waitlist-deferred group improved at 4 Hz ($t(21)=2.18$, $p=0.041$). No changes were observed at 128 Hz. No significant between-group differences were found for either SMD or SAM detection at any time point. After correcting for multiple comparisons, significant correlations were found between SMD at 0.5 cyc/oct and both BabyBio +5 ($r=-0.385$, $p=0.015$) from baseline to 12 months and CNC phoneme recognition ($r=-0.403$, $p=0.010$) from baseline to 24 months, SMD at 1.0 cyc/oct and vowel recognition ($r=-0.613$, $p=0.007$) from baseline to 12 months, and SAM at 128 Hz and both CNC word ($r=-0.549$, $p=0.012$) and CNC phoneme recognition ($r=-0.483$, $p=0.031$) from baseline to 12 months.
8
Conclusions: This study demonstrated significant improvements in both spectral and temporal resolution for both the immediate IGCIP and waitlist-deferred groups over two years, though no significant between-group differences were found. Changes in spectral and temporal resolution were correlated with speech recognition outcomes: spectral resolution was linked to more complex tasks (e.g., speech in noise and vowel recognition), while temporal resolution was linked to simpler tasks (e.g., speech in quiet). These findings suggest that improving spectral resolution, as seen in the immediate IGCIP group at both modulation rates from baseline to 12 and 12 to 24 months, may significantly enhance speech recognition. Further analysis is needed to explore the individual impact of auditory maturation and IGCIP.

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Friday: 11:20 - 11:40

THE EFFECT OF VOICE TRAINING ON SPEECH-ON-SPEECH INTELLIGIBILITY AND LISTENING EFFORT IN COCHLEAR IMPLANT USERS

Ada Biçer[1,2], Thomas Koelewijn[1,2], Deniz Başkent[1,2]

[1]Department of Otorhinolaryngology/ Head and Neck Surgery, University Medical Center Groningen, University of Groningen, The Netherlands
[2]Graduate School of Medical Sciences, Research School of Behavioural and Cognitive Neurosciences, University Of Groningen, The Netherlands

Objective: Understanding speech in a multi-talker situation can be challenging and effortful especially for cochlear implant (CI) users. In normal-hearing listeners, it was previously shown that listening to familiar or trained voices can improve speech intelligibility and/or listening effort in speech-on-speech listening. In a recent study1, we showed that listening effort was reduced for trained voices compared to untrained voices, but only for vocoder processed speech. The aim of this study was to investigate if such benefits can also be provided to CI users with an explicit voice training of the target speaker presented in a speech masker.

Methods: Sixteen CI users, ages ranging between 20 and 78 (Mean age = 62.81, SD = 17.37), performed an explicit voice training via a speaker recognition task. Following the voice training, speech-on-speech intelligibility, in percent correct scores, and listening effort, using pupillometry, were measured with the Dutch Child-friendly Coordinate Response Measure (CCRM) test. The CCRM test involved a target sentence that consists of a call sign, a color, and a number (e.g. “Show the dog where the blue five is”), uttered by the trained voice and an untrained voice. The masker speech consisted of combined short randomized fragments of CCRM sentences, presented at 0 dB or +6 dB target-to-masker ratios (TMRs), and with shifted voice cues of fundamental frequency (F0) and vocal-tract-length (VTL) combined, at either 6.29 or 12.59 semitones (st) relative to the target voice.

Results: Results from a generalized linear mixed model analysis showed that, overall, voice training did not lead to an intelligibility improvement. Nevertheless, a 3-way interaction showed that listening to trained voices led to better intelligibility when TMR was increased from 0 dB to +6 dB, and when voice cue differences between the target and masker were increased from 6.29 st to 12.59 st. Pupillometry results showed significantly smaller pupil responses for trained voices than untrained voices, at the 0 dB 6.29 st condition, implying a benefit of voice training by reducing listening effort. However, pupil dilation responses were also smaller when listening to untrained voices than trained voices at +6 dB 6.29 st condition.

Conclusions: Results from the current study demonstrated that listening to a newly trained voice might lead to an intelligibility benefit when listening situations are the most optimal (+6 dB 12.59 st) for CI users. Nevertheless, less favorable listening situations might lead to a training benefit by a decrease in listening effort in the absence of an intelligibility benefit. Less favorable listening situations can also lead to better intelligibility for newly encountered voices, perhaps via making a better use of F0+VTL voice cue differences between the target and masker when intensity cues are not available (TMR = 0 dB). Together, these results imply that similar to normal hearing listeners, CI users might also benefit from listening to trained voices under certain conditions.

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Friday: 11:40 - 12:00

A NOVEL NATURALISTIC DUAL-TASK EAR TRAINING PARADIGM WITH REAL-TIME GAMIFIED NEUROFEEDBACK FOR COCHLEAR IMPLANT USERS

Filip Miscevic[1], Bowen Xiu[2], Andrew Dimitrijevic[2]

[1]Institute Of Biomedical Engineering, University of Toronto, Canada
[2]Department of Otolaryngology, Head and Neck Surgery, Faculty of Medicine, University of Toronto, Canada

Cochlear implants (CIs) are the oldest and most widely used neuroprosthetic, but CI users typically report a higher cognitive workload and listening fatigue compared to normal-hearing individuals. This can discourage consistent CI usage and lead to a reduced quality of life. Learning to manage the cognitive demand associated with CI use is therefore essential for good clinical outcomes. Using a mobile, EEG-based brain-computer interface system (Smarting PRO, mBrainTrain, Belgrade, Serbia), we aim to improve upon established ear training paradigms, which have been shown to improve real-world auditory attention and speech perception in CI users, by maximizing task engagement using naturalistic audiovisual stimuli and real-time, gamified neurofeedback. We developed a brain-computer interface platform where subjects must follow a target audiovisual stimulus while ignoring a distractor, which alternate between the left and right hemifields at cued intervals. Neural tracking of the audio envelope and lip area, both of which contribute to superlative speech perception, is quantified for both the attended and ignored stimuli using a multivariate temporal response function (mTRF). The mTRF is used to derive a reconstruction of the perceived stimulus from the EEG signal, which is then correlated with the ground truth stimulus. Reward signals, one for the auditory envelope-brain coherence and one for lip area-brain coherence, are provided as ‘gamified’ neurofeedback through animated stars and a point counter. A pilot study of n=10 normal hearing participants suggests that this novel dichotomous stimulus following task (DSFT) is better suited for ear-training with naturalistic stimuli than a traditional dichotomous stimulus task (DST), with higher mean neural tracking of the target stimulus (mean Pearson correlation coefficient of 0.13 vs. 0.09, $p<0.01$) and better suppression of the ignored stimulus. We found similar effects in a smaller group of CI users (n=3; data collection in progress). We expect task performance to be associated with improved speech perception and lip-reading abilities as a result of more efficient entrainment of auditory attention and utilization of cognitive resources, resulting in lower perceived cognitive workload and listening fatigue and improved real-world listening outcomes.

POSTER ABSTRACTS

M-T 1: COMPARING HEARING AIDS AND COCHLEAR IMPLANTS IN REALISTIC LISTENING ENVIRONMENTS

Lisa Maggs[1], Brett Swanson[2], Ronny Ibrahim[1], Kelly Miles[1], Zachary Smith[2], Megan Gradden[1], Joerg M. Buchholz[1]

[1]ECHO-Lab, Macquarie University, Sydney, Australia
[2]Cochlear Ltd, Sydney, Australia

Purpose: Cochlear implant (CI) candidacy guidelines utilise common clinical speech tests, which are not representative of the daily real-world environments in which patients may experience listening difficulty. This study seeks (1) to compare the real-world listening performance between bilateral and bimodal listeners with hearing aids (HAs) and CIs and (2) to understand the relationship between these realistic outcomes to those from common clinical tests used to determine CI candidacy.

Methods: Participants comprised 18 bilateral hearing aid recipients (HA+HA group), 15 bimodal recipients (HA+CI group), and 17 bilateral CI recipients (CI+CI group), aged between 40-80 years old. The HA ears had moderate to moderate-severe hearing loss (40 dBHL <= 3FAHL <= 80 dBHL). All HA ears were fitted with control devices using NAL-NL2 prescription and underwent a 2-week acclimatization period. All CI ears were fitted with loaner devices using the individuals' clinical maps. Participants at-tended 1-3 test appointments to complete a set of questionnaires, cognitive screening, audiometric testing and a series of clinical word and sentence tests typically used to determine CI candidacy in Australia. Additionally, they completed a realistic speech recognition task to predict their real-world listing performance. This task consisted of realistic ECO-SiN sentences [1] presented in six different realistic noise environments at realistic sound pressure levels, and involved realistic signal-to-noise ratios from -5 to +5 dB plus quiet. To derive a single-value metric, a sigmoid model was first fitted to the HA+HA group data with average HL (3FAHL) as a parameter, which was then applied to quantify the listening difficulty of each participant by fitting the model to their individual ECO-SiN scores. This proposed metric, termed ECO-PHL, predicts a listener's functional HL from their ECO-SiN score and can be classified, like HL, from mild (ECO-PHL ï‚³ 20 dB) to profound (ECO-PHL ï‚³ 80 dB).

Results: The ECO-PHL for the HA+HA group ranged from 33 to 90 dB and was highly correlated with both 3FAHL (R2=0.61, p<0.001) and CNC phoneme scores in quiet (R2=0.65, p<0.001). The ECO-PHL for the CI+CI group ranged from 43 to 76 dB and was moderately corelated with CNC phoneme scores (R2=0.54, p=0.001). The ECO-PHL in the CI+HA group ranged from 43 to 76 dB and was neither correlated with the 3FAHL nor CNC phoneme scores in the HA ear and was only weakly correlated with CNC phoneme scores in the CI ear (R2=0.29, p=0.04). Comparing the ECO-PHL values across groups suggests that HA+HA users with an ECO-PHL > 60 dB may benefit from a CI. Such a criterion is in reasonable agreement with current clinical CI candidacy criteria in Australia (i.e., 3FAHL ï‚³ 60 dBHL and best aided phoneme scores in quiet <= 60%), but for some of the HA+HA users it resulted in different recommendations.

Conclusions: The proposed ECO-PHL was found to be a useful metric for assessing and comparing realistic hearing device outcomes and should be considered for evaluating CI candidacy in addition to common clinical measures.

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M-T 2: CHARACTERIZING THE ELECTRODE-NEURAL INTERFACE IN AUDITORY BRAINSTEM IMPLANTS

Mahan Azadpour, Rahul Sinha, Maya Hatley, Nicole Capach, Megan Eitel, William Shapiro, J. Thomas Roland Jr., Mario Svirsky

New York University Grossman School of Medicine, New York, NY, USA

Auditory brainstem implants (ABIs) restore hearing in individuals with profound deafness who cannot benefit from cochlear implants (CIs) due to damaged or abnormal cochlear structures or auditory nerves. Speech perception outcomes with ABIs are typically much poorer than with CIs, potentially due to the complex electrode-neural interface. While ABI and CI devices share design similarities, their key difference lies in electrode placement: ABI electrodes are positioned on the surface of the cochlear nucleus in the brainstem, whereas CI electrodes are placed within the cochlea. The cochlear nucleus, where ABI electrodes are placed, comprises a variety of neuron types with diverse biophysical properties, some of which may not optimally convey speech information delivered by current ABIs.

To characterize the ABI electrode-neural interface, we measured electrically-evoked compound action potentials (ECAPs) and patterns of electric field spread in the brainstem using the implant device's voltage recording capabilities. We analyzed neural response morphologies, temporal recovery, and channel interactions though ECAP measures. Additionally, we investigated psychophysical auditory processing abilities, including gap detection, amplitude modulation detection, and pitch perception.

Our findings revealed substantial variability in ECAP responses both across ABI users and between electrodes within individual users. ABI ECAP waveforms often deviated from the characteristic negative-positive peaks seen in CIs, and recovery times sometimes exceeded typical CI measurements by an order of magnitude. Electric field measures showed more localized stimulation compared to CIs, with channel interaction decreasing more steeply as inter-electrode distance increased, albeit less systematically than in CIs. Psychophysical performance also varied markedly within and between subjects, sometimes showing order-of-magnitude deficits compared to CI users. Notably, electrodes producing poor neural or perceptual responses tended to form clusters within the ABI arrays.

The heterogeneity in ABI ECAP and psychophysical measures reflects the underlying diversity of cochlear nucleus neurons. These findings underscore how the neural populations activated by ABI electrodes may influence device performance. Our results emphasize the need to customize ABI stimulation to the properties of the stimulated cochlear nucleus neurons to optimize outcomes.

This study was supported by grants from NIH, Cochlear Ltd., and RNID (PI Azadpour)

M-T 3: EFFECT OF SPEECH MATERIAL ON THE PUPIL RESPONSE DURING EFFORTFUL LISTENING FOR COCHLEAR IMPLANT USERS AND TYPICAL HEARING LISTENERS

H. Christiaan Stronks[1,2], Robin van Deurzen[1], Paula L. Jansen[1], Jeroen J. Briaire[1], J. H. M. Frijns[1,2,3]

[1]Dept. of Otorhinolaryngology and Head & Neck Surgery, Leiden University Medical Center, Netherlands
[2]Leiden Institute for Brain and Cognition, Leiden University, Leiden, Netherlands
[3]Dept. of Bioelectronics, Delft University of Technology, Delft, Netherlands

Objective: Pupillometry has been identified as an objective measure of listening effort. Previous research has shown that the peak pupil response (PPD) for cochlear implant (CI) users is much less sensitive to task difficulty than for typical hearing (TH) listeners [1]. This study aimed to characterize what speech material yields PPDs most sensitive to the signal-to-noise ratio (SNR) for CI users. The results were compared to those of TH listeners. This work has, in part, been published [2].

Methods: PPDs were collected from 18 CI users while listening to speech-in-noise. We presented digits-in-noise (DIN), Matrix sentences, and LIST sentences at three SNRs, namely at the individual's speech-recognition threshold (SRT, the most challenging SNR), at SRT + 6 dBA and quiet (least demanding). After each test, the participant provided a subjective rating of listening effort. The data were compared to 18 age-matched TH listeners using linear mixed modeling (LMM).

Results: PPD for CI users increased significantly with SNR when DIN triplets and LIST sentences were used. The PPD was most sensitive to high SNRs for the DIN triplets and low SNRs for LIST sentences. The Matrix sentences yielded PPDs that were insensitive to SNR. TH listeners showed significant dependency of PPD on SNR for all three speech tests, and subjective ratings significantly depended on SNR for both groups.

Conclusions: The LIST sentences are a viable option for determining PPD as a function of SNR for CI users when listening conditions are challenging. DIN triplets are most sensitive to SNR at more favorable SNR ranges. The type of speech material has much less impact on TH listeners, showing that they may process speech differently than CI users. Subjective effort ratings depended on SNR in both groups regardless of SNR range, corroborating earlier reports that objective and subjective measures reflect different dimensions of listening effort.

This work was financially supported by the Dutch Research Council under the 'INTENSE' grant and Advanced Bionics, Hannover, Germany.

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M-T 5: COCHLEAR IMPLANT USERS' PERCEPTUAL TEST SCORES MATCH SELF-ASSESSED MUSIC PERCEPTION, BUT NOT SELF-ASSESSED MUSIC ENJOYMENT

E. E. Harding[1,2,3], B. Deniz[4], E. Gaudrain[5], R. Harris[6,1], B. Tillmann[5,7], B. Maat[1], R. H. Free[1,3], D. Başkent[1,3]

[1]Department of Otorhinolaryngology/Head and Neck Surgery, University Medical Center Groningen, University of Groningen, Groningen, NL
[2]Center for Language and Cognition, University of Groningen, Groningen, NL
[3]The Research School of Behavioural and Cognitive Neuroscience, University of Groningen, Groningen, NL
[4]Department of Audiology, Faculty of Health Sciences, İstanbul University-Cerrahpaşa
[5]Lyon Neuroscience Research Center, CNRS UMR5292, Inserm U1028, Université Lyon 1, Lyon, FR
[6]Prince Claus Conservatoire, Hanze University of Applied Sciences, Groningen, NL
[7]Laboratory for Research on Learning and Development (LEAD), CNRS UMR5022, Université de Bourgogne, Dijon, FR

Purpose: Cochlear implant (CI) users previously reported that music enjoyment was important to their quality of life. However, the perception of music remains challenging to CI users. Moreover, while computer-based tests measure music perception through objective acoustic parameters, it is not clear whether such perceptual abilities are linked to enjoyment of music. This study aimed to investigate the link between computer-based measures of music perception and subjective assessments of music enjoyment in adult CI users. We further explored the relationship between computer-based and subjective assessments of music perceptual abilities.

Methods: Participants were 28 adult, non-musician CI users. Non-musicians were defined as have less than three years of musical training, ending at least 1 year before enrollment in the study. Computer-based assessments included 1) the Melodic Contour Identification (MCI) Test, conducted with two conditions: organ target alone and organ target with an A5 piano masker, 2) the Instrument Identification Test (IDT), and 3) the Instrument Family Classification Test (ICT). Subjective self-reported measures were excerpted from the Dutch Musical Background Questionnaire (DMBQ), including individual questions about perception (Can you discriminate instruments in music? Can you recognize the melody in music?); averaged questions about perception (How well can you discriminate the following instruments?) and averaged questions about enjoyment (How much do you enjoy listening to music in the following situations? How much do you enjoy listening to different instruments?). Positive correlations between DMBQ individual and averaged questions and the MCI, IDT, ICT scores were explored using JASP. The study was conducted as part of a larger music training project with CI users (CIMUGAME).

Results: Scores from the individual question about discriminating instruments in music correlated with IDT scores. The individual question about hearing the melody in music correlated with scores from MCI organ target with an A5 piano masker. There were no other significant correlations.

Conclusions: Instrument identification is closely linked with discriminating instruments in music, and moreover hearing melody in music is similar to the MCI condition with the organ playing with another simultaneous instrument, the piano masker. Thus specific, narrowly defined questions about perception correlated with narrowly matched perceptual test measures. If future research can map very narrowly defined subjective assessments with perceptual ability, this might lead to refined data collection techniques, as questionnaires require fewer resources than in-lab tests. Questions about enjoyment did not correlate with any objective measures of perception, calling for more broad holistic approaches to estimating the connections between perceptual accuracy and subjective enjoyment.

M-T 6: LONGITUDINAL CHANGES IN SOMATOSENSORY P300 RESPONSES IN SINGLE-SIDED DEAF PATIENTS FOLLOWING COCHLEAR IMPLANTATION

Ghislain Sofack[1], Kotaiba Raouafi[1], Sven P. Heinrich[2], Antje Aschendorff [1], Maria Michael[1], Thomas Wesarg[1], Susan Arndt[1], Pascale Sandmann[3], Iva Speck[4]

[1] Department of Otorhinolaryngology - Head and Neck Surgery, Medical Center - University of Freiburg, Faculty of Medicine, University of Freiburg, Freiburg, Germany
[2] Eye Center, Medical Center – University of Freiburg, Faculty of Medicine, University of Freiburg, Freiburg, Germany
[3] Department of Otorhinolaryngology, Head and Neck Surgery, University of Oldenburg, Oldenburg, Germany
[4] Department of Nuclear Medicine, Medical Center – University of Freiburg, Faculty of Medicine, University of Freiburg, Freiburg, Germany

The aim of this research was to investigate the longitudinal effects of cochlear implantation on the somatosensory P300 component in individuals with single-sided deafness (SSD).

We conducted a longitudinal EEG study on patients with SSD (N = 9, ongoing) undergoing cochlear implantation. EEG recordings were obtained at baseline (pre-implantation) and three months post-implantation. Participants performed a somatosensory discrimination task, wherein stimuli were applied via a piezoelectric stimulator to the right index finger. The task required distinguishing between a deviant frequency of 180 Hz and a frequent frequency of 250 Hz. In addition to behavioral measures, we analyzed P300 amplitude and latency changes between the two timepoints.

Behavioral data revealed a significant decrease in accuracy ($p < 0.05$) and an increase in reaction time ($p < 0.05$) post-implantation. P300 amplitudes were significantly reduced post-implantation (mean ± SD: 1.50 ± 1.28 μV) compared to pre-implantation (3.36 ± 1.53 μV, $p < 0.001$). Similarly, P300 peak times were significantly shorter post-implantation (448.89 ± 12.69 ms) compared to pre-implantation (536.67 ± 24.49 ms, $p < 0.001$).

The observed changes post-implantation suggests an initial adjustment period during which cognitive and sensory resources are redistributed as auditory input is restored. This transitional period may temporarily compromise performance and attention as the brain adapts to the newly integrated auditory signals. Long-term follow-up will reveal the functional implications of these neural changes on sensory processing and cognitive performance.

M-T 7: OUTCOMES OF COCHLEAR IMPLANTATION IN ADULTS WITH ASYMMETRIC SENSORINEURAL HEARING LOSS

Eung-Kyung Cho[1], Myung-Whan Suh[2], Sang-Yeon Lee[3], Moo-Kyun Park[2], Jun Ho Lee[2], Seung-Ha Oh[2], Heonjeong Oh[2]

[1]Department of Speech & Hearing Center, Seoul National University Hospital, Seoul, Republic of Korea
[2]Department of Otorhinolaryngology-Head and Neck Surgery, Seoul National University Hospital, Seoul, Republic of Korea
[3]Department of Genomic Medicine, Precision Medicine & Rare Disease Center, Seoul National University Hospital, Seoul, Republic of Korea

Objective: Asymmetric sensorineural hearing loss (ASNHL) presents unique challenges in auditory rehabilitation. While cochlear implantation (CI) is increasingly considered for ASNHL, the variability in patient outcomes and the role of bimodal stimulation (CI with a contralateral hearing aid) remain topics of interest. This study evaluates the impact of CI on speech perception in adults with ASNHL and explores factors influencing bimodal use post-implantation.

Methods: A retrospective analysis was conducted on 21 adults with ASNHL who underwent CI. Speech perception outcomes, including word and sentence recognition, were assessed preoperatively and one-year post-implantation. Factors associated with bimodal use, such as age at implantation, duration of hearing loss, interaural differences in pure-tone average (PTA), and unaided contralateral word recognition scores (WRS), were analyzed.

Results: Speech perception significantly improved post-implantation across all participants. In the bimodal group, speech recognition was superior in the bimodal condition compared to CI alone. No significant difference was observed in speech perception between the CI-alone and bimodal groups at one-year post-implantation. The only significant predictor of bimodal use was the duration of hearing loss in the implanted ear.

Conclusions/Implications: CI significantly improves speech perception in adults with ASNHL, with some individuals benefiting from bimodal stimulation. The duration of hearing loss in the implanted ear appears to influence bimodal use. These findings highlight the importance of individualized auditory rehabilitation strategies in ASNHL management.

M-T 9: UNDERSTANDING BILATERAL SPEECH INTERFERENCE IN SINGLE-SIDED DEAFNESS COCHLEAR IMPLANT USERS

Julianna R. Voelker[1], Sandeep A. Phatak[1], Matthew J. Goupell[2], Joshua G. W. Bernstein[1]

1. Walter Reed National Military Medical Center, Bethesda, Maryland, USA
2. University of Maryland – College Park, College Park, Maryland, USA

Single-sided-deafness cochlear implants (SSD-CIs) provide spatial benefits such as improved sound localization and speech understanding in noise. SSD-CI users can sometimes experience bilateral speech interference, whereby speech presented to the acoustic ear can impede speech understanding in the CI ear, reducing the head-shadow benefit a CI otherwise provides. Previous studies of bilateral speech interference used the closed-set coordinate response-measure (CRM) speech corpus, with target and masking talkers producing highly confusable sentences with identical structure. It is unknown if interference also occurs in more realistic situations with different speech materials and masker types. Furthermore, interference depends strongly on target-to-masker ratio (TMR) in the target ear, but the effect of the relative levels in the two ears has not been examined. This has implications for clinical level setting.

The goal of this study was to examine how target and masker type and stimulus level influence bilateral speech interference. Experiments 1 and 2 examined how interference was influenced by target speech [closed-set CRM or open-set Institute of Electrical and Electronics Engineers (IEEE) sentences] and masker type (related or unrelated single-talker speech, time-reversed speech, speech-modulated noise, or stationary speech-shaped noise). Experiment 3 examined the effect of target and masker stimulus levels in the two ears using CRM sentences. For all experiments, the monaural condition presented the CI ear with target speech alone or with a masker at TMRs between -5 and 15 dB. The bilateral condition was the same as the monaural condition, with the addition of a copy of the masker presented to the acoustic ear. Interference was defined as the difference between the monaural and bilateral speech-identification scores.

Preliminary data from 7 (of 13 planned) subjects for Experiments 1 and 2 show that interference decreased as maskers became less similar to the target speech. While not as large as the 20-30 percentage-points of interference observed for CRM targets and maskers, 5-10 percentage-points of interference was still observed for unrelated speech maskers and for the more realistic IEEE-sentence target speech. Preliminary data (N=5) for Experiment 3 show a strong effect of the relative stimulus levels in the two ears: more interference was observed for relatively low CI-ear or high acoustic-ear levels. Overall, these results suggest that the problem of bilateral speech interference persists for more realistic speech stimuli than the small, contrived CRM corpus and that balancing loudness across the ears might mitigate these interference effects.

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M-T 10: DEVELOPING A PARADIGM TO ASSESS THE IMPACT OF COGNITIVE STATUS ON COCHLEAR-IMPLANT AUDIO-VISUAL BENEFIT

M. Salorio-Corbetto[1,2], E. Koubeh[1], M. Fernández Ledesma[1,3], N. Haywood[1], D. A. Vickers[1]

[1]Cambridge Hearing Group, SOUND Lab, Department of Clinical Neurosciences, University of Cambridge, UK
[2]Emmeline Centre for Hearing Implants, Cambridge University Hospitals, UK
[3]European University of Madrid, Spain

Objective: Cochlear-implant users typically rely on lip reading at least for some listening situations. Audio-visual benefit for speech recognition varies across individuals, even when performance for visual alone presentation is accounted for. Increased engagement of language-processing areas on presentation of visual speech is associated with better performance in speech tasks. The engagement of higher-order processing regions could be mediated by cognitive status. This project investigates the effect of cognitive status on audio-visual speech recognition for adults with typical hearing.

Methods: Individual audio-visual profit was investigated combining two conditions of visual degradation (Gaussian blurring parameter 15 and 45), three conditions of auditory degradation (SPIRAL vocoding [1] with 4, 8, or 16 activated electrodes) and two types of sentences (BKB [2] or IEEE [3]) in a sentence-recognition task. Additionally, participants rated their accuracy, the level of difficulty, and the usefulness of visual cues.

Results: Three normal-hearing participants screened for hearing loss with pure-tone audiometry completed piloting. Performance improved with the number of activated electrodes until reaching a plateau, but this trend might have been obscured by ceiling effects. Profit from visual cues varied across performance levels. Ratings for accuracy mimic the shape of the performance functions. Ratings for difficulty seem to be influenced by visual degradation depending on the level of performance. For the BKB sentences (lower complexity) the usefulness of visual cues was rated lowest for the clearest condition, but the same trend is not evident for IEEE sentences (highest complexity).

Conclusions: The visual degradation settings led to distinct levels of information for the participants. The auditory degradation was increased in order to avoid ceiling effects in the main experiment. Profit from visual cues depends on the level of performance. This needs to be considered when quantifying visual-cue profit for the main experiment. The number of active electrodes was reduced to 2, 4, and 8 to avoid ceiling effects. Data collection for the main experiment is ongoing, with two out of 30 participants tested. Participants undergo hearing and visual screening and complete a battery of cognitive tests capturing fluid intelligence [4], [5], [6] and a measure of visual working memory [7].

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M-T 11: SYSTEMATIC COMPARISONS OF ECAP MEASUREMENTS BETWEEN ADULT AND PEDIATRIC COCHLEAR IMPLANT USERS I: COCHLEAR NERVE RESPONSIVENESS AND ELECTRODE-NEURON INTERFACE INDEX

Zi Gao[1], Yi Yuan[2], Christopher R. Mueller[1], Shuman He[1]

[1]Department of Otolaryngology – Head and Neck Surgery, The Ohio State University
[2]Department of Audiology, San José State University

Background: Adult and pediatric cochlear implant (CI) users differ in age, duration of deafness, and etiology (Varadarajan et al., 2021). To date, response properties of the cochlear nerve (CN) have not been systematically compared between these two patient populations. To address this critical knowledge gap, we designed three research projects to evaluate and compare neural response of the CN evoked by single or trains of biphasic pulses between pediatric and postlingually deafened adult CI users. As the first installment of this series, the current study measures the electrically evoked compound potential (eCAP) elicited by single biphasic pulses in these two patient groups, and performs between-group comparisons of eCAP-derived indices that reflect different aspects of cochlear nerve (CN) responsiveness: eCAP threshold, maximum amplitude, the slope of the amplitude growth function (AGF), absolute and relative refractory periods (ARP and RRP), as well as the electrode-neuron interface index (ENI), a comprehensive index obtained through machine learning that reflects how effectively the electrodes stimulate the target CN fibers (Skidmore et al., 2022a).

Methods: Participants consist of 44 postlingually deafened adult CI users (six bilateral; age range: 24.8 - 89.2 yrs, mean = 62.0 yrs) and 42 pediatric CI users (14 bilateral; age range: 1.7 - 18.8 yrs, mean = 9.0 yrs). Adult and pediatric users were tested at seven and three electrodes with roughly equal separation along the full electrode array, respectively. For each participant, the eCAP AGF and refractory recovery function (RRF) were measured at each electrode. AGF depicts the relationship between eCAP amplitude and stimulation level, ranging between the threshold and the behaviorally identified maximum comfort level. The overall and the maximum slopes of the AGF were fitted using linear regression and the window method (Skidmore, 2022b), respectively. RRF represents the degree of the CN recovering from a refractory state at different time intervals following an initial stimulation, and the ARP and RRP were acquired by fitting the RRF to an exponential decay function. ENI was calculated using a machine-learning model based on the eCAP threshold, ARP, the maximum slope of AGF, and the N1 latency of the eCAP with the maximum amplitude. Linear mixed effect models (LMM) were used to evaluate the effect of electrode location on each eCAP index within each group. Combining the data at three electrodes (basal, middle, and apical) from both groups, additional LMMs were performed to evaluate the effect of patient group, as well as the interaction between patient group and electrode location, on each eCAP index.

Results: A majority of the LMM results shared the pattern of apical responses being better than basal responses, as indicated by lower thresholds, larger slopes, shorter ARPs and RRPs, and higher ENIs; and the pattern of pediatric subjects having better responses than adults, as indicated by lower thresholds, larger slopes, and higher ENIs. The interaction between patient group and electrode location, when observed, was primarily driven by adults being worse than pediatrics at the basal electrode, consistent with the established pattern of age-related degeneration (Wu et al., 2023). However, analyses on the RRF indices showed that adults had shorter refractory periods than pediatric subjects at the middle electrode, resulting in an age main effect for ARP and an interaction between patient group and electrode location for RRP.

Conclusion: The eCAP measurements indicate better overall CN health in pediatric than adult CI users, particularly at basal electrode locations. The variation patterns of AGF, RRF, and ENI across electrode locations are overall similar between adult and pediatric CI users.

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M-T 12: A COMPUTATIONALLY EFFICIENT ALGORITHM FOR MUSIC COMPLEXITY REDUCTION IN COCHLEAR IMPLANTS USING AN AUDITORY ADAPTATION MODEL

Anil Nagathil[1], Benjamin Lentz[1], Giselle Mojica[1], Ian C. Bruce[2], Christiane Völter[3], Rainer Martin[1]

[1]Institute of Communication Acoustics, Ruhr-Universität Bochum, Germany
[2]Department of Electrical and Computer Engineering, McMaster University, Canada
[3]Cochlear Implant Center, Department of Otorhinolaryngology, Head and Neck Surgery, St. Elisabeth Hospital, Ruhr-Universität Bochum, Germany

Despite tremendous advances in cochlear implant (CI) technology, music enjoyment remains a significant challenge for most users of CIs. This can be attributed to a limited number of available stimulation electrodes, spread of excitation in the cochlea, and insufficient encoding of temporal fine structure information, leading to poorly represented pitch and timbre cues. Hence, CI listeners often perceive music as too complex and unenjoyable. However, since temporal envelopes of CI sub-band signals are encoded with sufficient detail, rhythmic information can be transmitted accurately. This has motivated research into music pre-processing algorithms that emphasize vocals and rhythmic components in comparison to the accompaniment, thereby reducing the perceived complexity of music pieces. Such methods include remixing schemes based on harmonic/percussive sound separation (HPSS; Buyens et al., 2015) or DNN-based source separation (Gajecki & Nogueira, 2018; Gauer et al., 2022), or subspace approaches for spectral complexity reduction (Nagathil et al., 2017). While these algorithms have proven to provide improved listening preferences in CI users relative to the unprocessed music, they are computationally demanding and may not be suitable for real-time application in a CI. To address this issue, in this work we propose a novel music complexity reduction algorithm inspired by the temporal adaptation mechanism of an auditory periphery model (Dau et al., 1996). The adaptation model, implemented as a sequence of computationally efficient non-linear filter stages, is applied in the short-time Fourier domain and enhances onsets while attenuating slowly-varying components, thereby preserving essential vocal and rhythmic elements. The parameters of the auditory adaptation model were optimized using a global optimization algorithm and a criterion originally proposed for measuring speech intelligibility in CI listeners (Chen et al., 2013).

The effectiveness of the proposed algorithm was evaluated for 16 selected pop/rock music pieces in a listening experiment with 12 normally-hearing (NH) listeners in combination with a vocoder-based CI simulation. Using a two-alternative forced choice test design, the listeners compared music signals processed by the proposed algorithm with corresponding unprocessed versions and with HPSS-based remixes in terms of pleasantness and distinctness. The proposed algorithm was significantly preferred over the unprocessed condition with an average preference score of 81.8% ($p = 0.001$). The experiment revealed a non-significant difference between the proposed algorithm and the HPSS-based remix (60.4% average preference in favor of the proposed method, $p = 0.125$), despite a considerably lower computational complexity of the proposed algorithm. For both experiments, statistical significance was measured using a Wilcoxon signed-rank test with Bonferroni-Holm-adjusted significance levels.

Thus, this work offers a promising step towards computationally efficient, real-time music processing with the aim of making music more accessible and enjoyable to CI listeners. In future work, the results obtained with NH listeners will be further corroborated by listening experiments with CI users.

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M-T 13: SELF-OPTIMIZED ACOUSTIC MODELS OF COCHLEAR IMPLANT SOUND QUALITY VARY ACROSS SINGLE-SIDED DEAF COCHLEAR IMPLANT USERS.

Ariel Edward Hight[1], Rohit Makol[1,2], Maya Hatley[1], Megan Eitel[1], Nicole H. Capach[1], Jonathan Neukam[1,3], Sean K. Lineaweaver[4], Robert C. Froemke[1 *], Mario A. Svirsky[1 *]

[1]NYU Langone Medical Center
[2]University of Connecticut Health
[3]Vanderbilt University Medical Center, [4]Cochlear Ltd.
[*]co-senior authors

Purpose/Objective: Single-sided deaf cochlear implant (SSD-CI) users offer a unique opportunity to directly assess CI sound quality by comparing it with normal hearing in their contralateral ear. We investigated CI sound quality distortions by having SSD-CI users optimize acoustic models to best match their CI perception, selecting from multiple model types.

Methods/Approach: Nineteen subjects optimized two types of acoustic models: (1) traditional models encompassing all electrodes using speech stimuli, and (2) novel single-electrode models, in a method that represents a generalization of electroacoustic pitch matching, albeit with stimuli that were more complex than simple tones or noise bands. Each optimization was performed at least twice to assess reliability. Model quality was evaluated through double-blind questionnaires comparing optimized models to controls.

The biophysically-inspired models first processed acoustic stimuli through a simulation of each subject's CI processor. Extracted envelopes were then delivered to the normal ear via acoustic carriers. The modifiable parameters were: (1) type of acoustic carrier (pure tones, narrow band noise, low noise noise, pulse-spreading harmonic complex, spiral, or the novel SILVO carrier), (2) center frequency, and (3) bandwidth of these carriers. An interactive genetic algorithm (iGA) facilitated model optimization, similar to methods used for optimizing CI clinical maps [1].

Results/Findings: Optimized models consistently outperformed or matched control conditions (frequency-matched tone or narrowband noise carriers). Subject ratings showed high reliability across repeated optimizations, ranging from 4-9 on a scale of 1 ('not at all similar') to 9 ('exactly like the sound of cochlear implant'). Model parameters varied substantially across users in both frequency ranges and preferred acoustic carriers. The iGA proved efficient, with optimization convergence averaging under 29 minutes across more than 101 optimizations.

Conclusions/Implications: Acoustic models that are adjustable over cochleotopic mismatch, bandwidth, and acoustic carrier closely match the sound quality of cochlear implants in SSD-CI subjects. Modeling of single electrodes often resulted in better rated models than pure tones.

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M-T 14: CLICK AND TONEBURST ELECTROCOCHLEOGRAPHY TO ASSESS COCHLEAR AND NEURAL FUNCTION - AN EXTENSION OF THE TOTAL RESPONSE

Jonathan D. Neukam, Terrin N. Tamati, Aaron C. Moberly, Rene H. Gifford

Vanderbilt University Medical Center Hearts for Hearing

Objective: Electrocochleography (ECochg) is a sound-evoked potential representing electromechanical components inside the cochlea and the subsequent propagation of the electrical signal through the auditory nerve. In postlingually deafened adult cochlear implant users, the ECochg response has been shown to account for a significant portion of the variance in speech perception outcomes. The technique used is the derived frequency specific composite response known as the Total Response (TR). This project expands upon the application of ECochg as a predictor of cochlear implant outcomes by investigating the relationship of the ECochg response and TR in normal-hearing listeners and their relationship to speech perception. Additionally, this project uses a paired click and toneburst paradigm to isolate and characterize neural and cochlear components. The central hypothesis is that there will be strong relationships between the robustness of the ECochg response, neural attributes, and spatial hearing abilities, and this project will provide proof of concept that the TR can be recorded non-invasively in normal-hearing subjects.

Design: Data will be presented for fifteen normal-hearing adults. ECochg will is recorded using 250, 500, 1000, and 2000 Hz toneburst stimuli (11ms stimuli with 1ms ramps) and paired click/toneburst stimuli with varying degrees of temporal separation in both ears, using a bipolar montage and an electrode placed in the ear canal. Typical clinical tests of speech understanding (words and sentences in quiet or collocated noise) do not capture the variability seen in normal-hearing individuals, therefore, hearing in spatial noise, measured as spatial release from masking (SRM), uses a female target talker presented at zero degrees azimuth and two female-gender maskers in collocated and two asymmetrically separated positions. Spectral-Temporally Modulated Ripple Test (SMRT) stimuli are presented diotically and unilaterally. Interaural time differences (ITDs) are measured using a 250 Hz tone in a 3-interval forced choice paradigm with 2-down, 1-up tracking. Standard audiological measures are also recorded.

Results: Preliminary data for three normal-hearing listeners revealed an average TR of 21.63 dB muV. The average SRM was an increase in 36 percentage points. The average bilateral SMRT was 9.5 ripples/octave, and the average ITD threshold was 274 mus. Data collection is ongoing.

Conclusions: This study establishes feasibility that a TR recording is possible in awake participants using an electrode in the ear canal. Findings suggest that the response is related to broader measures of auditory function, specifically measures of peripheral fidelity.

M-T 15: QUANTIFYING LONGITUDINAL OBJECTIVE AND SUBJECTIVE CHANGES IN SPEECH PERCEPTION PERFORMANCE IN ADULT CI USERS IN EXPERIMENTAL PROCESSING STRATEGIES

Caylin McCallick, Julie G. Arenberg, PhD; Charles Hem, Faten Awwad

Massachusetts Eye and Ear, Harvard Medical School, 243 Charles, St, Boston, MA, 02114, USA

Purpose/Objective: There is substantial evidence of the vast variability in listening performance in adult cochlear implant (CI) users. Prior work has illustrated that much of this variability can be captured with peripheral estimates of the quality of the electrode-neuron interface. Estimates are based on detection thresholds obtained with focused electrical fields. Programming can be tailored to individuals with selective channel deactivation of the highest threshold channels and/or use of focused electrical fields, thus reducing channel interaction. This study compared an optimized programming strategy and a monopolar (MP) control over two, five-week periods during which time subjects wore an Advanced Bionics Harmony research processor full time and completed speech perception testing once per week at home. To capture subjective performance, a subset of subjects also completed weekly questionnaires to rate the overall quality of the maps. We hypothesized 1) that listeners would improve with the optimized programs over time, 2) that the optimized program would outperform the MP program but may require more time to acclimatize, and finally 3) that the subjective data would align with objective performance metrics.

Methods/Approach: Five listeners participated, including one subject currently in progress. Thresholds were obtained for all electrode channels using a fast, sweep procedure and a highly focused electrical field (sigma 0.9). Conditions varied across subjects. Optimized programs mostly deactivated high threshold channels, while the remaining channels were either dynamically focused or MP. Dynamic tripolar (DT) stimulation focuses current proportionate to input such that low-intensity sounds are focused at sigma = 0.8 and high-intensity sounds are focused at sigma = 0.5 reducing channel interaction and increasing spatial selectivity. Three of the four subjects used clinical-like MP processing strategy for a control in which current steering was on and all electrodes were active. The fourth and fifth subjects used their clinical program and processor for control. Speech perception testing was performed weekly and completed on a tablet at home (except for baseline). Testing included vowel identification in the h/|v|/d context and IEEE Sentences. Testing was completed in quiet and in noise with varying signal-to-noise ratios (SNRs) to assess a range of performance for easy to difficult conditions. Two of the five subjects completed questionnaire data. For this questionnaire, subjects are prompted to answer pre-speech testing and post-speech testing questions on the tablet. The questions require listeners to rate the clarity and listening ease of speech in quiet and speech in noise compared to their clinical program. At the end of testing, subjects are asked to rate their overall perceived performance and add any additional comments.

Results: Performance was variable from week to week. Data suggests that the average performance increased over time in the easy and difficulty SNR conditions for the optimized program in sentence testing, while average performance is relatively flat for vowels in the optimized condition. While one of the two subjects who completed the questionnaire testing is still in progress, results from the other subject are complete. Responses for questions of speech clarity and ease of listening in quiet with the optimized program were the same from baseline to her final week. However, satisfaction with speech clarity and ease of listening in noise increased over time, as did her objective performance scores for m conditions with the exception of the hard SNR for sentences.

Conclusion: While results are preliminary, the data suggests listener-tailored strategies may improve speech perception outcomes when listeners are provided time to acclimatize. Further, self-perception of performance in noise increased over time with the easy and hard SNR conditions for vowels, and in the easy condition for sentences. This study demonstrates a need for further testing with a larger study population.

M-T 16: THE EFFECT OF DIFFERENT SIMULATED REVERBERANT ENVIRONMENTS ON COCHLEAR IMPLANT USERS' AND NORMAL HEARING LISTENERS' BINAURAL FUSION

Justin M. Aronoff, Prajna Bk, Natalie Gustafson, Itunu M. Oyebamiji

Department of Speech and Hearing Science, University of Illinois Urbana-Champaign,
Champaign, IL, USA

Interaural coherence (the statistical similarity of signals at both ears, excluding interaural time differences) strongly affects whether a listener perceives a single binaurally fused and punctate sound or two separate sounds from each ear. Reverberant environments can decrease the interaural coherence of a signal, decreasing the likelihood of hearing a punctate sound. While cochlear implant (CI) users are sensitive to changes in interaural coherence, the narrow dynamic range of electric stimulation combined with broad current spread might reduce the difference in the interaural coherence across different reverberant environments. Therefore, CI users may experience limited differences in binaural fusion across different reverberant environments. The goal of this study was to investigate the effect of simulated reverberation on CI users' binaural fusion of speech sounds and compare that to that of normal hearing (NH) listeners.

Three CI users and four NH listeners were tested using a room simulation of reverberant environments. The T-60 of the room was systematically manipulated, ranging from 0.1 to 16 seconds. The stimulus consisted of two second clips of AzBio two speaker babble presented one meter away from the receiver. Participants were asked to indicate the size and number of auditory images that they heard in the various simulated environments as a measure of binaural fusion. Preliminary results indicated that the NH listeners' binaural fusion dispersion (i.e. how diffuse the sound appeared to be) increased as T-60 increased from 0.1 to approximately 2.0 seconds, after which it did not further decrease. On average, CI users perceived a sound that was more diffuse than what was perceived by the NH listeners in even the least reverberant environment. Additionally, the diffuseness of that sound did not change with increasing T-60. However, one CI user did demonstrate a systematic increase in binaural fusion dispersion with increasing T-60.

The results indicate that reverberant environments can degrade binaural fusion for NH listeners. While such an effect can occur for CI users, indicating that there are potentially detectable changes in interaural coherence with an increasingly reverberant room even after CI processing, in general, even a small amount of reverberation was sufficient to yield a diffuse percept for the CI group on average. It is possible that using even smaller values in T-60 would yield a graded effect of reverberation on CI users' binaural fusion perception.

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M-T 17: CHARGE INJECTION COMPARISON ACROSS DIFFERENT RETURN ELECTRODES AND ELECTRODE CONFIGURATIONS FOR NEURAL STIMULATION

Christopher K. Nguyen, **Stuart F. Cogan**

Department of Bioengineering, The University of Texas at Dallas, Richardson, TX, USA

Introduction: Neural stimulation devices, such as cochlear implants, deep brain stimulators, and spinal cord stimulators, rely on electrodes to deliver controlled electrical pulses. The electrochemical properties of the active electrode and return electrode(s) influence charge-injection capacity, electrode stability, and power consumption. This study investigates how return electrode materials and stimulation configurations affect charge injection dynamics to optimize electrical stimulation performance.

Methods: Experiments were conducted using 18-pin floating microelectrode arrays (FMAs) with 2,000-mum² activated iridium oxide film (AIROF) electrodes. Return electrodes tested included platinum-iridium (PtIr), platinum (Pt), stainless steel (SS), titanium (Ti), and tungsten (W). Stimulation configurations consisted of common ground (CG), monopolar (MP), bipolar (BP), tripolar (TP), partial bipolar (PBP), and partial tripolar (PTP). The effect of pulse polarity (cathodic- and anodic-first) was also evaluated. Pulsing was performed in phosphate-buffered saline (PBS) at 37 degC with a Plexon PlexStim Electrical Stimulator and captured with a Tektronix TBS1104 oscilloscope. Potential measurements were versus Ag|AgCl reference electrode using a Plexon Differential Amplifier.

Results: Return electrode composition significantly influenced charge injection and polarization. AIROF paired with return materials exhibiting lower open-circuit potentials (OCPs) demonstrated improved charge injection, particularly under anodic-first pulsing. However, the W return electrode induced excessive negative bias, increasing impedance and limiting charge injection. Partial multipolar configurations improved energy efficiency by increasing charge injection while requiring lower driving voltages. These findings highlight the importance of return electrode selection in optimizing charge-injection dynamics and minimizing power consumption.

Conclusions: This study underscores the influence of return electrode material and stimulation configuration on charge injection and polarization. Variations in electrode polarization demonstrate the role of return electrode OCP in determining charge-injection capacity. Additionally, partial multipolar configurations reduce power consumption by lowering driving voltage requirements. These insights contribute to designing more efficient neural stimulation protocols for clinical applications.

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M-T 18: THE ROLE OF SELECTIVE ATTENTION IN BILATERAL SPEECH INTERFERENCE FOR SINGLE-SIDED DEAFNESS COCHLEAR-IMPLANT USERS

Michael A. Johns[1], Sandeep A. Phatak[1], Matthew J. Goupell[2], Joshua G. W. Bernstein[1]

[1]Walter Reed National Military Medical Center, Bethesda, MD, USA
[2]University of Maryland, College Park, MD, USA

Cochlear implants (CIs) for single-sided deafness (SSD) can partially restore the ability to use binaural interactions to better understand speech masked by other speech. Despite this, SSD-CI users can sometimes experience interference that diminishes the benefits that a CI would otherwise provide. When target and masking speech are presented to the acoustic-hearing (AH) ear, presenting a copy of the masking speech to the CI ear improves speech perception ("contralateral unmasking"). The reverse is not true: presenting a copy of the masking speech to the AH ear can impede CI-ear speech perception. This "bilateral speech interference" has been found to correlate with age, perhaps due to selective-attention deficits impacting older listeners' ability to ignore distracting speech. In addition, interference for normal-hearing listeners with vocoder simulations of SSD-CIs was found to correlate with monaural perception of unprocessed speech masked by a different-sex speaker-an auditory proxy of selective attention. We hypothesized that selective attention, independent of CI-ear performance, would predict how much interference SSD-CI users experience. SSD-CI users provide a unique opportunity to test this: selective attention can be assessed through both non-auditory domain-general tasks and auditory measures of speech-on-speech perception in the AH ear, independent of the CI.

Masked speech intelligibility was assessed for 9 (of 24 planned) SSD-CI users (ages 40-77 years). Using the small, closed-set Coordinate Response Measure corpus, we measured bilateral speech interference in the CI ear and contralateral unmasking in the AH ear by comparing performance in a monaural condition (target and maskers to one ear) to a bilateral condition (target to one ear, maskers to both ears). The different-sex benefit for monaural AH-ear speech-on-speech perception-thought to reflect auditory selective attention-was measured by comparing performance with same-sex versus different-sex maskers. Participants also completed two non-auditory domain-general selective-attention tasks: Stroop (identify the font color of a word while ignoring the word text) and Flanker (identify the direction of a central arrow while ignoring surrounding arrows).

Linear mixed-effects modeling (LMEM) found that better non-auditory selective attention was strongly related to reduced bilateral speech interference. Participants with higher Flanker accuracy (chi2=15.0, p<.001) and faster Stroop responses (chi2=16.0, p<.001) experienced less bilateral speech interference. Flanker accuracy ranged from 72-100% and Stroop response time ranged from 1085-1983 ms. Over these ranges (from best to worst performance), the magnitude of interference increased from 0 to 28 percentage points.

These promising preliminary findings point to a critical role of domain-general selective attention in modulating interference. Rather than reflecting individual differences in asymmetric experience or performance with the CI, bilateral speech interference appears to correspond to a general selective-attention deficit. This deficit surfaces in multiple modalities but is exacerbated by asymmetric SSD-CI input. Possible clinical applications include pre-operative screening to identify individuals likely to experience interference that could limit their outcomes.

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M-T 19: OBJECTIVE MEASURES OF BINAURAL HEARING IN SIMULATED BILATERAL CI USERS

J.D. Galeano-Otalvaro[1], B. Dieudonné[1,2], J. Wouters[1]

[1]ExpORL, Department of Neuroscience, KU Leuven, Herestraat 49/721, 3000 Leuven, Belgium
[2] BrainPhonics BV, 3000 Leuven, Belgium

Cochlear implants (CIs) enable sound perception and speech understanding for individuals with severe-to-profound hearing loss, with good performance in quiet scenarios. However, speech understanding in adverse conditions, like noisy environments, remains significantly poorer for CI users compared to those with normal hearing (NH). In monaural conditions, CI users depend on spectral and temporal cues, which are less effective for separating multiple sound sources. Although bilateral CIs offer some improvement, they often fail to restore full binaural processing. One key limitation lies in the poor encoding of binaural cues-interaural time differences (ITD) and interaural level differences (ILD)-which are essential for spatial hearing and speech segregation in complex acoustic environments. Bilateral CI (BiCI) users face challenges due to independent signal processing in each device, leading to disruptions in binaural cue perception, poor sound localization, and degraded performance in noisy scenarios. Binaural hearing is typically assessed behaviorally through subjective measures such as binaural masking level differences (BMLDs). However, outcomes in CI users often display high interindividual variability, only demonstrating minimal benefits from binaural hearing [1], [2]. This variability underscores the need for a deeper understanding of the neural mechanisms underlying binaural processing and how these might be leveraged to improve CI performance. Recent studies have begun to overcome these limitations by objectively measuring binaural benefit in speech understanding using electroencephalography (EEG) [3]. EEG offers the potential to directly link neural processing of binaural cues to perceptual outcomes, providing insights into binaural hearing mechanisms, their variability, and certain aspects of CI processing through studies with normal hearing subjects.

In this study, we investigate masking release and neural correlates of binaural processing in NH listeners with simulated BiCI listening. Data are being collected from participants tested on BMLDs tasks using two types of stimuli: (1) speech signals, and (2) speech-weighted noise modulated by an envelope mimicking the temporal modulations of speech using the TEMPEST framework [4]. These stimuli are preprocessed to simulate the reduced fine temporal structure characteristic of CI sound processing. Behavioral masking release thresholds will be measured by comparing two conditions: (1) target stimuli presented in phase between ears, and (2) target stimuli phase-inverted between ears. Both conditions will feature a masking noise source that is inverted between ears to enhance binaural masking effects. Neural responses will be recorded using electroencephalography (EEG). Neural tracking differences between masked and unmasked conditions will be assessed for both types of stimuli, and auditory steady-state response (ASSR) amplitudes elicited by the envelope stimuli will be analyzed.

We hypothesize that behavioral masking release will correspond to enhanced neural tracking and stronger ASSR amplitudes under conditions that exploit binaural cues. Finally, as different modulation rates will be used, we expect them to elicit activity in different regions along the auditory pathway.
Our findings aim to bridge the gap between perceptual and electrophysiological assessments of binaural hearing. The results will provide a foundation for understanding how neural processing of binaural cues relates to auditory performance and allow to measure binaural processing objectively in CI users and inform the design of improved stimulation strategies for CI users. Ultimately, this work seeks to enhance binaural hearing in real-world scenarios for individuals relying on cochlear implants.

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M-T 20: EFFECTS OF CONTRALATERAL ACOUSTIC MASKING ON SPEECH RECOGNITION AS A FUNCTION OF AGE FOR PEDIATRIC AND ADULT COCHLEAR IMPLANT USERS WITH ASYMMETRIC HEARING LOSS

Margaret T. Dillon, Margaret E. Richter, Lisa R. Park, Amanda D. Sloop, Samantha P. Scharf, Nicholas J. Thompson, Kevin D. Brown, Emily Buss

University of North Carolina at Chapel Hill

Objective: The population of cochlear implant (CI) recipients now includes children and adults with moderate or better unaided hearing thresholds in the contralateral ear, including unilateral hearing loss (UHL; normal or near-normal thresholds) and asymmetric hearing loss (AHL; mild or moderate thresholds). For CI users with bilateral severe-to-profound hearing loss, speech recognition with the CI alone is typically assessed in the sound field with the non-implanted ear unaided. For CI users with UHL or AHL, assessment of speech recognition with the CI alone requires isolation of the stimulus to the implanted ear, but masking the acoustic ear can influence performance for some listeners due to central masking. The present study assessed the effect of contralateral masking for pediatric and adult CI users with UHL or AHL.

Methods: The CNC word recognition with the CI alone for pediatric and adult CI users with UHL or AHL was assessed with two methods: (1) presenting the stimulus via a loudspeaker in the sound field (SF) and presenting a noise masker to the acoustic ear via an insert earphone (method name: SF+masker), and (2) presenting the stimulus to the CI via direct audio input (method name: DAI). Participants were assessed with their familiar CI maps with both methods. Performance with each test method was scored as the percent of words correctly repeated. A difference score of performance with the DAI and SF+masker methods was calculated to analyze susceptibility to contralateral masking.

Results: To date, 85 children and adults (aged 5-87 years at time of test) have completed the procedures. Whereas word recognition scores obtained using the two methods are similar for young adults, young children and older adults tend to perform better with the DAI method than with the SF+masker method.

Conclusions: The speech recognition with the CI alone for pediatric and adult CI users with UHL or AHL can depend on the test method. The present data are consistent with the idea that the susceptibility to contralateral masking changes over the lifespan. This result has implications for the optimal test method to use clinically to evaluate an individual's performance over their lifetime.

M-T 21: A NEURAL PERSPECTIVE ON TEMPORAL ENVELOPE MODULATION ENCODING AND SPEECH PERCEPTION VARIABILITY IN CI USERS

E. Verwaerde[1], W. David[1], J. Schott[1,2], R. Gransier[1], N. Verhaert[1,3], J. Wouters[1]

[1]ExpORL, Dept. of Neurosciences, KU Leuven, Herestraat 49/721, 3000 Leuven, Belgium
[2]STADIUS, Dept. of Electrical Engineering, KU Leuven,Kasteelpark
Arenberg 10/2440,3001 Leuven, Belgium
[3]Dept. of ORL-Head and Neck Surgery, UZ Leuven, Herestraat 49, 3000 Leuven, Belgium

Temporal envelope modulations (TEMs) are essential for speech perception in cochlear implant (CI) users. Understanding neural sensitivity to these modulations is critical for optimizing CI performance. Electrically evoked auditory steady-state responses (eASSRs) have been proposed as an objective measure of TEM sensitivity, evaluated through modulation detection tasks. eASSRs are phase-locked responses from (sub)cortical regions of the auditory pathway and can be evoked at high pulse rates with amplitude-modulated (AM) stimuli. Previous research has demonstrated a significant relationship between the behavioral modulation detection thresholds, the modulation encoding ability of the neural ensembles and speech perception in noise performance. Furthermore, newly developed methods enable to measure these neural responses, evoked with clinically applied high pulse rate stimuli [900 pulses per second (pps)] and a monopolar stimulation mode, despite the challenges posed by the stimulation artifacts that corrupt the EEG. These findings highlight the potential of eASSRs as an objective measure for assessing site-specific temporal sensitivity in CI users.

This study aims to investigate the neural encoding of TEMs across the electrode array and the relation to speech perception outcome in CI users. First, we evaluate the electrophysiological measure based on neural TEM processing that provides clinicians with direct insight into the temporal processing ability of CI users. Second, we assess the neural ability to encode and process TEMs by measuring speech perception performance based on the electrophysiology of each individual CI user. In the present study, we measured 40-Hz eASSRs on six intracochlear electrodes and evaluated TEM encoding across the dynamic range of ten good performing adult CI users with a CochlearTM Nucleus Implant. AM stimuli were presented at 900 pps and in monopolar mode using a multi-electrode stimulation paradigm. Two intracochlear electrodes were alternated within each of three EEG sessions. EEG was recorded with a custom BioSemi hyper-rate sampling system with a sampling frequency of 262 kHz to optimize modeling of stimulation artifacts. Objective stimulation levels were derived from the resulting growth functions and six new experimental stimulation programs, i.e. TEM MAPs [1) ASSR T-level, clinical C-level, 2) ASSR T-level, behavioral C-level, 3) clinical T-level, ASSR T-level, 4) random T- & C-level, 5) T=C-level at ASSR T-level, 6) ASSR T-level, fixed C-level 2 current units above T-level], were created based on these objective results, enabling speech perception based on TEM encoding. Speech perception tests were performed with the new experimental programs as well as the subject's own clinical program.

The collected data shows that the multi-electrode paradigm is feasible for measuring artifact-free growth functions in adult CI users. Furthermore, results indicate that the good-performing adult CI users obtain similar speech perception outcomes with the new TEM MAPs and their clinical program. Though, a significant difference exists between the new programs and the clinical program, indicating that subjects perform better with a stimulation program they are used to. Follow-up research is ongoing in CI users with lower speech perception performance. We hypothesize that this population will demonstrate increased variability in speech perception outcomes, facilitating the identification of distinct TEM encoding patterns and their associations with speech perception. This study provides further insight into the utility of eASSRs in studying TEM encoding in the electrically stimulated auditory pathway and their relation to speech perception (in noise). Moreover, this research emphasizes the potential of the eASSR-based approach as an objective fitting framework.

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M-T 22: ESTIMATING ELECTRODE ARRAY PLACEMENT USING TIM AND VALIDATION

Christopher J Bennett, Ryan O Melman, Zachary Smith, Joerg Pesch

Cochlear Ltd

Without tools such as intraoperative x-ray and intraoperative fluoroscopy, cochlear implantation is a blind surgery. Once the electrode array is inserted into the cochlea, it is unknown whether an optimal placement of the electrode array has occurred. Software such as Cochlear Ltd's SmartNav, comprising the Placement Check feature, can indicate whether a malplacement has occurred using the transimpedance matrix (TIM). From first principles, the TIM (a measure of the propagation of the electric field within the cochlea induced by electrical stimulation) will also be sensitive to morphological features such as the relative difference between the size of the cochlear duct at different angular depths and the electrode array's proximity to structures of high electrical resistance. This research set out to develop a data-driven algorithm to estimate the placement of Cochlear Ltd's Slim Modiolar Electrode Array to aid surgeons in achieving an optimal placement. The algorithm is comprised of statistical models that estimate placement features, and a Monte Carlo simulation which uses the estimated features as initial conditions to estimate the curvature of the array around the modiolar spiral. When applied to an independent dataset of 53 in vivo insertions, the algorithm achieves an R^2 of 0.98 and a 95% prediction interval of 29.16 degrees when estimating individual electrode angle of insertion, and an R^2 of 0.93 and a 95% prediction interval of 0.49 mm when estimating individual electrode distance from the mid-modiolar axis. This highly accurate algorithm is a candidate for use in the surgical setting to provide the theatre with valuable feedback on the placement of the electrode array without intraoperative imaging.

M-T 23: SPATIAL ACUITY UNDER REVERBERATION BY PEDIATRICALLY IMPLANTED CHILDREN AND ADULTS WITH BILATERAL COCHLEAR IMPLANTS

Z. Ellen Peng, Victoria Sweeney, Darby Durbin

Center for Hearing Research, Boys Town National Research Hospital

Purpose: For children with severe-to-profound hearing loss, bilateral cochlear implants (BCI) provide some access to spatial hearing that improves spatial acuity-the ability to discriminate two sounds at different spatial locations and is typically measured using the minimum audible angle (MAA). When assessed in free-field such as the anechoic chamber or sound booths, spatial discrimination emerges as early as 2-3 years of age following early bilateral implantation and may improve to ~10 deg MAA by school age. However, in real-world listening (e.g., classrooms), indoor reverberation distorts the binaural cues, resulting in binaural decorrelation and poorer spatial acuity even for normal-hearing listeners. For NH adults, MAA can increase from ~1-2 deg in anechoic to ~4 deg in low-reverberation. Compared to NH listeners, we hypothesize that BCI listener's access to both binaural and monaural cues for spatial discrimination is even more restricted from reverberant signals after CI processing, which leaves only envelope-based auditory cues for spatial hearing.

Methods: Participants included 18 BCI users who received implantations during childhood and 100 NH children and young adults as controls; all listeners were between 6 and 30 years old. We measured MAA under three acoustic conditions: (1) anechoic or free-field, (2) low-reverberation similar to a K-12 classroom, and (3) high-reverberation similar to a large college lecture hall. Acoustic simulation was done using room acoustics modeling with highly accurate reflection patterns. For each listener, MAA was repeated using two tokens: Speech-shaped noise (SSN) of 500 ms and a disyllabic word ("bluejay"). In the 3-interval, 2-alternative forced choice task, listeners heard the first two intervals from a spatial location off midline with the third interval in the opposite hemi-field of the same angular midline offset. Listeners indicated the direction in which the third interval moved relative to the first two.

Results: Preliminary results suggest that, on the group level, BCI listeners' MAA has a small increase of ~2-3 deg from anechoic to low-reverberation but a much larger increase of ~13 deg to high-reverberation. A similar trend is observed among NH controls, although smaller MAA across all conditions than BCI listeners. Compared to SSN, word tokens with more salient envelope modulation only slightly improve (lower) MAA for NH listeners but not for BCI users.

Conclusion: For BCI users who are pediatrically implanted, even though spatial acuity is generally poorer, they may be just as resilient to low reverberation as their NH peers. Modulation salience in the signal envelope did not seem to be a source for protecting reverberant distortion, which requires further investigation. This work provides insights into how BCI listeners can access spatial hearing under reverberation from real-world listening.

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M-T 24: CORTICAL EFFECTS OF CHRONIC COCHLEAR IMPLANT STIMULATION IN CHILDREN WITH LEFT AND RIGHT SIDED UNILATERAL DEAFNESS

Hanne Bartels, Melissa J. Polonenko, Hyo-jeong Lee, Jaina Negandhi, Sharon L. Cushing, Blake C. Papsin, Karen A. Gordon

Archie's Cochlear Implant lab, The Hospital for Sick Children, Toronto, Ontario, Canada

Objectives: The objective of the present study was to investigate whether cortical effects of cochlear implantation are different in children with unilateral deafness in the left versus right ear.

Design: Sixty-nine children who received a cochlear implant (CI) for early onset asymmetric hearing loss were included in this study. Children had normal hearing in the contralateral ear [(n = 42 (60.9%)] or used a hearing aid for a mild to moderate hearing loss [PTA < 60dB, n = 27 (39.1%)]. Mean (IQR) age at implantation was 2.54 (1.51-4.29) years, and 39 (55.7%) children were implanted in the left ear. Cortical effects with ongoing CI use were assessed using stimulus evoked multi-channel electroencephalography. An average (SD) of 3.1 (1.5) recordings were collected per child (mean [SD] follow-up time of 25.3 [20.3] months), and recordings were grouped at initial (<= 2 weeks, n= 20), early (1-3 months, n = 49), and chronic CI-use (>= 3 months, n=96). Stimuli consisted of 36ms trains of acoustic clicks/biphasic electric pulses delivered at 250 Hz and repeated at 1 Hz in 3 conditions (acoustic hearing ear [AH-ear] alone, CI-ear alone and bilaterally [bimodal]). Source localization of cortical auditory detection was performed using the Time-Restricted Artifact and Coherent Source suppression beamformer. Measurements were peak dipole moments and corresponding latencies. Cortical lateralization (CL) and aural preference (AP) were calculated from dipole moments in the left and right auditory cortex, with more positive values indicating stronger right hemispheric dominance and right ear preference, respectively.

Results: Overall, immature P1 peak dipole moments were significantly larger in the right compared to the left auditory cortex (AC) ($p < 0.001$), and for stimulation of the AH-ear and bilateral condition compared to the CI-ear alone ($p < 0.001$ and $p = 0.005$, respectively). Peak latency decreased with time ($p < 0.001$) and was shorter for stimulation of the AH-alone than CI-alone ($p < 0.001$) or bilateral stimulation ($p = 0.001$). At initial CI-use, CL [median (IQR) = 11.14% (-21.73% - 40.19%)] and aural preference [median (IQR) = 0.24% (-27.9% - 23.14%)] showed considerable variation among children, with no correlation to side of deafness ($p=0.39$) or stimulation mode ($p=0.26$). Chronic CI-use revealed proportional shifts in CL and AP over the first few months of CI-use across all conditions.

Conclusions: Both left and right unilateral deafness in early childhood allow reorganization of auditory cortices. Initial cochlear implant stimulation reveals immaturity in the deprived pathways and shifts in cortical responses with ongoing CI use reveal plasticity to bilateral input.

M-T 25: A COMPREHENSIVE STUDY ON TEMPORAL LOUDNESS INTEGRATION IN COCHLEAR IMPLANT USERS

C. M. Castañeda González[1], L. Hu[1], D. Jiang[1], S. Karg[2], A. Dietze[1], D. Schwanda[3], M. Obando Leitón[1], W. Hemmert[1]

[1]Bio-Inspired Information Processing, Munich Institute of Biomedical Engineering, Technical University of Munich, Munich, Germany
[2]Technical University Ingolstadt, Biomedical Engineering and Biosignal Processing, Ingolstadt, Germany
[3]Munich University of Applied Sciences, Department of Applied Sciences and Mechatronics, Munich, Germany.

Objective: Detection thresholds (DTs) decrease with increasing stimulus duration, a phenomenon known as temporal loudness integration (TLI). In normal hearing (NH), DTs decrease with 6.7 dB/dec [1] up to a critical duration of 200 ms. We investigated TLI in cochlear implant (CI) users for a comprehensive range of stimulation rates, between 100 pps and 25 kpps, and pulse train durations between a single pulse (SP) and up to 1.5 s.

Methods: 17 CI users with MED-EL CIs (9 female, 8 male, 21 ears; mean age: 55 ± 14 years) participated in multiple studies. Stimuli were sent directly to the electrode array via a coil connected to MED-EL's MAXBOX. Subjects adjusted the stimulation amplitude to their DT using a keyboard (adjustment method). During the experiment, stimuli were continuously repeated after a 500 ms pause until the DT was saved by the subject. DTs for each stimulus were adjusted 4 times in random order. Stimuli were biphasic cathodic-leading pulse trains with varying pulse train durations. Phase durations varied between studies (15, 23.3, and 40 μs), depending on the stimulation rate. The following TLI curves were measured: TLI between SP and 6 ms (7 stimulation rates between 500 pps and 10 kpps) at the middle electrode E6; TLI between SP and 300 ms (1.5 and 18 kpps) and between SP and 1.5 s (100 pps, 600 pps, 1.2 and 25 kpps), at an apical and a basal electrode, respectively. TLI curves for 1.5 and 18 kpps were additionally measured at 60 % of the dynamic range (DR) and at the maximum acceptable level (MAL).

Findings: For rates lower than 1 kpps, TLI was observed only in some subjects and at some electrode locations. For stimulation rates equal to and higher than 1 kpps, DTs consistently decreased with increasing stimulus duration. On average, TLI curves steepened with increasing stimulation rate and approached TLI slopes found in NH: -1.7 dB/dec (100 pps), -3.6 dB/dec (1.2 kpps), -5.2 dB/dec (10 kpps), and -6.0 dB/dec (25 kpps). TLI was strongest for DTs; TLI curves at 60 % DR and MAL (18 kpps) exhibited shallower slopes (60 % DR: -3.3 dB/dec, MAL: -3.1 dB/dec) than at the DT (-5.5 dB/dec). Average critical durations ranged between 180 ms (100 pps) and 286 ms (25 kpps), comparable to NH values. In general, the studies revealed high inter- and intra-subjective TLI variability, especially at the lower rates (<= 600 pps).

Implications: TLI was consistently observed for stimulation rates equal to or higher than 1 kpps. Our results suggest that the slope of TLI in CI users can be gradually controlled by the stimulation rate and approaches, at high rates (>= 18 kpps), values found in NH. This is rather surprising as, e.g., the non-linear compression in the inner ear is missing in electrical stimulation. Overall, appropriate TLI reconstruction in CIs is essential for natural sound perception and avoiding unpleasantly loud distortions. Furthermore, TLI has important implications for the discrimination of brief speech cues (< 50 ms), such as consonants.

This work was funded by MED-EL (Innsbruck) and the German Research Foundation (DFG) [project number 415658392].

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M-T 26: EVALUATION OF SUBJECTIVE QUALITY/ENJOYMENT OF MUSIC AND SPEECH IN A GROUP OF CI SUBJECTS WITH SINGLE-SIDED DEAFNESS

Tobias Weissgerber, Sophia Kreuz, Uwe Baumann

Audiological Acoustics, ENT Department, University Hospital,
Goethe University Frank-furt/Main, Germany

Objective: In unilateral deafness with contralateral normal hearing (single-sided deaf-ness, SSD), the lack of ability to localize sounds and decreased speech perception in noise could lead to the desire for cochlear implantation. Furthermore, a study by Landsberger and co-workers [1] showed that in SSD subjects listening to music is more enjoyable with a cochlear implant (CI) than listening with the normal hearing (NH) ear alone. The aim of the present study was to assess the subjective rating of sound quality for music and speech in SSD-CI users depending on interaural frequency mismatch and CI frequency mapping.

Methods: 12 CI users with SSD and 14 subjects with NH took part in this study. The sound quality of 5 (7 for NH group) pieces of music from different genres (e.g. hard rock, pop, classical, solo piano, movie score) and one speech recording was rated using a modified MUSHRA test with unilateral stimulus presentation in the NH ear as a reference. For the CI group, tonotopic characteristic frequency at the place of CI electrodes was assessed with X-ray scans or cone-beam CTs for the use of anatomy-based fitting (ABF). Stimuli in the MUSHRA test were acoustic only (reference), CI only with either standard mapping or ABF, binaural stimulation with loudness matched CI, or 10 dB reduced CI stimulation. In the NH group, CI stimulation in one ear was simulated using a noise vocoder with different parametrizations mimicking standard and anatomy-based fitting.

Results: The results confirmed the results by Landsberger et al. that (1) with the addition of the CI sound quality improved significantly ($p<0.001$) compared to listening with the NH ear alone and (2) that this beneficial effect could not be replicated in a NH group with simulated SSD-CI listening. The quality of speech was also rated as significantly better with binaural stimulation ($p<0.001$). Sound quality declined when the CI stimulation was softer than in the NH ear. In both study groups, no significant effect of interaural frequency mismatch and anatomy-based frequency mapping on the perception of music and speech was found.

Conclusions: Although listening to music and speech with a CI alone was rated as rather bad, quality in binaural (or bimodal) hearing in SSD-CI users was substantially improved to listening with the NH ear alone. Further studies are necessary to assess the effect of interaural frequency mismatch compensation (ABF), since the current data was assessed in an acute test procedure without any acclimatization time.

This work was funded by MED-EL.

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M-T 27: SPEAKER-IN-THE-LOOP: THE ROLE OF RECOGNIZABLE VOICES IN COCHLEAR IMPLANT SPEECH INTELLIGIBILITY

Hazem A. F. Younis, **John H. L. Hansen**

Cochlear Implant Processing Laboratory (CILab), Center for Robust Speech Systems (CRSS), The University of Texas at Dallas

Cochlear implant (CI) users often experience challenges in speech perception during daily communications, particularly when listening to unfamiliar voices. Speech intelligibility varies depending on speaker-specific characteristics, since voices contain intrinsic speaker traits that make them either more or less accessible for CI listeners than others. This study examines how the presence of recognizable speaker traits impact CI speech intelligibility. CI participants rated recognizability of speakers from 12 public known speaker voices based on short interview clips (e.g., ranked 12 speaker voices based on familiarity from 1-to-12). Next, CI users then completed a speech intelligibility test, transcribing sentences spoken by these speakers as well as an additional out-of-set speaker who was unseen/unlabeled. CI participants had higher intelligibility scores for voices rated as more recognizable vs. the unknown speaker, supporting the hypothesis that CI users benefit from voices with familiar characteristics. Earlier studies suggest that older listeners exploit their familiarity with a speaker's voice to mitigate the effects of sensory and cognitive decline (Johnsrude et al., 2013). The "Familiar Talker Advantage" has been observed in speech perception where listeners show improved intelligibility for familiar voices (Case et al., 2018). Cognitive factors including working memory training have also enhanced speech perception in difficult listening environments (Ingvalson et al., 2015). The ability to recognize and predict speech from familiar voices plays a crucial role in effective communication. This study extends that understanding to CI users by evaluating how speaker recognizability influences intelligibility outcomes. Analysis of intelligibility scores in quiet and noisy conditions further supports this hypothesis. The highest-rated familiar female speaker showed nearly equal intelligibility in quiet (0.82) and noise (0.83), suggesting robustness to environmental background variation. On average, female speakers demonstrated better intelligibility in quiet (0.78) vs. noise (0.66). The unknown female speaker showed lower intelligibility in noise (0.55) compared to quiet (0.72). Among male speakers, the highest-rated male speaker exhibited higher intelligibility in quiet (0.59) vs. noise (0.48), while the unknown male speaker performed similarly across conditions (0.43 in quiet vs. 0.41 in noise). On average, male speakers showed higher intelligibility in quiet (0.65) vs. noise (0.55). These findings support the hypothesis that CI users achieve greater speech intelligibility when listening to voices they perceive as more recognizable. These results provide insight into how speaker-in-the-loop strategies could optimize speech perception for CI users by leveraging speaker-dependent acoustic cues. Future work will develop a GAN-based voice modification approach to improve CI speech intelligibility by moving unfamiliar voices to more recognizable ones.

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M-T 29: CHARACTERIZING VARIABILITY IN MODIOLAR PROXIMITY AND ITS INFLUENCE ON COCHLEAR IMPLANT SPEECH RECOGNITION OUTCOMES WITH PRECURVED ELECTRODE ARRAYS

Michael W. Canfarotta, Aaron C. Moberly, Andrea J. DeFreese, Ankita Patro, Jourdan T. Holder, René H. Gifford, David S. Haynes, Jack Noble

Vanderbilt University Medical Center, Nashville, TN
Vanderbilt University, Nashville, TN

The design of a precurved cochlear implant (CI) electrode array is intended to benefit from proximity to the modiolus, with the closer site of neural stimulation offering a potential decrease in channel interaction. Traditionally, the distance to the modiolus has been reported using average values across the entire electrode array. However, the use of a single average value may oversimplify the complex nature of modiolar proximity and fail to identify specific regions of the electrode array that may be driving the known relationship between speech recognition outcomes and modiolar proximity. As such, the present study aimed: 1) to characterize variability in modiolar proximity across the electrode array and 2) to examine the relationship between modiolar proximity across the electrode array and speech recognition outcomes for CI-alone users implanted with a slim modiolar electrode array.

Eighty-one adult CI recipients with a slim modiolar electrode array (Cochlear 532/632) underwent postoperative computed tomography to determine angular insertion depth and modiolar proximity of each electrode contact. A complete insertion located entirely within the scala tympani was confirmed on imaging for each patient. Multivariable linear regression was used to examine the effects of clinical, demographic, and imaging characteristics on consonant-nucleus-consonant (CNC) word recognition scores at 12 months post-activation.

There was substantial variability in modiolar proximity for the basal and middle portions of the electrode array, which became less pronounced in the apical portion beyond 270 deg. A deeper basal insertion depth was associated with closer modiolar proximity for basal electrode contacts but displacement of electrode contacts away from the modiolus in the middle portion of the array. Regression models demonstrated no effect of mean modiolar proximity across the entire electrode array on CNC word scores; however, reduced distance to the modiolus of the middle portion of the array was associated with improved outcomes at 12 months post-activation. Deeper apical insertion depths and greater daily device use measured through datalogging were also predictors of better CNC word recognition scores.

Although proximity to the modiolus for precurved electrode arrays is highly variable, an average metric across the entire array does not appear to capture subtle nuances across various regions and was not found to be significantly associated with CNC word recognition outcomes in this dataset. Modiolar distance is most variable in the middle portion of the electrode array and closer proximity of electrode contacts in this region was found to be significantly associated with better CNC word recognition scores at 12 months post-activation.

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M-T 31: USER-MEDIATED ADJUSTMENT OF THE CI AND CROS SIGNAL MIXING RATIO IMPROVES SPEECH INTELLIGIBILITY IN NOISE AT VARIOUS TALKER LOCATIONS.

Anne van Alphen[1], H. Christiaan Stronks[1,2], Jeroen J. Briaire[1], Johan H.M. Frijns[1,2,3]

[1] Department of Otorhinolaryngology and HNS, Leiden University Medical Center, Leiden, The Netherlands
[2]Leiden Institute for Brain and Cognition, Leiden University, Leiden, The Netherlands
[3]Department of Bioelectronics, EEMCS, Delft University of Technology, Delft, The Netherlands

Objective: A contralateral routing of signals (CROS) device is useful for asymmetric hearing loss by decreasing the head shadow effect. In the case of unilateral cochlear implant (CI) users, it redirects signals from the side contralateral to the CI to the CI. Wearing a CROS device enhances intelligibility when speech is presented to the CROS side. However, in reverse situations, it can degrade the speech signal. A possible solution is to adjust the mixing ratios to adapt the relative contributions of the CROS and CI microphone to the overall output level in the CI system. This study assessed the benefits of adjustable mixing ratios under the CI user's control. To achieve this, speech intelligibility in noise was assessed using speech presented from multiple spatial locations around the head.

Methods: 16 unilateral CI users participated in this study. Speech recognition thresholds (SRTs) were assessed using the Dutch/Flemish Matrix test. The SRT is the signal-to-noise ratio (SNR) where 50% of speech is recognized correctly. The maximal CROS effect was assessed by presenting speech and noise stimuli on opposite sides of the participant. To evaluate the effectiveness of manual adjustment of the mixing ratio, participants were presented with speech from 5 different angles (+/- 90o, +/- 45o, or 0o, negative angles indicating the CI side) in a background of diffuse stationary speech shaped noise. Two conditions were tested: (1) CI-only and (2) CI+CROS with mixing ratio. CI users used a digital slider to set the mixing ratio for each speech location. The noise level was 60 dB(A). The CROS ear was plugged to minimize the influence of residual hearing.

Results: The maximal benefit of CROS (fixed mixing ratio 1:1, speech at 90o on the CROS side) improved speech intelligibility by 4.7 dB SNR ($p < 0.001$). However, when speech was presented to the CI side (-90o), we found a disadvantage of 4.3 dB SNR ($p < 0.001$). The mixing ratios set by the participants correlated significantly with the angle of speech ($R2=0.47$, $F (1,78) = 67.88$, $p < 0.001$). Compared to listening with CI-only, SRTs improved significantly by 3.8 dB when speech was presented from angles on the CROS side when participants manually set the mixing ratio ($p < 0.001$). When the speech was presented at angles located on the CI side, the expected disadvantage of CROS was effectively eliminated to 0.5 dB (at -90o) or less (at -45o) ($p = 0.21$).

Conclusions: Participants were able to adjust the mixing ratio such that CROS was beneficial when speech was presented at angles on the CROS side and effectively mitigating the disadvantage of CROS when speech was presented on the CI side. These results show that manual adjustment of mixing ratios can be useful in everyday life. Moreover, the results show that unilateral CI users can effectively utilize sound-level cues to enhance speech perception in noise, improving their speech intelligibility.

This work was funded by the Dutch Research Council (NWO), INTENSE project.

M-T 32: PROBING DISCREPANCIES BETWEEN PERCIEVED LOUDNESS AND ECAP AMPLITUDES ALONG THE ELECTRODE ARRAY IN COCHLEAR IMPLANT USERS

Charlotte Garcia, Dorothee Arzounian, Francois Guerit, Robert P. Carlyon

Cambridge Hearing Group, MRC Cognition & Brain Sciences Unit, University of Cambridge, UK

Objective: Electrically Evoked Compound Action Potentials (eCAPs) capture the synchronous response of the auditory nerve (AN) to electrical stimulation. They are sometimes used to fit cochlear-implant (CI) programming levels, particularly thresholds. However, evidence that they correlate with behavioral measures of loudness is mixed [1]. Furthermore, our measurements show that the eCAP amplitude can differ markedly between electrodes within individual CI users, despite being elicited at similar ("most-comfortable") loudness (MCL). Here we describe two experiments exploring peripheral and central factors, respectively, that might explain the discrepancies between perception and eCAP responses. The first experiment explores two peripheral factors likely to affect eCAPs and loudness differently: (i) refractory properties that affect the extent to which a masker pulse reduces the excitation produced by a subsequent probe in the forward-masking (FM) artefact-reduction method, where more masking would increase the eCAP but reduce loudness; (ii) relative contributions of anodic and cathodic currents to loudness, with cathodic currents assumed to produce asynchronous firing of the AN that may contribute to loudness but not to eCAPs [2]. The second experiment investigates variation in central gain downstream of different stimulation locations along the length of the cochlea.

Methods: Experiment 1 involved measuring eCAPs at MCL on all electrodes for 11 users of Advanced Bionics devices in three stimulating conditions: symmetric, cathodic-leading, biphasic current pulses using (i) the alternating-polarity (SYM_AP) and (ii) FM artefact-reduction methods (SYM_FM), and (iii) pseudo-monophasic, anodic-dominant pulses (PSA_FM) with a cathodic-leading long, low-current phase followed by a short, high-current anodic phase using the FM method. In Experiment 2 we present loudness-balanced stimuli at 6 electrodes along the electrode array in response to which eCAPs, electrically-evoked auditory brainstem responses (eABRs), and electrically-evoked auditory steady state responses (eASSRs) are recorded simultaneously. This therefore captures responses from the AN, the brainstem, and the thalamus/cortex, respectively.

Results: The first experiment did not find that the between-electrode standard deviation of eCAP amplitudes differed significantly between conditions (Kruskal-Wallis One-Way ANOVA: $\chi^2(2) = 0.25$, $p = 0.88$). Across electrodes, SYM_FM eCAP amplitudes correlated both with SYM_AP eCAPs ($r(162) = 0.77$, $p < 0.0001$) and PSA_FM eCAPs ($r(162) = 0.49$, $p < 0.0001$). The lack of effect of stimulation condition on within-ear eCAP variation combined with the fact that each condition elicits similar eCAPs suggest that behavioral ~ eCAP discrepancies cannot be explained entirely by AN mechanisms of polarity sensitivity nor refractoriness. Data collection for the second experiment is underway at the time of abstract submission, and results will be presented at the conference. A smaller degree of variation in thalamic and/or brainstem responses across the array compared to AN measurements would suggest place-specific central compensation for varying AN responsiveness at different locations within the cochlea, or that eCAP amplitudes are substantially contaminated by non-neural factors like variations in recording electrode positions or impedances.

Conclusions: The first experiment provides no evidence that the substantial variation in ECAP amplitude between equally-loud stimuli could be attributed to variations in refractoriness or in AN stimulation by cathodic current (and by proxy, asynchronous firing contributing to loudness but not eCAPs). The contribution of central factors will be assessed once data collection is completed.

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M-T 33: NEURAL ADAPTATIONS TO NEW COCHLEAR IMPLANTS: A LONGITUDINAL ELECTROENCEPHALOGRAM STUDY

Shimin Mo[1,2,3], Claude Alain[1,3,5,6], Andrew Dimitrijevic[1,2,3,4]

[1] Institute of Medical Sciences, Temerty Faculty of Medicine, University of Toronto, Toronto, M5S 1A8, Ontario, Canada
[2] Evaluative Clinical Sciences Platform, Sunnybrook Research Institute, Toronto, M4N 3M5, Ontario, Canada
[3] Rotman Research Institute, Baycrest, Toronto, M6A 2E1, Ontario, Canada
[4] Department of Otolaryngology-Head and Neck Surgery, Temerty Faculty of Medicine, University of Toronto, Toronto, M5S 1A1, Ontario, Canada
[5] Department of Psychology, University of Toronto, Toronto, M5S 3G3, Ontario, Canada
[6] Music and Health Research Collaboratory, Faculty of Music, University of Toronto, Toronto, M5S 2C5, Ontario, Canada

Background: Cochlear implants (CIs) can help improve auditory function, but post-implantation outcomes vary widely and often do not correlate well with each other. Standard clinical tests (e.g., AzBio) assess speech perception in controlled environments but overlook cognitive demands, such as selective attention, that are critical for real-world speech-in-noise listening. Consequently, these tests do not effectively predict Patient-Reported Outcome Measures (PROMs), which reflect the daily listening challenges faced by CI users. Hence, there is a need to develop ecologically valid measures to assess post-CI outcomes.

Objective: To address these gaps, this study aims to (1) examine post-CI neural adaptation trajectory using ecologically valid tests and (2) evaluate their predictive value for PROMs.

Methods: Eighteen newly implanted CI users participated in four sessions (0-, 3-, 6-, and 12-months post-activation), completing behavioral digits-in-noise (DiN) and EEG audiobook listening tasks. In both tasks, participants attended to a target speaker while ignoring distractors varying in speaker identity and location (DiN) or identity only (EEG). Lower speech-distractor threshold and greater Temporal Response Function (TRF) weights indicate better objective speech perception outcomes.

Results: Speech-distractor threshold significantly decreased over time. TRF analysis of current data (n = 7) revealed an approaching-significance session effect, suggesting neural adaptations in cognitively demanding speech tracking over time. Linear mixed-effects modeling showed significant interactions between session and both TRF and DiN performance in predicting PROMs within the speech domain.

Conclusions: Preliminary findings suggest that neural adaptations to continuous speech tracking improve post-CI, with distractor identity influencing the magnitude of improvement. Few studies have tracked interim changes in post-implantation out-comes using naturalistic speech. This longitudinal study will help uncover neuroplastic changes that impact naturalistic speech perception following sensory restoration, ad-dressing a significant gap in the field. These ecologically valid measures could also guide the development of personalized, long-term interventions to enhance CI outcomes.

M-T 34: EFFECT OF CONTRALATERAL STIMULI ON PERCEPTUAL LEARNING OF VOCODED SPEECH

M. Jambois[1], **A. Hervais-Adelman[2,3]**, **O. Macherey[1]**

[1]Aix-Marseille University, CNRS, Centrale Méditerranée, LMA, Marseille, France
[2]Department of Basic Neurosciences, University of Geneva, Geneva, Switzerland
[3]Zurich Center for Linguistics, University of Zurich, Zurich, Switzerland

A few months after implantation, single-sided deaf (SSD) patients listening to their cochlear implant (CI) alone often show worse speech recognition than bilaterally deaf CI patients. This suggests that contralateral hearing hinders perceptual learning of CI-transduced speech. Chavant et al. (2021) simulated unilateral CI-processing with a channel vocoder and tested word recognition performance in normal-hearing listeners who received different forms of training - hearing vocoded speech in one ear and either clear speech (similar to SSD implantees), low-pass filtered speech or no input in the contralateral ear. Consistent with data from CI listeners, they showed that participants who were trained with clear speech in the contralateral ear progressed less in their vocoded speech recognition than participants who were trained with unintelligible lowpass-filtered speech or than participants who did not receive any contralateral signal. However, all participants were provided subtitles during training which may have particularly helped those who only heard the vocoder.

Here, we re-examine this issue in a similar protocol, without subtitles. Our hypothesis was that equal intelligibility in the two ears may boost perceptual learning compared to providing no contralateral signal. Perceptual learning of vocoded speech was measured in four groups of 32 normal hearing participants exposed to different dichotic training conditions. Three groups were presented with vocoded speech in one ear and either clear speech, lowpass filtered speech or no signal in the contralateral ear, while the fourth group received no training with the vocoder. These groups are referred to as Clear, Lowpass, No-signal and No-training, respectively. Vocoder difficulty was adjusted on an individual basis by varying the amount of spectral smearing to reach 70% recognition on the French Matrix sentence test. Similarly, the cutoff frequency of the lowpass-filtered speech was adjusted to reach the same level of intelligibility as the vocoder for the Lowpass group. Lists of 10 vocoded sentences extracted from the French Harvard corpus were presented at four time points over a 1-hour testing session. These test lists were interspersed with 3 training of 5 lists during which the participants simultaneously heard the vocoder in one ear and a contralateral signal (or nothing, depending on the group) in the other ear.

A generalized linear mixed-effects model analysis showed a significant improvement in speech recognition for the Lowpass (+12.56%, $p < 0.0001$) and No-signal (+21.68%, $p < 0.0001$) groups. In contrast, the Clear and No-training groups showed no significant progression. Finally, the No-signal group improved significantly more than the Clear and No-training groups, whereas the Lowpass group improved more than the No-training group only.

These results are not consistent with our hypothesis that equal intelligibility across ears boosts perceptual learning of vocoded speech. However, this study confirms that the presentation of clear speech in the contralateral ear reduces or slows down perceptual learning of contralaterally presented vocoded speech. Potential implications for the rehabilitation of CI patients with partial or full contralateral hearing will be discussed.

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M-T 35: FOCUSED ULTRASOUND STIMULATION OF SPIRAL GANGLION NEURONS

E. Brunet[1,2], V. Parameshwarappa[1], E. Debieu[1], A. Moqrich[2], D. Kovacic[3,4], E. Franceschini[1], O. Macherey[1]

[1]Aix-Marseille University, CNRS, Centrale Méditerranée, LMA, Marseille, France
[2] Aix-Marseille University, CNRS, IBDML, Turing Center for Living Systems, Marseille, France
[3] Faculty of Science, University of Split, Croatia
[4]The Center of Research Excellence for Science and Technology Integrating Mediterranean Region – STIM, University of Split, Croatia

In recent years, several stimulation techniques have been proposed to overcome the lack of spatial selectivity of intracochlear electrical stimulation. These alternatives include intraneural, magnetic, or optogenetic stimulation. Here, we investigate if and how focused ultrasound (FUS) stimulation activates spiral ganglion neurons (SGNs) in vitro.

Primary cultures of SGNs were prepared based on modioli extracted from 40 rat pups (P5). 24 hours after culture, the cells were incubated with a calcium dye (Fluo4) prior to the calcium imaging experiments. The cultures were stimulated by a FUS transducer positioned at the center of the optical microscope's field of view. The positioning of the transducer was achieved by operating the transducer in pulse-echo mode and focusing on the culture dish in which a polystyrene microbead was placed. Calcium imaging experiments were performed using an inverted microscope. Each FUS stimulus consisted of a single 20-MHz sinusoidal burst with an acoustic pressure ranging from 4.2 to 5.4 MPa and a duration ranging from 0.1 to 1 ms. Each culture dish was sonicated 8 times in different zones. Each zone was stimulated only once, in order to avoid potential cumulative effects. To evaluate the effects of the presence of non-neuronal cells in the culture, we developed a method for culturing isolated neurons using a Percoll gradient: 4 mL of Percoll 28.5% and 4 mL of Percoll 12.5% were first transferred to a 15-mL Eppendorf, taking care of not mixing the two solutions. The cultured cells were then deposed above the gradient and centrifuged. As SGNs are less dense than other cells in the culture, they regroup at the junction between the two solutions, whereas non-neuronal cells end up at the bottom of the tube. These purified cultures were stimulated with the same transducer at a pressure of 5.4 MPa and for several durations. The percentage of SGN calcium responses was then compared in the presence and absence of non-neuronal cells. Finally, the physical mechanisms underlying FUS stimulation of SGNs were investigated. The more likely hypothesis is that FUS-mediated calcium transients are due to mechanical forces causing membrane deformation. To examine whether the DRG neurons were deformed due to the FUS-induced mechanical forces, a high-speed camera (100 000 fps) was used to image 40 SGNs. Each cell was stimulated several times with increasing acoustic pressure or stimulus duration. The cellular deformation was quantified by calculating the percent change in the projected area of the neuron's image.

For a fixed duration of 1 ms, the percentage of responding SGNs showing a calcium response increased from 5% to 72% with increases in acoustic pressure from 4.2 to 5.4 MPa. Similarly, for a fixed pressure of 5.4 MPa, the percentage of responding SGNs increased from 1 to 70% with increases in stimulus duration from 0.1 to 1 ms. Furthermore, the proportion of responding SGNs was very similar in the presence and the absence of non-neuronal cells, showing that SGNs can be directly activated by FUS. Finally, high-speed imaging revealed that the cells started responding when deformed by 3% or more. This deformation increased both as a function of acoustic pressure and stimulus duration. This demonstrates that SGN deformation is concomitant with SGN activation and strongly suggests that mechanical forces are responsible for the FUS neurostimulation of SGNs. Implications for hearing restoration using FUS will be discussed.

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M-T 37: NEURONS IN THE COCHLEA VERSUS NEURONS IN THE COCHLEAR NUCLEUS - REFRACTORY PERIODS AND POLARITY EFFECTS IN HUMANS WITH DIFFERENT AUDITORY PROSTHESES

Lutz Gärtner[1,] Marko Takanen[2], Konrad Schwarz[2], Thomas Lenarz[1,3], Andreas Büchner[1,3]

[1] Department of Otolaryngology, Hannover Medical School, Hannover, Germany
[2] Research and Development, MED-EL GmbH, Innsbruck, Austria
[3] Cluster of Excellence "Hearing4all", Hannover, Germany

To optimize signal processing strategies for auditory prostheses in the future, it is crucial to characterize the responses of the neurons the prostheses are targeting with the stimulation. For cochlear implants (CI), auditory sensation stems from action potentials evoked by peripheral auditory nerve fibers (ANFs) from the cochlea. In contrast, for auditory brainstem implants (ABI), it stems from potentials evoked by neurons in the cochlear nucleus (CN). Here, we investigated potential differences in recovery properties between CN neurons and ANFs.

So far, twelve ABI and six CI patients have participated in this prospective study. We measured recovery functions with a research software for anodic- (AC) and cathodic-leading (CA) charge-balanced stimuli using the revised forward-masking paradigm (1). Parameters for absolute (T_0) and relative (tau) refractory periods were derived by fitting a function U(t)=A (1-"exp" (-(t-T_0)/tau) to the measured data. Here, U is the response amplitude, A is the saturated response amplitude of fully-recovered neuron, and t is the inter-pulse interval between the masker and the probe pulse (2).

Our preliminary data shows the absolute refractory period T_0 being similar for both implant types: T_0^ABI=0.5 ±0.15 ms and T_0^CI=0.51 ±0.14 ms. However, significantly shorter time constant of the relative refractory period tau was observed for ABI than for CI: tau^ABI=0.55 ±0.37 ms, tau^CI=1.0 ±0.52 ms (t_215.0=7.3, p<0.0001).

The faster relative recovery of the CN nuclei bolsters the idea that ABI fitting could make use of higher stimulation rates for better encoding of the speech envelope, providing that the stimulus strength requirements are kept low by means of good electrode placement. This could help to reduce the gap in speech outcomes between CI and ABI users.

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M-T 38: THE RELATIONSHIP BETWEEN NEURAL-HEALTH ASYMMETRY AND INTERAURAL LOUDNESS MISMATCH FOR BILATERAL COCHLEAR-IMPLANT USERS

Obada J. AlQasem[1], Joshua G. W. Bernstein[2], Matthew J. Goupell[1]

[1] University of Maryland, College Park, MD, USA
[2] Walter Reed National Military Medical Center, Bethesda, MD, USA

Binaural cues-interaural time differences (ITDs) and interaural level differences (ILDs)-are crucial for perceiving changes in spatial locations. For intracranial lateralization tasks, diotic stimuli (i.e., 0-ITD/ILD) are commonly assumed to be perceived as a single, fused, and centered auditory image. Bilateral cochlear-implant (BICI) users often experience interaural loudness mismatch (ILM), where bilateral stimulation, adjusted to produce equal-loudness perception across the ears when presented sequentially, produces a non-centered perception when presented simultaneously. The reasons BICI users experience ILM are currently unknown.

The auditory nerve encodes intensity through the magnitude of the neural response. Normal-hearing individuals are assumed to perceive 0-ILD stimuli as both equally loud (for sequential presentation) and centered (for simultaneous presentation) due to symmetrical neural responses in the two ears. For BICI users, asymmetrical neural responses due to differences in neural survival might explain ILM. This study investigated the hypothesis that neural response asymmetry for BICI users would positively correlate with ILM.

Number-matched electrode pairs were tested at three places for each participant (basal, middle, apical). BICI participants performed an interaural loudness-balancing procedure for each electrode pair by adjusting the intensities of sequentially presented stimuli to determine the levels required to perceive them as equally loud. Next, ILD discrimination thresholds were measured. Finally, lateralization was performed using ILDs of ±50, 100, 150, 200, 250, and 300% of the ILD discrimination threshold. Electrically evoked compound action potential amplitude growth functions (ECAP AGF) assessed auditory-nerve health. Neural asymmetry was quantified by the ECAP AGF slope difference across the ears.

Preliminary analysis (N=5 out of 20 planned subjects) showed a trend where greater ECAP AGF asymmetry was associated with increased ILD lateralization biases. The findings of this study could inform the development of objective ECAP-based clinical tools for estimating and compensating for ILM, with an end goal of improving spatial hearing in BICI users.

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M-T 40: FACIAL NERVE STIMULATION IN A COMPUTATIONAL MODEL OF THE IMPLANTED COCHLEA

R. K. Kalkman[1], J. J. Briaire[1,2], J. H. M. Frijns[1,2,3]

[1] Department of Otorhinolaryngology and Head & Neck Surgery,
Leiden University Medical Centre, Leiden, the Netherlands
[2] Leiden Institute for Brain and Cognition, Leiden, the Netherlands
[3] Bioelectronics, EEMCS, Delft University of Technology, Delft, the Netherlands

Facial nerve stimulation (FNS) is a relatively common complication for CI users, and is often dealt with by disabling electrode contacts, limiting the number of usable CI channels. FNS is known to be affected by several factors, such as electrode array position [1], stimulus pulse shape [2,3], current focusing [3], and the presence of otosclerosis [1]. The goal of this computational modelling study was to gain insight into the mechanisms behind FNS and examine means to avoid it without having to disable electrode contacts.

The study uses an established computational biophysical model of cochlear implant stimulation [4], which consists of a three-dimensional volume conduction model of the implanted human cochlea, coupled with a deterministic active nerve fiber model. The volume conduction model is based on the Boundary Element Method and uses realistic geometries of human cochleae based on histological and radiological data, implanted with representations of electrode designs from all major CI manufacturers, in perimodiolar, mid-scalar and lateral positions. The auditory and facial nerve fibers are modelled as active electrical double cables, controlled by Schwarz-Reid-Bostock neural kinetics [4]. Stimulation of the auditory and facial nerves was simulated for biphasic and monophasic pulses with a range of phase durations, for monopolar and (partial) tripolar stimulation modes. In addition, to mimic the effects of otosclerosis, the electrical conductivity of the temporal bone surrounding the cochlea was varied.

Simulations showed that the facial nerve was far more sensitive to the cathodic phase of the stimulus than it was to the anodic one, due to the shape of the electrical field along the part of the facial nerve that is closest to the cochlea. Results further showed that current focusing could raise FNS thresholds relative to auditory thresholds, but this depended on the relative distances of the stimulating contacts to the facial nerve and targeted auditory nerves, which meant that it was an effective way to reduce FNS for perimodiolar arrays, but not for arrays positioned along the lateral wall. Decreasing phase duration was shown to have a very minor effect on FNS, only raising the FNS threshold relative to auditory M-level by about 1 dB when reducing the phase duration from 40 μs to 5 μs. Lastly, in concordance with one of our previous modelling studies [5], increasing the conductivity of temporal bone raised auditory thresholds, while FNS thresholds were much less affected, thereby increasing the likelihood of FNS.

In conclusion, the modelling results suggest that changing the stimulus pulse shape to one where the anodic phase is dominant (e.g., a pseudomonophasic anodic pulse or triphasic pulse with an anodic middle phase) is an effective way to treat FNS. Current focusing can either reduce or increase FNS, depending on electrode position, while changing phase duration is not likely to be effective.

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M-T 41: PULSE RATE AND PULSE AMPLITUDE MODULATION SENSITIVITY IN THE INFERIOR COLLICULUS OF COCHLEAR IMPLANT RATS

Qinjie Zhang[1,2], Pui Chung Wong [2], Fei Peng[1], Shiyi Fang[1,2], Muhammad Zeeshan[1,2], Huan Jia[3], Jan Schnupp[1,2]

[1] Gerald Choa Neuroscience Institute; Department of Otolaryngology; School of Biomedical Sciences, Chinese University of Hong Kong, Hong Kong SAR
[2] Department of Neuroscience, City University of Hong Kong, Hong Kong SAR
[3] Department of Otolaryngology-Head and Neck Surgery, Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai 200011, China

Both place and temporal cues contribute to pitch perception, current cochlear implant (CI) coding strategies primarily rely on place coding and discard temporal fine structure by using fixed pulse timing. CI users also experience poor pitch perception, and therefore struggle to appreciate melodies, understand tonal languages, or process speech in noisy environments. Psychoacoustic studies investigating varying pulse rates as pitch cue struggle the potential confound of loudness effects, given that higher pulse rates with constant pulse amplitude will increase stimulus intensity. To look deeper into this potential confound, we investigated the joint sensitivity of multi-units recorded from the inferior colliculus (IC) of CI-implanted rats to ~1.25 s long CI stimulus pulse trains, each comprising five cycles of square wave pulse rate (FM) or pulse amplitude (AM) modulation. In a first step, we recorded responses to either AM or FM alone, testing 20, 10, 5, and 2.5% AM depth and 40, 20, 10 and 5% FM depth. When responses to these stimuli indicated that the recorded multi-units were sensitive to both AM and FM, then we further investigated the AM/FM joint sensitivity for near-threshold modulation depths. This near-threshold regime is of particular interest to us as we were interested in the limits of the ability of IC neurons to encode small pulse rate changes as a possible pitch cue, and in how the encoding of these temporal cues interact with loudness cues such as those created by changes in pulse amplitude. To map out the AM/FM joint sensitivity, we first estimated, for AM and FM separately, the modulation depth that would modulate the responses by ~15%, and then recorded responses to stimuli in which AM and FM both varied, independently and in and out of phase, by 0, 25, 50, 75 or 100% of the 15% response modulation point. From these joint AM/FM sensitivity functions we can estimate, for example, how much AM might be required to "offset" the effect of a given FM. These data were collected for FMs around a baseline rates of 300 pps, and, when time permitted, the recordings were repeated for 100, 450 or 900 pps.

A total of 408 responsive multi-units were recorded. Of those, 61.8% were found to be sensitive to both AM and FM at 100 pps, 67.6% at 300 pps, 58.8% at 450 pps, and 21.3% at 900 pps. Importantly, we observed that, while neural responses always covaried with the phase of the AM (that is, larger stimulus amplitudes resulted in stringer responses), neural response modulation in response to FM could be either in phase or in counterphase to the stimulus (that is, faster pulse rates could result in either stronger or weaker neural responses). The proportion of multiunits for which response strength was anti-correlated with FM depended on the baseline pulse rate (7.2% for 300 pps, 76.3% for 450 pps, and 46.0% for 900 pps).

Our results reveal a wide diversity of AM and FM sensitivity in IC neurons of CI stimulated rats tested with pulse trains varying in both pulse rate and amplitude. Combining information across these diverse neural responses, it should be fairly straight-forward to disambiguate changes in pulse amplitude from changes in pulse rate. We therefore propose that loudness confounds may be less of a problem in studies investigating the sensitivity to changes in pulse rate than is sometimes assumed.

M-T 42: HOW TO MEASURE BINAURAL HEARING IS A CLINICAL SETTING, TOWARDS A UNIFIED TESTING FRAMEWORK FOR SINGLE-SIDED DEAFNESS (SSD)

Martijn Agterberg

Radboud University

In recent years it has become clear that percutaneous bone conduction devices (BCDs) are an inferior treatment for single-sided deafness (SSD). Cochlear implants (CIs) have increasingly become a treatment choice. The CI is the only device capable of providing bilateral input to the auditory system, and potentially realizing binaural hearing. We identified 23 studies that were cited >100 times in which sound localization was tested as measure of binaural hearing. It turned out that each study used a unique localization test setup. Only with a consistent use of defined and agreed-upon outcome measures across centers can high-level evidence be generated to assess the efficacy of CIs and alternative treatments in recipients with SSD and other types of hearing loss.

Methods: A previous consensus paper by Van de Heyning et al. (2017) provides recommendations for a localization setup using a loudspeaker resolution of 30 deg in their consensus paper. The argument for this choice was that 7 loudspeakers are needed with 30 deg resolution to cover the frontal hemisphere, and that commercially available 8-channel sound cards can be used. Furthermore, it was mentioned that Hartmann et al. (1998), who provide a guide to the design of sound localization experiments based on a theoretical statistical model, claimed that seven loudspeakers are sufficient to resolve localization performance.

Results: We demonstrate that when speakers are positioned 45, 30 and 20 degrees apart, the mean absolute error (MAE) for normal hearing subjects is 0°. When speakers are positioned 10 or 5 degrees apart the MAE is 5° (SD 3°). The spatial resolution of the loudspeaker layouts used in the 23 reported studies varies between 7.5 deg and 45 deg. According to our calculations with the model and values for normal-hearing localization accuracy (sigma0) and bias provided by Hartmann et al. (1998), with 18 or more loudspeakers, the resulting RMS error for normal-hearing localization performance no longer depends on the number of loudspeakers but only on the localization accuracy and bias used in the model. We provide exemplary data of different patient groups with our proposed sound localization test setup (loudspeakers positioned 10 degrees apart) and demonstrate the clinical importance of accurately testing of sound localization abilities.

Conclusion: In order to provide high-level evidence for treatment options loudspeakers should be positioned 10 degrees apart. A higher resolution of loudspeakers is not needed in a clinical setting. Consensus about the type and duration of stimuli, visibility of the loudspeakers and amount of roving of the sound level are needed to generate a growing body of high-level evidence how to obtain binaural hearing with hearing implants.

M-T 43: COCHLEAR MICROPHONIC POTENTIALS IN FRONT OF THE INTACT AND BEHIND THE OPENED ROUND WINDOW MEMBRANE: IS THERE A DIFFERENCE?

I. Brill[1], S. Brill[2], S. Hans[2], S. Dazert[1]

[1] Ruhr University Bochum ENT, Germany
[2] MED-EL GmbH, Starnberg, Germany

Introduction: Cochlear micophonic potentials (CMP) represent the response of outer hair cells to acoustic signals and can be used to monitor hearing preservation during cochlear implantation. One step of cochlear implant surgery that can potentially be damaging to the residual hearing is the opening of the round window (RW). The aim of our study was to determine the influence of the round window membrane opening on CMPs.

Material and Methodes: In 10 patients during the intervention of receiving a cochlear implant we measured CMPs with a low frequency stimulus and with a SPL of 30 dB above the hearing threshold, while maintaining 80 dB SPL as the minimum stimulation level. The measurements took place via the cochlear implant with the first electrode contact in front of and after opening of the RW and immediately behind the round window membrane at the entrance of the cochlea.

Results: Recording of CMPs through the implant before opening the RW was possible in 6 of the 10 patients. The round window opening resulted in an CMP amplitude increase of about a factor of 2. In those cases were we could not record CMPs before opening the RW membrane, we could still detect CMPs after opening it in 3 of 4 cases.

Conclusions: The CMP measurement via the implant before and after opening of the round window membrane is feasible. The RW represents a significant electric insulation and thus opening it has an impact on the amplitude. This observation could however be confounded by the possible effect the RW opening has on the acoustic sound level in the cochlear liquid.

M-T 45: SPIRAL GANGLION NEURON PATH TRACING IN HIGH-RESOLUTION MUCT SCANS

Albert Croner[1,2], Johannes Ségur-Eltz[1,2], Siwei Bai[1,2], Mahdi Fallahtaherpazir[3], Alissa Breit[1,4], Johannes Melcher[1,4], Martin Dierolf[1,4], Rudolf Glueckert[3], Anneliese Schrott-Fischer[3], Werner Hemmert[1,2]

[1]Munich Institute of Biomedical Engineering, Technical University of Munich, Garching, Germany
[2]Bio-Inspired Information Processing, School of Computation, Information and Technology, Technical University of Munich, Garching, Germany
[3]Department of Otorhinolaryngology, Medical University of Innsbruck, Innsbruck, Austria
[4]Chair of Biomedical Physics, Department of Physics, TUM School of Natural Sciences, Technical University of Munich, 85748 Garching, Germany

Motivation: Both peripheral and central processes of spiral ganglion neurons (SGNs) measure only a few mum in diameter. In addition, high contrast from bone obscures soft tissue in CT scans. Due to these difficulties, and since their approximate position in the cochlea is known, previous computational models primarily relied on artificially placed SGNs with smooth geometries at physiologically expected positions. Here, we present high-resolution muCT scans of human cochleae with good visibility of SGNs and a new algorithm that can trace the paths SGNs take inside the cochlea, enabling computational models with SGN trajectories based on related scan data.

Methods: 18 human temporal bone samples were decalcified, osmium-tetroxide-stained, and scanned with a phase contrast muCT system at the Munich Compact Light Source. Subsequently, 12 nerve volume meshes, quantifying the space occupied by SGNs, were segmented. The SGN path-tracing algorithm was based on the segmented nerve volume and directional vectors, which provided a coarse estimate of the SGN trajectories. Tracing began from starting points spread along the cochlear length, close to the Organ of Corti. The tracing algorithm repeatedly searched for the next point in the nerve mesh so that the next point was connected to the latest computed point by a vector most similar to the directional vector.

Results: High-resolution muCT scans with a voxel size of 6 mum and strong contrast for myelinated SGN processes were obtained. Visible fine structures included thin SGN bundles (approximately 20 mum diameter) inside the spiral lamina, which the tracing algorithm closely followed. Near the inner wall of scala tympani, SGNs as well as traced paths merged into thicker bundles (50 to 100 mum diameter). In the central nerve, inside the modiolar bone, slight coiling around the modiolar axis was observed. The new tracing algorithm provided more accurate paths than previously employed shortest-path approaches.

Conclusions: We obtained high-quality scans of human cochleae, with good visibility of SGN bundles, even near the Organ of Corti. The tracing algorithm successfully traced paths inside the nerve volume and improved over previously employed shortest path algorithms. The new scans and traced SGN paths enable a new generation of computational models of the human cochlea with highly accurate morphology.

M-T 46: TEMPORAL PITCH PROCESSING BY COCHLEAR-IMPLANT RECIPIENTS: INSIGHTS FROM FREQUENCY-FOLLOWING RESPONSES AND BEHAVIOURAL PITCH RANKING

Evelien De Groote[1,*], Wouter David[2,*], Charlotte Garcia[1], Robin Gransier[2], Jan Wouters[2], Robert P. Carlyon[1]

[1] Cambridge Hearing Group, MRC Cognition and Brain Sciences Unit, University of Cambridge, Cambridge, UK
[2] KU Leuven, Department of Neurosciences, ExpORL, Belgium
[*] Shared first authorship

Purpose: Temporal pitch processing varies considerably across cochlear-implant (CI) recipients, which may be due to a biological limitation that is related to the electric stimulation itself and/or the degenerative process underlying the hearing loss. Furthermore, idiosyncratic and reliable variations have also been reported within individual CI recipients (i.e., across different electrodes). This observation provides an interesting opportunity to examine how behavioural performance relates to objective markers of temporal processing, such as the electrically-evoked frequency-following response (eFFR), and to explore the biological limitations that hinder CI recipients from effectively using temporal pitch cues. This is especially important given the fact that some signal processing strategies attempt to convey temporal fine-structure information, the success of which partly relies on how well CI recipients can make use of these cues to derive a pitch.

Methods: Nineteen Cochlear CI recipients participated in this three-session study. On each session, eFFRs and behavioural pitch ranking were assessed on one of three electrodes (E22, E11, E1). EEG was recorded using a hyper-sampling rate system in response to six pulse rates between 128 and 314 pps, and a novel template-subtraction method was used to derive eFFRs free from stimulation artefacts (1). The behavioural upper limit of temporal pitch perception was estimated from a rate-pitch ranking task, which used the MidPoint Comparison procedure for the ranking of eight rates between 128 and 1042 pps.

Results: We were able to record significant and artefact-free eFFRs in 12 out of 19 participants. For these participants, eFFR amplitude generally decreased with increasing pulse rate. Behaviourally, pitch ranks increased monotonically for most participants until an average upper limit of about 500 pps. Neither the eFFR amplitude nor the estimated upper limit showed a significant effect of electrode location at the group level. Finally, eFFR amplitude did not correlate significantly with the upper limit either across or within participants.

Conclusions: The results of this study showed a lack of a clear relationship between the upper limit of temporal pitch perception and the eFFR. This may suggest that the limitations on temporal pitch perception cannot be fully accounted for by phase-locking capabilities at the level of the brainstem, and that other processes (either beyond the brainstem and/or reflected in non-phase-locked responses) affect temporal pitch perception.

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M-T 47: A TRANSCANAL CATHETER FOR DELIVERY OF THERAPEUTIC HYPOTHERMIA TO THE INNER EAR: EXPERIMENTAL AND NUMERICAL ANALYSIS

Maria F. Yepes[1,2,3], Pavan S. Krishnan[2], Curtis King[4], Suhrud Rajguru[1,2,4]

[1]Department of Biomedical Engineering, University of Miami
[2]Department of Otolaryngology, University of Miami Miller School of Medicine
[3]Department of Neuroscience, University of Miami Miller School of Medicine
[4]RestorEar Devices LLC

Background: Mild therapeutic hypothermia (MTH) has been shown to protect residual hearing function post cochlear implant surgeries in preclinical models. Our previous work has shown that MTH is safe, protects auditory brainstem response thresholds and wave I amplitudes and latency, but also preserves the cochlear structure against the surgical trauma and inflammation. To translate this work to patient benefit, we have designed a transcanal catheter and device to deliver MTH non-invasively. This approach that does not require alternations to surgical procedure nor additional time pre- or post-operatively. Here, we present results of numerical and cadaver testing that highlight efficacy of the catheter and device in delivering MTH to the inner ear endorgans.

Methods: We performed a mastoidectomy, extended facial recess approach, stapedotomy, and fenestration of all three semicircular canals to access the auditory and vestibular endorgans. For temperature recording, thermistors were placed through the round window into the cochlea, in all three semicircular canals, near the otolith organs, and the scalp and nasopharynx (as controls). Cadaver heads were pre-warmed to 35.5-38 degC to simulate human body conditions. Once stabilized, a cooling device comprising of a saline-filled catheter and balloon tip, connected to a cooling machine, was positioned in the ear canal near the eardrum. Temperature changes were recorded every minute in the inner ear organs, ear canal, and scalp/nasopharynx throughout the procedure. The same approach was extended in a preclinical rodent model to measure temperature changes in vivo. Finally, numerical analysis of temperature changes in the inner ear in response to external, transcanal cooling are discussed.

Results: In the preclinical rodent and cadaveric models, the cooling applied using the catheter reduced the temperature at the inner ear by 4ºC. In the cadaver samples, we observed between 3-6ºC drop in temperature across the semicircular canals and the auditory system. The finite element model closely followed the experimental results.

Conclusion: The results from our study indicate that efficacious delivery of MTH to the inner ear endorgans during surgical procedures is feasible with a transcanal approach. This approach will be utilized in the first-in-human studies at the University of Miami to ascertain safety and efficacy of MTH for residual hearing preservation.

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M-T 48: LONG-TERM USE OF COCHLEAR IMPLANTS IN OLDER ADULTS

Maya G. Hatley[1], Emily R. Spitzer[2], Susan B. Waltzman[2]

[1]NYU Grossman School of Medicine, New York, NY, 10016 USA
[2]Department of Otolaryngology-HNS, NYU Grossman School of Medicine, New York, NY, USA

Objective: Rates of hearing loss in the elderly population are estimated to be 60-70%, while the proportion of this population with hearing loss severe enough to be a candidate for a cochlear implant (CI) is estimated to be around 10%. One concern regarding auditory outcomes in elderly CI users is the potential for their performance to decline over time due to age-related factors such as increased medical comorbidities, decreased cortical plasticity, or cognitive decline. The objective of this study is to evaluate long-term speech perception performance and the stability and potential mediating factors of this performance in CI users >= 60 years old at the time of implantation.

Methods: In this retrospective study, the charts of all patients implanted at our institution between 2006-2024 were reviewed, and those who were >= 60 years old at the time of surgery and had audiologic follow-up for >= 10 years were included (n=107). The main outcome measure was unilateral (CI-only) speech perception scores as measured with Consonant-Nucleus-Consonant (CNC) word testing in quiet at 10-years postoperatively in comparison to scores preoperatively and at 1- and 5-year follow-ups. Additional data collected on chart review included demographics and cognitive status, medical co-morbidities, residential circumstances, and employment at the most recent appointment.

Results: The mean age of these patients at implantation was 70.4 years (standard deviation (SD): 6.5 years), and the mean duration of CI experience was 12.7 years (SD: 2.7 years). The mean CNC scores at 1-, 5-, and 10-years postoperatively were 59.04% (SD: 21.1), 62.04% (SD: 19.6), and 62.37% (SD: 19.9), respectively. Scores were significantly improved from preoperative scores at 1- ($d = 51.68$, $p < 0.0001$), 5- ($d = 54.69$, $p < 0.0001$), and 10-years ($d = 55.01$, $p < 0.0001$) postoperatively, and CNC scores at these postoperative time points were not significantly different from one an-other. Age over 70 at implantation was not shown to have a significant effect on CNC scores at any time point postoperatively compared to those implanted earlier than 70 years old ($F(3, 254) = 0.3800$, $p = 0.7675$). Increased daily usage of the CI at the most recent follow-up appointment was shown to be associated with higher CNC scores at 1- ($r = 0.435$, $p<0.0001$), 5- ($r = 0.451$, $p < 0.0001$), and 10-years ($r = 0.491$, $p < 0.0001$) postoperatively. On the other hand, inability to live independently at the most recent follow-up appointment was associated with significantly lower CNC scores at 5- ($d =16.68$, $p = 0.004$) and 10- years ($d = 14.95$, $p = 0.0283$) postoperatively.

Conclusions: In patients who were implanted at >= 60 years old with 10 or more years of CI experience, speech recognition scores were shown to be stable up to 10 years postoperatively. Age at implantation was not shown to have a significant effect on speech perception scores. However, factors associated with better speech perception at 10 years postoperatively may include increased daily usage of the CI and the ability to live independently.

M-T 50: HIGH-RESOLUTION MODELS OF HUMAN COCHLEA FOR STUDYING NEURAL ACTIVATION

Siwei Bai[1,2], Albert Croner[1,2], Carmen M Castañeda González[1,2], Mahdi Fallahtaherpazir[3], Rudolf Glueckert[3], Anneliese Schrott-Fischer[3], Werner Hemmert[1,2]

[1] Bio-Inspired Information Processing, School of Computation, Information and Technology, Technical University of Munich, Garching, Germany
[2] Munich Institute of Biomedical Engineering, Technical University of Munich, Garching, Germany
[3] Department of Otorhinolaryngology, Medical University of Innsbruck, Innsbruck, Austria

Cochlear implant users usually regain the ability to understand and use spoken language with or without visual aid, but there remains a wide variability in CI user performance after implantation. Factors that lead to such variability may be evaluated with the help of computational models of human cochlea. In order to develop the most realistic cochlea models, high-resolution three-dimensional scans of human cochlea are essential.

Freshly excised human temporal bones were stained with OsO_4 and decalcified in EDTA. The processed specimens were then scanned using an XRadia MicroXCT-400 at 45 kVp with an isotropic voxel size of 15 μm. Anatomically realistic models were reconstructed from eight sets of the μCT scans, and the finite element method was used to simulate how the current delivered by CI electrodes spread inside the cochlea. 500 spiral ganglion neurons were automatically traced in every cochlea model, and biophysical multi-compartment model was implemented to simulate the biophysical response of neurons to a single monopolar biphasic pulse delivered externally. At the same time, psychophysical measurements were performed on CI users to measure both the detection threshold and the maximum comfortable level with a single biphasic monopolar pulse.

With the aid of a linear mixed-effects model, we were able to statistically match the measured detection threshold and maximum comfortable level with the simulated current amplitude at specific levels. Interestingly, degeneration did not lead to statistical significance in the shifts in excitation amplitude in general. By analyzing the correlation between stimulus amplitude and a number of morphological parameters using Kendall's tau coefficient, our simulations suggested morphological differences alone accounted for large variations in the measurement of electrical dynamic range.

Our findings provided an in-depth insight into the electrical excitation of large neuron populations. They are relevant for all types of electrical and optogenetic stimulation paradigms. Further development of the models can aid us in the advancement of the next generation of CIs and coding strategies. In addition, our spectacular visualizations provide detailed and illustrative insights into the function of the most delicate sensory organ.

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M-T 51: IMPACT OF CENTRAL AUDITORY ATTENTION ON LISTENING EFFORT AND SPEECH PERFORMANCE IN COCHLEAR IMPLANT USERS

Yue Zhang[1], Amparo Callejón-Leblic[2], Ana M Picazo-Reina[2], Sergio B Trejo[2], Serafín Sánchez-Gómez[2]

[1] Cochlear, Vallauris, France
[2] Virgen Macarena University Hospital, Seville, Spain

Objective: Despite constant technological innovations, cochlear implant (CI) users continue to report high listening effort, especially in noisy conditions. Normally hearing (NH) and hearing-impaired (HI) listeners have shown that the relation between speech performance in noise and listening effort (as measured by peak pupil dilation) is not linear and exhibits an inverted-U shape. A previous study suggested that CI users also displayed such pattern, but individual differences in central cognitive, peripheral auditory abilities and quality of life affected the relationship. Current results further investigate the impact of central attention, measured by cortical auditory evoked responses (CAEP) and baseline pupillary response, on listening effort and speech performance.

Methods: 17 post-lingually deaf CI adults performed speech-in-noise tasks from 0 to 20 dB SNR with a 4 dB step size. Simultaneously, their pupillary responses were recorded, both during baseline period (i.e., listening to background noise) as indication of attention and task evoked period (i.e., listening to target sentences embedded in noise) as indication of listening effort. Spectro-temporal modulation task, a set of cognitive abilities (Nback, Stroop word-colour test and Matric progression), Quality of Life, and CAEP responses at 500Hz, 1000Hz and 4000Hz were measured. To characterize how attention varied across speech-in-noise tasks, pupil baseline changes from 1st to 20th sentences in each block were fitted with a linear shape and the coefficient corresponded to the rate of baseline decline. Correlation analysis was performed to investigate how cortical evoked and central attention was associated with listening effort and speech performance.

Results: Preliminary analysis showed that older age, longer CI duration and better working memory efficiency were associated with slower decline of pupillary baseline within a block. Shorter P1, N1 and P2 latency were related to quicker behavioural response time of Stroop test. Smaller N1_P2 amplitude was related to better Stroop correct score. Analysis is still ongoing.

Conclusions: This study aims to characterize how central attention, measured by cortical evoked responses and pupillary responses, is affected by individual differences and contributes to listening effort variations during speech in noise recognition. Results will inform future studies and clinical practice on important clinical predictors of CI hearing outcomes.

M-T 52: THE EFFECT OF BROADBAND AND FREQUENCY-SPECIFIC DELAY COMPENSATION IN BIMODAL CI USERS

S. Zirn [1], F. U. Mueller[1,2], S. Roth [1,2], J. Angermeier [1,3], W. Hemmert[2]

[1] Peter Osypka Institute of Medical Engineering, University of Applied Sciences Offenburg, Germany
[2] School of Computation, Information and Technology,
Technical University of Munich, Munich, Germany
[3] Osypka AG, Rheinfelden, Germany

Background: Angermeier et al. (2023) demonstrated that the bias in sound localization towards the faster modality in subjects provided with a CI ipsi- and a hearing aid contralateral can be reduced when the faster modality is delayed by a broadband delay. But actually, the mismatch varies across frequencies, due to frequency-dependent cochlear delays on the acoustic hearing side. Although some manufacturers' filter settings take these latencies into account, the individual electrode positions and their corresponding frequencies must be considered to determine appropriate frequency-dependent delays that can be applied to the CI's bandpass filter bank.

Methods: The present study evaluates the effects of broadband and frequency-specific delay compensation on sound localization performance in bimodal users. Dedicated CI fitting software features are used to compensate the temporal and frequency mismatch between the two modalities, based on computed tomography imaging and HA latency measurements.

Results: Preliminary findings indicate that broadband delay compensation alone yields the main improvement in signed localization bias (SB) and root mean square error. However, individual cases show further reductions in SB, when frequency-specific delays are used.

Conclusion: Whereas broadband delay compensation offers quick improvements in sound localization in almost all bimodal listeners, frequency-specific delay compensation is methodologically much more complex and has so far only proved useful in a subgroup. However, frequency-specific delay compensation sometimes offers further improvements, especially for test subjects with shorter electrode arrays.

Reference:

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M-T 54: FOCUSED THRESHOLD PROFILES RELATE TO VOWEL IDENTIFICATION CONFUSIONS IN ADULT COCHLEAR IMPLANT LISTENERS

Andrew M. Burleson, Charles Hem, Caylin McCallick, Julie Arenberg

Harvard Medical School / Massachusetts Eye and Ear, Department of Otolaryngology Head and Neck Surgery, Eaton Peabody Laboratory

Introduction: Poor electrode-neuron interface (ENI) quality in cochlear implant (CI) users leads to increased current spread, causing reduced spectral fidelity and poorer speech recognition. Focused thresholds, which can serve as a proxy for ENI quality, are elevated for electrodes with greater neural degeneration or electrode-neuron distances. Methods: Focused threshold profiles were measured in 67 postlingually deafened adults using Advanced Bionics CIs. The fast, sweep procedure validated in Bierer et al., 2015 was used with a focusing coefficient of sigma=0.9. Profiles were grouped into four clusters based on focused threshold profiles centered by participant mean using generalized additive mixed modeling (GAM). The four clusters were defined by the shape of the threshold profile rather than threshold magnitude. Medial vowel identification performance was obtained in a subset of 28 participants in the presence of +10 signal-to-noise ratio with Auditec four talker babble in the /h vowel d/ context. Percent correct was obtained and confusion matrices were analyzed.

Results: Cluster 1 was characterized by a high-arched shape (M = 43.8 dB, SD = 7.7) with thresholds peaking near the center of the array. Cluster 2 exhibited a flat profile across the array (M = 46.1 dB, SD = 5.0), while cluster 3 demonstrated a low-arch shape with thresholds peaking near the mid-array and low basal thresholds (M = 44.4 dB, SD = 6.0). Finally, cluster 4 had high apical thresholds and a downward-sloping pattern (M = 45.8 dB, SD = 5.0). Cluster 1 (high-arched) demonstrated the best performance (M = 76.9% percent correct), with vowel recognition patterns consistent with middle-array degradation patterns observed by DiNino et al. (2016) in vocoded sentence recognition by normal-hearing listeners. Cluster 2 (flat) exhibited moderate performance (M = 67.8%), with diffuse errors across the vowel space. Cluster 3 (low-arched) performed similarly to cluster 1 (M = 73.8%) with error patterns consistent with mid-array degradation. Cluster 4 (sloping) had the lowest overall performance (M = 60.3%), with vowel confusion patterns similar to the similar apical degradation in our vocoder study.

Conclusions: These findings highlight the complex relationship between ENI quality, threshold profile shape, and vowel confusion patterns. Vowel confusion analyses reinforce the importance of assessing the ENI to identify regions of spectral degradation, as listeners tend to shift recognition patterns away from degraded regions toward preserved regions. Tailored programming approaches that account for ENI quality using focused threshold profiles may improve recognition outcomes, patient satisfaction, and quality of life for CI users with suboptimal electrode-neuron interfaces.

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DiNino, M., Wright, R. A., Winn, M. B., & Bierer, J. A. (2016). Vowel and consonant confusions from spectrally manipulated stimuli designed to simulate poor cochlear implant electrode-neuron interfaces. The Journal of the Acoustical Society of America, 140(6), 4404-4418.

M-T 55: OUTCOMES OF COCHLEAR IMPLANTATION IN CHILDREN WITH SINGLE-SIDED DEAFNESS IN A MULTICENTER CLINICAL TRIAL

Jill Firszt, Laura Holden, Noël Dwyer, Tim Holden, Ruth Reeder, Craig Buchman, Pediatric Asymmetric Hearing Study Team

Washington University School of Medicine, St. Louis, MO, USA

Objective: Children with single-sided deafness (SSD) have impaired binaural cues, which de-grades communication in daily life. Consequences of SSD in children include increased difficulty with speech recognition in noise and localization, both of which may contribute to increased listening effort and fatigue. While some evidence suggests benefit from a cochlear implant (CI) for children with SSD, guidelines regarding candidacy criteria, assessment tools and expected out-comes are not well defined. Currently, we are conducting an FDA-approved, prospective clinical trial to evaluate behavioral outcomes in children with SSD who receive a CI.

Methods: This clinical trial is a multicenter, two phase, longitudinal study, comprised of five sites. A hearing aid (HA) phase assesses performance with current HA technology and is followed by a CI phase. Up to 40 children, ages 4-14, with SSD will be enrolled. Hearing criteria for the poor ear expands the current FDA-approved criteria. Objective and subjective measures are designed to elucidate communication challenges encountered by children with SSD, including word understanding at soft levels, speech understanding in spatially separated noise, and localization/lateralization. To better characterize the impact of SSD, quality of life assessments are administered twice during the HA phase and twice during the CI phase.

Results: Data collection is ongoing. To date, 34 children with SSD have enrolled. Twenty-nine children have completed the HA phase. For the CI phase, the following are complete: 27 CI surgeries and initial activations, 26 3-month CI evaluations, 25 6-month evaluations, and 23 12-month evaluations. Group mean results for the poor ear indicate improvement in audibility after 3 months CI use compared to using a HA. Word recognition for the CI-alone condition is significantly improved after 12 months. Datalogging indicates that wear time is higher with a CI than devices worn during the HA phase. In the bilateral condition, after 3 months CI use, some participants show increased lateralization abilities and speech in noise improvements; however, considerable variability exists. The Speech, Spatial and Qualities of Hearing Scale probes speech recognition in various sound environments. Parent ratings are substantially higher at 6-months post compared to pre-CI. The Hearing Environments and Reflection of Quality of Life includes subscales that address the impact of SSD on various environments, activities, social interactions and feelings. The Peds Quality of Life Inventory-Multidimensional Fatigue Scale examines general fatigue, sleep/rest fatigue and cognitive fatigue. The Vanderbilt Fatigue Scale was developed for children with hearing loss to quantify mental fatigue and physical listening related fatigue. Initial questionnaire results generally support higher (worse) parent ratings pre-CI compared to 6-months post-CI, with significance observed for the subscales of general fatigue and mental fatigue. Results of the Bern Benefit Questionnaire for SSD show that parents rate benefit of device technology as better with a CI than a HA. However, areas that parents' rate as difficult for their child vary and reveal individual differences among children.

Conclusion: A multicenter clinical trial is underway to prospectively quantify outcomes and investigate factors affecting successful use of a CI in children with SSD. Quality of life questionnaires provide additional unique information for each child with SSD and further quantify the consequences of SSD. Study results will provide new information to inform and improve clinical management and treatment of children with SSD.

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M-T 56: PREDICTING AUDITORY NERVE FIBER ACTIVATION THRESHOLD IN IMAGE-BASED COCHLEAR IMPLANTS MODELS USING MLP

Minh Vu, Erin L. Bratu, Jack H. Noble

Department of Electrical and Computer Engineering, Vanderbilt University, Nashville, TN 37235, USA

Objective: Speech recognition rates (SPR) vary greatly among cochlear implant recipients. Channel interaction is known to impact SPR. Image Guided Cochlear Implant Programming (IGCIP) leverages patient-customized modeling of the electro-neural interface to customize programming to attempt to reduce channel interaction [1]. CT images and electrophysiological measurements from the CI are used to account for patient-specific electrical properties and electrode positioning. We're currently developing a custom channel activation ordering selection scheme based on model estimated neural refractory state predictions that aims to reduce refractory induced channel interaction in each stimulation frame. A critical modeling step is the prediction of the threshold current at which different fiber bundles generate a detectable response given the predicted voltage pattern for each unique fiber bundle-stimulating electrode pair. The threshold is calculated through iterative simulation of nerve fibers' responses to the electrical signal using the NEURON package [2,3]. This process is computationally time-consuming. In this work we devel-op and test a multi-layer perceptron (MLP) neural network that aims to predict the nerve fiber activation threshold directly from the voltage pattern. The MLP is trained using the NEURON-calculated thresholds from 6 patients, augmented with varying tissue resistivity parameters and CI electrode locations. Our goal is to reduce computation time, allowing for model creation and patient-specific programming recommendations during a single patient visit.

Methods: We propose a 5-layer MLP network. Our network takes in potential distribution along a single bundle of nerve fibers. We model a total of 75 nerve bundles, each composed of hundreds of fibers, along the length of the cochlea. Each fiber is assumed to consist of 85 nodes of Ranvier. Our training set is constructed using thresholds predicted for each bundle using the NEURON package. Our training set is also augmented by generating results for 35 different sets of assumed tissue resistivity parameters and 4 different cochlea implant electrode locations. We validate our results using leave-one-out method within the 6 patients and 2-fold cross validation within each patient's dataset to simulate custom fit models.

Results: Our method managed to generate threshold values that averaged 78.20 ï,± 20.58 mV in mean ab-solute error (MSE), which translates to around 8% in mean absolute percentage error (MAPE), with the leave-one-out validation process. For 2-fold cross validation and single patient training/testing, we narrow down to an average 52.09 ï,± 15.01 mV, which is around 5% in MAPE. Our leave-one-out model's results also have an R2 value of 92%, indicating that the model can accounts for 92% of the variation in our threshold dataset. We are also conducting ongoing investigation in comparing the output of our channel order optimization algorithm based on our MLP predictions versus the traditional method.

Conclusions: With a dataset of 6 patients, we generated threshold values that are within 8% of the traditional model output, while greatly reducing the computational overhead from hours to seconds. The reduction in computing time would help enable same-day customized programming.

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M-T 58: BINAURAL FUSION IN SINGLE-SIDED DEAF COCHLEAR IMPLANT USERS

Lucrèce de Villars[1], John Galvin[2,3], Qian-jie Fu[3,4], Faustine Legrand[5], Mathieu Robier[5], David Bakhos[1,2,3]

[1]CHRU de Tours, France
[2]INSERM U1253, Université de Tours, France
[3]House Institute Foundation, Los Angeles, CA, USA
[4]David Geffen School of Medicine, UCLA, Los Angeles, CA USA
[5]Audilab, Saint-Pierre-des-Corps, France

Objective: While binaural fusion has been studied in bilateral and bimodal cochlear implant (CI) users, it has yet to be investigated in single-sided deaf (SSD) CI patients, for whom fusing acoustic and electric stimulation patterns may be difficult. Poor binaural fusion leads to deficits in sound localization, speech understanding in noisy environments, spatial perception, and quality of life. Given the differences in stimulation patterns with acoustic hearing (AH) and the CI, fusion may be quite challenging for SSD CI users. Fusion may also be affected by different stimulus types. For example, sound quality differences across AH and CI ears may be quite different for pure-tone stimuli than for noisy stimuli. In the present study, binaural fusion was measured for 20 different speech and non-speech stimuli (environmental sounds, sentences, pure tones, words) to evaluate how acoustic and linguistic properties of stimuli influence the fusion in SSD CI participants. Similarity ratings were collected with the AH and CI ears for the same stimuli used to measure binaural fusion. We hypothesized that fusion would be significantly correlated with the degree of similarity of the stimulation patterns in the AH and CI ears.

Methods: Eight adult SSD CI users participated in the study. Binaural fusion was measured using direct audio input to the CI ear and insert earphone to the AH ear; stimuli were simultaneously presented to both ears. Multiple speech and non-speech stimuli were used to measure fusion. A three-stage method was used for each test trial. First, listeners indicated whether they heard one or two auditory images. Second, listeners indicated how diffuse the sounds were in each ear. Third, listeners lateralized the sounds in a virtual space. Similarity ratings between the AH and CI ear were obtained for the same stimuli used to measure binaural fusion. Quality of life was assessed using speech, spatial, and qualities of hearing (SSQ) questionnaire.

Results: Binaural fusion and similarity ratings were highly variable across participants. Across all participants and stimuli, a single auditory image was perceived only 40.23 ± 38.46% of the time. Sensitivity to stimulus types varied greatly across participants, but in no consistent manner. The mean diffusion index of all stimuli showed a small-to-moderate diffusion of stimuli that was highly variable across participants. Diffusion was significantly larger for words and environmental sounds than for sentences and tones. When one image was perceived, stimuli were generally lateralized towards the center. When two images were perceived, the mean lateralization was 57.11 ± 56.67 degrees relative to center, with no effect of stimulus type. Again, lateralization was highly variable across participants. Similarity ratings were significantly correlated with fusion (percent perception of one auditory image) only for the word stimuli. The total SSQ score was 6.28 ± 1.95. There was no significant association between SSQ scores and binaural fusion.

Conclusions: Binaural fusion in the present SSD CI users was much less than observed in previous studies with bilateral CI users. There was great inter-subject variability between those participants in terms of binaural fusion and similarity ratings, which was correlated only for the word stimuli. Poor fusion may be due to differences in stimulation patterns between acoustic and electric hearing, interaural frequency mismatch, and/or limited adaptation to the CI. Further studies are needed to better understand and improve the poor binaural fusion observed in SSD CI users.

M-T 59: PERCEPTUAL CUES UNDERLYING COCHLEAR IMPLANT USERS' AND NORMAL HEARING LISTENERS' ABILITY TO DISTINGUISH REVERBERANT ROOMS

B. K. Prajna, Justin M. Aronoff

Department of Speech and Hearing Science, University of Illinois Urbana-Champaign, Champaign, IL, USA

Our ability to comprehend speech (or any target sound of interest) in reverberant environments depends, in part, on separating the reverberant characteristics of the space from those of the target speech. While reverberation (late reflections introduced by a room) generally introduces similar types of distortions, different rooms uniquely affect the signal due to their specific transfer functions (or, impulse response functions). Segregating the effects of the room from the distorted speech requires identifying the room's unique perceptual characteristics, which are influenced by acoustic features in the distorted signal. These features include the rate of decay of sound energy, increased energy in certain frequency regions compared to others, and reduced modulation depths. Based on these characteristics, two rooms can be distinguished by the specific distortions they introduce. Understanding how effectively listeners can differentiate between rooms and what acoustic cues primarily drive this perception can help identify the critical cues necessary for room characterization.

In cochlear implant (CI) users, the signal undergoes further alterations due to signal processing stages, such as bandpass filtering, envelope extraction, and dynamic range compression. These stages may affect the fidelity with which reverberant distortions are represented, potentially influencing CI users' ability to characterize and differentiate rooms.

This investigation aims to identify the acoustic features of reverberant speech that influence the perceptual differentiation of rooms. Five normal-hearing (NH) listeners and Five CI users were tested. Room impulse response functions of eight rooms of varying reverberant characteristics were convolved with a sentence and the resulting signal was presented in random pairs in each trial. Participants in both groups were tasked with rating the similarity of pairs of rooms on a scale of 1 to 7 in each trial and completed four such blocks with 128 trials each. Multidimensional scaling analysis was then performed to determine the number and characteristics of the perceptual dimensions necessary to capture the room differences and whether they differ between the NH and CI listeners.

Preliminary results indicate that NH listeners' perception of a room is influenced by its reverberation time, early decay time, and speech clarity index (measured using D50) in the mid-frequency range (~350-1500 Hz), which is least absorbed by typical rooms compared to low and high frequencies. For CI users, room perception was also correlated with early decay time and speech clarity in the mid-frequency range. However, unlike NH listeners, CI users' perceptual characterization of the room did not correlate with reverberation time across all frequency ranges. This may be a consequence of the effects of CI processing on the reverberation tail.

M-T 60: THE EFFECT OF ELECTRODE LENGTH, NUMBER OF ELECTRODES, AND FREQUENCY RANGE ON BOTH SPECTRAL REPRESENTATION AND SPECTRAL RESOLUTION

Emily R. Spitzer, David R Friedmann, Madeleine Campbell, David M. Landsberger

New York University Grossman School of Medicine, New York, NY USA

Background: There is considerable research into how to improve cochlear implant (CI) outcomes. Recent directions include "anatomy-based" fitting, electroacoustic stimulation (EAS), and channel deactivation based on objective or perceptual measures. These manipulations often involve changing the frequency allocation of the CI, the effective "length" of the electrode, or the number and/or locations of active electrodes in the cochlea. Perhaps without intention, the spectral representation of the signal usually changes as a result. Spectral representation refers to the physical output of the CI in terms of frequency information and is independent of a listener's perceptual ability.

Given that spectral coding is a critical component of outcomes with a CI, it is likely that changes in spectral representation contribute to (if not completely explain) the benefits observed in studies where the frequency allocation, electrode length, or number of active electrodes are manipulated. For example, anatomy-based fitting strategies often reduce the mismatch between spiral ganglion-based place-pitch and CI place-pitch by increasing electrode length or reducing the frequencies presented. However, both manipulations improve spectral representation by creating increased separation between locations in the cochlea in which frequencies are represented. Through a similar mechanism, raising the low-frequency cutoff for an EAS patient will also improve the spectral representation provided by an electrode array by reducing the frequency range represented for a fixed cochlear length. To aid interpretation of these studies, it is important to understand the effect of changing electrode length, number of channels, and frequency range on spectral resolution, the perceptual correlate of spectral representation.

Methods: Models of spectral representation within the cochlea were derived from estimates of various electrode insertion depths (161, 279.9, or 380.5 degrees), number of electrodes (11, 17, or 22) and frequency allocations (188-7938 Hz or 438-7938 Hz). Multiple combinations of these parameters were created to measure the effect of manipulating each variable independently. Spectral resolution was measured with two common broadband tests (SMRT and QSMD) for standard-length electrode maps corresponding to each of the models.

Results: Consistent with the model, increasing the length of electrode coverage, increasing the number of electrodes, and decreasing the frequency range improved scores on both SMRT and QSMD. Scores on the two tests were highly correlated, suggesting that both metrics are sensitive to spectral resolution. The slope of an angle-to-frequency function was calculated as a proxy for spectral representation. The slopes were correlated with SMRT and QSMD scores, implying better spectral representation was related to better spectral resolution.

Conclusions: Improvements in spectral representation appear to enhance spectral resolution. Spectral resolution has also been shown to correlate with speech perception, making it an important psychophysical ability for measuring CI outcomes. It is crucial to consider how new signal processing algorithms or changes to electrode arrays affect spectral representation, whether intentional or not to better understand perceptual correlates.

M-T 62: EXPLAINING BINAURAL SPEECH BENEFITS FOR COCHLEAR-IMPLANT LISTENERS USING MONAURAL MEASURES OF ASYMMETRY

Matthew J. Goupell[1], Kylie Kelleher[1], Erin Catob[1], Michael A. Johns[2], Sandeep A. Phatak[2], Julianna R. Voelker[2], Joshua G.W. Bernstein[2]

[1] University of Maryland, College Park, MD, USA
[2] Walter Reed National Military Medical Center, Bethesda, MD, USA

Healthy visual and auditory sensory systems capitalize on symmetrical inputs to extract information about the location of objects. Asymmetries could distort auditory spatial maps and disrupt speech understanding in noise in cases of spatially separated target and interfering sound sources. However, it is unclear how to best characterize asymmetry to predict spatial-processing deficits. Bilateral cochlear-implant (BI-CI) and single-sided-deafness-CI (SSD-CI) users provide a valuable model system to study the impact of asymmetry on spatial hearing. Previous studies in CI users have primarily considered asymmetry in speech perception in quiet, with limited success in explaining spatial-hearing outcomes. This study investigated how binaural benefit for speech-on-speech masking is related to several behavioral and objective measures of asymmetry.

The current sample size included 15 bilateral cochlear-implant (BI-CI) and 5 SSD-CI listeners. First, binaural unmasking was measured using a closed-set speech corpus. This paradigm presented a target talker to one ear, and a same-sex interfering talker to just the same ear ("monaural") or to both ears ("bilateral"). The binaural-unmasking benefit was defined as the performance difference between the bilateral and monaural conditions. Next, monaural broadband functional measurements of auditory processing were carried out. This included: (1) open-set sentence perception in quiet, (2) open-set sentence perception in steady-state noise, (3) spectral-temporal modulation discrimination, and (4) electrophysiological electrode-to-neural interface measurements (electrically evoked compound action potential amplitude growth functions, averaged over electrodes). The magnitude of binaural unmasking was compared to asymmetry (across-ear difference in performance) for each monaural measure.

The current analysis was justified for the BI-CI listeners and will be extended when the SSD-CI sample size is appropriate. For the BI-CI listeners, the best (and only significant) monaural predictor of binaural unmasking was asymmetry in sentence perception in noise ($p<0.001$). This result adds another piece to the puzzle of understanding the neural mechanisms that contribute to the large variability in the binaural benefits experienced by BI-CI and SSD-CI users. For the development of predictive and rehabilitative clinical tests of binaural benefit, speech perception in noise might serve as a superior tool to characterize asymmetry than the more commonly used speech perception in quiet.

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M-T 63: THE INTERACTION BETWEEN LISTENING EFFORT AND ROLLOVER IN OLDER ADULTS WITH HEARING LOSS FOR DEGRADED SUSTAINED SPEECH

Natalie A. Field, Matthew J. Goupell, Chengjie G. Huang

Department of Hearing and Speech Sciences, University of Maryland, College Park, Maryland, USA

One of the most common problems affecting people with hearing loss and hearing aids is understanding speech in noise. This can be attributed to the intricacies of speech, and even assuming ideal environmental conditions for communication, there are individual factors associated with the listeners that can affect perception and understanding. Compounding this experience is a phenomenon known as "rollover." Clinically, rollover is used as a retrocochlear diagnostic tool and is defined as a decline in speech recognition when sound level is increased past maximum performance. Recent studies have indicated rollover occurs in the absence of such pathologies for single word tests when presented in noise. Ecologically, the question becomes whether this is present as a hindrance in our everyday dialogues. The primary goal of this project is to understand how increased listening effort modulates rollover for degraded sustained speech. Using a discourse comprehension task at varying presentation levels and signal-to-noise ratios (SNRs) in conjunction with pupillometry, we assessed how listening effort is utilized and sustained over extended timescales.

Participants were recruited within one of three groups, with age being a continuous variable: older normal hearing (ONH), younger normal hearing (YNH), and older with a hearing impairment (OHI). Participants completed a discourse comprehension task employing comprehension questions alongside pupillometry in order to evaluate the effects of rollover and listening effort. Passages were recorded by a single female talker and presented at different sound levels; 35, 55, 65, 75, and 85 dB SPL as well as different SNRs with 4-talker babble: in quiet, -5, 0, and +5 dB.

This study found that rollover is experienced to different extents for those with and without hearing loss as well as across ages. Rollover is especially pronounced across the ONH and OHI groups for the -5 dB SNR condition. Overall, the performance of the OHI participants was lower than that of the YNH and ONH participants. Pupillometry revealed that the ONH and OHI groups exhibit more listening effort at higher levels than that of the YNH group. Furthermore, the separation of pupillometry traces between SNRs in OHI listeners is greater than ONHs and YNHs. This demonstrates that while OHIs utilize more listening effort to perform the task, they do not achieve the same behavioral performance as their ONH counterparts. In addition, the separation of pupillometry traces between SNRs is minimal at 65 dB SPL, and becomes larger as presentation levels increase to 85 dB SPL, especially in ONH and OHI groups, demonstrating a rollover level effect in listening effort. Considering the preceding results, there is likely a Age x Level interaction effect which influences listening effort and behavioral performance.

Given how amplification is used as our primary treatment for hearing loss, the presence of this phenomenon could restrict the benefit users experience, forcing clinicians to look toward the next step: cochlear implants. Furthermore, the interaction between cochlear implants and rollover is not fully understood. For this purpose, we will expand testing to include our YNH participants completing the task with vocoded speech. Ideally, this will offer some perspective on the potential interaction between rollover, listening effort, and cochlear implants.

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M-T 64: LINKS BETWEEN MUSIC INTERVENTION, INFORMAL MUSIC ACTIVITIES, SINGING PITCH ACCURACY, AND SEMANTIC VERBAL FLUENCY

Ritva Torppa[1], Li Xu[2], Lotta Keitilä[1], Valerie Looi[3]

[1]University of Helsinki, Finland
[2]Ohio University, Athens, Ohio, USA
[3]Spiral Therapeutics, San Francisco, USA

Objective: Children with hearing loss (HL) often demonstrate poor singing pitch accuracy and music perception, with many also struggling with poor language skills. Music intervention and informal music activity participation have shown potential to enhance these skills. We investigated the links between singing-based music intervention, the frequency of informal music activities, singing pitch accuracy, and semantic verbal fluency performance in children with bilateral HL.

Participants: The participants of the two studies presented here were children aged under 7 years with bilateral HL (bilateral cochlear implants, hearing aids, or bimodal devices) (N = 18 in study 1; N = 36 in study 2) and children with normal hearing (NH) (N = 20 in study 1; N = 43 in study 2).

Methods: Only children with HL participated in remote or in-person music intervention conducted over a 10-week period. This intervention was based on singing. A crossover study design was employed, with a waiting or follow-up period established before or after the intervention, respectively. The measurements were conducted three times, before and after each period (at T1, T2 and T3). Children with NH were measured only once. In Study 1, children sang the song "Twinkle twinkle little star", and their singing pitch accuracy was measured following the methodology in Xu et al. (2022). Mean note deviation assessed the accuracy of each individually sung note, with mean interval deviation assessing the accuracy of the relatively pitch between two consecutively-sung notes (e.g. C4 - F4 = 4th) averaged across the sung sequence. A mean of these was used in statistical analyses. Both studies assessed language skills using semantic verbal fluency tasks where children listed words belonging to a given semantic category (animals or clothes) within one minute. The number of correct words was calculated and used in statistical analyses. Both studies also used a questionnaire requiring parents to rate the frequency of their child's participation in informal music activities (e.g., spontaneous or informal singing by the child (i.e. not in a singing lesson or choir), making music performances for fun, and listening to music). A mean of the frequency of these activities was used in statistical analyses. Study 2 also included a questionnaire for parents to rate their child's perception of pitch and loudness in music.

Results: Study 1 showed that surprisingly, the singing pitch accuracy of the bilateral HL group was similar to children with NH at T1, and there were no significant effects of intervention vs. waiting period on scores for mean note/interval deviation. The Linear Mixed Modelling (LMM) showed that the more children with HL participated in informal music activities, the better their singing pitch accuracy (main effect of informal music, $p = .031$), and the better they were at the semantic verbal fluency task, the better their singing pitch accuracy (main effect, $p = .010$). The preliminary results from Study 2 indicate that prior to the intervention, children with HL performed more poorly in semantic verbal fluency, melody and loudness perception tasks than their NH peers. For children with HL, music intervention resulted in improved performance on these tasks, as well as increased their informal music activity levels (outside of the intervention itself). Statistical analyses has yet to be conducted as Study 2 is still in progress. No significant changes were observed for these measures during the waiting or follow-up period.

Conclusions: The results from Study 1 indicate that informal music activities and language skills are important for singing pitch accuracy of children with HL, which was surprisingly good plausibly because of their participation regularly in informal music activities already before the study began, leading to null-results regarding the music intervention. The preliminary results from Study 2 so far indicate that this cohort of children with HL performed poorer than the children with NH, but that the music intervention was helping to improve their language and music perception skills. Taken together, the results of both studies continue to support existing research demonstrating the benefits of music participation to improve semantic verbal fluency, regardless of whether the music participation is formal or informal in nature.

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M-T 65: BEHAVIORAL AND NEURAL PROCESSING OF PITCH RELATIONS WITHIN SPECTRALLY SPARSE MUSICAL CHORDS IN COCHLEAR IMPLANT LISTENERS

Marie-Luise Augsten, Martin J. Lindenbeck, Bernhard Laback

Acoustics Research Institute, Austrian Academy of Sciences, Vienna, Austria

Musical harmony is essential in western music perception. However, in cochlear implant (CI) listeners, harmony perception is severely limited. One potential limitation in CI listeners is that the simultaneous occurrence of music chord components (voices) leads to complex interactions between electrodes in the cochlea, especially for stimuli composed of broadband real-world sounds such as piano tones. A possible solution might be a reduction of spectral complexity of sounds. In a previous study, we showed that behavioral discrimination of two successive loudness-balanced musical triads (i.e., three simultaneous complex tones) was higher for triads with low spectral complexity (i.e., three spectral components per voice) compared to triads with higher spectral complexity (i.e., nine spectral components per voice).

The aim of the current study was to further investigate perception of spectrally sparse musical triads in CI listeners by targeting higher-level harmonic integration instead of only peripheral discrimination. To that end, we measured behavioral as well as neural responses to changes in tone relations of triad voices in an oddball paradigm.

So far, we tested eight post-lingually implanted CI listeners and ten normal-hearing (NH) controls. Participants were presented with frequent standard triads and infrequent deviant triads. Depending on the task, standard triads were either (A) physically similar (i.e., identical major chords), (B) structurally similar (i.e., major chords) but arranged at continuously ascending or descending F0s, or (C) structurally similar (i.e., major chords) but arranged at randomly varying F0s. Deviant triads differed from standard triads by one semitone in one or two voices and were, thus, structurally different (i.e., with respect to voice relations) from standard triads. Critically, the design of tasks B and C procedurally ensured that participants judge voice relations rather than track individual voices, with task C exhibiting the highest need for abstraction or harmonic integration. Participants responded by keypress whenever they perceived a deviant triad. In addition to behavioral judgements, we investigated neural activity by using electroencephalography (EEG).

Results of both NH and CI listeners yielded significant behavioral sensitivity in all tasks, with highest sensitivity in task A and lowest sensitivity in task C. Although performance was lower in CI than NH listeners, results show that CI listeners can process voice relations within spectrally sparse musical chords. Analysis of EEG data is ongoing and will be discussed.

M-T 66: NOVEL METHOD FOR PRECISE IN-SITU INTRACOCHLEAR THERAPEUTIC DELIVERY ANALYSIS

Peter Baumhoff[1], Per Cayé-Thomasen[2], Peter Erfurt[1], Wiebke Konerding[1], Andrej Kral[1], Charlotte Amalie Navntoft[3]

[1] Department of Experimental Otology and Institute of AudioNeuroTechnology, Clinics of Otolaryngology, Head and Neck Surgery, Hannover Medical School, Hannover, Germany
[2] Department of Otorhinolaryngology, Head & Neck Surgery and Audiology, Rigshospitalet, Copenhagen University Hospital, Copenhagen, Denmark
[3] Eriksholm Research Centre, Oticon A/S, Denmark

It is increasingly common to combine cochlear implantation with treatments to enhance cochlear health, preserve residual hearing, or promote regeneration. These methods often require precise delivery of therapeutics directly to intracochlear target structures. Similarly, cell therapy for the auditory nerve necessitates direct delivery into Rosenthal's canal, the modiolus, or the internal auditory canal. In preclinical studies, developing delivery methods is complicated by difficulties in quantifying injectable volumes and retention at the application site. Conventional histological techniques are limited, as tissue preparation can result in the loss of applied substances and hinder accurate volume assessment. This study presents a method using micro-computed tomography (micro-CT) and histology for precise localization and quantification of microvolumes in cadaveric animal models and human temporal bones.

To establish a route for administering small volumes to the modiolus (Caye-Thomasen et al., 2025, ON, in press), we used microspheres (15-48 µm diameter) made of glass or stainless steel. In guinea pig cochleae (n=2), glass microspheres mixed with hydrogel (<2 µl) were injected using a 10 µl Hamilton syringe (30G blunt needle) and an automated injection pump. In human temporal bones, glass (n=2) and stainless-steel microspheres (n=3) mixed with Hank's Balanced Salt Solution and hydrogel (0.6-2 µl) were injected using a 24G blunt needle. Micro-CT imaging (<20 µm/voxel) determined injection sites and volumes, which were verified with histological analysis of micro-sliced, epoxy-embedded samples.

Micro-CT imaging enabled 3D reconstruction, precise localization, and volume quantification of injection sites. In guinea pigs, glass microspheres provided strong contrast against surrounding tissue and bone. In human temporal bones, higher bone density and size made visualization of glass microspheres more challenging, but stainless-steel microspheres offered improved localization and volume accuracy. Retained volumes in the modiolus reached up to 97% of the injected volume after optimization. Leakage outside the modiolus was detectable down to individual microspheres. Steel microspheres caused minimal imaging artifacts, allowing visualization even in CI-implanted temporal bones.

This study highlights the utility of glass and steel microspheres for investigating intracochlear therapeutic applications. Micro-CT imaging enabled precise 3D analysis of location, distribution, and volume. Glass microspheres are particularly suited for in vivo applications and longitudinal tracking in animal models, while steel microspheres are advantageous for human temporal bones due to their enhanced visibility. Overall, microsphere injection offers a powerful tool for preclinical research into intracochlear delivery methods.

Caye-Thomasen, P., Erfurt, P., Baumhoff, P., Kral, A., & Navntoft, C. A., 2025: Surgical transcanal procedure for injection of cells and substances into the human cochlear modiolus. Otology & Neurotology, (in press).

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M-T 67: ANATOMICAL AND COCHLEAR IMPLANT PLACEMENT ANALYSIS USING NAUTILUS: AN AUTOMATIC IMAGE ANALYSIS TOOL

R. Hussain[1*], R. Kamraoui[1], J. Margeta[2], R. Calixto[1]

[1]Advanced Innovation, Cochlear, 2720 Chem. de Saint-Bernard, 06220 Vallauris, France
[2]Research & Development, KardioMe, Trencianska 82/21, 01851 Nova Dubnica, Slovakia

Knowledge about intra-cochlear anatomical variability and electrode placement through automated image analysis is crucial for improving clinical outcomes in cochlear implant patients and reducing trauma. Pre- and post-operative CT image analysis plays a pivotal role in ensuring the success of these delicate procedures. Preoperative CT scans allow for detailed assessment of cochlear anatomy, aiding in the selection of suitable electrode arrays and insertion trajectories, while postoperative CT imaging confirms correct electrode placement and identifies complications such as electrode fold, scalar dislocation, or flap necrosis.

This study analyzes 2000 clinical preoperative CT/CBCT images and 500 postoperative images implanted with EA22 and EA32 electrode arrays (Cochlear Ltd, Australia) using a semi-automatic web-based image analysis tool [1] (Nautilus, Cochlear Ltd, Australia). Global and local cochlear size and shape parameters were obtained to perform regression and correlation analysis. The analysis revealed that cochlear morphology generally follows a Gaussian distribution, and the scala tympani size varies considerably, generally decreasing along the insertion depth, with a mean radius of 0.43 mm, 0.49 mm, 0.47 mm, 0.32 mm near the 180 deg, 360 deg, 450 deg, 720 deg insertion angles respectively. Preliminary postoperative analysis revealed a mean insertion depth of 366 ± 66° (median = 363°; n=48 EA22, n=44 EA32). The EA22 had mean distances to the approximated spiral ganglion and basilar membrane locations of 1.82 ± 1.08 mm and 0.26 ± 0.32 mm (n=48) respectively, while the EA32 had respective mean distances of 0.96 ± 0.48 mm and 0.36 ± 0.28 mm (n=44). Electrode array trajectories and cochlear centerlines associated with different key landmarks such as basilar membrane, modiolar and lateral walls were also analyzed to assess the spiral curvature. These analyses are essential for verifying accurate electrode placement and modiolar proximity and ensuring optimal auditory outcomes.

This study, the largest database analysis to date, investigates the variability and correlation of cochlear parameters and electrode placement using deep learning-based automated image analysis tools. Our results provide important insights into cochlear morphology, electrode placement and implant development, crucial for reducing insertion trauma and preserving residual hearing, ultimately enhancing the effectiveness of cochlear implants.

M-T 68: RECONSTRUCTING PERCEPTUALLY INTEGRATED CONSONANTS BY COCHLEAR IMPLANT USERS WITH CONTRALATERAL HEARING AID (BIMODAL HEARING)

Caroline Grady[1], Magdeline Schwarz[1], Corinne Cancila[1], Allison Leach[1], Benjamin Estell[2], Yang-Soo Yoon[1]

[1]Department of Communication Sciences and Disorders, Baylor University, Waco, TX, USA
[2]Department of Computer Science, Baylor University, Waco, TX, USA

Objective: In bimodal hearing, speech information processed by a cochlear implant (CI) and a hearing aid (HA) is very different. In the CI ear, differing insertion depth of the electrode array results in an upward shifting of frequency energy relative to the natural tonotopy, leading to distortion of the spectral envelope. In the HA ear, functional residual hearing is typically limited to frequencies lower than 1000 Hz. Thus, auditory systems must integrate different spectral information across electric and acoustic modalities. Currently, there is no method to accurately characterize the integrated percepts of sounds between a CI ear and an HA ear. The objective of this study was to reconstruct spectral contents perceptually integrated across a CI ear and an HA ear in bimodal hearing.

Methods: Adult bimodal users participated in the study. The most frequently used four consonants (/ba, da, pa, ta/ with a common vowel /a/) were used as stimuli. The reverse correlation (RC) technique was used to reconstruct the internal spectral representation of perceived sounds by presenting a subject two sounds: an original sound and 1.5 seconds later, a random sound that RC generates. A subject was asked "Do these two sounds appear similar or not similar?" The first random sound that RC generated was a sound that shares 50% spectral contents with the original consonant. The reconstructed sound was obtained through an averaging procedure over 200 responses, whereby the mean of stimuli eliciting a "different" response is subtracted from the mean of stimuli eliciting a "similar" response. Before beginning the test, a calibration of the computer sound level output was performed. Subjects moved the audio slider until a 1-kHz tone is barely audible, providing a reference point to normalize all future audio stimuli.

Results: Overall, spectra are significantly different between original consonants and RC reconstructed sounds, with substantial differences in the first three formant frequencies. The integrated spectral contents are unique for each user, and variations of the three formant frequencies are somewhat related to residual hearing in the HA ear.

Conclusions: The RC-based integrated spectral contents provide detailed information on how electric and acoustic stimulation interact and interfere, helping the development of efficient clinical fitting protocols tailored to the unique integration abilities of bimodal listeners and enhancing bimodal benefit in speech perception.

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M-T 69: MEET ME HALFWAY - CONNECTING OBJECTIVE BOTTOM-UP AND BEHAVIOURAL TOP-DOWN APPROACHES TO SPEECH PERCEPTION BASED ON TEMPORAL ENVELOPE MODULATIONS

Brent Sterckx[1,2], **Marc Moonen[1]**, **Jan Wouters[2]**

[1]STADIUS, Dep. of Electrical Engineering, KU Leuven, Leuven, Belgium
[2]ExpORL, Dep. of Neurosciences, KU Leuven, Leuven, Belgium

Natural speech is a complex acoustical signal that contains both spectral and temporal information. Temporal information can be subdivided into periodicity, temporal fine structure (TFS) and temporal envelope modulations (TEMs). Among these, especially TEMs are crucial for speech perception as they encode important temporal cues at several different time-scales, i.e. ranges of modulation frequencies. For instance, the TEMs of speech typically contain components at ~4 Hz (250 ms) and ~20 Hz (50 ms), corresponding to resp. the syllable and phoneme rate. TEMs are particularly important for CI users, as current implants primarily convey the temporal envelope of the speech signal. Recent neurophysiological findings suggest a hemisphere-specific specialization for processing distinct ranges of modulation frequencies [1]. Coupled with the typical contralateral dominance of auditory pathways, this specialization may underlie the right-ear advantage observed in speech perception tests. However, it remains unclear how the overall speech perception can be decomposed into the contributions due to the different components of the natural speech signal in each ear.

In contrast to this top-down approach - dissecting natural speech to disentangle the overall performance - a bottom-up approach instead selectively modulates a synthetic carrier signal at specific modulation frequencies to mimic the basic building blocks of the speech signal. This stimulus evokes an auditory steady-state response (ASSR) that is often presented as an objective measure probing the brains TEM processing at that modulation frequency. Yet, it has so far not been shown that the results obtained using these simplistic stimuli are specifically indicative of the contribution of the encompassing range of modulation frequencies of a natural speech signal to the overall performance, or whether they rather reflect a more general measure of the brains ability to process TEMs.

The goal of this study was therefore to decrease the gap between such top-down and bottom-up two approaches to explaining TEM-based speech perception, by on the one hand separating the overall speech perception performance with natural speech into the contributions from each component, and on the other hand to investigate the connection between these individual contributions and the corresponding ASSRs.

In the top-down approach, a framework similar to Chait et al. [2] was used to selectively retain only specific modulation frequency ranges. By selectively vocoding the speech or not, the periodicity and TFS could also be isolated. This allowed to measure the isolated contribution to the speech perception performance that is due to the retained components only, disentangling the overall performance. In the bottom-up approach, modulated speech-weighted noise stimuli were used to elicit ASSRs at modulation frequencies matching the ranges used in the top-down approach. The responses were recorded using EEG.

Together, these complementary approaches aim to provide a more comprehensive understanding of the role of specific TEMs and side of stimulation in speech perception, and to assess the precision of ASSRs as biomarkers for TEM processing.

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M-T 70: MEASURING AUDITORY AWARENESS BY COCHLEAR IMPLANT LISTENERS

Clément Gaultier[1], **Paul Avan**[1], **Tobias Goehring**[2]

[1] Center for Research and Innovation in Human Audiology, Institut de l'Audition, Paris, FR
[2] Cambridge Hearing Group, MRC Cognition and Brain Sciences Unit,
University of Cambridge, Cambridge, UK

Cochlear Implant (CI) listeners typically understand speech well in quiet acoustic settings but often face challenges in background noise and with reverberation [1] as common in work, school, and social environments. These challenges can lead to social isolation and mental health issues. Existing methods to improve speech intelligibility focus on the removal of noise and reverberation via directional processing or speech enhancement techniques [2]. However, these methods can eliminate crucial auditory cues and introduce distortions, that may compromise the perception and awareness of environmental sounds and negatively affect safety and quality of life. There is a lack of knowledge on how speech intelligibility and auditory awareness interact in challenging listening situations [3].

We present a method to objectively measure auditory awareness as well as speech intelligibility in CI listeners using behavioral tests. Speech intelligibility is assessed using established procedures to determine Speech Reception Threshold (SRT) scores [4]. We developed a novel test inspired by the Familiar Environmental Sound Test (FEST [5]) to assess the perception of various environmental sounds in noise. These single-perception tasks are compared with a joint-perception task where participants listen to realistic sound scenes and perform a dual task to identify familiar environmental sounds and short speech sentences in noise as a measure of auditory awareness. Both CI listeners and participants with typical hearing take part in this study.

Preliminary results confirm that CI listeners are able to identify environmental sounds in quiet conditions, reaching up to 97% correct environmental sound identification (ESI) and perform the single and joint tasks with noise. A first CI pilot participant could tolerate -2.6 dB Signal-to-Noise Ratio (SNR) in multi-talker noise to reach 50% correct for ESI. We hypothesize that speech intelligibility and ESI increase with SNR when performed separately as single-perception tasks. In the joint-task with concurrent speech recognition and ESI, participants may prioritize speech. We speculate the existence of an optimal SNR range where both speech intelligibility and ESI can be maximized. We further predict that the optimal SNR differs between CI participants and is associated with their individual listening performance. In contrast, we expect more homogenous outcomes across typically hearing participants.

An objective measure of both auditory awareness and speech intelligibility has the potential to improve diagnostics and inform clinical fitting in CI listeners. It is required for assessing the impact of advanced speech enhancement techniques on the perception of environmental sounds and could in the future guide the development of personalized CI speech enhancement strategies that preserve auditory awareness whilst enhancing speech perception in noisy environments.

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M-T 71: THE OPTO-ELECTRICAL COCHLEAR IMPLANT

Joaquín Cury, Maaz Shakur Haji, Xiaodong Tan, Claus-Peter Richter

Department of Otolaryngology, Northwestern University,
Feinberg School of Medicine, Chicago, Illinois, U.S.A.

BACKGROUND: Deafness and hearing loss are widespread in the world. At the moment, more than 1.5 billion people live with hearing loss. By 2050, nearly 2.5 billion people are projected to have some degree of hearing loss and at least 700 million will require hearing rehabilitation [1].

Assistive technologies, such as cochlear implants (CIs), can help people with hearing disabilities. While widely used, CIs rely on electrical stimulation, which has low spatial precision due to current spread, affecting sound perception. Neural stimulation with light offers a promising alternative, enabling selective targeting of neuron groups. Two methods have been proposed: optogenetics (OG) and infrared neural stimulation (INS). OG employs viral vectors to deliver photosensitive ion channels (op-sins) to spiral ganglion neurons (SGNs), while INS relies on photon absorption by tissue fluids to generate transient temperature changes that activate cell membranes. Each technique faces challenges: OG involves efficient delivery, tissue viability, immune responses, vector clearance, gene size limitations, and slow opsin dynamics that limit stimulation rates. INS, on the other hand, bares the risk of heat accumulation and tissue damage, which restricts the maximum pulse repetition rate during stimulation. An additional challenge for INS is the generation of a pressure wave, which could restrict the neural stimulation method to patients with a hearing loss of more than 50 dB. Animal models for optical stimulation in the cochlea include mice, gerbils, and guinea pigs for both OG and INS. Moreover, INS has been tested in larger models, such as white deaf cats, and in genetically deaf models, including VGLUT3 KO mice. This work presents the development of a novel fully implantable cochlear implant that combines electrical stimulation and INS. This device, denoted as the opto-electrical cochlear implant (oeCI), is discussed with a focus on design considerations, device development, and prototype testing, highlighting both progresses and challenges.

METHODS: Our oeCI has 42 stimulation channels: 24 for electrical and 18 for optical. The number of optical channels is selected to avoid interaction. The device consists of four main parts: A) an electrical driver with 24 current stimulators with charge-recovery circuits; B) an optical driver with 18 channels switching at various rates; C) ultra-low-power 32-bit microcontroller and D) a microphone. With a compact dimension of 3.5*3.5x0.8 cm^2, the oeCI is designed to operate in three modes: fully electrical, fully optical, and hybrid. To deliver light along the cochlea, we produced a bundle of waveguides, each comprises of a polymer core named OrmoComp and a polyimide cladding. Prior studies have measured the mechanical properties, including stiffness and insertion forces, of individual waveguides. In the present study, we will evaluate these properties for a bundle.

RESULTS AND CONCLUSIONS: We will conduct short-term preclinical trials in dogs to evaluate the oeCI's performance, casing, immune response, and optrode placement. Dogs are a promising model due to their trainability and ability to perform behavioral assessments. This study will assess the implant's biocompatibility, durability, and functions for future clinical applications. In parallel, trials are underway to assess the feasibility of INS in humans. These studies aim to determine whether light delivery systems can be accurately positioned in the human cochlea while delivering sufficient energy to evoke a compound action potential in the auditory nerve. Additionally, they will verify that the fluence rate remains within safe limits to prevent cochlear damage and explore whether combining optical and electrical stimulation can lower the optical activation threshold. Patient recruitment is currently in progress.

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M-T 72: PHONOLOGICAL PROCESSING AND TALKER DISCRIMINATION IN ADULT COCHLEAR IMPLANT USERS

Gizem Babaoglu, Aaron C. Moberly, Terrin N. Tamati

Vanderbilt University Medical Center, Department of Otolaryngology – Head & Neck Surgery

Objective: Cochlear implants (CIs) are effective in restoring speech communication in quiet environments for adults with acquired hearing loss. However, many CI users may face challenges in understanding speech in real-world settings with background talkers due to limitations in the perception of talker-specific acoustic cues like pitch. However, individual CI users vary in their sensitivity to talker details, which cannot be fully explained by the auditory factors alone. In normal-hearing (NH) adults, phonological processing has been shown to be related to talker identification or discrimination. This research aims to explore the relationship between phonological and talker-specific auditory processing abilities in adult CI users. We hypothesized that performance on a nonword repetition task (NWRT), which requires phonological sensitivity, storage, and production, would be positively correlated with utilizing talker-specific acoustic cues in a talker discrimination task.

Methods: Twenty-two postlingually deafened adults (aged 24 to 78 years) with more than one year of CI use completed two tasks. An NWRT involved presenting 40 nonwords (ranging from one to four syllables, with ten per length) audio-visually by a male talker. Participants' responses were recorded and scored as a total percentage of correct nonwords. In the Talker Discrimination Test, CI users indicated whether word pairs were produced by the 'Same Talker' or 'Different Talkers'. These word pairs consisted of monosyllabic words produced by 5 male and 5 female talkers, presented in quiet or in a multi-talker babble (MTB) condition.

Results: The preliminary results revealed that CI users can better utilize mixed-gender talker differences than same-gender pairs, both in quiet and MTB conditions. The NWRT total nonword percentage score showed a moderate and statistically significant positive correlation with the talker discrimination scores specifically in mixed-gender quiet conditions ($r = 0.52$, $p < 0.05$). However, NWRT total nonword scores and talker discrimination were not significantly correlated in the same-gender talker and MTB conditions, which were the most challenging.

Conclusions: Our preliminary findings align with existing research on the potential relationship between phonological processing and talker-specific auditory processing in CI users. We observed that phonological processing underlies individual variability in CI outcomes, influenced by both degraded auditory input and top-down cognitive components. The interaction between auditory and cognitive-linguistic factors suggests that CI users may partially compensate for the degraded talker-specific cues by using cognitive strategies, which vary among individuals. Given the significant variability in performance outcomes among CI users, identifying predictors of successful CI adaptation continues to be challenging. Our results support the potential of targeted training programs that simultaneously address phonological and auditory processing could enhance speech understanding and real-world communication abilities for CI users.

M-T 73: STREAM SEGREGATION FOR COCHLEAR IMPLANT LISTENERS

Nicholas R Haywood, Ben Williges, Marina Salorio-Corbetto, Deborah Vickers

University of Cambridge Essen

When listening to a sequence of tones which alternate between low (L) and high (H) frequency, those with typical hearing (TH), are more likely to perceive the two subsets as segregated perceptual streams when: 1) The frequency separation (ΔF) between L and H is increased and 2) The inter-stimulus interval (ISI) between tones is decreased, increasing the presentation rate. Although cochlear implant (CI) listeners hear greater segregation as ΔF is increased, there is currently no clear evidence that ISI affects segregation judgements.

In this on-going research, we asked groups of TH and CI listeners to detect a temporal delay imposed on the H tone of LHL triplet. Performance was measured in an adaptive procedure where the size of the delay was adjusted - as stream segregation should make the task more difficult, so thresholds were expected to rise as ΔF increased. We also measured performance when the LHL triplet was preceded by a precursor sequence of five L tones. Previous TH studies have shown that such a precursor should further promote the segregation of the H tone, but only when there is a ΔF between subsets. The experiment was run with three ΔFs (H frequencies corresponding to +0, +3, or + 5 electrode channels from L) and three presentation rates (ISIs between L and H of 50, 100, or 200 ms).

Preliminary results from the TH group (n = 7) suggest listeners performance was influenced by stream segregation only at the shortest ISI (50 ms). Any influence of ΔF or precursor was not apparent at longer ISIs. This is consistent with the notion that segregation is reduced at slower presentation rates. All listeners tested in the CI group to date (n = 11) performed more poorly than the TH group at the shortest ISI, and ceiling effects obscured the extent stream segregation influenced performance. However, CI listeners demonstrated clear stream segregation effects when the ISI was 100 ms, and these effects diminished when the ISI was increased to 200 ms. Overall, these findings suggest CI listeners may experience stream segregation at slower presentation rates than TH. We speculate that this may reflect increased neural adaptation from CI stimulation.

From the CI group's results at 100 ms ISI, we quantified the extent of individual stream segregation effects by calculating a ratio between thresholds in the presence or absence of the precursor (a 'precursor ratio'). This ratio shows a negative correlation with speech-on-speech segregation - those who showed a greater effect of stream segregation on delay detection thresholds achieved lower signal-to-noise ratios (SNRs) when following a target speaker in the presence of a cooccurring irrelevant speaker (as measured using a version of the coordinate response measure task). Although data collection remains on-going, our initial findings suggest that stream segregation may be a useful metric for assessing aspects of cochlear implant performance, including; frequency selectivity, neural adaption, and aspects of speech-in-noise performance.

M-T 74: BINAURAL AND MONAURAL PULSE RATE DISCRIMINATION: DOES A SECOND EAR HELP?

Tanvi Thakkar[1], Serena Fincher[1], Stephen R. Dennison[2], Josh Stohl[2]

[1]University of Wisconsin-La Crosse
[2] MED-EL Research Laboratory, Durham, NC, USA

Both typical hearing (TH) listeners and cochlear implant (CI) users can discriminate the pitch of two stimuli based on the temporal information present in the stimulus-specifically the repeated temporal patterns in a series of pulses that create the sensation of a stable pitch. However, unlike TH listeners, who can use these temporal cues to distinguish pitch up to 2 kHz, CI users struggle to discriminate pulse rates above 300 pulses per second (pps). This limitation, likely arising from constraints in either peripheral or central auditory structures, is a consequence of electrical stimulation. Prior research indicates that this rate limitation extends to binaural discrimination tasks, suggesting a shared peripheral mechanism underlying both pitch discrimination and sensitivity to interaural time differences. However, most studies have used single-electrode stimulation with different stimuli and tasks for monaural versus binaural discrimination of temporal cues, making direct comparisons challenging. We hypothesized that presenting redundant temporal information to the second ear would enhance pitch discrimination compared to discrimination in one ear alone, particularly as stimulus rate decreases.

Participants included 20 TH and 12 bilateral CI listeners. Stimuli consisted of pulse trains with pulse rates ranging from 100-2000 pps for TH listeners and 100-600 pps for CI listeners, delivered through (simulations of) multi-electrode configurations. Three stimulus conditions were tested: unilateral, dichotic, and diotic. In the diotic condition, the same rate was presented to both ears in all intervals. In the dichotic condition, the rate in the contralateral ear was not adjusted, potentially adding an interaural difference cue that could also impact stimulus discrimination. A 3-alternative forced-choice task was employed, where participants identified an "oddball" pulse rate amidst reference pulses. Data were analyzed using linear mixed effect models to examine the effects of stimulus configuration, pulse rate, and their interaction.

In TH listeners, mixed-effects modeling revealed a significant main effect of pulse rate ($p < 0.001$) and a significant interaction between condition and pulse rate ($p = 0.005$). In CI listeners, significant main effects of pulse rate ($p < 0.001$) and condition ($p = 0.028$) were observed but the interaction failed to reached significance, suggesting that the effects of contralateral stimulation were independent of pulse rate. Further analyses revealed that the diotic listening conditions showed improved pitch discrimination in relation to either of the dichotic conditions in CI listeners.

Currently, it remains unclear how the addition of a second ear in a dichotic configuration interacts with pulse rate discrimination in CI listeners. Further analyses revealed discrimination in the diotic condition did not exceed the discrimination ability in the unilateral condition. Performance in the dichotic listening condition was worse than in the diotic condition in CI listeners, suggesting that binaural processing has the potential to enhance or limit unilateral temporal processing, depending on the contralateral input. The existence of one or more potential mechanisms will be discussed.

M-T 75: HEARING LOSS, NOT SPEECH RECOGNITION, IMPACTS COGNITIVE FUNCTION IN COCHLEAR-IMPLANTED CHILDREN

Angelika Illg[1,3], Melina Schipper[1], William Kronenberger[2], Andrej Kral[1, 3]

[1]Clinic for Otorhinolaryngology, Head & Neck Surgery, Hannover Medical School, Hannover, Germany
[2]Riley Child and Adolescent Psychiatry Clinic, Department of Psychiatry,
Indiana University School of Medicine, Indianapolis, USA
[3]Cluster of Excellence “Hearing4All”, Hannover Medical School, Hannover, Germany

Hearing loss impacts effective connectivity in the developing brain, leading to non-auditory consequences, including an increased risk of cognitive deficits (Kral et al., 2016, Lancet Neurol). Using a parent questionnaire (LEAF) that assesses cognitive function in school-age children (Kronenberger et al., 2014, JAMA ORL), translated into German, we evaluated cognitive functioning in 229 age-matched, normal-hearing (NH) children and 127 children with hearing impairment (HI) and cochlear implants. The LEAF score quantifies cognitive function across three categories: normal (score 0-4), borderline (5-9), and clinically abnormal (10-15). Consistent with previous reports (Kronenberger et al., 2014), children with hearing loss significantly underperformed in sustained sequential processing, processing speed, working memory, reading skills, written expression, novel problem-solving, mathematical skills, and comprehension and conceptual learning (two-tailed Wilcoxon test, $p<0.05$). They did not differ from NH children in visual-spatial organization, factual memory, or attention ($p>0.05$). Overall, hearing-impaired children had lower LEAF composite cognitive scores (NH: 1.6±1.18, HI: 3.64±2.36, p=0.00011). A generalized linear model with Poisson distribution (GLM), with the LEAF composite score as the dependent variable and duration of deafness and group (NH vs. HI) as predictors, confirmed a significant effect of group on the mean score (b=0.904, estimate = 0.280±0.09, p=0.0020).

Speech recognition data were available for 63 HI children. No correlation was found between monosyllabic test scores and the mean LEAF score (r=-0.03, p=0.833) or the HSM sentence test in noise (r=-0.18, p=0.217). A GLM with the mean LEAF score as the dependent variable and monosyllabic and sentence test scores in noise as predictors failed to converge. However, using the HSM sentence test in noise as the dependent variable and the LEAF score and monosyllabic test scores as predictors converged ($Chi^2=608$, $p=2.21^{*131}$), and documented a significant interaction between the monosyllabic test and LEAF score.

Bivariate correlations of individual subdomain scores with each other revealed significant inter-relationships (r ranging from 0.3 to 0.88). The median correlation in NH children was 0.67±0.07, with the highest correlations observed between working memory and other subdomains. The median correlation in HI children dropped to 0.62±0.10 ($p=8.068*10^{-8}$¸), with a smaller interquartile range and greater intracognitive discrepancies ($p<0.001$). Subscores were grouped into Academic, Executive, and Comprehension/Learning domains. A GLM showed that only the learning subscale significantly predicted HSM sentence test outcomes in noise (b=4.39, estimate=-0.061±0.011, $p<<0.001$), with no interactions.

These findings demonstrate that while some HI children performed cognitively at the level of the best NH controls, on average, their cognitive function was negatively impacted and variance within subdomains increased. The most pronounced deficits were observed in executive function and academic achievement. Notably, language proficiency was unrelated to these cognitive deficits. However, cognitive function significantly influenced speech recognition in noise, particularly by comprehension/learning performance.

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M-T 76: ACOUSTIC CUES FOR EMOTIONAL PROSODY PERCEPTION USED BY SCHOOL-AGE CHILDREN AND PRELINGUALLY DEAF YOUNG ADULTS WITH COCHLEAR IMPLANTS

Aditya M. Kulkarni[1], Abby Pitts[1], Parker Hagemann[1], Jessica Combs[1], Dawna Lewis[1], Denis Fitzpatrick[1], John Galvin[2], Xin Luo[3], Monita Chatterjee[1]

[1]Auditory Prostheses & Perception Laboratory, Center for Hearing Research, Boys Town National Research Hospital, 555 N 30th St, Omaha, NE 68131
[2]House Institute Foundation, 1127 Wilshire Boulevard, Los Angeles, CA 90017
[3]Program of Speech and Hearing Science, College of Health Solutions, Arizona State University, 975 S Myrtle Av, Tempe, AZ 85287

Cochlear implant (CI) users have been shown to have lower accuracy in identifying emotional prosody than their counterparts with typical hearing, but the underlying mechanisms and predictors of individual variability remain unknown. This project investigated the acoustic cues used to identify vocal emotional prosody by school-age and young-adult individuals with cochlear implants (YCI; N=28) compared to post-lingually deaf adult CI users (ACI; N=14), school-aged children with typical hearing (YTH; N=23), and adults with typical hearing (ATH; N=43). We hypothesized that the utilization of acoustic cues to emotional prosody is malleable in YCI group: specifically, the YCI group benefits from experience-driven plasticity as well from earlier age at implantation.

Using a cue-weighting method in which the sentence "Time to go" was manipulated to have 125 combinations of 5 voice pitch (F0) contours, 5 durations, and 5 intensity levels, we estimated listeners' weightings of each of these cues to identify the stimuli as "Happy" or "Sad". Findings to date indicate that, relative to the YTH and ATH groups, the YCI group weighted F0 contour cues and duration cues significantly less strongly. The YCI group also weighted F0 contour cues significantly more and duration cues significantly less than the ACI group. Examining predictors of cue weightings by the YCI group, we found that age at implantation and device experience (how many years the listener had used the CI) were both significant predictors. As these important predictors were correlated (because older YCI had generally been implanted later), we analyzed their effects separately using subgroups. While increased age at implantation was associated with reduced weighting of the F0 contour cue, increased device experience was associated with increased weighting of the F0 contour cue. Those who were implanted later weighted the duration cue more strongly, as did those with longer device experience. Many of the YCI listeners (N=21) also completed an emotional prosody identification task that used naturally recorded stimuli and five emotions (happy, angry, sad, neutral, and scared). Among these YCI listeners, weighting of both F0 contour cues and duration cues in the cue-weighting task predicted their accuracy in emotional prosody identification.

Taken together, these results indicated that YCI listeners weight acoustic cues to emotional prosody differently from YTH, ATH, and ACI listeners. Further, in support of our hypothesis, among YCI listeners, device experience and age at implantation predicted utilization of specific prosodic cues. Finally, the cue weights obtained from the cue-weighting study predicted emotional prosody identification using naturally-recorded materials and a larger range of emotions, suggesting real-world validity.

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M-T 77: EVALUATING TONOTOPIC HETEROGENEITY IN ELECTROPHYSIOLOGICAL AND PSYCHOACOUSTIC MEASURES IN COCHLEAR IMPLANT USERS

Leanne Sijgers[1], Marlies Geys[1], Patrick Boyle[2], Josef Chalupper[2], Alex Huber[1], and Flurin Pfiffner[1]

[1]Department of Otorhinolaryngology, Head&Neck Surgery, University Hospital Zurich, University of Zurich, Zurich, Switzerland
[2]European Research Center, Advanced Bionics, Hannover, Germany

Objectives: A wide range of electrophysiological and psychoacoustic measurements exist to estimate neural health and auditory processing abilities across cochlear regions in cochlear implant (CI) users. These methods are believed to reflect distinct aspects of auditory processing ability and, therefore, do not necessarily correlate with one another. Narrowband spectrotemporal modulation (STM-nb) tests measure sensitivity to temporal and spectral modulations-key features for speech understanding. This study examined whether cochlear regions that perform poorly on narrowband spectrotemporal modulation tests (STM-nb) also exhibit weaker performance on other electrophysiological and psychoacoustic measurements.

Methods: Fourteen Advanced Bionics CI candidates were prospectively enrolled prior to CI surgery. Two electrophysiological measurements-electrocochleography (ECochG) and panoramic electrically-evoked compound action potential (PECAP) recordings-were obtained during surgery and approximately three months post-implantation, respectively. Temporal modulation detection recordings in the presence of a neighboring interfering electrode (TED-RT) were obtained six months post-implantation, while STM-nb measurements were conducted one year after surgery. All measurements were either directly obtained for four distinct cochlear regions, each comprising four electrodes, or averaged afterwards to obtain a single value for each region.

Results: Linear mixed model analyses revealed a significant difference in STM-nb results between the cochlear region performing the poorest on this test and the three other regions ($p < 0.001$). However, ECochG, PECAP, and TED-RT recordings did not show significant differences between the region with the weakest STM-nb performance and the other three cochlear regions.

Conclusion: This study demonstrates that cochlear regions performing poorly on an STM-nb test do not necessarily exhibit differences in other electrophysiological and psychoacoustic measurements. To guide CI processing optimization strategies based on objective and subjective recordings, it is essential to consider the specific hearing deficiencies or neural degeneration patterns that each test reflects.

T-W 1: A NOVEL CI CODING STRATEGY BASED ON A COCHLEAR MODEL AND DEEP NEURAL NETWORK

Maryam Hosseini[1,3], Tim Brochier[2], Brett Swanson[3], Alan Kan[1], Richard F. Lyon[4]

[1]Macquarie University, Sydney, Australia
[2]Cochlear Ltd, Melbourne, Australia
[3]Cochlear Ltd, Sydney, Australia
[4]Google Research, Australia

Objective: Many CI recipients face difficulties in understanding speech in noisy environments and express frustration with the quality of music. This may be partly due to the simple filter banks used in current CI technology, which do not fully replicate the natural processes of the cochlea. This project aims to improve CI perception by more accurately mimicking the responses of the auditory nerve.

Method: Audio signals were applied to CARFAC (Cascade of Asymmetric Resonators with Fast-Acting Compression) [1] to produce a representation of the auditory nerve response, known as a normal hearing (NH) "neurogram". NH neurograms were used as input features to a deep neural network (DNN) to produce 22 electrode stimulation currents. In the loss function, these currents were applied to an electrical hearing (EH) model incorporating current spread, neural adaptation, and refractoriness, to produce a CI neurogram. The DNN was trained on open-source speech and noise materials to minimize the difference between the NH and CI neurograms, as measured by a custom loss function.

Results: The CI neurograms produced by the CARFAC-DNN strategy were more similar to the NH neurograms than the CI neurograms produced by the Nucleus ACE strategy. Similarity was quantified by the structural similarity index and mean squared error.

Conclusions: The CARFAC-DNN strategy may provide a more natural auditory nerve response than traditional CI sound coding strategies. A sound-booth study with CI recipients is planned.

This work was funded by Google through the Australian Future Hearing Initiative.

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T-W 2: NOVEL APPROACHES TO INVESTIGATING BINAURAL PROCESSING IN BILATERAL COCHLEAR IMPLANTS USING NEURAL PROCESSING AND PSYCHOPHYSICAL MEASURES

Aditi Gargeshwari[1], G. Nike Gnanateja[1], Karen Gordon[2], Lulia Snan[2], Mohammad Maarefvand[1], Ruth Y. Litovsky[1]

[1]University of Wisconsin-Madison, Madison, WI, USA
[2]Univeristy of Toronto, Toronto, CA

Background and Rationale: Over two decades of research on binaural sensitivity in cochlear implant (CI) users have shown that there are severe limitations to binaural integration, in particular for low-frequency interaural differences in time (ITDs) that depend on temporal fine structure (TFS) cues. The factors that are thought to limit ITD-TFS sensitivity include lack of binaural synchronization and weak or absent TFS information conveyed in CI speech processing strategies. In contrast with poor TFS-ITD access, CI users show sensitivity to ITDs in the envelopes (ENV) of amplitude-modulated high frequency stimuli, likely because these stimuli are conveyed through everyday listening with CIs. Very little is known about associations between perceptual sensitivity and neural processing of TFS and ENV binaural cues. Our work is the first to investigate this question by comparing active attentive stages of neural processing of binaural cues, measured by electroencephalography (EEG) in an oddball paradigm, with psychophysical measures of ITD sensitivity. The hypothesis is that ITDs presented in TFS are easily accessed than in ENV stimuli in typically hearing listeners (TH), as measured by increased amplitude of P300 responses and better behavioral sensitivity, but that this will be reversed in CI users due to limited access to TFS cues.

Methods: Brief stimuli of 50ms were designed to minimize CI artifact in EEG. TFS stimuli were 100 pulses/sec, and ENV stimuli were 4000 pulses/sec, modulated at 125Hz. Research CI processors were programmed to deliver ITDs in TFS and ENV at single pairs of mid-array electrodes. Novel acoustic stimuli were designed to evaluate ITD access in TFS and ENV dominated stimuli in TH listeners. These novel acoustic stimuli were designed with particular attention to temporal characteristics and excitation patterns in CI stimulation. Behavioral just-noticeable-difference (JND) ITD thresholds were obtained for both the TFS and ENV stimuli. EEG measures, recorded at 64 cephalic surface electrodes, were evoked by these two stimuli individually in a passive control condition to evoke obligatory cortical responses as well as in an active oddball paradigm to evoke the well-described P300 response. In the active oddball task, ITD=0 was presented in 75% of stimuli (standard) and ITD=750mus were presented in 25% (deviant) in pseudo-random order for TFS and ENV stimuli separately. Participants were asked to indicate when they heard the stimulus change and the hit accuracy and reaction times were measured. Differences in global field power (GFP) were objectively assessed across all the conditions.

Results: In 5 TH listeners [mean = 21.8 years (SD = 1.64)], smaller behavioral JND thresholds were noted for TFS compared to ENV stimuli. JNDs were negatively correlated with hit accuracy and positively with reaction times in the oddball paradigm, suggesting that ITD sensitivity correlates with success at detecting the large ITD change in an active oddball paradigm. Analysis of cortical potentials showed robust obligatory P1, N1, and P2 responses, indicating good auditory detection of both TFS and ENV-ITD stimuli in all TH listeners. Similar to the behavioral results, the active oddball task revealed large P300 peak amplitudes [mean = 3.46muV (SD=0.96)] for TFS-ITD at expected latencies [mean = 364ms (SD=49.37)] while ENV-ITD elicited slightly smaller peak amplitudes [mean = 2.41muV (SD=0.80)] at later latencies [mean = 411.8ms (SD=41.55)]. Overall, these findings reveal greater active processing of ENV stimuli than for TFS stimuli in TH listeners. Preliminary data from one adult CI user with synchronized bilateral stimulation confirms good access to TFS-ITD as measured by obligatory P1, N1, and P2 responses, and active P300 response. Further evaluations of adult CI users are ongoing.

Conclusions: Results demonstrate that TH adults have access to ITDs in both TFS and ENV stimuli but perceptual processing of ENV-ITD induces more challenges than TFS-ITD, as shown by higher JNDs, lower and later P300 amplitude, lower accuracy and larger response times. Ongoing work is expected to confirm the hypothesis that adults with cochlear implants exhibit the opposite effect, demonstrating greater access to ENV- than TFS-ITDs, both cortically and behaviorally. Further, cortical responses to TFS- and ENV-ITD are expected to provide information about the auditory system's access and the extent of use of these binaural cues in CI listeners, that cannot be readily inferred from behavioral methods alone.

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T-W 3: AUDITORY SEQUENCE LEARNING IN CHILDREN WITH COCHLEAR IMPLANTS COMPARED TO NORMAL HEARING: WHAT DID WE LEARN FROM COMPARING SPEECH VERSUS NON-SPEECH STIMULI?

Liat Kishon-Rabin[1], Shira Cohen[1], Ronen Perez[2]

[1]The Department of Communication Disorders, Steyer School of Health Professions, Faculty of Medicine and Health Sciences, Tel Aviv University, Israel
[2]Department of Otolaryngology and Head and Neck Surgery, Shaare Zedek Medical Center and Faculty of Medicine, The Hebrew University of Jerusalem, Jerusalem, Israel.

Implicit sequence learning (SL) is crucial for language acquisition and processing and has been studied primarily in the visual modality. Most studies have used speech or non-speech stimuli, the latter meaningless to the listeners. The results of the few studies that investigated SL in children with cochlear implants (CI) were equivocal. The purpose of the present study was to investigate sequence learning in the auditory modality in children with cochlear implants and to compare their performance to normal hearing using two types of stimuli: speech and environmental sounds. A total of 174 participants were included in the study: 134 with normal hearing aged 6.5-85 years old, 15 children aged 7.9-16 years old with cochlear implants (8 prelingual implanted under 20 months and 7 implanted later due to progressive hearing loss) and 25 children from low socioeconomic status (SES) aged 6.5-8.3 years old. Two Serial Reaction Time (SRT) tasks with syllables and environmental sounds and cognitive tests were conducted. Each SRT task included 5 blocks of stimuli: blocks 1-3 and 5 contained the same 108 stimuli (9 repetitions of a 12-stimulus sequence), and block 4 contained 9 repetitions of a random sequence. Measures included the shape of the learning curve and the reaction time of the final block, reflecting a combination of complex processes, including categorization, decision-making, and motor execution. Results showed a typical auditory SL curve for speech and non-speech stimuli for all participants, suggesting that SL is resilient to degradation of auditory input in CI users, language deprivation of the low SES, and age. These results also support that SL is not specific to speech and reflects a more general mechanism. However, absolute reaction time (RT) was found to be a sensitive measure for differentiating between groups and between types of stimuli. Specifically, all normal hearing groups showed longer RT for speech compared to environmental stimuli. In contrast, such prolongation was not evident for the CI group, suggesting that CI had similar perceptual strategies for both sound types; and RT of Low SES children was the longest for speech stimuli compared to other groups of children, evidence of the negative impact of language deprivation on speech processing. Age was the largest factor in the RT displaying a 'U-shape' curve followed by cognitive abilities. However, CI children showed decreased RT with age only with speech sounds and not with environmental sounds. This supports the notion that the CI device provides appropriate acoustic input that allows the development of age-appropriate SL processing for speech stimuli, possibly due to extensive speech-targeted training protocol. The lack of prolonged RT for speech sounds suggests CI children use different listening strategies than normal-hearing peers, such as explicit learning strategies or different use of acoustic features for categorizing environmental sounds (as a basis for identification). In contrast, NH peers may have relied on associative conceptual context. Current data collection with postlingual CI users may provide further insight into these hypotheses.

T-W 5: UMBOMIC: DESIGN AND FABRICATION OF AN IMPLANTABLE MICROPHONE

John Z. Zhang[1], Emma F. Wawrzynek[1], Julie G. Arenberg[2], D. Bradley Welling[2], Ioannis Kymissis[3], Elizabeth S. Olson[3], Jeffrey H. Lang[1], Hideko Heidi Nakajima[3]

[1] Massachusetts Institute of Technology, Cambridge, MA
[2] Mass Eye and Ear, Boston, MA
[3] Columbia University, New York, NY

Cochlear implants, despite being the most successful neuro-prosthesis, can be bulky, visible, and not durable or practical for all environments, leading to discomfort and social stigma. An invisible cochlear implant would be a life changing technology, but the remaining challenge is the microphone. Recent studies have proven that implantable battery and processor technology are adequate for the realization of a totally implantable cochlear implant (TICI) [1-2].

The UmboMic is a piezoelectric bimorph sensor that measures umbo motion [3]. Audio recordings and measurements in cadaveric human ears have demonstrated that the UmboMic has comparable performance to current hearing aid microphones and would be suitable as the sound input for a TICI. In this work, we present recent progress on the design, fabrication, testing and surgical fixation of the UmboMic. This includes optimizing sensor geometry via analytical models, sensor fabrication from a fully biocompatible polyvinylidene-fluoride (PVDF) substrate, testing sensor shielding against electromagnetic interference (EMI), and measuring sensor performance in a human cadaveric ear using a fixation system.

UmboMics are fabricated in the MIT.nano. Prototype fixation systems are manufactured by i.materialise and Sculpteo through laser powder-bed fusion of stainless steel and titanium. UmboMics are tested in electrically- and acoustically-isolated sound chambers at Mass Eye and Ear. During EMI testing, an UmboMic is exposed to a 500 Hz, 100 µT magnetic field, and a 500 Hz, 2.1 kV/m electric field, per the World Health Organization's threshold for safe exposure. The ability of the fixation system to position the UmboMic is tested in human cadaveric temporal bones prepared via a mastoidectomy to access the middle-ear cavity. The UmboMic is modeled as an Euler-Bernoulli beam coupled to an umbo approximated as a spring-mass system. The analytical model is verified by a finite-element analysis of the coupled UmboMic and middle ear using COMSOL Multiphysics.

Measurements of UmboMic linearity, equivalent input noise, and sensitivity are made with the UmboMic supported by the fixation system. Experience with the current design indicates opportunities for improving the locking mechanism for ease of surgical insertion. The analytical UmboMic model prescribes an optimal triangular UmboMic shape that maximizes UmboMic sensitivity and bandwidth when coupled to the umbo.

Future UmboMic development must consider different aspects of design and function. Physiological differences between users must minimally impact microphone performance. Once implanted, a well-designed fixation system should not degrade sensor performance. Material selection must consider sourcing and long-term stability. Next steps towards a viable microphone system for a TICI include studies in animal models, accelerated aging, and the design of a more adaptable fixation system. The maturation of implantable microphone technology would enable the first commercially available invisible cochlear implants.

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T-W 6: INVESTIGATING INTER-BRAIN SYNCHRONY IN CHILDREN WITH COCHLEAR IMPLANTS AND THEIR MOTHERS: A COMPARATIVE FNIRS ANALYSIS WITH NORMALLY HEARING DYADS

Hilal Dogan, Efstratia Papoutselou, Samantha Harrison, Guangting Mai, Douglas Hartley, Derek Hoare

NIHR Nottingham Biomedical Research Centre, Hearing Sciences, Mental Health and Clinical Neuroscience, School of Medicine, University of Nottingham

Abstract: Parent-child interaction plays a crucial role in the socio-emotional and linguistic development of both normally hearing (NH) and cochlear implant (CI) children1. However, current clinical assessments mainly rely on subjective methods, lacking real-time neural insights. Inter-brain synchrony (IBS)2-the alignment of neural activity between interacting individuals-has emerged as an objective marker of communication efficiency. While IBS has been widely studied in NH parent-child dyads, its presence in CI child-mother interactions remains largely unexplored 3,4. Understanding IBS in this population is crucial for optimizing communication strategies and fostering better language development outcomes. Functional near-infrared spectroscopy (fNIRS) hyperscanning, a non-invasive, child-friendly technique, offers an ideal tool to measure IBS, being fully compatible with CIs, minimizing motion artifacts, and enabling real-time neural synchrony assessment during natural interactions.
This study aimed to: (1) measure of IBS in CI child-mother dyads; (2) compare IBS mechanisms between CI and NH child-mother dyads, exploring developmental trajectories across two age groups and (3) investigate link between IBS and communication behaviors such as turn-taking and eye contact.

Methods: Two cross-sectional fNIRS experiments were conducted: (i) CI children aged 4-6 years (n=1) and (ii) CI children aged 6-12 years (n=11), each paired with their mothers. Age-matched NH control groups were also included: (i) NH 4-6 years (n=24) and (ii) NH 6-12 years (n=21). Dyads participated in a free-play paradigm with both interactive and independent conditions. IBS was measured over the frontal and temporo-parietal regions, and connectivity was analyzed using Phase Transfer Entropy. Video recordings, PRAAT analysis, and eye-tracking were employed to evaluate turn-taking and gaze patterns.

Results: Across all groups (NH 4-6-years, NH 6-12-years, CI 4-6-years and CI 6-12 years), IBS levels were significantly higher during the interactive condition compared to the independent condition ($p<0.0001$). Analysis of fNIRS data revealed distinct age-related patterns and different region on interest (ROI). At the parent's right temporoparietal junction (TPJ), a consistent pattern emerged across all groups: child-led synchrony was greater than parent-led synchrony. In contrast to the TPJ findings, for other ROIs (left TPJ, right PFC, and left PFC), a different pattern emerged. In the NH 4-6-year-old group, parent-led synchrony was greater than child-led synchrony. However, this pattern reversed in the 6-12-year-old groups (both NH and CI), with child-led synchrony becoming greater than mother-led synchrony. Moreover, subsequent analysis will explore how IBS correlates with behavioral conversational patterns such as turn-taking, and the frequency of eye contact.

Conclusion: This study provides preliminary evidence of age-related modulation and distinct roles for different brain regions of IBS in mother-child dyads, with a particular focus on the CI population. This study enhances our understanding of the neural mechanisms underlying parent-child interaction, providing a foundation for future development of objective tools that can serve as markers for IBS. These tools have promising implications for creating targeted interventions aimed at monitoring the progress of parent-child communication skills, ultimately maximizing language learning opportunities for deaf children.

T-W 7: FREQUENCY RANGE PREFERENCES, PERCEPTUAL ABILITIES, AND MUSIC-RELATED QUALITY OF LIFE IN ADULT COCHLEAR IMPLANT USERS

Katelyn A. Berg[1], Barak M. Spector[1], Emily R. Spitzer[2], Terrin N. Tamati[1], Aaron C. Moberly[1], David S. Haynes[1], David M. Landsberger[2]

[1]Vanderbilt University Medical Center, Nashville, TN
[2]New York University Grossman School of Medicine, New York, NY

Cochlear implants (CIs) effectively encode envelope-based temporal information for speech and rhythm perception.1 However, CIs provide limited spectral, temporal fine structure, and dynamic range information critical for music perception and appreciation.2 This limitation significantly impacts music enjoyment, as music listening rates drop from 50% pre-implantation to just 13% post-implantation.3 A key challenge in CI music perception involves the transmission of fundamental frequency through temporal or place-coding mechanisms, though the precise processing remains poorly understood.4 While temporal pitch coding is the dominant cue at lower frequencies (~ <300 Hz) and place pitch coding is the dominant cue at higher frequencies,5 little is known about CI users' preferences for different frequency ranges. Understanding these preferences and their relationship to perceptual abilities could provide insights for optimizing music listening experiences. This study pursued three objectives: 1) To determine CI users' preferred music listening frequency range, hypothesizing that they will prefer lower frequencies which provide better temporal pitch cues, especially as music complexity increases; 2) To correlate frequency range preferences with their spectral resolution and melodic contour identification abilities, hypothesizing that they prefer frequency ranges they perceive more accurately; 3) To correlate CI users' perceptual abilities with their self-perceived music abilities and the importance they place on music, hypothesizing that those with higher self-perceived music abilities and those who place greater importance on music will have better perceptual abilities.

Four adult MED-EL CI users (expected n=10; mean age=56 years, range 45-68; all female) with at least 6-months of CI experience completed three perceptual tasks. A pitch scaling task measured preferences for simple (piano melody) and complex (full piano arrangement) stimuli across low (125-2000 Hz), mid (250-4000 Hz), and high (500-8000 Hz) frequency ranges, with higher ratings indicating a greater preference. Spectral resolution abilities were assessed using a modified version of the Spectral-temporally Modulated Ripple Test (SMRT)7 with stimuli generated to represent four frequency regions: low-, mid, high-frequency, and full bandwidth (100-6000 Hz), with higher scores indicating better resolution. Contour identification was evaluated using melodic contour identification (MCI) with 2, 4, and 6 semitone intervals across six frequency band conditions (125-8000 Hz in octave steps). Participants also completed the Music-Related Quality of Life (MuRQoL) questionnaire,8 which measures current abilities and importance ratings for music perception and engagement with higher scores indicating better abilities and greater importance, respectively.

Preliminary data show a trending preference for higher frequencies, contrary to our initial hypothesis that they would prefer lower frequencies. This trend is consistent for both simple melodies and complex melodies. The data show a trending negative relationship between participants' preferences for a particular frequency range and their SMRT scores, contrary to our initial hypothesis that these would be positively correlated. A similar negative trend is emerging between frequency range preferences and MCI scores, again contrary to our initial hypothesis. These negative relationships suggest that poorer perceptual abilities correlate with stronger frequency range preferences. There is also a trending positive relationship between perceptual abilities and self-perceived ratings on the MuRQoL in support of our initial hypothesis that CI users who rate their music abilities higher and consider music to be more important exhibit better MCI and SMRT scores.

These results reveal unexpected patterns in how CI users engage with music across different frequency ranges. The trending preference for higher frequencies challenges theoretical predictions based on temporal and place pitch coding mechanisms, and highlights the complex interaction between music perception and appreciation. Additionally, the observed relationships between self-perceived musical abilities and perceptual performance suggests that supporting a CI user's confidence in their musical abilities could be an important factor in rehabilitation approaches. Given that music perception remains a primary concern for CI users, validating these patterns in a larger cohort is critical towards developing targeted music rehabilitation strategies for CI users.

T-W 8: THE DANCEABILITY OF MUSIC THROUGH A CI FOR SINGLE-SIDE DEAF LISTENERS

Gabriel McDerment[1,2], Natalia Stupak[1], David M. Landsberger[1]

[1]New York University Grossman School of Medicine, New York, NY USA
[2]New York University Gallatin School of Individualized Study, New York, NY USA

Background: Although cochlear implants (CIs) have considerable difficulty at delivering most aspects of music to a listener, it is generally assumed that rhythm cues are well provided and perceived through a CI. Seeberg et al. (submitted) recently documented that CI users are similar to acoustic hearing listeners in their sensitivity to rhythmic groove. In a first experiment, we expand on the Seeberg et al. findings by studying how instrumentation effects danceability through a CI. Landsberger et al. (2015) demonstrated that for Single-Side Deaf (SSD) CI users, listening to music through both their CI and acoustic hearing ears is more enjoyable than listening to music through the acoustic ear alone. In a second experiment, we study the musical components provided to a CI that provide a binaural benefit in danceability for Single-Sided Deaf (SSD) CI users.

Methods: Participants for both experiments are SSD listeners with a CI. Stimuli consisted of five-second clips of popular songs presented either to the acoustic hearing ear alone over headphone, to the CI alone via a direct audio input cable or streaming, or both together. After each stimulus presentation, participants were asked to scale "How easy is this to dance to?" by clicking on a clicking on a line whose endpoints were labeled "Least Easy" and "Most Easy". Stimuli consisted of a subset of songs originally used by Roy et al. (2012) provided by Charles Limb. The songs were split into components of drums, bass, and vocal, and other instrumentation as extracted by the OpenVINO AI model. Stimuli consisted of each of these components in isolation, in combinations of multiple components up to and including the complete unprocessed song. The order of stimuli was randomized across songs, stimuli, and listening conditions.

Experiment 1: All stimuli combinations were presented unilaterally to either ear as well as bilaterally. In bilateral stimulation conditions, the stimuli provided to each ear was the same. Using this data, we can determine if the contribution of each component to danceability is similar for the acoustic and CI ears using a within-subject design. An interaction would suggest that the contributions of instrumentation to danceability are different for a CI and acoustic hear ear. Analyses comparing danceability with the acoustic ear alone and the two together would describe the effect of each component on danceability in an SSD-CI listener's daily listening experience.

Experiment 2: Stimuli were presented unilaterally to either ear as well as bilaterally. CI-only stimulation consisted of the same CI-only combinations of instrumentation. Unilateral acoustic stimuli were only the unprocessed clips. With the bilateral stimuli, the CI is presented with the same combinations presented in the CI-only conditions while the acoustic ear is presented with the complete unprocessed clips. Using this data, we can determine the components of instrumentation in the CI that provide benefit (or detriment) for danceability.

Results: Preliminary results with three SSD CI listeners suggest that the contribution of instrumentation to danceability varies considerably across listeners but tends to be similar across the two ears. When listening with both ears together, danceability is rated as considerably higher than with either ear alone.

Conclusions: SSD CI listeners prefer music binaurally. To obtain the maximal listening experience a subset of instrumentation appears to be optimal. If so, an algorithm for the CI which removes or attenuates a subset of instrumentation may lead to an improved listening experience in either SSD or bilaterally deaf CI users.

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T-W 9: SOE MILLER SUMS ADD UP TO CHANNEL CROSSTALK?

Chris J. James, Joerg Pesch

Cochlear France SAS, Toulouse, France.

Objective: Previously we identified channel crosstalk with potentially a neural cause using ECAP measurements in 13 of a cohort of 32 CI recipients (James et al, 2025). In those data, spread-of-excitation (SOE) recordings used only two probe electrodes, one towards the base and one towards the apex, each combined with nine maskers. Where masking was greater for distant electrodes than for the same electrode, the probe, this implied that the probe was stimulating only distant neurons. However, apart from the general localization of a neural dead region adjacent to the probe electrode, little could be said about its extent. We further investigated crosstalk in new set of data where panoramic ECAPs, or many masker/probe electrode SOE combinations, were collected3.

Methods: SOE series data were collected from the PREVA study database. These series had been recorded in Nucleus(R) CI recipients according to the method of Garcia et al2 using to give a matrix of masker-probe (m,p) combinations. Stimuli were loudness balanced across electrodes, with the same pulse amplitudes used as probes (p) and maskers (m). Cases were initially screened using the conventional forward masking technique (as provided in Cochlear CustomSound EP V6.2) to identify suspect cases1. Then, the Miller sum method3 was applied: For each probe electrode, a Miller SOE function was constructed as the N1P1 amplitude for the sum of each m!=p, B (masker+probe) minus C (masker alone) response minus the m=p, B minus C signal. Large positive N1P1 amplitudes for distant electrodes indicate the probe electrode is most effective as a masker, whereas negative/inverted N1P1 amplitudes indicate distant electrodes are more effective.

The presence of coherent crosstalk (sequences of negative Miller amplitudes) across several probes would lend evidence that the technique may identify patchy or dead neural regions. Similarly, the presence of discrete off-centre peaks in the Miller SOE functions, seen in the James et al data, may be better understood using the PECAP data. Preliminary results will be presented at the time of the conference.

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T-W 10: THE ROLE OF TALKER VARIABILITY AND VISUAL CUES ON EMOTION IDENTIFICATION TASKS

D. P. Major, A. Pitts, K. Lalonde, M. Chatterjee

Boys Town National Research Hospital, Omaha

In the auditory-only (AO) domain, emotion is conveyed through how an individual speaks, referred to as emotional prosody. Voice pitch (f0) is a primary cue for accurately perceiving emotion in typically hearing (TH) individuals. However, cochlear implant (CI) recipients have limited access to f0 cues and generally perform worse at identifying spoken emotions1. Substantial talker variability exists in the use of f0 when expressing emotional speech. Because CI recipients have limited f0 cues available, they may be less sensitive to talker variability. Currently, it is unknown how talker variability in f0 use influences CI recipients' ability to accurately identify emotion. In audiovisual (AV) conditions, auditory emotional prosody is supplemented by visual cues. Expression in the eye/eyebrow region significantly contributes to emotion perception and may compensate for degraded auditory emotional prosody. However, even when these visual cues are available, CI recipients can show a deficit in AV emotion identification2. One possible explanation is that CI recipients focus more on the talker's mouth than TH counterparts, potentially missing crucial visual emotion cues. The objectives of this project are (1) to quantify how talker variability in f0 use affects emotion identification in TH and CI adult participants, and (2) to determine whether the gaze patterns of TH and CI recipients differ while viewing dynamic stimuli during an emotion identification task.

Audiovisual stimuli from 12 talkers (6 male) were selected from the Ryerson Audio-Visual Database of Emotional Speech and Song3. Each talker produced the sentence "dogs are sitting by the door" in six emotional tones (happy, sad, angry, scared, surprised, disgusted) plus a neutral sentence. The f0 contour for each sentence was extracted using Praat4. The standard deviation of the f0 contour for each emotional sentence was calculated and normalized to the mean f0 of the talker's neutral sentence. Stimuli were presented in two blocked conditions (AO and AV) of 84 target sentences. After each sentence, participants selected the emotion that the talker was portraying. For the AV condition, the video of the talker was duplicated and played simultaneously on the right and left sides of a monitor located ~68 cm in front of the participant. On one side of the screen, the talker's eye/eyebrow region was blurred, while on the other side, the mouth region was blurred. During the AV condition, a Tobii eye tracker recorded participants' eye gaze.

Preliminary results from 17 TH and nine post-lingually deaf CI recipients, aged 20-75, are reported. Overall, the TH group achieved higher accuracy on the emotion identification tasks compared to the CI group. F0 cue was correlated with emotion identification accuracy for both groups. For emotions typically produced with a wide f0 range and complex f0 contour (e.g., happy, scared), accuracy increased as the f0 cue increased. Conversely, for emotions with a narrower f0 range and relatively flat f0 contour (e.g., sad, disgusted), increased f0 cue lowered accuracy. Although both groups exhibited similar patterns, the slope of regression lines for the TH group were steeper for some emotions (e.g., scared, disgusted), suggesting that f0 cues played a more substantial role in identification for these emotions in the TH group. Accuracy improved for both groups with the addition of visual cues. The two groups differed in gaze patterns: the CI group looked more toward the side with the clear mouth region compared to the TH group, except when the talker portrayed happiness. This finding aligns with previous research indicating that TH listeners tend to look more at the mouth when a happy emotion is portrayed compared to other emotions5.

These results suggest that CI and TH individuals differ in how they use f0 cues for specific emotions and in how they allocate their gaze during emotion identification tasks. These differences likely affect the visual information CI users can utilize to supplement the limited availability of f0 cues transmitted through their speech processors.

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T-W 12: SCORING SPEECH PERCEPTION TESTS USING ARTIFICIAL INTELLIGENCE

Rohit Makol[1,2], Maya Hatley[1], Sofiya Yusina[1], Megan Eitel[1], Mahan Azadpour[1], Mario A. Svirsky[1], Ariel E. Hight[1]

[1]Department of Otolaryngology, New York University Grossman School of Medicine, New York, NY, [2]University of Connecticut School of Medicine

Objective: Over 1 million humans have been implanted world-wide [1], and accurate assessment of speech perception remains crucial for tracking outcomes. Given demonstrated abilities of artificial intelligence (AI) in speech recognition and transcription [2], we investigated whether AI-based tools could provide a fast, accurate, and objective method for scoring speech recognition tests. This study compared the accuracy of two AI-based automatic speech recognition (ASR) models, Whisper and Assembly AI, against expert human scorers in evaluating open-set word and phoneme recognition in cochlear implant users.

Methods: Speech perception in cochlear implant users was assessed using CNC word list pairs [3]. Subjects provided typed self-transcriptions immediately after verbalizing each response to serve as the benchmark for comparing AI and Human scoring accuracy. Audio recordings of these responses were transcribed and scored independently by: (1) AI-based models (Whisper and Assembly AI, both using the large model), and (2) expert human scorers who were blinded to participant self-transcriptions. Performance was assessed using word error rate (WER) as the primary outcome measure, comparing AI and human scores to the benchmark self-transcriptions. Intraclass correlation coefficient (ICC 3,1) analysis was conducted to evaluate agreement between scoring methods, including inter-rater reliability among human scorers.

Results: Data from two subjects were analyzed, each completing six CNC word pairs (50 words per list), totaling 600 words. Mean speech perception scores were 73.67 ± 4.3% and 40.08 ± 4.72% for the two subjects respectively. Both AI models showed high transcription accuracy, with Whisper scoring showing mean error rates of -1.38 ± 3.35% (words) and -1.00 ± 1.88% (phonemes), while Assembly AI showed error rates of -1.34 ± 5.84% (words) and -1.91 ± 2.50% (phonemes). The negative error rates indicate slight underestimation compared to subject self-transcriptions. Human expert scorers showed error rates of 3.03 ± 2.76% (words) and 2.53 ± 1.58% (phonemes). ICC analysis demonstrated strong agreement across all comparisons: Whisper vs. benchmark (.990), Assembly AI vs. benchmark (.977), and human scorers vs. benchmark (.994). Inter-rater agreement between human scorers and AI models was similarly high (ICC: .993 and .987 respectively).

Conclusions: This novel investigation of AI-based ASR models for speech perception scoring reveals that both Whisper and Assembly AI demonstrate comparable accuracy to human scorers. Our findings suggest that human scorers may overestimate speech perception scores compared to subject-transcribed orthographic benchmarks, possibly due to priming from having access to CNC word lists. AI-based scoring could enhance clinical speech perception testing and facilitate longitudinal tracking of speech outcomes. Future work will expand the subject pool and human scorer comparison group to validate these preliminary findings.

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T-W 13: RELIABILITY OF USING CBCT SCANS TO DERIVE THE PARAMETERS OF THE DIMENSIONS OF THE FACIAL CANAL

S. Govender[1,3], T. Hanekom[2], R. Human-Baron[3]

[1]Department of Anatomy, School of Medicine, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa.
[2]Department of Electric, Electronic and Computer Engineering, Faculty of Engineering, Built Environment and Information Technology, University of Pretoria, South Africa.
[3]Department of Anatomy, School of Medicine, Faculty of Health Sciences, University of Pretoria, South Africa.

Purpose/Objective: The purpose of this study is to derive the reliability and accuracy of the parameters from the facial canal on cone beam computed tomography scans by comparing them to morphometric analysis of the facial canal of the same embalmed cadaver heads.

Methods/Approach: Twenty embalmed cadaver heads were scanned with a Planmeca Promax 3D CBCT scanner, thereafter the facial canals were dissected. Parameters that define the proximal and distal diameters, and lengths of each of the segments of the facial canal were measured on both the CBCT scans and dissected cadaver temporal bones. For statistical analyses, the level of significance was set at 5%. Descriptive statistics included the mean, standard deviation, minimum and maximum were calculated at a 95% confidence interval. A Shapiro-Wilk test indicated that all group measurements were normally distributed ($p>0.05$), and thus comparisons between group means (i.e., segments from the dissected temporal bones vs segments from the CBCT imaging) were made using a paired t-test. The Bland-Altman plot was used to assess the agreement between the CBCT measurements and dissected measurements of temporal bones by plotting the difference against the means of the measurements from the CBCT and dissected temporal bones. Intra- and inter-observer errors were ana-lysed using Lin's concordance correlation coefficient test to test for reliability and repeatability, respectively.

Results/Findings: The paired t-test indicated significant differences ($p<0.05$) between the CBCT parameters and the dissected embalmed cadaver heads. The dimensions of the facial canal of the dissected temporal bones were consistently higher than the CBCT measurements for all segments of the facial canal. However, Bland-Altman plots showed a mean difference close to zero with a wide scatter of the arrangements of the points within the 95% limits of agreement. This visual representation indicates an agreement between the parameters derived from the CBCT images and dissections. There is consistency between the parameters from each modality irrespective of the differences in the size of the measurements. Intra-observer error scores for the dimensions of the facial canal from the CBCT scans and the dissected facial canals were 0.996 and 0.979 respectively. Interobserver error values were 0.963 and 0.950 for the dimensions of the facial canal from the CBCT scans and the dissected facial canals respectively. These values indicate a high agreement of reliability and repeatability.

Conclusions/Implications: It is worth noting that a potential difference in segment sizes may exist between populations but will have no effect on the use of parameters derived from CBCT scans as a pre-operative assessment of the facial canal and its use in constructing user patient-specific neural compound three-dimensional models of the facial canal of the cochlea.

T-W 14: INVESTIGATION OF INTRACOCHLEAR ELECTRICAL FIELDS WITH SPREAD OF EXCITATION AND VOLT-AGE MATRIX AND THEIR LINK TO SPEECH PERCEPTION

Tobias Rader, **Pascal Nachtigäller**

Division of Audiology, Department for Otorhinolaryngology, LMU University Hospital Munich, Germany

Objective measures and their relation to listening performance are of interest in the study of cochlear implants. For cochlear implant users, measurements of electric field spread such as the voltage matrix (VM, MED-EL) and the transimpedance matrix (TIM, Cochlear) are increasingly equated with neural masking (spread of excitation, SoE) measurements [1]. For intraoperative position control, especially the detection of tip foldover in cochlear implants during implantation, the faster VM measurement is preferred over the more time-consuming SoE measurement. The relationship between SoE and VM has so far been little investigated in experienced CI users.

Methods: Postoperative SoE and VM data were normalized before comparison. The similarity in 17 patients between postoperatively measured SoE curves and the VM and their link to speech perception was investigated. RMS differences and the VM separation index (from Hughes, 2008) [2] were calculated for SoE and VM measurement paradigms and correlated with results of speech perception.

Results: The curves of VM and SoE correlate strongly in most CI-users, but some deviations were observable: an average RMS-difference of 0.159 normalized amplitude was found between SoE and VM data. Asymmetric width measures extracted from exponential fitting differed significantly between SoE and VM data. The VM separation index correlated with speech perception.

Conclusion: SoE and VM are closely related measurements, however they are not identical. The VM separation index appears to be a promising approach for predicting listening performance. Nevertheless, further research is required to corroborate this finding.

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T-W 15: NEW INSIGHTS ON FOCUSED ANALOG STIMULATION IN A GUINEA PIG MODEL OF THE COCHLEAR IMPLANT

V. Adenis[1], R. Bartholomew[1], J. I. Lee[2], A. Jung[1], M. C. Brown[1], D. J. Lee[1], S. Fried[2,3], J. Arenberg[2]

[1]Eaton-Peabody Laboratories, Dept. of Otolaryngology, Massachusetts Eye and Ear, Harvard Medical School, Boston, MA
[2]Dept. of Neurosurgery, Massachusetts General Hospital, Harvard Medical School, Boston, MA
[3]Boston VA Medical Center, Boston, MA

Background: The goal of the cochlear implant (CI) is to provide speech comprehension in individuals with severe to profound hearing loss. Since the 1990s, encoding of the speech waveform has relied almost exclusively on envelope extraction and non-simultaneous, interleaved pulse stimulation. Alternative coding strategies based on feature extractions (F0 and formants frequencies) were also proposed but, unfortunately, they were coupled with simultaneous sinusoidal analog stimulation with monopolar or bipolar stimulation modes. These modes led to elevated channel interactions due to current summation and spread. Progress in methods for focusing electrical fields with tripolar stimulation are leading us to revisit sound coding strategies based on analog stimulation and spectral feature extraction. In this study we used advanced current focusing to compare analog with pulsatile stimulation in an in vivo guinea pig CI model.

Methods: We used a round window approach to insert an 8-electrode cochlear implant array into the scala tympani of the basal half of the cochlea. Multiunit responses were recorded in the central nucleus of the inferior colliculus (IC) using a penetrating 16-channel probe (Neuronexus). First, IC probe placement along the tonotopic axis was confirmed by acoustic stimulation with pure tones from 8 to 40 kHz. Next, deafness was induced via 10% neomycin infusion and confirmed by auditory brainstem responses (ABR). We compared pulsatile and analog monopolar, bipolar and tripolar CI stimulation modes to characterize analog responses when coupled with current focusing. We measured spread of excitation (SOE) in IC during analog stimulation, single biphasic pulses, low-rate pulse trains (50-100Hz) and clinical rate pulse trains (1kHz). Finally, we stimulated two channels simultaneously, each having a specific rate (19 vs. 37 Hz or 119 vs. 337Hz) to quantify channel interactions in the temporal domain by looking at vector strength patterns across the IC.

Results: Overall, tripolar analog stimulation mode evoked very focal IC activations as previously described with single pulses and pulse trains. IC activations were tonotopically organized and consistent with apical-to-basal positioning of stimulating electrode. Responses were strongly phase-locked with stimulation pulse rate and/or sinusoidal period. In general, SOE in IC tended to be narrower with analog stimulation compared with biphasic pulse trains. A strong polarity effect of increased evoked responses was observed in that the IC neurons respond to both phases of the sinusoid. This effect seemed to be largest with higher levels of stimulation in the monopolar mode and for most levels with the tripolar mode. Analyses of evoked response synchronization index are ongoing to further characterize the viability of tripolar analog stimulation.

Conclusion: The focal and tonotopic responses observed demonstrate that place cues were well-conveyed by focused analog stimulation presented in tripolar mode. Furthermore, the strong phase locking observed demonstrates that temporal cues can also be provided by focused analog stimulation. Future studies will be needed to characterize and minimize channel interactions in analog stimulation, although current analyses points toward relatively small channel interactions when coupled with tripolar mode. Potential uses of the polarity effect observed during our experiment remain to be explored as it could serve as a tool to test the electrode-neuron interface. Overall, tripolar analog stimulation shows promise for conveying important sound features like temporal fine structure that could improve hearing performance among CI users.

T-W 16: ELECTROPHYSIOLOGICAL DIFFERENCES BETWEEN LATERAL WALL AND PERIMODIOLAR ELECTRODE ARRAYS

Viral Tejani[1,2]

[1]ENT Institute, University Hospitals Cleveland Medical Center, Cleveland, OH
[2]Department of Otolaryngology-Head and Neck Surgery, Case Western Reserve University School of Medicine, Cleveland, OH

Purpose: Two major cochlear implant electrode array designs exist presently - perimodiolar and lateral wall. Studies provide conflicting information on the superiority of one array type over the other in terms of speech recognition outcomes[1,2,3,4]. The current study measures electrically evoked compound action potentials (ECAPs), which are a direct measure of auditory nerve activity, to understand factors that may contribute to speech perception outcomes of perimodiolar and lateral wall array cochlear implant users. We use ECAPs to measure neural encoding of spectral and temporal information, which includes spread of excitation, coding of amplitude modulated pulse trains, and recovery from neural adaptation. In addition, the TransImpedance Matrix tool can be used to measure voltage spread along the cochlea, which is independent of neural status. These measures have been theorized to correlate with outcomes in past studies but no direct correlations have been made.

Methods: Thirty participants implanted with current generation lateral wall electrode arrays (Nucleus CI 422, 522, 622) or current generation perimodiolar electrode arrays (Nucleus CI 532, 632) will be recruited (15 per group). For ECAP spread of excitation, two biphasic pulses were delivered sequentially to two electrodes, and the resulting ECAP was measured to reflect the neural interaction between the two electrodes. This was repeated for all two-electrode combinations. For TransImpedance measures, a biphasic pulse was delivered to one electrode (stimulus electrode), and the resulting voltage and impedance was measured across all electrodes. This was repeated for all 22 stimulus electrodes. ECAP amplitude modulation measures were made using a 900 Hz, 100 ms pulse train modulated at 25, 50, 90, and 225 Hz. ECAPs were recorded over the last two periods of each pulse train. Measures were made at five test electrodes spaced equally across the array. ECAP neural adaptation recovery measures were also made using a 900 Hz, 100 ms pulse train at the same five test electrodes.

Results: Preliminary data suggest greater current spread / neural spread of excitation and greater ECAPs to amplitude modulated stimuli for the lateral wall arrays compared to the perimodiolar array. The impact of array design on neural recovery from adaptation is inconclusive.

Conclusions: Though data collection is on-going, the direct measurement of current spread and temporal processing will potentially provide insight into neural processing of these stimuli for perimodiolar and lateral wall CI users. The overall goal is to combine these measures with future studies on psychophysical measures of spectral and temporal processing to understand their combined impact on speech understanding outcomes.

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T-W 18: HOW FREQUENCY-BASED TESTING MAY ENHANCE OUR UNDERSTANDING OF COCHLEAR IMPLANT ADAPTATION TO FREQUENCY-TO-PLACE FACTORS?

L. Villejoubert[1], D. Vickers

SOUND Lab, University of Cambridge, Cambridge, United Kingdom

Purpose/Objective: The adaptation to cochlear implants (CIs) remains a poorly understood topic. While some CI users quickly achieve good levels of speech perception, even in challenging situations, others struggle to reach similar levels. This variability may indicate the contribution of individual factors to CI adaptation. In the present study, we explore the influence of two specific "frequency-to-place factors": the frequency-to-place mismatch (FTPM) and the quality of the electrode-neuron interface (ENI).

Methods/Approach: The first test focuses on speech perception and its relationship with FTPM. We developed a test based on vowel identification, in which artificial sounds with different combinations of the first two formants are presented to CI users. From a closed list of vowels, CI users select the closest vowel and then rate their confidence in the selection. Based on their responses, we generate "heat maps" for each vowel and compare them with those obtained from normal-hearing listeners. These heat maps are also compared with the degree of FTPM to estimate the level of adaptation. The second test examines chord perception and its relationship to ENI quality. For this test, we synthesized major chords that contain only the fundamental frequency for each note. These chords were presented in pairs to participants, with each pair consisting of the root version and the inverted version of the chord. In this context, each chord is designed to specifically stimulate a different range of electrodes, intended to differ by just one electrode site. Participants indicate quality preferences which could be the same even if they perceive the spectral differences between chords but if the electrode range for one chord elicits distortion this should result in the respondent scoring it as a less pleasant sound quality. Using Bayesian analysis, we created a pleasantness index for each electrode. We plan to compare these pleasantness indices to the Panoramic Electrically Evoked Compound Action Potential (PECAP), which evaluates neural responses across multiple electrodes in a CI array.

Results/Findings: Ten post-lingually deafened adult CI users with over 12 months of experience participated in our pilot study. Preliminary findings indicate good test-retest reliability of the measures. Vowel experiments showed a preference for certain shifted configurations, while chord tests revealed significant variability across electrodes, linked to CI mapping settings. These participants will be retested with the refined stimulus set to understand the consistency and value of the measures.

Conclusions/Implications: These methods have the potential to serve as clinical tools for optimizing CI settings, ultimately enhancing sound quality for users. Further analyses will be presented at CIAP, particularly on adaptation to FTPM and the relationship between electrode pleasantness and neural responses.

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T-W 19: THE INTERACTION BETWEEN PROCESSING STRATEGY AND MASKER TYPE ON SPEECH PERCEPTION IN NOISE WITH SIMULATED COCHLEAR IMPLANTS

Lidea Shahidi, Caleb Lee, Robert P. Carlyon, Tobias Goehring

Cambridge Hearing Group, MRC Cognition and Brain Sciences Unit, University of Cambridge, Cambridge, UK

Speech perception remains challenging for cochlear-implant (CI) recipients in conditions containing background noise. The majority of CIs use envelope-based speech processing strategies, in which the amplitude envelope of the bandpass-filtered speech signal is used to modulate the amplitude of pulse trains applied to each electrode. Envelope-based strategies either stimulate all (M) electrodes, as in the case of the Continuous Interleaved Sampling (CIS) strategy, or a subset (N-of-M) of electrodes, as in the case of the Advanced Combination Encoder (ACE) strategy, which selects the N electrodes corresponding to the frequency bands with the highest energy. Previous comparisons of speech-in-noise perception with ACE and CIS either found no significant difference between speech intelligibility with either strategy (Cucis et al. 2019; Hwang et al. 2012) or moderate improvements in speech intelligibility with ACE over CIS (Wong et al. 2008; Skinner et al. 2002; Kiefer et al. 2001). Notably, studies that found improved speech intelligibility with ACE tested intelligibility at positive target-to-masker ratios with relatively stationary maskers, where ACE likely selects target-dominated pulses for stimulation and may provide a benefit over a CIS strategy. Real-world listening conditions often contain non-stationary maskers, such as competing talkers, in which the instantaneous target-to-masker ratio fluctuates over time and frequency and where non-positive target-to-masker ratios may occur. The highest-energy criterion used by ACE may select masker-dominated pulses in situations where the energy of the masker dominates the energy of the target signal such that the perception of ACE-processed speech may show a greater deterioration with decreasing SNR with a non-stationary than a stationary masker. Whether the highest-energy criterion for channel selection interacts with the stationarity of the masker remains to be determined.

This study investigates the possible interaction between strategy and masker type on speech intelligibility. To avoid confounds due to heterogeneity in processing parameters (e.g. channel stimulation rate or number of active channels), variable hearing outcomes across CI recipients, or familiarity with either processing strategy, the study tests typical-hearing listeners using a vocoder that simulates the spread of electrical current within the cochlea (Grange et al., 2017). Experiment 1 characterized psychometric functions of speech intelligibility by target-to-masker ratio for three maskers: speech-shaped noise, four-talker babble noise, and a single competing talker. It provided measures of the slopes of the psychometric functions for the three maskers, informing the design of experiment 2 such that the measurement precision of speech reception thresholds (SRTs) would be similar for the three masker types. Speech intelligibility was measured as the percent of words correctly identified in the closed-set UK matrix sentence test from a target-to-masker ratio of -12 dB to 9 dB. Psychometric functions were obtained using vocoded speech in two realistic levels of simulated current spread: -8 dB/octave and -16 dB/octave. Ten typical-hearing participants took part and all stimuli were vocoded with a 22-channel vocoder, simulating the CIS strategy in Cochlear(TM) devices. Experiment 2 then measured SRTs across the three maskers and two processing strategies (CIS and ACE). To simulate the ACE strategy, 8 of the 22 vocoder channels were selected for presentation within each temporal frame and gated using a 4-ms raised-cosine ramp. Twenty-six typical-hearing participants took part. Two measures of the SRT were measured adaptively for each strategy and masker combination using the UK matrix sentence test. We will discuss results from the ongoing listening experiments, revealing whether differences in speech intelligibility with either strategy depend on the temporal characteristics and level of the masker.

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T-W 20: COMPARISON OF THE EFFECT ON THE AUDITORY NERVE RESPONSE OF ACE AND FIDELITY 120 IN A COMPUTATIONAL MODEL

I. M. Venema[1], S. S. M. Martens[1], J. J. Briaire[1], J. H. M. Frijns[1,2,3]

[1]Department of Otorhinolaryngology and Head & Neck Surgery,
Leiden University Medical Center, Leiden, The Netherlands;
[2]Leiden Institute for Brain and Cognition, Leiden University, Leiden, The Netherlands;
[3]Department of Bioelectronics, EEMCS, Delft University of Technology, Delft, The Netherlands

Purpose/Objective: A major limitation in cochlear implant (CI) research is the inability to compare implant strategies of different manufacturers in the same patient, which means that research into their effectiveness is only possible using large patient groups. Using a computational model allows the analysis of different strategies in the same cochlea for both frequency and loudness encoding. Settings of the strategies, such as pulse rate or input dynamic range can easily be changed to match previous clinical studies. The virtual implanted cochlea can also be compared to the virtual typical hearing (TH) system like the one developed by Bruce et al. [1]. This can provide additional insight in clinical findings of CI research and assist in the improvement of speech encoding.

Methods/Approach: The newest version of the Leiden implanted cochlea model, developed by Martens et al. [2], simulates the response of the auditory nerve to audio signals after they are processed by a CI speech encoding strategy. The existing model works with HiRes Fidelity120 (F120) from Advanced Bionics and was extended for this study with the Advanced Combination Encoder (ACE), developed by Cochlear. Stimuli used were pure tone sounds of different frequencies and loudnesses as well as harmonic sounds. The model uses (digital) sounds as an in-put to create neurograms as output.

Results/Findings: Neurograms obtained with the models show large spectral resolution differences between the TH and CI implanted cochlea. Differences in frequency encoding between speech strategies were reflected in spectral resolution and neural fiber activation patterns. Differences in loudness were reflected in the neural firing rate and the width of neural activation. The model clearly illustrated that loudness growth at high levels differs between strategies: F120 achieves this by applying higher currents, whereas ACE utilizes multiple contacts to enhance loudness. However, despite these differences, both strategies result in a comparable growth of firing rate.

Conclusions/Implications: This model provides insight into the translation of electric signal to neural signal for two different cochlear implants when compared to typical hearing. It enables objective visualization of the effect of speech encoding strategies on neural activity, eliminating the need for patient testing. In the future, this model can assist in the improvement of existing or the development of new speech encoding strategies for CI users.

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T-W 21: A NOVEL METHOD TO ASSESS CONTRIBUTIONS OF SPECTRAL AND TEMPORAL PITCH CUES IN REALISTIC SPEECH STIMULI

F. Rotteveel[1,2], A. Maat[1], C. James[3], D. Kovačić[4], L. A. J. Reiss[5], D. Başkent[1], E. P. C. Gaudrain[2]

[1] University Medical Center Groningen / University of Groningen, Groningen, The Netherlands
[2] Lyon Neuroscience Research Center, CNRS UMR5292, Inserm U1028, Université Lyon 1, Lyon, France
[3] Cochlear France SAS
[4] University of Split-Faculty of Science, Split, Croatia
[5] Oregon Health & Science University, Portland, Oregon, USA

Purpose: Pitch perception is known to be significantly impaired in cochlear implant (CI) users. Previous research has indicated that pitch perception of CI users depends mainly on temporal envelope cues. However these studies used either well-controlled but artificial stimuli or indirect measures of assessing cues. A recent study examining electrodograms obtained with more realistic stimuli of speech concluded that temporal envelope cues were not particularly salient. The authors proposed that some spectral pitch cues may also be available. Using a novel approach, this study aims to directly quantify the relative contributions of spectral and temporal cues to pitch discrimination of CI users in speech stimuli.

Methods: Psychometric functions for fundamental frequency (f0) discrimination were collected in CI listeners, using triplets of consonant-vowel syllables in a three-alternative forced choice task. The preliminary data includes five late-implanted, adult CI users. Two modalities of stimulation were used: acoustic, via a loudspeaker with the participants own processor, and electric, through a research interface. For the latter, electrodograms were recorded in advance with the participants' own program settings, as if they were seated in the soundproof booth. Then, the electrodograms were processed to produce four conditions: unaltered, temporal cues suppressed, spectral cues suppressed, and both cues suppressed. Temporal cues were suppressed by filtering the temporal envelope of each channel with a comb-filter based on the f0. Spectral cues were suppressed by raising or lowering current levels to produce similar spectral envelopes for all three triplets, while mostly preserving the temporal envelopes of each channel. During the experiment, the electrodograms from the four conditions were streamed to the CI user. This recording and restreaming method allowed us to precisely control the available cues while working with natural speech stimuli and incorporating all the bells and whistles of a modern processor.

Results: The preliminary data shows that the acoustic and unaltered electric streaming conditions have similar performance. Suppressing temporal cues decreases pitch discrimination performance, i.e. shifting the psychometric function towards larger f0 differences. Suppressing spectral cues decreased performance of one CI user, although the effect was smaller than suppressing temporal cues.

Conclusions: The similar performance between acoustic and unaltered electric conditions verifies that the streaming of prerecorded stimuli can give a near-normal electric hearing percept. Therefore, this novel method is capable of producing realistic speech stimuli while giving the researcher precise control over the stimulation. The preliminary data on suppressing pitch cues suggests that CI users are mostly relying on temporal cues for pitch discrimination, while spectral cues are utilized less and only by some. Although these findings mostly agree with the previous literature, it seems that some users might be utilizing spectral cues in their pitch perception. Which CI users are utilizing what cues remains to be seen.

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T-W 22: DEVELOPMENT OF A MACHINE LEARNING SYSTEM FOR PREDICTING COCHLEAR IMPLANT PERFORMANCE: A COMPARATIVE ANALYSIS WITH EXPERT PREDICTIONS AND A WEB-BASED DEMONSTRATION

Alexey Demyanchuk, Eugen Kludt, Thomas Lenarz and Andreas Buechner

Hannover Medical School, Hannover, Germany

Introduction and Objective: Hearing loss affects over 17% of the global population, significantly impacting quality of life. Cochlear implantation is a well-established intervention; however, predicting postoperative outcomes remains a major clinical challenge. To address this, we developed a machine learning (ML) system for predicting cochlear implant (CI) performance using a large retrospective dataset of approximately 2000 adult patients with post-lingual hearing loss. The dataset included key epidemiological and clinical variables, such as age at implantation, duration of deafness, preoperative pure tone audiometry, and word recognition scores. The primary outcome variable was the postoperative monosyllabic word recognition score at one year post-implantation.

Methods: The ML pipeline involved data preprocessing, feature selection, and model development using decision tree-based approach, evaluated via k-fold cross-validation. The best-performing model was validated on a hold-out dataset. Additionally, a web-based demonstration of the ML system was developed to enable interactive exploration of model predictions. Furthermore, we compared our model's predictive accuracy with estimates provided by subject matter experts (SMEs) to assess its clinical relevance.

Results: Our ML system demonstrated robust predictive capabilities, achieving a mean absolute error (MAE) of 17.3% (SD: 14.3%) on the hold-out dataset. When evaluated on chrono-logically new unseen implantation data, the model yielded an MAE of 17.8% (SD: 12.4%). To assess its performance relative to clinical expertise, we collected predictions from SMEs and compared them to model-generated estimates. The decision tree-based model produced an MAE of 19.1%, while expert predictions achieved a comparable MAE of 18.9%. Visual analyses revealed that both approaches deviated similarly from actual postoperative scores, highlighting the model's potential to support clinical decision-making.

Conclusion: This study presents a machine learning-based predictive system for cochlear implant performance, demonstrating accuracy comparable to expert predictions. The integration of a web-based demonstration further enhances accessibility and usability for clinicians. Future research will focus on improving generalizability by incorporating additional clinical and demographic factors.

T-W 23: AUDITORY AND COGNITIVE CONTRIBUTIONS TO GATED WORD RECOGNITION IN COCHLEAR IMPLANT USERS

Ariana Bennaim, Nirmal Srinivasan, Chhayakant Patro

Towson University

Objective: This study examined the sensory and neurocognitive factors underlying differences in gated word recognition performance among cochlear implant (CI) users. Specifically, we aimed to determine whether auditory spectral resolution, working memory, and executive function distinguish high- and low-performing CI users on a word gating task.

Method: Participants completed a gated word recognition task in which progressively longer word-onset segments were presented. After each gate, listeners identified the target word. Performance was compared between high- and low-performing CI users. Sensory perception was assessed using the Spectral-Temporally Modulated Ripple Test (SMRT), which evaluates auditory spectral resolution. Neurocognitive functioning was measured through the Abbreviated Reading Span Test, assessing working memory, and the Trail Making Task, evaluating executive function.

Results: Preliminary findings indicate that auditory spectral resolution, as measured by the SMRT, was the primary factor distinguishing high- and low-performing CI users. In contrast, non-verbal cognitive measures of working memory and executive function showed minimal contributions to performance differences. Additional analyses are in progress to further explore the relative contributions of spectrotemporal auditory processing and cognitive factors to word recognition performance in CI users.

T-W 26: CI ADULTS' NEURAL ENCODING OF EMOTION AND GENDER DISCRIMINATION IN SPEECH

Xinyi Yao[1,2,3], Emily Graber[4], Andrew Dimitrijevic[1,2]

[1] Sunnybrook Research Institute, Sunnybrook Health Sciences Center, Toronto, Canada
[2] Department of Physiology, University of Toronto, Toronto, Canada
[3] Department of Otorhinolaryngology-Head & Neck Surgery, West China Hospital of Sichuan University, Chengdu, China
[4] Department of Computer and Information Science, Allegheny College, Meadville, USA

Objective: This study is aimed to compare the capability of differentiating speech emotion and gender in patients with cochlear implants (CI), and investigate the underlying mechanism of neural processing.

Method: Twenty-two CI adults were recruited and completed emotion and gender discrimination tasks with a 64-channel electroencephalogram (EEG) recording the neural response. The stimulus were 400 semantically neutral sentences, with emotional articulation (happy/angry) and gender (male/female) of the speaker varied across trials. Participants were required to discriminate the emotion or gender of the speaker based on a visual priming cue presented prior to the auditory stimuli.

Result: Behaviorally, significant shorter reaction time and better accuracy were respectively observed in distinguishing angry emotion as compared to happy ones, and telling female voices as compared to male voices. Similarly, it was more challenging to differentiate emotion than gender. As for EEG data, temporal response function (TRF) mapping of envelope and pitch features revealed similar patterns. CI participants displayed significantly greater N1 amplitude and longer P2 latency when detecting angry stimuli compared to happy stimuli, and showed shorter P2 latency in male voices than female voices and in emotional discrimination than gender differentiation. Delta accuracy was calculated by subtracting the r-value of one single TRF model from the full model, finding that envelope and pitch were equally utilized to distinguish emotion and gender.

Conclusion: CI users exhibited better performance in discriminating happy emotions and female voices. Both emotion and gender discrimination equally rely on envelope and pitch features, though emotion discrimination proved more challenging.

T-W 27: WHEN TO CONSIDER AIDED THRESHOLDS AND TIME ON AIR ABNORMAL: INSIGHTS FROM BIG DATA

Saji Maruthurkkara, Quang Thai, Griet Goovaerts, Yue Zhang

Cochlear Limited

The Aided Threshold Test (ATT), which measures the quietest sounds a person can hear with their cochlear implant (CI), is the most commonly used performance test by clinicians worldwide. However, there is significant variability in the accepted target for what constitutes a clinically significant aided threshold that warrants intervention. Some clinicians consider 25dB HL to be problematic, while others accept 40dB. Remote Check functionality in the Nucleus SmartApp enables the self-measurement of ATT at levels lower than traditional audiometry, and it is highly accurate and repeatable. However, the target threshold for ATT in Remote Check to be considered acceptable is currently unknown.

Time on Air (TOA) is one of the most easily modifiable factors. Emerging evidence suggests that more than 12 hours of TOA is acceptable. However, CI recipients may experience day-to-day variations in TOA due to life events. The acceptable variation in TOA is also unknown.

Objectives: Identify what aided threshold levels from Remote Check are clinically problematic and determine what variation in TOA should be considered acceptable.

Methods: Optimal aided threshold targets were determined using technical analysis of signal processing along with published literature on the effects of minimum stimulation levels (T levels) on aided thresholds. Big data analysis of clinician reviews of real-world ATT from Remote Check was used to evaluate the proposed aided threshold targets. Additionally, big data analysis was used to determine the natural variation in TOA.

Results: The presentation will describe the approach and the detailed results of the ongoing analysis. It will cover the methods used to determine optimal aided threshold targets and the evaluation of these targets through big data analysis of clinician reviews. Additionally, the natural variation in Time on Air (TOA) will be discussed.

Conclusion: Clear guidelines for clinicians on clinically significant aided threshold levels and acceptable variations in TOA could improve the management and outcomes for CI recipients. This study helps determine these guidelines and demonstrates how big data can offer valuable insights into these areas.

T-W 28: INSIGHTS FROM MONOPOLAR AND 3-POINT IMPEDANCES COLLECTED DAILY FOR THREE MONTHS FROM THE DAY OF SURGERY

Patrick Boyle[1], Faizah Mushtaq[2], Efstratia Papoutselou[2], Doug Hartley[2]

[1]Advanced Bionics GmbH, Germany
[2]Rinri Therapeutics Ltd, UK

Objectives: This study aimed to evaluate the daily development of cochlear implant (CI) electrode contact impedances from the date of surgery for 3 post-operative months. Specifically, we sought to compare monopolar and 3-point impedances within individual subjects to assess their relationship across the electrode array and to explore how impedance changes over time reflect cochlear tissue responses.

Methods: Eight adult CI recipients were provided with an AIM tablet, enabling them to measure their electrode contact impedances at home on a daily basis for 3 months. Standard monopolar impedances were recorded, and 3-point impedances were derived from the cross-impedance matrix. Comparisons were made within subjects to examine the temporal evolution of both impedance types along the electrode array. Further comparisons were made to impedance data collected daily from implant recipients who had used their device for at least one year.

Results: Participants successfully recorded impedances nearly every day. Initial impedances measured approximately 5.5 kOhms at the apical electrodes, decreasing to around 4.0 kOhms at the basal end. Over three months, apical impedances remained largely unchanged, whereas basal impedances increased to approximately 7 kOhms, consistent with the progression of fibrosis from the basal cochlea. On some days the impedances were 2 to 3 kohms lower on individual electrode contacts, with this being more common in the immediate post-surgery data than in the data collected after one year of use. Derived 3-point impedances provided more localized insights into impedance changes over time, also revealing fluctuations at specific electrode contacts throughout the recording period.

Conclusions: These findings indicate that substantial post-implantation changes in electrode impedances occur over time, particularly at the basal end of the electrode array. Regular impedance monitoring could enhance programming strategies, potentially improving patient outcomes by maintaining compliance limits and preserving sound quality. The use of 3-point impedance measurements offers a more localized view of cochlear tissue responses, which may aid in refining electrode programming. Future studies should involve larger cohorts to further investigate how impedance variations relate to cochlear changes and their impact on auditory perception. For the recording of 3-point impedances a bipolar measurement is recommended to avoid noise and insensitivity associated with deriving these from monopolar recordings.

T-W 29: OUTCOMES FOR SINGLE-SIDED-DEAFNESS COCHLEAR-IMPLANT USERS WITH SHIFTED FREQUENCY ASSIGNMENTS TO REDUCE INTERAURAL FREQUENCY MISMATCH

Joshua G. W. Bernstein[1], Julianna R. Voelker[1], Sandeep A. Phatak[1], Elicia M. Pillion[1], Kenneth K. Jensen[1], Megan M. Eitel[1], and Matthew J. Goupell[2]

[1]Walter Reed National Military Medical Center, Bethesda, Maryland, USA
[2]University of Maryland–College Park, College Park, Maryland, USA

For cochlear-implant (CI) users with single-sided deafness (SSD), standard clinical programming yields interaural frequency mismatch that might degrade spatial hearing abilities. This longitudinal study examined how non-standard frequency-to-electrode assignment ("remapping"), designed to reduce mismatch, affects spatial-hearing outcomes.

Nine experienced CI users with SSD or asymmetric hearing loss participated. Remapping and outcome testing was performed through videoconferencing and remote control of a research-dedicated laptop and circumaural headphones lent for this purpose. Remapped frequency-to-electrode assignments were derived from computed-tomography (CT) scans. In pilot tests, several subjects disliked the large shift required for interaurally matched stimulation. Therefore, the study examined the impact of a novel map with a frequency shift halfway (on a Greenwood scale) between the participant's original map and the CT-based frequency allocation.

At each timepoint, participants were tested with the novel and original maps. Four outcome measures were assessed at baseline (prior to any mapping changes) and approximately 3 and 6 months after the participant began using the novel map for everyday listening. (1) Contralateral unmasking: With target speech presented to the acoustic ear, binaural benefit was assessed by comparing performance when masking speech was presented to just the acoustic ear versus to both ears; (2) Speech in noise: Head-related transfer functions (HRTFs) were used to present target speech from the CI side and noise from the acoustic-hearing side; (3) Localization: HRTFs were used to present narrow-band noise complexes from a virtual array of target azimuths; and (4) Speech in quiet: Sentences were presented monaurally to the CI ear with masking noise in the acoustic ear.

As expected, the CI produced a broad range of benefit for all measures. On average the CI provided 2.5 dB of contralateral-unmasking benefit, 8 dB of speech-in-noise benefit, a 25 deg reduction in mean absolute azimuthal localization error, and 70% CI-alone word identification in quiet. However, there were no discernable differences between outcomes with the original and novel maps at any timepoint. Possible reasons include: (1) the halfway shift was inadequate to produce a benefit; (2) large current spread, possibly in conjunction with plasticity, might minimize the detriments of interaural frequency mismatch; or (3) interaural timing or loudness mismatch might overshadow any effects of frequency mismatch.

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T-W 30: TOWARDS CLOSED LOOP COCHLEAR IMPLANT FITTING BASED ON INTRACOCHLEAR CORTICALLY AUDITORY EVOKED POTENTIALS

Jonas Althof, Nina Aldag, Waldo Nogueira

Department of Otolaryngology, Hannover Medical School and Cluster of Excellence "Hearing4all"

For individuals with profound hearing loss, a cochlear implant (CI) can significantly enhance access to sounds that support speech perception. The effectiveness of these devices depends on the precise fitting of stimulation parameters, particularly the threshold levels of audibility and the loudest comfortable sound sensation. These parameters are typically derived from patient feedback, which is subjective and variable. Therefore, it would be advantageous to assess perceived loudness using an objective measure.

Previous studies have investigated the amplitudes of electrically evoked compound action potentials (eCAPs) as a function of stimulation level, forming the amplitude growth function (AGF) as a method to estimate threshold levels of stimulation. The success of eCAPs in clinical routine can likely be attributed to their ease of measurement using the CI electrodes without requiring additional hardware or software. However, the precise correlation between eCAP responses and perceived loudness is debatable.

More recently, cortical auditory evoked potential (CAEP) thresholds have been shown to correlate well with behaviorally determined hearing thresholds (Mao et al. 2018). CAEPs are typically recorded using scalp electroencephalography (EEG). However, CAEPs require extra hardware and software, making this measure challenging to include in routine clinical CI fitting. Recently, it has been shown that it is possible to record cortical responses from intracochlear electrodes (iEEG) in single-sided deafened CI users with acoustic stimulation and recording on the contralateral side (Aldag et al. 2022), as well as in bilateral CI users with contralateral electric stimulation (Bell-Souder et al. 2024).

In the current study, we measured eCAPs and CAEPs in five participants implanted with an Advanced Bionics CI. The stimulus amplitudes for eight different loudness levels on a 10-point loudness scale were approximated based on the subjects' feedback. The CAEPs and eCAPs for loudness levels from 1 (threshold of audibility) to 8 (uncomfortably loud) were measured simultaneously with EEG and iEEG. A loudness growth function was derived and the correlation between increased loudness levels and increased neural responses of eCAPs, CAEPs and iEEG-CAEPs was assessed.

Similar to the study by Mao et al. (2018), the results of the current study suggest that features derived from CAEPs show potential as a clinically relevant hearing threshold estimate. Pilot data of CAEPs recorded with iEEG demonstrate the feasibility of recording some neural activity, although these recordings present significant contributions from CI artifacts. Further research is required to refine the iEEG recording system to make it a clinically applicable measure.

T-W 31: NATURALISTIC COCHLEAR IMPLANT FIELD TESTING WITH ECOLOGICAL MOMENTARY ASSESSMENT

Taylor Lawson, **John H. L. Hansen**

CRSS: Center for Robust Speech Systems; Cochlear Implant Processing Laboratory (CILab), Department of Electrical and Computer Engineering, University of Texas at Dallas, USA

A range of diverse indoor and outdoor naturalistic environments were employed as in-field testing spaces for cochlear implant users to provide ecological momentary assessment (EMA) feedback using personalized CRSS-CILab portable monitoring devices. CI User feedback for audio environment and CI user experience was rated on a 5-point scale, with input captured using a customized Smart-Watch/Model-Tablet application during testing. Simultaneous audio monitoring capture was also recorded along with post CI-user EMA data entry, to quantify acoustic soundscape dynamics as well as noise/random acoustic event occurrences for audio content tagging. Results of this EMA based CI user benchmark experiment will be presented for further in-field CI testing evaluation and review.

T-W 32: IMPACT OF COCHLEAR IMPLANT PROCESSING ON ACOUSTIC CUES CRITICAL FOR ROOM ADAPTATION

B. K. Prajna, Justin M. Aronoff

Department of Speech and Hearing Science, University of Illinois Urbana-Champaign, Champaign, IL, USA

Speech comprehension in real-world listening environments, such as restaurants, can be particularly challenging for cochlear implant (CI) users compared to typical-hearing listeners. This difficulty arises both from late reflections (reverberation) in the room, which interfere with the sound source of interest, and from the signal processing strategies used in CI devices. Typical-hearing listeners rely on several mechanisms to compensate for these distortions, one of which is adaptation.

Adaptation refers to the short-term learning effect induced by prior exposure to the distortion patterns of a reflective environment, enhancing signal comprehension. This learning process makes use of specific acoustic distortion cues introduced by reverberation, such as the attenuation of modulation depth in the temporal envelope, spectral coloration introduced by the room, and statistical properties of the reverberation tail, including skewness and kurtosis.

Signal processing strategies in CIs can alter acoustic cues, potentially reducing their availability to CI users and affecting their ability to adapt to reflective environments. To examine the effects of CI processing, dry and reverberant speech signals were analyzed before and after simulating key stages of CI signal processing, including dynamic range compression, bandpass filtering, envelope extraction, and current spread.

Preliminary findings indicate that CI processing causes slightly greater attenuation of the modulation depth of the speech envelope compared to reverberation alone, relative to the dry signal. Additionally, room-induced spectral coloration was altered by CI processing, and reductions in the kurtosis and skewness of the reverberation tail were observed. These findings may partly explain the difficulties CI users face in reverberant environments.

T-W 33: A DEFORMABLE CONVOLUTION GAN FOR REVERBERATION SUPPRESSION IN COCHLEAR IMPLANT USERS

Hsin-Tien Chiang, John H. L. Hansen

Cochlear Implant Processing Laboratory (CILab), Center for Robust Speech Systems (CRSS)
The University of Texas at Dallas

Cochlear implant (CI) users struggle with reduced word recognition in diverse and changing reverberant environments. Unlike individuals with normal hearing (NH), who can generally understand speech even with moderate reverberation, CI users face significant difficulties under the same conditions. Moderate levels of reverberation can severely impair a CI user's ability to recognize speech, requiring the use of de-reverberation algorithms/solutions. While deep learning (DL) advancements have been made in speech dereverberation, most existing methods are primarily designed for NH individuals, leaving CI users with limited attention. In this study, we propose a deep learning (DL)-based approach entitled DeformGAN, which is based on a deformable convolution generative adversarial network designed to address speech dereverberation. The deformable convolutional network includes additional convolutional layers for kernel offset prediction which can help for situations where reverberation specifics might shift within a given location based on conversational subject pairs (e.g., normal hearing (NH) speaker to cochlear implant (CI) listener separation/orientation within the space). This GAN mechanism addresses the smearing effects of reverberation across both time and frequency by allowing the network to adaptively identify the optimal time-frequency regions within the input reverberant speech spectrogram. To evaluate the system performance, we compared DeformGAN with traditional signal processing methods (e.g., Blind Spectral Weighting (BSW) Sadjadi & Hansen,2014, Ideal Binary Mask (IBM)), and three DL-based approaches (SkipConvNET and SkipConvGAN Kothapally & Hansen, 2022) using the REVERB Challenge evaluation set. Results show that the proposed DeformGAN significantly outperforms prior signal processing and DL based approaches in the evaluation, thus confirming its effectiveness in suppressing reverberation. Additionally, we conducted subjective tests to assess intelligibility for two CI users with three reverberation conditions (RT60=0.3,0.6,0.7). There was an average 28.8% loss in intelligibility due reverb (e.g., 78.8% in clean to 50.0% in reverb), while DeformGAN was able to improve CI listener performance by 23.6% (e.g., 50.0% in reverb, to 73.6% with DeformGAN). These preliminary results highlight the potential improvement in speech intelligibility using DeformGAN under reverberation for CI users. Future work will include naturalistic field evaluations with the CCi-MOBILE Research Platform (Hansen, et el, 2018) in take-home scenarios.

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T-W 34: EXAMINING THE RELATIONSHIP BETWEEN LANGUAGE, PHONOLOGICAL PROCESSING, AND LITERACY SKILLS AMONG CHILDREN WITH COCHLEAR IMPLANTS

M. A. Lighterink[1], R. H. Gifford[2], and S. Camarata[1]

[1]Department of Hearing and Speech Sciences, Vanderbilt University, Nashville TN, U.S.A.
[2]Hearts for Hearing, Oklahoma City, OK, U.S.A.

Purpose: Although literacy outcomes among children with severe-profound hearing loss have significantly improved with intervention advances, including cochlear implants (CIs), some children with CIs still have delays in their reading development. The purpose of this study is: 1) to compare performance across several language domains among children with CIs; 2) to evaluate the contribution of these domains to literacy skills.

Methods: Participants included 47 prelingually deafened children with CIs who completed a battery of language and literacy assessments. Scale and subscale scores from the assessments were converted to Z-scores and aggregated to quantify performance in the domains of receptive and expressive language, memory, phonological processing for words and nonwords, and literacy. A repeated measures ANOVA was used to compare performance across these domains. A multiple linear regression model was utilized to evaluate the five language domains as predictors to literacy skills.

Results:
1) Participants had poorer scores for phonological processing in comparison to all other domains, including literacy.
2) The domains of expressive language and phonological processing (for words) were the strongest predictors of literacy skills.

Conclusions: On average, our sample of pediatric CI users displayed age-appropriate literacy skills despite relatively poor performance on tasks of phonological processing. These findings suggest that the relationship between language comprehension, phonological processing, and reading may be different among children with CIs in comparison to those without hearing loss.

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T-W 35: NEAR-INFRARED LIGHT PROTECTS RESIDUAL HEARING AND PRESERVES SPIRAL GANGLION NEURONS IN AN ANIMAL MODEL OF CI SURGERY

Dietmar Basta[1], Max Meuser[1], Moritz Gröschel[1], Sivan Faraj[1], Susanne Schwitzer[1], Patrick Boyle[2], Arne Ernst[1]

[1]Department of Otolaryngology at UKB, Charité Medical School, University of Berlin, Berlin 12683, Germany
[2]Advanced Bionics GmbH, Hannover, Germany

Given that today´s cochlear implant (CI) candidates present with substantial residual low-frequency hearing, the preservation of residual hearing is becoming an increasingly crucial but yet to be adequately resolved aspect of CI surgery. A recent study has shown that a 15-minute treatment with light in the red to near-infrared range (NIR) before the insertion of a CI-array resulted in a significant reduction of hearing loss especially in the frequency range of residual hearing, accompanied by a significant conservation of outer hair cells. Given that the total number of rescued hair cells was insufficient to account for the observed reduction in hearing loss, the present study aims to investigate the potential protective effect of NIR on spiral ganglion neurons and ribbon synapses in the context of a cochlear implant (CI) surgery.

Guinea pigs underwent initial auditory brainstem recordings (ABR) to confirm they were normally hearing. Subsequently, a unilateral NIR irradiation of the cochlea was performed followed by a bilateral insertion of a CI-array. After 4 weeks, a final ABR measurement was repeated and the cochleae were collected for histological analysis of spiral ganglion neurons and ribbon synapses.

A significant reduction of hearing loss for the NIR-pretreated ears was found in the frequency range between 8 and 32 kHz, with the highest effect at low frequencies. While the number of ribbon synapsis was unchanged by the electrode insertion and NIR-treatment, a significant amount of spiral ganglion neurons was lost by electrode insertion and rescued at the NIR-irradiated side, specifically in the apical portion of the cochlea where residual hearing is located.

The present findings show a significant neuroprotective effect of NIR on SGNs. The effect of NIR on ribbon synapses is unclear, since no loss was induced by the electrode insertion. The apically located rescue of SGNs suggests that the protective effect is specific to the frequency range of residual hearing.

T-W 36: SEMANTIC CUES IN CI SPEECH PROCESSING: EFFECTS OF "NEURAL CONTEXT GAIN" IN ANOMALOUS AND MEANINGFUL SPEECH PERCEPTION

Abigail Mollison, Sandy Snyder, Maureen J. Shader

Purdue University, Dept. of Speech, Language, and Hearing Science, Lafayette, IN, United States

While cochlear implants (CI) are a highly successful sensory prosthetic, the underlying mechanisms of individual variability in speech perception remain largely unknown. Acoustic information processed through a CI undergoes significant signal degradation, resulting in the loss of clarity in speech signals. To compensate for this, CI users may rely more heavily on top-down cognitive-linguistic processes to maintain functional speech recognition. One such process includes the use of semantic context within speech, where listeners are able to call upon known linguistic cues to accurately recognize the signal. Thus, the presence of semantic cues is positively correlated with improved speech-recognition scores. The goal of this study is to further investigate individual differences in the relationship between CI speech recognition and cognitive-linguistic functioning using a neural measure of semantic processing.

Neural activity in brain regions associated with semantic processing and executive function was measured using functional near-infrared spectroscopy (fNIRS). The amount of neural engagement in semantic-processing regions was estimated by contrasting neural activity in response to meaningful speech vs anomalous speech, otherwise known as "context gain." Anomalous sentences block the use of se-mantic and contextual cues to sentence recognition by maintaining correct grammatical and syntactic structure while eliminating all semantic meaning. This experiment tested the hypothesis that individuals with stronger neural activity in response to meaningful speech (i.e., larger neural "context gain") will demonstrate better speech-recognition outcomes with their CI, consistent with greater cognitive-linguistic functioning.

Ten adult CI users (mean age 56.9 years, SD = 22.5) listened to segments of running speech that were either semantically meaningful or anomalous. Meaningful speech segments were taken from passages in the Connected Speech Test. Anomalous speech segments were concatenated sentences from the Harvard-Anomalous corpus. A systemic-physiology augmented fNIRS (SPA-fNIRS) neuroimaging system was used to measure speech-evoked brain activity in response to both stimulus types in the premotor cortex, middle frontal gyrus, inferior frontal gyrus, and primary and secondary auditory cortices. To ensure participants were actively engaged in the task, listeners performed a word-monitoring task in which they were asked to identify if the previous stimulus contained a particular word shown on a screen. Hemodynamic response amplitudes in each region of interest were calculated for both the meaningful and anomalous sentence conditions. Behavioral speech-recognition scores were also collected for both meaningful and anomalous sentences in quiet.

Behavioral speech-recognition scores demonstrated excellent meaningful-sentence recognition in all participants (mean = 95.8%, SD = 2.74), while performance for the anomalous sentences was relatively poor and more variable across participants (mean = 60.9%, SD = 11.06). Neural contrasts between cortical activity in meaningful vs anomalous conditions showed that 9 out of 10 participants demonstrated significant neural context gain-- reflecting greater activation in the meaningful condition compared to the anomalous condition. This result suggests that those listeners were engaging greater cognitive-linguistic neural resources when contextual cues were available.

These findings suggest that the differences in cortical engagement between meaningful and anomalous sentence processing may reflect individual differences in listeners' ability to take advantage of the se-mantic and contextual cues in everyday speech. This may help explain some degree of individual variability in CI outcomes and allow for further research to identify commonalities across CI users showing similar neural activation patterns. Participants with a wide range of speech recognition ability will be recruited in order to further investigate the relationship between cognitive-linguistic functioning and CI outcomes.

T-W 38: RESTORING MULTI-ELECTRODE INTERAURAL-TIME-DIFFERENCE SENSITIVITY BY ADJUSTING INTER-ELECTRODE PULSE TIMING

Paul G. Mayo, **Matthew J. Goupell**

University of Maryland, College Park, MD, USA

Most studies of interaural-time-difference (ITD) sensitivity in bilateral cochlear-implant (BI-CI) listeners have used single-electrode stimulation, and it is unclear how best to convey ITDs via multi-electrode stimulation like that used clinically. Typical clinical processors use interleaved stimulation (ILS), where pulses from different electrodes are uniformly distributed within the pulse period. Because of current spread, which causes electrodes to stimulate broad neural populations, increasing the number of stimulating electrodes with ILS effectively increases the stimulation rate. This is important because there are severe rate limitations in BI-CI listeners, where ITD sensitivity is poorer with increasing stimulation rate even for single electrodes. In other words, increasing the number of stimulating electrodes is confounded by an increased stimulation rate. It is possible that "pseudo-simultaneous" stimulation (PSS), where pulses from neighboring electrodes are as close together as possible in time, could bypass this form of rate limitation. Yet, this stimulation approach has not been systematically evaluated, and both the effects and neural mechanisms behind the approach remain unclear. Therefore, this study focused on how inter-electrode timing affects ITD sensitivity for multi-electrode stimulation in BI-CI listeners. We hypothesized that a PSS-type strategy would bypass rate limitations and result in better multi-electrode ITD sensitivity than ILS.

BI-CI listeners completed an ITD lateralization task under direct stimulation using interaural-place-matched electrodes with various inter-pulse intervals (IPIs) and numbers of stimulating electrodes. The IPIs of the stimuli were manipulated by having the pulses evenly distributed across 0% (fully PSS), 25%, 50%, 75%, and 100% (fully ILS) of the pulse period on 1, 2, 3, 4, or 5 stimulating electrodes at 100 pps. There also included control conditions where a single electrode was stimulated at 100, 200, 300, 400, or 500 pps.

Preliminary results revealed that lateralization ranges for PSS were larger than ILS by a factor of two, suggesting ITDs were conveyed more effectively. Lateralization ranges also sharply increased when absolute IPIs were less than 1 ms, regardless of the percent of the pulse period or number of stimulating electrodes. This cutoff is consistent with neural facilitation and/or refractoriness from successive electrical pulses observed in human and animal work. Additionally, increasing the number of electrodes with ILS had the same negative effects on ITD sensitivity as increasing the pulse rate on a single electrode.

These preliminary data support our working hypotheses that PSS results in better ITD sensitivity and adding electrodes with ILS increases the effective stimulation rate. Using PSS to create periodic bursts of pulses within the auditory nerve's facilitation and/or refractory windows appears to circumvent rate limitations. One explanation for these results is that each pulse burst in PSS produces a single compound action potential. Electrode-neural interface measures such as electrically evoked compound action potentials, multi-pulse integration, and inter-phase gap effects may offer insight into the neural mechanisms behind these results. Additionally, a clear next step will be to combine PSS with other stimulation approaches to evaluate its effects on speech and spatial functional outcomes in a mixed-rate sound processing strategy.

T-W 39: BENEFIT OF LEARNING SYSTEMS FOR THE SITUATION-SPECIFIC OPTIMIZATION OF HEARING SYSTEMS IN EVERYDAY LIFE

Josef Chalupper[1], Manuel Kohl[1], Sven Kliesch[2], Andreas Büchner[2]

[1]Advanced Bionics, European Research Center, Hannover, Germany
[2]Department of Otolaryngology, Medical School Hannover, Hannover, Germany

Objectives: State-of-the-art hearing systems allow cochlear implant and hearing aid wearers to make situation-specific settings changes in everyday life via smartphone applications. Several studies have already shown that such self-adjustments carried often lead to a subjective improvement of the auditory experience under laboratory conditions (Goesswein et al. 2024, Kliesch et al. 2024). This contribution investigated to which extent self-adjustments in everyday life correlate with situation-specific descriptors (e.g. level, time, signal-to-noise ratio, classified listening situation) and thus, might be used by a learning system to automatically (i.e. without user interaction) perform an individually preferred adjustment after a learning phase.

Methods: 18 bimodal and bilateral cochlear implant recipients used an app that allowed situation-specific adjustments of volume and timbre over a period of six months in everyday life. In addition to the adjustments, a large number of situation-specific descriptors and a subjective assessment of the adjustment were recorded and analyzed. The aim of the retrospective evaluation was to identify descriptors that can be used for a learning system.

Results: The results show that the possibility to adjust volume and timbre was actively used by almost all subjects during the entire study period and led to a subjective improvement of the auditory experience without degrading speech intelligibility. However, few consistent associations were found between descriptors and changes of volume and timbre.

Conclusion: Based on these data - at least for the descriptors available here - a learning system does not seem to offer a clear benefit for bimodal and bilateral CI recipients compared to a simple momentary self-adjustment in everyday life.

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T-W 40: ENVELOPE-FOLLOWING RESPONSES IN COCHLEAR IMPLANT USERS: EFFECTS OF TEMPORAL ENVELOPE MODULATION COMPLEXITY

Julian Schott[1,2], Robin Gransier[1], Marc Moonen[2], Jan Wouters[1]

[1] ExpORL, Department of Neurosciences, KU Leuven
[2] STADIUS, Department of Electrical Engineering, KU Leuven

Electrically evoked auditory steady-state responses (EASSRs) are potentially useful neural responses for quantifying temporal envelope modulation (TEM) encoding of the auditory pathway in CI users [Luke et al. (2015); 10.1016/j.heares.2015.02.006]. Unfortunately, they are difficult to detect in electroencephalography (EEG) recordings due to the electrical stimulation artifacts of the CI. A recent artifact removal approach has shown good detection results, even with clinically relevant stimulation parameters, but has practical limitations, such as requiring more than one EEG recording of different EASSRs [Schott et al. (2023) - 10.1109/TBME.2023.3316838].

It is hypothesized that increasing the complexity of the TEMs of the stimulation, i.e., using temporal envelopes with time-varying modulation frequency, has benefits in a clinical setting. For instance, using a CI stimulation with time-varying modulation frequency removes the necessity of more than one EEG recording to detect envelope-following responses.

Interestingly, the systematic increase of TEM complexity has been proposed in a stimulation framework for normal hearing subjects to assess the envelope processing in the auditory pathway [Gransier Wouters (2021) - 10.1016/j.heares.2021.108374]. It has been shown, that it may be useful for identifying differences in temporal envelope processing among various listener groups with distinct auditory processing deficits [David et al. - 10.3389/fneur.2022.852030]. However, its applicability to CI users has not yet been tested, mostly due to the challenges posed by the CI stimulation artifacts.

In this work, we created different CI stimulation paradigms using TEMs of higher complexity, i.e., systematically and randomly changing modulation frequency, and investigated the effect. First, we analyzed, whether an increased complexity in TEMs has benefits for the CI stimulation artifact removal and response detection. For this, we created a hybrid dataset of EEG recordings with real CI stimulation artifacts and simulated neural responses. Second, we recorded EEG from 4 CI users, using stimuli with different TEMs, and investigated, whether envelope-following responses can be evoked and detected with the different stimulation types.

Preliminary results suggest that CI stimulation using TEMs with time-varying modulation frequency are beneficial for artifact removal and response detection. From a technical standpoint, these stimuli are superior over conventional stimuli, used to evoke EASSRs, as they can reduce clinical testing time, and can be detected in an online routine.

Moreover, envelope-following responses can be reliably evoked and detected in all CI users using TEMs of varying complexity. From a neurophysiological perspective, these findings demonstrate that the proposed stimulation framework is also applicable to CI users.

T-W 41: CI SELECT: AN IPHONE APP FOR PATIENT-DRIVEN FREQUENCY ALLOCATION TABLE SELECTION

Megan Eitel, Victor Treaba, Dan Jethanamest, Nicole Capach, Mario Svirsky

New York University Grossman School of Medicine, New York, NY, USA

While research indicates that many cochlear implant users could benefit from customized Frequency Allocation Tables (FATs) due to the mismatch between frequency-place functions (the normal physiological one and that imposed by cochlear implants), the clinical implementation of personalized FAT selection remains challenging due to time constraints in standard care. We present CI Select, a novel iPhone application that enables cochlear implant users to independently explore different FAT configurations in real-world environments.

CI Select implements a de facto modification of frequency mapping through audio preprocessing, delivering the output to the user's speech processor. The app allows users to explore a wide range of frequency maps by adjusting the low- and high-frequency edges of analysis filters. These filter outputs modulate pure tones (one per active channel) matched to the center frequencies of the user's speech processor filters. This approach results in primarily single-channel stimulation with minimal adjacent channel spread, enabling the simulation of arbitrary FAT configurations without requiring physical device reprogramming.

This mobile platform represents a paradigm shift in personalized CI fitting by allowing users to experience different frequency-electrode functions independently, complementing existing clinical tools. While CI Select may not achieve the precision of laboratory-based approaches, it offers unique advantages through its accessibility and real-world applicability. Users can evaluate different FAT configurations in their daily environments and, upon identifying preferred settings, communicate these preferences to their audiologists for potential permanent implementation in their speech processors.

The successful development and deployment of CI Select (available free on the App Store) demonstrates the feasibility of patient-driven parameter exploration in cochlear implant fitting. This approach could significantly enhance the current standard of care by enabling users to actively participate in optimizing their hearing experience while maintaining professional audiological oversight.

This project is supported by NIH R01-DC021980 (Svirsky).

T-W 42: EXPLORING THE IMPACT OF NOISE EXPOSURE AND COCHLEAR IMPLANTATION ON HEARING PRESERVATION

Kayla Minesinger[1,2], Rachele Sangaletti[2], Maria Camila Salzar[2], Maria Yepes[2,3], Federica Raciti[2], Suhrud Rajguru[1,2,4]

[1]Department of Biomedical Engineering, University of Miami
[2]Department of Otolaryngology, University of Miami Miller School of Medicine
[3]Department of Neuroscience, University of Miami Miller School of Medicine
[4]Department of Veterans Affairs, Bruce W. Carter Department of Veterans Affairs Medical Center

Background: Noise-induced hearing loss (NIHL) is a preventable form of sensorineural hearing deficit caused by excessive noise exposure which primarily affects cochlear hair cell and nerve fibers. Cochlear implantation (CI) is the standard-of-care and effective treatment option for severe sensorineural hearing loss (SNHL). Recent research has focused on developing otoprotective strategies to prevent or minimize residual hearing loss from cochlear implantation trauma. However, the severity and location of cochlear damage due to noise exposure can affect CI performance. Significant damage to hair cells and nerve fibers due to noise exposure may impact the implant's effectiveness in transmitting sound signals in the long-term. Therefore, this study aimed to ascertain how noise exposure and electrode insertion trauma (EIT) contributes to poor residual hearing outcomes.

Methods: Given age at implantation and the duration of profound SNHL prior to receiving a CI can influence outcomes, our study design was designed to be translational in both age and timeline in this animal model. Awake adult Brown Norway rats were exposed to broadband noise (4-16 kHz) for 1 hour at 110 dB SPL to induce SNHI mimicking profiles of CI candidates. To mimic this, unilateral EIT was performed at 3-months post-NIHL in the rats. Electrophysiological measures primarily consisting of auditory brainstem responses (ABRs) were measured serially starting with baseline and up to 3 months post-EIT (a total of 6 months). Histology and mechanistic experiments were carried out to further detail changes that may be responsible for the differential residual hearing profiles and CI outcomes.

Results: The broadband noise induced significant and permanent elevation in ABR thresholds when compared to the nonexposed control thresholds. The double-insult group (Noise + EIT) displayed significantly elevated thresholds when compared with rats who received implants without NIHL as well as sham (no EIT). Histological and mechanistic studies suggest that confounding factors in the negative outcomes post-EIT may include inflammation and structural and neuronal damage.

Conclusion: The results from our study indicate that while cochlear implants offer significant benefits for individuals with NIHL, outcomes can vary based on the extent of cochlear damage, residual hearing, and may be further complicated by other individual factors in human subjects.

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T-W 43: IMPEDANCE SUBCOMPONENT FOR DIFFERENT TYPE OF ELECTRODE ARRAYS. A GLIMPSE INTO THE IMPLANTED COCHLEA.

S. A. Ausili[1], F. A. Di Lella[2]

[1] University of Miami. Department of Otolaryngology. Miami, Florida, USA.
[2] Hospital Italiano. Department of Otolaryngology. Buenos Aires, Argentina.

Objective: Cochlear implant electrode designs have evolved significantly to minimize insertion trauma and preserve cochlear structures, ultimately leading to improved hearing outcomes. Understanding the interaction between electrode arrays and the cochlear environment is essential for optimizing performance. This study aims to compare impedance subcomponents across different electrode arrays, particularly CI612 and CI632 models, to evaluate their effects on cochlear health and function.

Methods: We impedance measurements on patients implanted with CI612 (Contour Advance) and CI632 (Slim Modiolar) electrodes. Clinical impedances were measured to assess the overall function of the implant, while complex impedance subcomponents-access resistance and polarization capacitance-were analyzed to provide deeper insights into the electrode-tissue interaction. Additionally, four-point impedance (4PI) measurements were taken to determine the presence of insertion-related trauma and inflammatory response. We also included data from CI632D electrodes with self-eluting dexamethasone to investigate its impact on impedance trends and its potential in mitigating tissue response.

Results: Clinical impedances showed significant differences between electrode arrays, with the newer CI632 electrode model exhibiting lower overall values. However, when examining impedance subcomponents, access resistance between non-self-eluting electrodes suggested similar values, implying comparable bulk resistance between them. The primary differentiating factor appeared to be polarization capacitance, which was significantly higher in CI632. Additionally, self-eluting dexamethasone electrodes demonstrated a substantial reduction in clinical impedance, access resistance, and a major increase in polarization capacitance. Four-point impedance coupling mode measurements also suggested localized potential damage be-tween electrodes, reinforcing its potential as an indicator of cochlear trauma.

Conclusions: Impedance subcomponent analysis provides valuable insight into the cochlear response to different electrode arrays. The distinct impedance characteristics of CI612 and CI632 models highlight the importance of electrode design in influencing cochlear health. The use of self-eluting dexamethasone in CI632 appears to mitigate the inflammatory response, demonstrating potential advantages for long-term cochlear integrity and auditory outcomes. These findings contribute to refining CI electrode technology and optimizing surgical approaches to enhance patient outcomes and hearing preservation.

T-W 44: A PROSPECTIVE, MULTI-CENTRE CASE-CONTROL TRIAL EXAMINING FACTORS THAT PREDICT VARIABLE CLINICAL PERFORMANCE IN POST LINGUAL ADULT CI RECIPIENTS

Pam W. Dawson[1], Amanda Fullerton[1], Harish Krishnamoorthi[1], Kerrie Plant[1], Robert Cowan[2], Nadine Buczak[3], Christopher J. Long[1], Chris J. James[1], Fergio Sismono[4], Andreas Büchner[3]

[1]Cochlear Limited,1 University Ave, Macquarie Park NSW 2113, Australia.
[2] HEARnet Clinical Studies, Dept of Audiology & Speech Pathology,
The University of Melbourne, Australia.
[3]Medizinische Hochshule Hannover, Hannover, Niedersachsen, Germany.
[4]ZAS Augustinus, European Institute for ORL-HNS, Antwerp, Belgium.

This study investigated which of a range of factors could be predictive of performance in two distinct groups of experienced, adult cochlear implant (CI) recipients differentiated by their performance on words in quiet: 72 with poorer word scores versus 77 with better word scores.

Tests measured the potential contribution of sound processor mapping, electrode placement, neural health, impedance, cognitive and patient-related factors in predicting performance. A systematically measured sound processor MAP was compared to the subject's walk-in MAP. Surgical measures included modiolar distance, basal and apical insertion angle and presence of scalar translocation. Neural health measurements included bipolar thresholds, polarity effect using asymmetrical pulses, and evoked com-pound action potential (ECAP) measures such as the interphase gap (IPG) effect, total refractory time, and panoramic ECAP. Impedance measurements included trans impedance matrix and 4-point impedance. Cognitive tests comprised vocabulary ability, the Stroop test, and the Symbol Digits Modality Test (SDMT). Performance was measured with standard speech perception tests and basic auditory sensitivity measures including phoneme discrimination in noise and in quiet, amplitude modulation detection thresholds and quick spectral modulation detection.

A range of predictor variables accounted for between 33% to 60% of the variability in performance outcomes. Multivariable regression analyses showed four key factors that were consistently predictive of poorer performance across several outcomes: substantially underfitted sound processor MAP thresholds, higher average bipolar (BP) thresholds, greater total refractory time, and greater IPG offset. Scalar translocation, cognitive variables, and other patient related factors were also significant predictors across more than one performance outcome.

These findings highlight the importance of precise sound processor mapping, correct scalar placement, and consideration of neural health and cognitive factors in improving and predicting CI outcomes. This study is a step towards the development of a test battery to diagnose the causes of poor auditory sensitivity, which can in turn provide targeted, personalized CI care. A better understanding of potential contributors of poor auditory sensitivity may also inform development of future devices, fitting algorithms, surgical tools, and electrodes.

T-W 45: THE PHYSIOLOGICAL MECHANISM UNDERLYING THE POLARITY EFFECT ON THE ELECTRICALLY EVOKED COMPOUND ACTION POTENTIAL MEASURED USING SYMMETRIC, BIPHASIC PULSES IN HUMAN COCHLEAR IMPLANT USERS

Shuman He[1], Jacob J. Oleson[2], Xiuhua Chao[3], Lei Xu[3], Ruijie Wang[3], Jianfen Luo[3], Yi Yuan[4]

[1]Department of Otolaryngology – Head and Neck Surgery, The Ohio State University, 915 Olentangy River Road, Columbus, OH 43212
[2]Department of Biostatistics, The University of Iowa, Iowa City, IA 52242
[3]Department of Auditory Implantation, Shandong Provincial ENT Hospital, Jinan, Shandong, People's Republic of China
[4]Department of Audiology, San José State University, San José, CA 95192

Objective: This study aimed to determine whether the effect of changing stimulus polarity on the electrically evoked compound action potential (eCAP) - referred to as the polarity effect - could be used to assess the degeneration of the peripheral axon of the cochlear nerve (CN) in human cochlear implant (CI) users. To achieve this, the polarity effect was compared among four patient populations with varying CN statuses: children with cochlear nerve deficiency (CND), children with biallelic Gap Junction Beta-2 (GJB2) gene mutations, children with idiopathic sensorineural hearing loss (SNHL), and postlingually deafened adults with various etiologies.

Methods: All study participants were implanted with a Cochlear (TM) Nucleus(R) device in the test ear. To aid in result interpretation, the phase locking value (PLV) - an index quantifying neural synchrony in the CN - was measured at three electrode locations across the electrode array in 15 ears from 13 children with CND and 24 ears from 21 children with biallelic GJB2 gene mutations. For the polarity effect, study results include data collected from 31 ears of 31 children with CND, 27 ears of 24 children with biallelic GJB2 mutations, 35 ears of 34 children with idiopathic SNHL, and 31 ears of 28 postlingually deafened adult patients. For each participant, the polarity effect was evaluated at three or four electrode locations across the CI electrode array. The parameters used to quantify the polarity effect included the stimulation level offset, the slope of the eCAP I/O function, the maximum eCAP amplitude, and the eCAP threshold. These parameters were quantified as the difference between the results measured for different polarities. Linear Mixed-effect Models (LMMs) were used to: 1) evaluate the effects of participant group, electrode location, and their interaction on the PLV, the eCAP amplitude and the stimulation level in children with CND and children with biallelic GJB2 gene mutations; 2) determine the effects of participant group, electrode location, and their interaction on the polarity effect results for the three pediatric participant groups; and 3) compare the polarity effect results among all participant groups at two electrode locations.

Results: No significant differences in PLV were observed at any electrode location between children with CND and those with GJB2 gene mutations. The polarity effect on various eCAP parameters differed across patient populations and was influenced by the quantification methods used.

Conclusions: Further studies are warranted to determine whether degeneration of the peripheral axon is the sole biological underpinning of the polarity effect on the eCAP measured using symmetric, biphasic pulses in a monopolar-coupled stimulation mode.

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T-W 46: SPECTRO-TEMPORAL PROCESSING USING THE SPECTRAL-TEMPORALLY MODULATED RIPPLE TEST (SMRT) AND ITS RELATION TO HEARING LOSS AND COGNITION IN ADULTS

Aaron C. Moberly[1], Katelyn Berg[1], Andrea J. DeFreese[2], Terrin N. Tamati[1]

[1] Department of Otolaryngology-Head & Neck Surgery, Vanderbilt University Medical Center, Nashville, Tennessee, USA
[2] Department of Hearing and Speech Sciences, Vanderbilt University Medical Center, Nashville, Tennessee, USA

The Spectral-Temporally Modulated Ripple Test (SMRT) (Aronoff & Landsberger, 2013) has emerged as a promising measure of spectro-temporal processing in adults with hearing loss, showing strong associations with speech perception outcomes in adults with hearing aids and cochlear implants. However, while the SMRT offers potential as an efficient non-speech auditory processing assessment in research and clinical settings, its 3-alternative forced choice design may capture both auditory and cognitive processes. For example, prior research has demonstrated that nonverbal intelligence and visual working memory can influence SMRT performance in children with hearing aids, independent of their aided audibility. However, the relation between cognitive processes and SMRT performance remains unexplored in older adults, who may be particularly susceptible to cognitive influences on the SMRT due to age-related cognitive decline. This study examined relationships among SMRT performance, hearing thresholds (unaided pure-tone average at 500, 1000, and 2000 Hz, PTA), age, and nonverbal intelligence (Raven's Progressive Matrices). Data were collected from 120 participants across three groups: young adults with normal hearing (YNH, n = 40, mean age 23.9 years, SD 2.9), older adults with age-normal hearing (ONH, n = 42, mean age 67.4 years, SD 6.9), and older postlingually deafened adult cochlear implant candidates with severe-to-profound hearing loss (CIC, n = 38, mean age 68.7 years, SD 10.7). Multivariable linear regression demonstrated main effects of group, PTA, and Raven's performance as predictors of SMRT scores. Additional multivariable linear regressions were performed for SMRT performance for each group separately. For the ONH group, both PTA and Raven's independently predicted SMRT. For the YNH group, neither PTA nor Raven's predicted SMRT. For the CIC group, only PTA independently predicted SMRT, while Raven's did not. These findings suggest that while nonverbal intelligence can influence spectrotemporal processing abilities measured by the SMRT, this influence varies by population. Notably, in older adult cochlear implant candidates, for whom auditory processing was poor, nonverbal intelligence did not independently affect SMRT performance, suggesting that SMRT is a reasonable behavioral measure of spectrotemporal processing in this patient population.

Reference:

Aronoff, J. M., & Landsberger, D. M. (2013). The development of a modified spectral ripple test. The Journal of the Acoustical Society of America, 134(2), EL217-EL222.

T-W 47: EFFECTS OF ELECTRODE POSITION AND T-NRT MEASUREMENT ON NEURAL HEALTH ESTIMATES IN CI USERS

Nadine Buczak[1,2], Eugen Kludt[1,2], Fergio Sismono[3], Thomas Lenarz[1,2], Andreas Büchner[1,2]

[1]Department of Otolaryngology, Hannover Medical School, Hannover, Germany
[2]Cluster of Excellence "Hearing4all", Germany
[3]ZAS Augustinus, European Institute for ORL-HNS, Antwerp, Belgium

Objective: Speech understanding in cochlear implant (CI) users is influenced by various factors, with electrode placement playing an important role. Research has shown that proximity to the mid-modiolar axis (MMA) influences evoked compound action potential (ECAP) thresholds, with electrodes placed closer to the modiolus resulting in lower ECAP thresholds. Lower ECAP thresholds are suggestive of better-preserved spiral ganglion neuron (SGN) function and enhanced cochlear health, both of which are critical for improving CI performance. This highlights the importance of electrode positioning, as it not only enhances neural stimulation but also provides valuable insight into the underlying neural health that impacts auditory performance.

Methods: A total of 46 postlingually deafened adult CI users with Cochlear™ Nucleus® implants, with both perimodiolar and straight electrode arrays, were included in this analysis. Pre- and postoperative computed tomography (CT) scans were retrospectively analyzed to determine insertion angles and electrode contact distances relative to the MMA [1]. ECAP thresholds were measured using monopolar AutoNRT. These ECAP thresholds were then related to the MMA distance, and a linear regression was per-formed to calculate the threshold-distance function. The slope of the threshold-distance function was subsequently correlated with various auditory and speech performance metrics. These included word recognition in quiet at 65, 50, and 45 dB SPL, adaptive speech-in-noise thresholds (S0N0), consonant discrimination (Language-Independent Test, LIT), phoneme discrimination in quiet (65/50 dB SPL), the Digit Triplet Test (DTT), aided auditory thresholds (250-6000 Hz), amplitude modulation sensitivity (AMDT), and spectral resolution (QSMD).

Results: A steeper slope of the threshold-distance function was linked to better CI performance, accounting for 12.46% of the speech variability in quiet at 65 dB SPL ($p=0.016$), 15.91% at 50 dB SPL ($p=0.006$), 12.77% at 45 dB SPL ($p=0.015$), and 8.43% in noise ($p=0.053$).The steeper slope of the threshold-distance function also showed a trend towards significance in consonant discrimination (LIT; $p=0.086$, $R^2=0.0685$), Quick Spectral Modulation Detection (QSMD; $p=0.0877$, $R^2=0.0678$), and the Digit Triplet Test (DTT; $p=0.0596$, $R^2=0.0926$). However, no significant correlations were observed for phoneme discrimination in quiet (65/50 dB SPL), Amplitude Modulation Detection (AMDT) and average aided auditory thresholds (250-6000 Hz).

Conclusions: Precise electrode placement near the mid-modiolar axis is associated with lower ECAP thresholds, which suggests that lowered distance to auditory neurons is related to more efficient stimulation. This improved efficiency may allow for more targeted and spatially selective stimulation, thus contributing to better cochlear implant outcomes. While direct evidence linking electrode positioning to improved speech understanding remains limited, the slope of the threshold-distance function could serve as a valuable indicator of neural health, aiding in the prediction and optimization of CI performance.

References:

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T-W 48: PIANO TRAINING DOES NOT IMPROVE COCHLEAR IMPLANT USERS' VOCAL OR MUSICAL EMOTION CATEGORIZATION

E. E. Harding[1,2,3], E. Gaudrain[4], R. Harris[5,1], B. Tillmann[6,4], B. Maat[1], Steven de Rooij[7], R. H. Free[1,3], D. Başkent[1,3]

[1]Department of Otorhinolaryngology/Head and Neck Surgery, University Medical Center Groningen, University of Groningen, Groningen, NL
[2]Center for Language and Cognition, University of Groningen, Groningen, NL
[3]The Research School of Behavioural and Cognitive Neuroscience, University of Groningen, Groningen, NL
[4]Lyon Neuroscience Research Center, CNRS UMR5292, Inserm U1028, Université Lyon 1, Lyon, FR
[5]Prince Claus Conservatoire, Hanze University of Applied Sciences, Groningen, NL
[6]Laboratory for Research on Learning and Development (LEAD), CNRS UMR5022, Université de Bourgogne, Dijon, FR
[7]Lectorate Design Driven Innovation, NHL Stenden University of Applied Sciences, Leeuwarden, NL

Purpose: Cochlear implant (CI users) experience challenges in perceiving fine-grained pitch information in acoustic signals such as speech or music. This missing information can in turn make it difficult to perceive nuanced acoustic changes related to vocal and musical emotions. In fact, previous research suggests common perceptual mechanisms might underlie vocal- and musical emotion perception in CI users, making a training in one domain potentially also impact the other domain. Music therapy, including the learning of new instruments, has previously been shown to improve vocal emotion perception in CI users. Therefore, the current study assessed whether a novel piano training designed to improve speech-on-speech perception in CI users might have a secondary outcome to improve vocal and musical emotion perception. Based on the technical similarity of hands-on instrument learning across the two trainings, and similarity in vocal and musical emotion perception in CI users, we predicted that CI users undergoing this training might experience improvements in both vocal- and musical emotion perception.

Methods: Twenty-four CI adult users were randomly assigned to one of three groups: piano training (n=8), Minecraft gaming lessons (n=7) as an active control training, and a no-training control group (n=9). The active control group participated in guided Minecraft gaming sessions, designed to match the piano training in duration, instructor interaction, and self-directed goal setting. Training lasted six months, while the no-training control group only completed the testing schedule. Vocal and musical emotion were assessed as secondary outcomes. For vocal emotion, participants categorized pseudospeech spoken by actors to express happy, angry or sad categories (the EmoHI test). For musical emotion, participants categorized 10-second classical music excerpts previously sorted into joy, fear, serenity and sadness categories. The primary outcome as well as additional secondary measures were collected as part of the broader CIMUGAME study but are not reported here.

Results: No significant improvement was observed when comparing post-training to pre-training scores, for either vocal- or musical emotion perception. Bayesian analysis indicates that the pre/post difference is inconclusive, but seems to trend towards a moderate level of evidence supporting a no-difference conclusion, which could likely be reached if more participants were included.

Conclusions: Our findings indicate that the specificity of the training plays a role in the intended outcomes. Indeed the previous music therapy intervention that improved CI users' vocal emotion perception may have generally targeted more emotion processing. And while the current piano training did in fact improve its intended outcome of speech-on-speech perception, the impact of the training did not necessarily extend to other perceptual processes measured by secondary measures. This suggests that training should be carefully designed around its intended outcomes. If future research can link specific training features to specific perceptual processes, perhaps individually designed training can target a combination of perceptual processes most important to the individual CI user.

T-W 49: PIANO TRAINING IMPROVES COCHLEAR IMPLANT USERS' SPEECH-ON-SPEECH PERCEPTION

E. E. Harding[1,2,3], E. Gaudrain[4], R. Harris[5,1], B. Tillmann[6,4], B. Maat[1], Steven de Rooij[7], R. H. Free[1,3], D. Başkent[1,3]

[1]Department of Otorhinolaryngology/Head and Neck Surgery, University Medical Center Groningen, University of Groningen, Groningen, NL
[2]Center for Language and Cognition, University of Groningen, Groningen, NL
[3]The Research School of Behavioural and Cognitive Neuroscience, University of Groningen, Groningen, NL
[4]Lyon Neuroscience Research Center, CNRS UMR5292, Inserm U1028, Université Lyon 1, Lyon, FR
[5]Prince Claus Conservatoire, Hanze University of Applied Sciences, Groningen, NL
[6]Laboratory for Research on Learning and Development (LEAD), CNRS UMR5022, Université de Bourgogne, Dijon, FR
[7]Lectorate Design Driven Innovation, NHL Stenden University of Applied Sciences, Leeuwarden, NL

Purpose: Understanding speech in multi-talker environments, or speech-on-speech, is particularly difficult for cochlear implant (CI) users. Neuroscientific research suggests that speech and music processing share functional networks within auditory and motor pathways. This overlap raises the possibility that musical training could enhance speech-on-speech perception, a hypothesis supported by some-but not all-comparisons between musicians and non-musicians. Prior studies exploring musical training in this population have yielded mixed results with small effect sizes. Notably, neural activity in dorsal-stream networks may play a role in improving speech perception for CI users. To investigate this, we implemented an innovative piano training program specifically designed to engage dorsal-stream networks through its learning and practice structure. We predicted that CI users undergoing this training would experience improvements in speech-on-speech perception.

Methods: A total of 24 CI adult users were randomly assigned to one of three groups: piano training (n = 8), an active control group receiving Minecraft gaming lessons (n = 7), and a no-training control group (n = 9). The piano training focused on activating dorsal auditory-motor pathways through improvisation exercises and an emphasis on finger movement learning rather than traditional music reading. The active control group participated in guided Minecraft gaming sessions, designed to match the piano training in duration, instructor interaction, and self-directed goal setting. Training lasted six months, while the no-training control group only completed assessments. The primary outcome measure was speech-on-speech perception, assessed using the Child-friendly Coordinate Measure Response, which evaluates the ability to identify number and color keywords within a single-talker gibberish masker. Additional secondary measures were collected as part of the broader CIMUGAME study but are not reported here.

Results: Speech-on-speech perception improved significantly in the piano training group after six months, with a Bayesian sequential analysis confirming a strong training effect. No substantial improvement was observed at the three-month mark, and the gains had diminished by the three-month follow-up period. Anecdotal evidence for minor speech perception improvements was observed in the Minecraft group, while no changes were observed in the no-training control group.

Conclusions: Our findings indicate that at least six months of neuroscience-informed musical training can enhance speech-on-speech perception in CI users. Continued training may be necessary to maintain these improvements. Additionally, participant feedback suggested greater enjoyment in the piano training group compared to the Minecraft group, highlighting the potential influence of motivation and engagement on training outcomes.

T-W 50: THE ROLE OF COCHLEAR IMPLANT-HEARING AID PERFORMANCE DISPARITY IN BIMODAL BENEFIT: A CONTROLLED SNR STUDY

Abigail Proctor, Priyanka Jaisinghani

Department of Speech and Hearing Sciences, Lamar University, Beaumont, Texas

Background: Bimodal hearing or using a cochlear implant (CI) in one ear and a hearing aid (HA) in the opposite ear allows users to benefit from electric and acoustic stimulation. While many users benefit from bimodal hearing, some report a lack of benefit. The reasons for this variability are unclear, but several possible causes have been suggested. There is speculation about performance differences between CI and HA ear influencing bimodal benefits, such as greater disparity causing reduced bimodal benefits or interference. In comparison, lesser performance disparity causes greater bimodal benefits. However, studies specifically examining the effect of performance disparity across predetermined or controlled disparity levels are currently lacking. The study aims to investigate the impact of performance disparity between the CI and HA on the bimodal benefit by combining different signal-to-noise ratio levels in the CI and HA ear.

Methods: Fifteen individuals with typical hearing and native speakers of American English will be subjected to sentence recognition (IEEE) in different listening conditions, viz., HA alone, CI alone, and bimodal. The CI and HA processed sentences will be mixed with speech-shaped noise and in various combinations of signal-to-noise ratios to simulate different performance disparity levels.

Results: Linear mixed modeling will be utilized to compare the bimodal benefit across different performance disparity levels created by different SNR combinations. Further, the results will highlight differences in bimodal benefits across conditions of similar HA and CI ear advantages.

Discussion: The study findings will provide insights into the extent of bimodal benefit expected for individual patients based on their specific performance disparities. Further, a greater understanding of CI and HA ear advantages acting similarly or differently on bimodal benefit will be rendered.

T-W 51: THE ROLE OF COCHLEAR IMPLANT-HEARING AID PERFORMANCE DISPARITY IN BIMODAL BENEFIT: A CONTROLLED SPECTRAL RESOLUTION PARAMETERS STUDY

Rebecca M. Jones, Priyanka Jaisinghani, Ph.D.

Department of Speech and Hearing Sciences, Lamar University, Beaumont, Texas

Background: Bimodal hearing or using a cochlear implant (CI) in one ear and a hearing aid (HA) in the opposite ear allows users to benefit from electric and acoustic stimulation. While many users benefit from bimodal hearing, some report a lack of benefit. The reasons for this variability are unclear, but several possible causes have been suggested. There is speculation about performance differences between CI and HA ear influencing bimodal benefits, such as greater disparity causing reduced bimodal benefits or interference. In comparison, lesser performance disparity causes greater bimodal benefits. However, studies specifically examining the effect of performance disparity across predetermined or controlled disparity levels are currently lacking. The study aims to investigate the impact of performance disparity between the CI and HA on the bimodal benefit by combining different spectral resolution parameters in the CI and HA ear.

Methods: Fifteen individuals with typical hearing and native speakers of American English will be subjected to sentence recognition (IEEE) in different listening conditions, viz., HA alone, CI alone, and bimodal. The sentences will be CI and HA processed with different spectral resolution parameter combinations to simulate different performance disparity levels.

Results: Linear mixed modeling will be utilized to compare the bimodal benefit across different performance disparity levels created by different spectral resolution parameter combinations. Further, the results will highlight differences in bimodal benefits across conditions of similar HA and CI ear advantages.

Discussion: The study findings will provide insights into the extent of bimodal benefit expected for individual patients based on their specific performance disparities. Further, a greater understanding of CI and HA ear advantages acting similarly or differently on bimodal benefit will be rendered.

T-W 52: IMPACT OF CONSISTENT DEVICE USAGE ON SELF-PERCEIVED LISTENING FATIGUE IN ADULTS WITH COCHLEAR IMPLANTS

Swarali D. Joshi[1,2], Kelly N. Jahn[1,2]

[1]Department of Speech, Language, and Hearing,
The University of Texas at Dallas, Richardson, TX
[2]Callier Center for Communication Disorders, The University of Texas at Dallas, Dallas, TX

Project Type: Preliminary/pilot research findings (work in progress)

Introduction: Cochlear implants (CIs) enable people with moderate-to-profound sensorineural hearing loss to perceive sounds, but speech perception outcomes with a CI remain highly variable from person-to-person. Individuals who wear their CI consistently tend to exhibit better speech perception outcomes than those who do not wear their CI as often. However, even the best-performing CI users typically exert more effort to understand speech than their peers with normal hearing, which can lead to high levels of listening-related fatigue. While the benefits of consistent CI use on speech perception abilities are well-established, little is known about how CI use influences factors beyond speech perception scores. In this study, we aim to understand whether the amount of time an individual wears a CI influences their listening-related fatigue. We hypothesize that individuals who wear their CI consistently will experience less listening-related fatigue than those who do not wear their CI as often.

Methods: To date, we have surveyed twenty-seven adults between 18 and 75 years of age (M= 44.78 years, SD = 20.80) who use at least one CI. Listening-related fatigue was estimated using the Vanderbilt Fatigue Scale - Adult (VFS-A). CI wear time was estimated in two ways: 1) average daily device usage hours as recorded by the participant's mobile app and 2) average daily device usage hours as self-reported by the participant.

Results: CI users received an average score of 78.30 (SD = 33.55) on the VFS-A, indicating a moderate level of listening-related fatigue. The mean scores were highest in the cognitive domain (26.48, SD = 8.23), followed by the emotional (23.48, SD = 9.34), social (21.93, SD = 8.35), and physical (19.22, SD = 9.42) domains. Participants self-reported an average daily device wear time of 13.28 hours (SD = 3.23), while the mobile app recorded an average of 8.44 hours (SD = 7.73) per day. A negative correlation was observed between device usage (both self-reported and mobile app-recorded) and total VFS-A score, suggesting that less consistent device usage is associated with greater listening-related fatigue, although these correlations were not statistically significant (self-reported: $r = -0.35$; $p=0.077$; mobile app: $r = -0.14$; $p=0.513$). When the VFS-A subscales were considered independently, we observed a statistically significant negative correlation between self-reported device usage and the physical subscale ($r=-4.88$; $p=0.01$). Specifically, participants who wear their CI less consistently report significantly more physical exhaustion than their peers who wear their CI more consistently. We also observed a statistically significant negative correlation between age and VFS-A total scores ($r = -0.48$; $p=0.012$), suggesting that younger age is associated with greater listening-related fatigue.

Conclusion: Preliminary results suggest that adult CI users who wear their device more consistently (i.e., more hours per day) experience less listening-related fatigue than those who do not wear their devices as often. Specifically, those who wear their CI more consistently report less physical exhaustion than those who wear their CI less consistently. Consistent CI use may promote positive neural plasticity, leading to improved speech perception outcomes and less listening-related fatigue. Ongoing work will evaluate the relationship between data logging information from the CI speech processor, speech perception scores, and listening-related fatigue in children and adults.

T-W 53: IMPACT OF INTERAURAL LEVEL DIFFERENCE ON BINAURAL FUSION IN THE PRESENCE OF INTERAURAL PLACE MISMATCH IN NORMAL HEARING LISTENERS USING VOCODERS

Itunu M. Oyebamiji, Justin M. Aronoff

Department of Speech and Hearing Science, University of Illinois Urbana-Champaign, Champaign, IL, USA

Bilateral cochlear implant (CI) users typically achieve some degree of binaural fusion, allowing them to perceive sounds simultaneously presented to both ears as a single auditory precept. However, some users struggle with fusion due to interaural place mismatches, which is a common issue in this population. Interaural place mismatch occurs when there are discrepancies in the region of the cochlea stimulated by the same sound delivered to both ears. Such mismatches interfere with the brain's ability to combine sounds from both ears into a single auditory image and disrupt the use of consistent binaural cues. This can negatively impact binaural fusion and, to a lesser extent, interaural level difference (ILD)-based lateralization.

Previous research from our laboratory suggests that adding large ILDs to a signal can increase binaural fusion when it is degraded by interaural decorrelation, which is the reduction in similarity between the signals reaching both ears. This study aims to investigate the role of ILDs in fostering binaural fusion in the presence of interaural place mismatches.

To investigate this, four normal-hearing participants were tested using a single-channel vocoder with varying magnitudes of interaural place mismatch and ILD. The experiment used a visual interface displaying a graphic of a head. Participants used a dial to indicate how they perceived the sound by changing the number, size, and position of an oval(s) superimposed on the head. This allowed them to indicate whether the sound was heard as one or two sources, punctate or diffuse and the extent to which it was lateralized to the left or right ear.

Preliminary findings suggest that large ILDs enhance binaural fusion in the presence of interaural place mismatches, consistent with previous studies on interaural decorrelation. With large ILDs in both ears, sounds were properly lateralized to either the left or right ear, even in the presence of interaural place mismatches. These results suggest that ILDs may serve as a compensatory mechanism, likely by providing a common spatial cue for all components of the sound, for improving binaural fusion in the presence of interaural place mismatches.

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T-W 54: EXAMINING ASYMMETRY, SELECTIVE ATTENTION, AND BINAURAL FUSION AS PREDICTORS OF BINAURAL UNMASKING (OR INTERFERENCE) IN COCHLEAR IMPLANT USERS

Emily A. Burg[1], Matthew B. Fitzgerald[2], Duane G. Watson[1], René H. Gifford[3]

[1]Vanderbilt University Medical Center, Nashville, TN, USA
[2]Stanford University, Palo Alto, CA, USA
[4]Hearts for Hearing, Oklahoma City, OK, USA

Binaural hearing refers to the auditory system's ability to compare and integrate information across ears, and is critical for navigating complex acoustic environments. Binaural hearing helps a listener separate a friend's voice from background noise in a crowded coffee shop, and identify the location of a car on a busy street. To access these functional benefits, the normal hearing (NH) auditory system analyzes the across-ear correlation of incoming signals to fuse sounds originating from the same source into a single percept, a process known as binaural fusion. Previous work has shown that cochlear implant (CI) users generally cannot access binaural hearing benefits to the same degree as NH listeners, likely due to pathological, surgical, and device related asymmetries that reduce interaural correlation and hinder binaural fusion. Additionally, asymmetries often result in ear-dependent binaural unmasking outcomes, with CI users obtaining more unmasking when attending to their higher performing ear. This suggests that the effects of asymmetry may extend beyond the periphery and influence executive functions like selective attention. To further our understanding of factors affecting binaural hearing outcomes in this population, this study examined the relationship between interaural asymmetry, selective attention, binaural speech fusion, and binaural unmasking in adults with NH (N=19) and bilateral CIs (BICIs; N=12, data collection is ongoing).

For BICI participants, interaural performance asymmetry was calculated as the difference in IEEE sentence recognition across ears. Ear-specific selective auditory attention was measured by comparing IEEE sentence recognition in quiet to a condition with an AzBio masker sentence presented contralaterally. Additionally, the NIH Toolbox Flanker Inhibitory Control and Attention Task was used as a non-auditory measure of selective attention. For NH and BICI participants, binaural unmasking was quantified by comparing CRM sentence recognition with a monaural target and masker to sentence recognition with a monaural target and diotic masker. Listeners who can fuse the masker across ears perceive a perceptual separation of target and masker, resulting in improved performance (i.e., unmasking) compared to the monaural condition. Alternatively, if listeners perform worse in the diotic condition, this is known as interference. Lastly, binaural speech fusion was measured using a dichotic formant vowel identification task, in which the first and second formants were presented to opposite ears.

On average, NH adults demonstrated binaural unmasking at all SNRs, while BICI adults demonstrated interference. For asymmetric BICI users, interference was greater and selective auditory attention was worse when the target was in the poorer performing ear. Additionally, several BICI users with symmetric speech recognition in quiet demonstrated asymmetric auditory attention and interference, and the magnitude of interference was greater when attending to the ear they demonstrated poorer attention towards. Finally, both groups demonstrated some degree of speech fusion, but NH adults were able fully fuse dichotic formants reaching baseline vowel recognition performance, whereas BICI adults did not.

These results provide further evidence that interaural asymmetries negatively affect binaural hearing outcomes in BICI users, and show that asymmetric auditory attention and binaural interference can persist even in BICI users with symmetric speech recognition in quiet. Additionally, BICI users' inability to fully fuse dichotic speech information suggests fundamental limitations in binaural integration, which may contribute to poorer spatial hearing outcomes like binaural unmasking of speech. Together, these findings emphasize the importance of considering both peripheral and attentional factors in clinical management and rehabilitation strategies for CI users.

T-W 55: INVESTIGATING THE RESPONSIVENESS OF THE AUDITORY NERVE WITH FOCUSED PERCEPTUAL THRESHOLDS, ECAPS, AND THE FAILURE INDEX (FI) ACROSS COCHLEAR IMPLANT ELECTRODES

Dietmar M. Wohlbauer[1,2], Charles Hem[2,3], Wiebke Konerding[4], Andrej Kral[4], Julie G. Arenberg[1,2]

[1]Harvard Medical School, Department of Otolaryngology - Head and Neck Surgery, Boston, MA, USA
[2]Massachusetts Eye and Ear, Department of Audiology, Boston, MA, USA
[3]Harvard University, Cambridge, MA, USA
[4]Hannover Medical School, Department of Experimental Otology, Hannover, Germany

Introduction: The responsiveness of the auditory nerve to cochlear implant (CI) stimulation varies along the electrode array due to various factors, such as the electrode placement or the survival of the spiral ganglion neurons. Furthermore, unintended electric signal spread, referred as spread of excitation (SOE), can activate neurons distant from the site of stimulation. These factors can affect CI listeners' performance outcomes, and identifying and deactivating electrodes showing "poor" transmission can improve performance. Site-specific differences can be measured perceptually with focused perceptual thresholds, an automatic procedure to assess the perceptual detection levels in CI listeners, or physiologically via electrically-evoked compound action potentials (ECAP). Recently, it was suggested to use the failure index (FI) to classify the neural responsiveness based on the ECAP input-to-output ratio, with a small FI representing a healthy region in the cochlea, and a large FI a degenerated neural region. Here we investigate the site-specific quality of electric CI stimulation via the link between perceptual focused thresholds and ECAP measurements. We furthermore extended the FI across all available CI channels, to investigate its role as neural classifier and potential tool for cochlear implant programming.

Methods: Focused thresholds and ECAPs were measured in seventeen adult Advanced Bionics CI subjects. Threshold profiles were extracted from the average of two apical- and two basal signal sweeps generated with partial quadrupolar electrode configurations and current steering across the CI electrode array. ECAP recordings were performed with the standard forward masking artifact subtraction technique in monopolar stimulation mode with loudness-balanced stimuli across all active CI electrode combinations. FI profiles across all measured electrodes were derived from the ratio between most comfortable stimulus level (maximum input current) and the ECAP response amplitude at that level (output voltage).

Results: Besides large individual differences across electrodes for both focused threshold and ECAP response amplitudes, a significant linear relationship between across-electrode averages of ECAP input levels and responses was found ($p=.015$). The relationship of averaged across-electrode focused thresholds and ECAP responses was not significant ($p=.76$), possibly related to the perceptually balanced input level. The FI profiles across all CI electrodes showed high FIs for electrodes with large deviations of input-to-output and vice versa, in line with previous findings. An intermediate analysis of ECAP SOE peak amplitudes, widths, and slopes showed large within and across subject variability, with SOEs skewed towards cochlear regions with low FI.

Discussion: The FI profiles revealed large variability of input levels and response amplitudes. Similarly, individual focused thresholds showed large channel-to-channel variability, in line with the variations of the FI. These outcomes support the robustness of the FI across CI electrodes and suggest that this input-to-output ratio might be an alternative tool to identify healthy neural regions for enhanced CI programming. Further analyses are currently ongoing.

T-W 56: EXPLORING THE IMPACT OF ARTIFACT REMOVAL ON ELECTRICALLY EVOKED COMPOUND ACTION POTENTIALS AND DERIVED METRICS: A COMPARISON OF NEW AND ESTABLISHED TECHNIQUES

Rachel A. Scheperle[1], Jeffrey A. Skidmore[2], Logan L. Flom[1], Brian J. Mostaert[1], Ibrahim Razu[1], Marlan R. Hansen[1]

[1] University of Iowa Hospitals and Clinics, Iowa City, IA, USA
[2] North American Research Laboratory, MED-EL, Durham, NC, USA

Objectives: Managing undesirable electrical artifact is fundamental to the measurement and interpretation of electrically evoked compound action potentials (eCAPs). This project aimed to evaluate a recently proposed technique that models the decaying residual stimulus artifact captured in the recording window with a rational polynomial function.1 The fitted function, which has a hyperbolic resemblance, is subtracted from the recording to expose the embedded neural response. The method assumptions are more heavily weighted toward features of the stimulus artifact (as opposed to the neural response). Previous work illustrated that eCAPs evoked in humans with stimulation levels near the top of the electrical dynamic range were more reliably extracted by subtracting the hyperbola-fitting (HF) method compared to eCAPs derived from the forward-masking (FM) method.1 The present study aimed to further evaluate the HF subtraction method for broader applicability. The objectives were (1) to evaluate the HF method across the electrical dynamic range and (2) to determine whether advantages extend to animal models. In animals, stimulation levels can exceed those used in humans, and artifact characteristics may differ due to hardware and anatomical differences. Additionally, the neural response can be orders of magnitude larger in animals, which may complicate the HF subtraction method that relies on modeling the artifact.

Methods: eCAP data from twenty mice of various genetic backgrounds (CBA/J wild-type, AD-Tau, 5XFAD) and ages were retrospectively analyzed. Acoustic hearing status was not controlled; mice were not intentionally deafened. The left cochleae were implanted with a 3-electrode array (Cochlear HL03). Input-output (I/O) eCAP functions were recorded intra-operatively within a FM paradigm using a 3.2-ms recording window. The HF subtraction method, modified to remove amplifier switching artifact and with start values for the HF fit set to reported parameter means1 was applied post-hoc. The eCAPs derived from FM and HF methods were compared on waveform morphology, threshold, I/O slope and amplitudes.

Findings: Preliminary analyses suggest that the effectiveness of both methods are level dependent. Shifts from baseline were frequently observed with FM-derived eCAPs. Following baseline-correction, morphology was sometimes grossly similar across the two methods. In other instances, the width of the peaks and the relative amplitudes of multiple positive peaks differed. Consistent with observations in humans, FM-derived eCAPs were generally larger than HF-derived eCAPs at suprathreshold levels, which has been attributed to insufficient masking for the former. Additionally, I/O function slopes were shallower, and thresholds were higher when HF methods were applied. Data analysis is ongoing. Histological results will be considered as available to assess the validity of the derived metrics against a gold standard.

Implications: Although FM and alternating polarity artifact reduction methods are widely used despite known limitations and assumption violations, alternative techniques, such as the HF method, are worth consideration. The ability to extract a more faithful representation of the neural response will impact how well the derived metrics reflect meaningful aspects of neural status.

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T-W 58: DEVELOPMENT OF MUSIC PERCEPTION WITH A CI IN AN ORCHESTRA MUSICIAN WITH SINGLE-SIDED DEAFNESS

Ritva Torppa[1], Jussi Jaatinen[1], Viljami Salmela[1], Tapio Lokki[2], Jussi Valtonen[3], Diamond Brown[4], David M. Landsberger[4]

[1]University of Helsinki, Finland
[2]Aalto University, Espoo, Finland
[3]University of Arts, Helsinki, Finland
[4]New York University Grossman School of Medicine, USA

Objective: Although a cochlear implant (CI) can provide excellent speech recognition, attributes of sound that relate to music are typically poorly perceived. Despite the underwhelming sound quality of music, single-sided deaf (SSD) listeners who receive a CI report that listening to music with both their acoustic hearing (AH) and CI ear is more pleasurable than listening with their AH ear alone. The specifics of music perception through a CI alone as well as in conjunction with a contralateral AH ear remain poorly understood. Even less is understood about the development of music perception from activation in these listening conditions. This case study represents a unique opportunity to study the development of music perception after implantation in an SSD professional musician. Comprehensive data is collected on a series of musical and other non-linguistic tests at many timepoints to document the development of the non-linguistic auditory experience through a CI over time.

Participant: The individual evaluated is a professional orchestra musician (an oboe player) with perfect pitch and SSD. He had sudden, unilateral hearing loss in 2022 and was implanted with a MED-EL FlexSoft electrode array with an insertion depth of 616 deg. He was activated on January 29, 2025.

Methods: Extensive quantitative and qualitative data are collected prior to CI activation, immediately post-activation, weekly for two months, and then monthly for one year. The experiments will be conducted binaurally and only with CI (sounds delivered wirelessly to CI). Additionally, the AH ear alone will be evaluated as appropriate. The tests include: A) Vocal mimicry and musical note identification tests, in which the participant imitates (sings or plays on the oboe or piano) the pitches of the notes. B) Listening tests: 1) Spectral-Temporally Modulated Ripple Test (SMRT); 2) Melodic Contour Interval Test; 3) Musical Chord Identification Test (Tests 2 and 3 are from derived from Angel Sound); 4) Pitch discrimination tests using sinusoidal and complex tones from string instruments across three registers; 5) Interval recognition and adjustment tests over different pitch ranges, utilizing naturally stretched-tuned piano tone samples; 6) Spatial hearing and sound source localization tests employing sounds from orchestra instruments and bursts of noise in an anechoic chamber with 45 speakers; 7) Overlapping sources object discrimination experiment, where the participant distinguishes one of three simultaneously played sound objects (such as spectrally similar human speech, music, or animal sounds); 8) Auditory Envelopment Test: Pink noise is used to gauge the audibility of low-frequency interaural fluctuations, with the phases of the pink noise stimuli either synchronized or randomized. C) Questionnaire and diary: The participant answers questions specifically designed for this research and shares his feelings and thoughts in the diary.

Results: On the day of activation, the participant describes music as having mostly the same pitch and with additional overtones causing interference. By the second day, he describes the contribution of the CI as an "auxiliary spatial expander, meaning it is more pleasant to listen to music with it than without." He describes pitch as somewhat understandable for the lowest register, but higher pitches are not clear at all. Immediately after activation, pitch discrimination and identification tasks were at ceiling performance when stimuli were presented binaurally suggesting that the CI was not interfering. However, CI performance on these tasks was typically much poorer and near chance. The extensive data quantifying these perceptions are in the process of being evaluated. His CI-only SMRT score of 3.1 two days after activation suggests that he is receiving good spectral information with his CI.

Conclusions: The results will provide a quantitative and qualitative description of musical auditory development post-activation with a CI in a professional musician with SSD. The combination of the unique individual and his willingness and ability to conduct extensive and highly time-consuming measurements will provide an unprecedented level of detail and insight into the musical experience with a CI.

T-W 59: STIMULATING THE COCHLEAR APEX WITHOUT LONGER ELECTRODE ARRAYS - STUDY UPDATE

Natalia Stupak, Emily R. Spitzer, Mariana Mejia Turnbull, Mary Shannon Carroll, Lisa Goldin, Alison Rigby, Catherine Flynn, Madeleine M. Beyer, Sarah Mantione, Justin Cotrell, David R. Friedmann, Daniel Jethanamest, Mario A. Svirsky, William H. Shapiro, Susan B. Waltzman, J. Thomas Roland, Jr., David M. Landsberger

New York University Grossman School of Medicine, New York, NY USA

Background: Most cochlear implant (CI) electrode arrays are designed to be inserted about one turn into the cochlea, leaving much of the cochlea unstimulated. Extending the stimulated region could improve tonotopic and spectral representation and stimulate auditory pathways to encode low-frequency information. However, longer electrode arrays increase the risk of cochlear damage and incomplete insertion and incorporate only lateral wall designs. We developed a novel surgical approach to extend the stimulated cochlear region without a longer electrode array (Landsberger et al., 2024) and conducted a pilot study on 4 participants (Landsberger et al., 2022). We have since implanted an additional 10 in an ongoing study.

Methods and Results: An existing electrode (ECE1), typically placed in the temporalis muscle and used as an external ground, was instead placed into the helicotrema via an apical cochleostomy and secured in place. A Nucleus peri-modiolar electrode array was inserted through a standard approach adjacent to the round window to provide basal cochlear coverage. In this configuration, the electrode array can be grounded to the CI case electrode (ECE2) for monopolar stimulation, or to ECE1 to reshape the electric field towards the apex.

Intraoperative Trans-Impedance Matrix (TIM) measurements through Custom Sound software were used to confirm ECE1 placement in the helicotrema. These measures were repeated at activation and subsequent visits. Pilot laboratory data suggest that TIM is a reliable indicator of ECE1 placement. Placement was also confirmed by intraoperative X-ray.

Participants maintained a standard follow-up schedule. In their daily maps, the lowest frequency channel was presented on electrode 22 with reference to ECE1 using "MP1" mode in the clinical fitting software. This configuration shifted the electric field more apically than standard configurations. The remaining channels were grounded to the case using "MP2" mode.

Participants underwent psychophysical testing, including pitch scaling and multi-dimensional scaling (MDS) during their first-year post-activation. Stimulation using the apically-located ECE1 as a ground produced a lower pitch percept than when grounding to ECE2 on the case. Monopolar stimulation of ECE1 as the active electrode with ECE2 as the ground was perceived as having the lowest perceived pitch.

Conclusion: This modified surgical approach and re-mapping allows conventional electrode arrays to stimulate deeper into the apex safely and effectively, extending place-pitch. Ongoing research aims to optimize fittings and explore implementing new signal processing to take advantage of this novel electrode configuration.

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Landsberger, D. M., Long, C. J., Kirk, J. R., Stupak, N., & Roland Jr, J. T. (2024). Effect of Return Electrode Placement at Apical Cochleostomy on Current Flow With a Cochlear Implant. Ear and Hearing, 45(2), 511-516.

T-W 60: SMRT FOR KIDS: VALIDATION OF A PEDIATRIC SPECTRAL-TEMPORALLY MODULATED RIPPLE TEST

Jun Zhang, Madeleine M. Beyer, Natalia Stupak, David M. Landsberger

New York University Grossman School of Medicine, New York, NY USA

Background: The Spectral-temporally Modulated Ripple Test (SMRT) is a psychoacoustic, non-linguistic task designed to assess auditory capability by measuring the ability to detect and discriminate spectral-temporal ripples (Aronoff & Landsberger, 2013). The SMRT stimuli consist of broadband (100-6400 Hz) spectral ripples with a phase that drifts at 5 Hz. The task requires listeners to distinguish a target stimulus with a relatively low number of ripples per octave (RPO) from reference stimuli with 20 RPO. SMRT is widely used in research and clinical settings to evaluate the auditory perception of individuals with hearing loss, including those using hearing aids (HAs) and cochlear implants (CIs).

The latest publicly released SMRT version (1.1.3) uses a visually neutral interface with high-contrast colors for visibility. However, this design may be less engaging for pediatric (or even adult) listeners, who are more prone to distraction and may struggle to maintain focus on the stimuli. An alternate pediatric version of SMRT was developed which is designed to be more visually engaging. This version adds the option to incorporate five themes of colorful images and backgrounds. These themes are "Outer Space", "Dinosaurs", "Under the Sea", "In the Garden", and "Forest Friends".

In this study, we validate the pediatric SMRT relative to the original SMRT. Given that the stimuli and protocol remain identical, it is possible that scores between the two tests will be equivalent and interchangeable. Alternatively, it is possible that the more engaging interface will improve SMRT performance as listeners are better able to maintain attention. It is also possible that SMRT performance will drop with the pediatric implementation if the visuals are distracting.

Method: Testing will include adults and children with varying hearing profiles using both SMRT versions. Thus far, five adult participants have completed the test. Testing was conducted in a sound booth at 60 dBA using a speaker placed 1m directly in front of the participants. The recruited adult participants completed three SMRT runs of both versions in a randomized order. We expect the pediatric population to complete multiple runs of each version, however, this will be dependent on the participants availability and attention span. All participants, including those already tested and those yet to be tested, perform the task in their best-aided condition.

Result: Preliminary results from five adult listeners suggest that SMRT responses are stable across repetitions. All five listeners showed slightly higher average scores in the pediatric version, suggesting that colorful themes may enhance attentiveness, even in adults.

Conclusion: Preliminary data suggest that the pediatric SMRT provides a stable metric of spectral-temporal ripple discrimination. However, if the scores remain consistently higher with the pediatric SMRT, then scores on the two tests may not be interchangeable. If the correlation between scores of the two tests are sufficiently strong, a regression line may be used to convert between the two scores. Additionally, this experiment serves as a reminder that experimental interface matters for data collection.

Aronoff, Justin M., and Landsberger, David M. "The development of a modified spectral ripple test." The Journal of the Acoustical Society of America 134.2 (2013): EL217-EL222.

T-W 61: LONGITUDINAL ANALYSIS OF INTRACOCHLEAR ELECTROCOCHLEOGRAPHIC RESPONSE PATTERNS

M. Geys[1], A. Dalbert[1], C. Röösli[1], A. Huber[1], F. Pfiffner[1], L. Sijgers[1]

[1]Department of Otorhinolaryngology, Head & Neck Surgery, University Hospital Zurich, University of Zurich, Switzerland

Objective: Intracochlear electrocochleography (ECochG) in cochlear implant (CI) recipients is a potential tool for monitoring residual hearing during electrode array insertion and assessing the cochlear function postoperatively. Nevertheless, the underlying mechanisms causing different ECochG response patterns along the cochlear duct remain controversial. Furthermore, many studies do not take into account the precise tonotopic location of the recording electrodes within the cochlea. Therefore, a longitudinal study was conducted to monitor ECochG response patterns from CI electrode insertion to one year post-implantation, accounting for the individual tonotopic locations of the recording electrodes.

Methods: ECochG recordings at various intracochlear locations were performed in 80 adult CI recipients. Recordings were obtained at four different timepoints: (1) intraoperatively during electrode array insertion, (2) intraoperatively, immediately after full insertion of the CI array, (3) approximately 7 weeks after surgery, and (4) approximately 1 year after surgery. A 500 Hz tone burst was used for acoustic stimulation. Pure-tone audiograms were conducted preoperatively, as well as 7 weeks and 1 year after surgery. The tonotopic locations of the recording electrodes were determined from postoperative CT scans using an open source script for generating the ZH-ECochG Bode Plot (Geys et al. 2024).

Results: Comparison of intraoperative ECochG recordings during electrode array insertion and post-insertion measurements showed that 71% of cases with valid responses during insertion, exhibited less than a 30% change in maximum ECochG amplitude, and 90% maintaining the tonotopic location of the peak within one octave. A significant reduction in maximum amplitude ($p<0.001$) was observed in the early postoperative recording compared to intraoperative recording (i.e. 67% of the CI recipients showing a greater than 30% reduction in amplitude). Among participants with detectable postoperative ECochG peak responses, 87% showed a stable tonotopic location of the peak between intraoperative and early postoperative recordings. One year post-implantation, 25% of the participants exhibited ECochG peak changes, defined as a >30% change in maximum amplitude or a tonotopic location shift greater than one octave, compared to the early postoperative recording. No clear relationship was found between ECochG response patterns and postoperative hearing preservation, although a reduction in maximum amplitude intraoperatively (after electrode array insertion) was a negative predictor of postoperative hearing preservation ($p=0.028$).

Conclusions: Intracochlear response pattern changes appear to be rare intraoperatively, with the majority (67%) showing a reduction in ECochG maximum amplitude in the early postoperative period. This supports the potential role of drug-eluting electrodes or other techniques to mitigate postoperative intracochlear processes such as inflammation or tissue growth. Additionally, postoperative changes in ECochG response patterns were detected and may reflect intracochlear alterations, underscoring the value of ECochG in understanding delayed post-implantation processes.

References:

[1] Geys, M., Sijgers, L., Dobrev, I., Dalbert, A., Roosli, C., Pfiffner, F., and Huber, A. (2024), ZH-ECochG Bode Plot: A Novel Approach to Visualize Electrocochleographic Data in Cochlear Implant Us-ers, Journal of Clinical Medicine, 13(12), 3470.

T-W 62: EVALUATING THE IMPACT OF LISTENER-SELECTED FREQUENCY ALLOCATION TABLES ON SOUND QUALITY AND SPEECH PERCEPTION IN SINGLE-SIDED DEAF CI USERS

Nicole Hope Capach[1], Allison Biever[2], Camille Dunn[3], Megan Eitel[1], Elad Sagi[1], Mahan Azadpour[1], Ariel Hight[1], William H. Shapiro[1], Mario A. Svirsky[1]

[1]New York University Grossman School of Medicine, New York, NY, USA
[2]Rocky Mountain Ear Center, Englewood, Colorado, USA
[3]Department of Otolaryngology, Carver College of Medicine, U. of Iowa, IA, USA

Background and Objectives: Despite the success of cochlear implants (CIs) in restoring hearing, postlingually deaf patients often experience unnatural and distorted sound quality immediately after CI activation, which can impact speech perception. A key factor affecting these outcomes is anatomical frequency mismatch, where the normal cochlear frequency-place function differs from that imposed by the CI. This study aims to address the adaptation process to frequency mismatch by evaluating different frequency allocation tables (FATs) in single-sided deaf (SSD) CI users.

Methods: In this experiment, SSD CI users are exposed to four FATs that compensate for varying levels of anatomical frequency mismatch. Beginning at CI activation, patients cycle through the FATs, using one per day. At one month post-activation, participants select their preferred FAT and continue to update their selection weekly for a year. This design will allow us to assess if individually selected FATs enhanced natural sound quality and bilateral speech perception in noise. Importantly, evaluations are conducted in a double-blind manner to ensure unbiased selection.

Results: We will report pilot data from this study demonstrating how SSD CI users adapt to different FATs. Preliminary results indicate that user-selected FATs significantly improve sound quality and speech perception compared to the standard-of-care FAT. We observed that the individually tailored FATs reduced perceptual frequency mismatch and led to better speech intelligibility in noisy environments, suggesting that personalized FATs offer a substantial benefit over conventional mappings.

Conclusion: If confirmed in the larger study, these findings would highlight the importance of personalized FATs in enhancing CI outcomes for SSD users. The ability of users to select and adapt to preferred FATs may improve immediate sound quality and speech perception but also suggests a potential for more rapid and complete adaptation to CI hearing. These results pave the way for incorporating listener-selected FATs into clinical practice, offering a more tailored approach to CI fitting and potentially improving long-term auditory outcomes for CI recipients.

T-W 63: EVALUATING GREENWOOD'S FUNCTION FOR TONOTOPIC MAPPING IN SINGLE-SIDED DEAF COCHLEAR IMPLANT USERS

A. Buechner[1], T. Weller[1], T. Lenarz[1], R. Penninger[1,2], D. Schurzig[1,3]

[1]Dept. of Otorhinolaryngology, Hannover Medical School, Hannover, Germany
[2]MED-EL, Innsbruck, Austria
[3] MED-EL Research Center, Hannover, Germany

Objective: Greenwood's function is frequently used to map the audible range (20-20,000 Hz) onto the cochlear duct for cochlear implant (CI) programming. To achieve a more natural, individualized pitch percept, it is critical to understand how accurately this theoretical frequency-to-place assignment aligns with CI users' actual pitch perception.

Methods: 12 postlingually deafened single-sided deaf (SSD) CI users (7 female, 5 male; mean age: 52.9 years, range: 35.5-80.6 years) were enrolled. All exhibited no functional residual hearing on the implanted side (>=65 dB HL at 250 Hz) and normal or near-normal hearing on the non-implanted side (four-frequency PTA <=30 dB HL). Each participant had at least 6 months of CI experience (mean: 20.2 months). Pitch-matching experiments were conducted at four appointments using two mapping strategies: (1) a standard CI frequency allocation table, and (2) an image-based mapping derived from Greenwood's function. Participants adjusted a tone presented to their normal-hearing ear to match the perceived pitch in the CI ear. Radiological imaging provided individual electrode positions for comparison against Greenwood's predicted frequency-to-place mapping. An n-way ANOVA (factors: subject, electrode contact, map, and study interval) assessed the significance of each factor on pitch-matching outcomes.

Results: ANOVA indicated that only "subject" ($p < 0.001$) and "contact" ($p < 0.001$) significantly affected pitch matches, whereas "map" ($p = 0.586$) and "study interval" ($p = 0.247$) did not. Subjects varied widely in pitch-matching reliability (root-mean-square error Deltaf_RMS = 3.4-17.2 semitones), with good performers (Deltaf_RMS < 6 semitones) typically aligning more closely with Greenwood's predictions. Some participants reached hardware-limited extremes (100 Hz or 7950 Hz) when matching the most apical or basal electrodes, suggesting that the true percept extended beyond the tested range.

Conclusions: Despite individual variability, pitch matches generally approximated Greenwood's function, suggesting that it provides a reasonable representation of cochlear tonotopy for CI programming. However, large inter-subject differences highlight the need for individualized mapping strategies, given factors such as neural survival and stimulation constraints. Further research focusing on "good performers" may help re-fine clinical mapping protocols to achieve more natural sound perception in CI users.

T-W 64: THE EFFECTS OF DEAFNESS ONSET ON SPATIAL HEARING AND MUSIC PERCEPTION IN YOUNG ADULTS WITH BILATERAL COCHLEAR IMPLANTS

W. S. Liu[1], N. R. Haywood[1], M. Salorio-Corbetto[1], F. Guerit[2], D. A. Vickers[1]

[1] SOUND Laboratory, Cambridge Hearing Group, Clinical Neurosciences, University of Cambridge, United Kingdom
[2]Cognition and Brain Sciences Unit, University of Cambridge, United Kingdom

Purpose: Bilateral cochlear implant (CI) users often report that it can be challenging to use their spatial hearing skills effectively to locate speakers and to understand speech in challenging noisy environments. Some CI users also report challenges with music perception and enjoyment. Interaural level differences (ILDs) and interaural time differences (ITDs) are key binaural cues for spatial hearing. CI users with prelingual onset of severe-to-profound deafness often have poor ITD and ILD sensitivity which is attributed to the lack of early auditory experience. Conversely, individuals with residual hearing or post-lingual onset of deafness can exhibit some spatial hearing abilities. Music perception and enjoyment can be different depending on the onset of deafness in adults with CIs and it isn't clear how well the different groups process cues that could enable music perception such as the use of temporal interactions to comprehend dissonance and consonance. This research explores the spatial hearing and music perception/enjoyment outcomes of young adults with bilateral CIs who were implanted before the age of 10 and compares outcomes for pre-lingual and post-lingual onset of deafness.

Methods: Thirty-two bilateral CI young adults will be recruited for the study, with sixteen being prelingually deafened and sixteen postlingually deafened. Demographic data to characterize music experience, and hearing experience, will be collected and residual hearing measured using a pure-tone audiogram. Participants will take part in four experiments. (1) to measure spatial speech in noise perception using virtual audio, (2) ITD and ILD sensitivity measured using direct stimulation via a research interface, (3) A beat detection and discrimination task, and (4) a dissonance-consonance discrimination task. Experiments 2-4 use a 3-Alternative Forced Choice procedure with participants identifying the odd-one-out. For the dissonance-consonance comparisons participant will also rate pleasantness of stimuli using a visual-analogue-scale from "pleasant" to "unpleasant." Pilot study results will be presented.

Implications: This study provides a deeper understanding of how the onset of deafness affects the underlying perceptual abilities for encoding spatial/binaural cues and for music perception in CI users.

T-W 67: ADVANCING HEARING DIAGNOSTICS AND DEVICES THROUGH EXTRACOCHLEAR ELECTRIC-ACOUSTIC STIMULATION

Waldo Nogueira, Daniel Kipping, Yixuan Zhang, Benjamin Krueger

Auditory Prosthetic Group, Department of Otolaryngology, Hannover Medical School
Cluster of Excellence “Hearing4all”

Introduction: Previous research has demonstrated that combining electric and acoustic stimulation of the auditory system can lead to interaction mechanisms (e.g., Krueger et al., 2017; Imsiecke et al., 2018). These interactions may stem from electroneural stimulation of auditory nerve fibers or electrophonic stimulation of hair cells (e.g., Kipping et al., 2020). Understanding these mechanisms could pave the way for new diagnostic tools for hearing loss and improve hearing by integrating electric and acoustic stimulation. Assessing low-frequency hearing below approximately 500 Hz in clinical settings remains challenging due to noise sensitivity (e.g., Wilson et al., 2016; Frank et al., 2017). Current diagnostic methods rely solely on responses to either acoustic or electric stimulation. A scientific challenge is to utilize electric-acoustic interaction mechanisms for diagnosing hearing loss, which only occurs if acoustic hearing is present. Restoring high-frequency audibility, such as for age-related hearing loss, is also challenging, especially in severe cases. Cochlear implant (CI) users with residual low-frequency hearing benefit from additional electric stimulation to receive combined electric-acoustic stimulation (EAS) (Turner et al., 2004; Buechner et al., 2009; Wilson et al., 2012). However, cochlear implantation can cause trauma and compromise low-frequency acoustic hearing (Pfingst et al., 2015; Quesnel et al., 2016). A less invasive alternative is extra-cochlear electric stimulation, inspired by the benefits of EAS, to deliver acoustic and minimally invasive electric stimulation.

Methods: We designed studies to explore the potential of extra-cochlear electric stimulation in auditory perception and its interaction with acoustic signals. Study 1 investigates whether sound sensations can be elicited through extra-cochlear electric stimulation alone. Study 2 examines the interaction between electric and acoustic stimulation when applied extra-cochlearly. Study 3 aims to measure these interactions objectively and through behavioral experiments. Study 4 evaluates whether combining acoustic and extra-cochlear electric stimulation can enhance speech understanding, potentially improving auditory solutions for hearing impairments. These studies are supported by simulations with a novel computational model of the electrically and acoustically stimulated auditory system (Kipping et al., 2024). Experiments were conducted with two subject populations: 1) Partial insertion CI users with some electrode contacts inside and others outside the cochlea, allowing investigation of electrical stimulation benefits near the round window. 2) Normal hearing listeners with an electrode in the ear canal and a tube for simultaneous acoustic stimulation.

Results: The experiments show that it is possible to elicit sound sensations with extra-cochlear electric stimulation using either a CI electrode placed at the round window or in the ear canal. Interaction effects between electric and acoustic stimulation were observed in normal hearing listeners using an ear-canal electrode, though these interactions were less clear with the round window electrode from the CI in subjects with only low-frequency hearing. These preliminary results may indicate that the interaction effects are caused by electrophonic stimulation rather than electroneural stimulation. Moreover, extra-cochlear electric stimulation delivered to the round window provided improvements in consonant identification. Consonant identification tests using the ear-canal electrode to provide electric and acoustic stimulation are currently ongoing.

Conclusions: This study shows promising results on electric-acoustic interaction mechanisms that motivate the development of novel hearing diagnostics as well as hearing devices to enhance hearing.

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T-W 68: EFFECTS OF SEMANTIC CONTEXT ON SPEECH RECOGNITION AND SPATIAL RELEASE FROM MASKING IN CHILDREN USING BILATERAL COCHLEAR IMPLANTS AND AGE-MATCHED TYPICAL HEARING CHILDREN

Nimesha D. Dantanarayana, Shelly P. Godar, Margaret A. Koeritzer, Sara M. Misurelli, Ruth Y. Litovsky,

University of Wisconsin, Madison, WI USA

Background: Spoken words can be more accurately identified in contextually meaningful sentences than words presented in isolation, since spoken sentences are typically processed by listeners as integrated linguistic units and not as isolated words. However, sentences with meaningful contexts have a complex rule-governed linguistic organisation that reflects the integration of acoustics in the speech signal with grammatical knowledge and top-down semantic predictive processing. Sentences that violate semantic contexts force the listener to rely more on acoustic information in the speech signal than top-down processing. That is anomalous sentences force the listener to engage cognitive processes to encode sequences of incompatible words. Studies that experimentally manipulate the semantic context in sentences in speech recognition have rarely been investigated in children using cochlear implants (CIs). We are interested in the reliance on semantic context as an important factor that could explain individual differences observed in speech recognition in noisy situations in children using bilateral CIs (BiCIs), along with factors such as auditory experience, spatial hearing skills, and cognitive skills. We are investigating effects of semantic context processing on speech recognition in noise by children using BiCIs, focusing on how semantic context interacts with source segregation introduced by spatially separating the target speech from noise (Spatial release from masking; SRM).

Methodology: Children using BiCIs (9-15 years old), and age-matched typical hearing (TH) children participated. Sentence materials were either semantically coherent or anomalous. Each participant was tested in quiet, and at several signal-to-noise ratios (SNRs), with target and maskers either co-located in front, or target in front and maskers spatially separated at +90degree or -90degree. Cognitive testing consisted of digit span forward, backward, dimensional change card sort, and flanker inhibitory control tests, to measure executive functioning skills including attention, working memory, cognitive flexibility, and attention inhibition, respectively.

Results: Preliminary data indicated that TH children scored better than children with BiCIs in all conditions tested. Speech recognition scores in both groups of children were higher for semantically coherent than anomalous sentences for all conditions tested, suggesting an effect of semantic context on speech recognition. Speech recognition scores varied with SNRs as expected, for both types of sentences and spatial configurations, in both groups. Effects of sentence type suggests that benefit of binaural cues in source segregation (SRM) is greater with anomalous than coherent sentences. This presentation will focus on differences between children with BiCIs and TH in how they engage with sentences based on semantic context, and the impact of spatial cues on performance. Novel aspects of cognitive abilities will also be analysed to better understand cognitive control processes during speech recognition in quiet and with maskers.

Conclusion: Children with BiCIs and TH were tested on novel measures of speech unmasking with a focus on the ability to extract speech information from sentences that vary in contextual cues. Our goal is to gain new insights into group differences in the association between speech recognition under semantically varying context and spatial cues, as well their associations with cognitive control.

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T-W 69: CONSUMER PERCEPTIONS OF AUDITORY PROSTHETIC DEVICES: EVALUATING PERFORMANCE, PRIVACY, SECURITY, AND USABILITY

Sohini Saha[1], Leslie M. Collins[1], Sherri L. Smith[2], Boyla O. Mainsah[1]

[1]Department of Electrical and Computer Engineering, Duke University,
[2]Department of Head and Neck Surgery & Communication Sciences,
Duke University School of Medicine

Advancements in auditory prosthetic technology have increased device interconnectivity, enabling features such as direct audio streaming from smartphones, remote adjustments by audiologists, smart home integration, and artificial intelligence/machine learning-driven sound enhancements [1]. This enhanced connectivity brings critical concerns regarding data privacy and security. Research on consumer awareness of privacy and security issues in connected auditory prostheses remains limited [2, 3]. There is also a lack of studies examining user perceptions of the usability of modern hearing aids (HAs) and cochlear implants (CIs), and consumers' mental models during the device purchase decision-making process. Understanding these considerations is essential to ensuring that auditory prostheses align not only with users' auditory needs but also with their broader expectations and concerns.

We conducted a survey study to gain insights into consumer perceptions and awareness of HAs and CIs. The survey encompassed questions covering demographics, device details, usage satisfaction, mobile app security, privacy, cybersecurity awareness, and purchase decision-making. We evaluated participants' satisfaction with various features of their auditory prostheses, which included the device's: performance in enhancing hearing and communication; reliability in consistent functioning; durability against wear and tear; quality of customer support from the manufacturer, privacy and security of personal data; usability in everyday life; and flexibility in adjusting device settings to different listening environments. Participants were asked to rank these device features, as well as security and privacy factors based on their level of importance when deciding which device to purchase.

We recruited 15 CI users and 22 HA users, who completed the survey using Research Electronic Data Capture (REDCap) [4]. Overall, 60% of CI users and 41% of HA users reported complete satisfaction with device performance. HA users showed greater satisfaction with usability (32% vs. 13% for CI users), while only 13% of CI users and 5% of HA users were completely satisfied with reliability. 36% of HA users were entirely dissatisfied with customer support, compared to 7% of CI users. 47% of CI users and 32% of HA users were completely dissatisfied with the devices' flexibility in adjusting to different listening environments. In purchasing decisions, 53% of CI users and 41% of HA users prioritized performance, while 27% of HA users and 13% of CI users considered price important. When ranking privacy and security concerns, 40% of CI users prioritized encryption, followed by regular updates (27%), user authentication (20%), and transparent privacy policies (13%), while 32% of HA users prioritized encryption, with regular updates, user authentication, and transparent privacy policies each cited by 23%. Only 26% of CI users and 14% of HA users found the accompanying mobile application user-friendly. Awareness of privacy and security practices was limited, with only 26% of CI users and 5% of HA users stating they had encountered relevant information regarding their devices.

Our study reveals that CI and HA users are highly satisfied with their devices' ability to enhance hearing and communication-a key factor in their purchasing decisions. Participants expressed concerns about device flexibility, noting dissatisfaction with adjustable settings, highlighting the need for more robust speech enhancement in complex listening environments. Participants demonstrated limited awareness of privacy and security practices associated with these devices and expressed a need for more education on these issues. Our findings emphasize the importance of strengthening privacy and security settings while maintaining user-friendly designs to enhance both safety and satisfaction.

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T-W 70: INVESTIGATING AGE AND BIOLOGICAL SEX INTERACTIONS ON TEMPORAL PROCESSING DEFICITS IN COCHLEAR-IMPLANT USERS

Anhelina Bilokon[1], Miranda Cleary[1], Maureen J. Shader[2], Matthew J. Goupell[1]

[1] University of Maryland, College Park,
[2] Purdue University, Department of Speech, Language, and Hearing Sciences

Cochlear-implant (CI) users show variability in speech perception outcomes influenced by factors like severe-to-profound hearing loss duration and age. While age-related declines in temporal processing are well-documented, investigations of sex differences remain neglected despite evidence of auditory function differences, including hormonal effects. The electrode-to-neural interface (ENI) plays a critical role in CI outcomes by influencing the effectiveness of auditory nerve stimulation through a combination of neural and non-neural factors. Acoustic hearing research suggests males may experience greater age-related neural degeneration evidenced by earlier onset of hearing loss compared to females, potentially impacting CI outcomes. Estrogen receptors in cochlear structures further suggest a link between hormones and auditory function, though their effect on CI outcomes remains unclear. This study examines how age and sex impact electrical compound action potential amplitude growth functions (ECAP AGFs; a neural health measure via ENI) and gap detection thresholds (GDTs; a temporal processing measure) in CI users. We hypothesized that males would show shallower ECAP AGF slopes, indicating poorer neural health, and consequently exhibit poorer GDT thresholds.

ECAPs were measured using CustomSound EP, with ECAP AGF slope reflecting ENI quality. GDTs at 500-, 1000-, and 4000-pps rates were assessed via direct electrode stimulation. Linear mixed-effects models analyzed sex, age, stimulus rate, and ECAP AGF slope effects on GDT performance in 30 participants (ages 21-83 yrs). Shallower ECAP slopes (poorer ENI quality) were associated with poorer GDT performance ($p < 0.0001$), while higher stimulus rates (4000 pps) improved GDT performance for both male and female subjects ($p < 0.001$). Females exhibited significantly higher GDTs than males, with a mean difference of 0.95 ms (39.9%; $p < 0.0001$). Males exhibited significantly better overall GDT performance. Females also exhibited a steeper ECAP slope-GDT relationship compared to males ($p = 0.0002$), suggesting that ENI quality more strongly influences GDT performance in females. Age effects were not significant ($p = 0.070$), indicating that once ECAP/ENI and sex are considered, age does not provide additional explanatory power for the GDT performance. In summary, males did not show worse GDT performance (contrary to the hypothesis) but exhibited a shallower ECAP slope-GDT relationship (partially supporting our hypothesis), suggesting a weaker influence of ENI quality on GDT performance compared to females.

These findings challenge the common view of CI outcomes and emphasize the need to consider biological sex, an often overlooked factor. This approach enhances our understanding of the biological basis of hearing by emphasizing the relationship between individual biological factors and auditory processing in CI users, ultimately guiding personalized rehabilitation strategies to improve CI programming.

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T-W 71: DEVELOPMENTS AND BARRIER FOR SURGICAL ROBOTS FOR COCHLEAR IMPLANTATION

Huan Jia[1,2], Haoyue Tan[1], Guo Jia[3], Hao Wu[1,2]

[1]Department of Otolaryngology-Head and Neck Surgery, Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai 200011, China

[2]Shanghai Key Laboratory of Translational Medicine on Ear and Nose diseases. (14DZ2260300）

[3]Shanghai Jiao Tong University School of Medicine, Shanghai 200025, China

Cochlear implantation is a highly delicate procedure that requires the precise insertion of fine and soft electrode arrays (EAs) into confined and deep surgical spaces. This minimally invasive process presents significant challenges, including the need for high dexterity, force control, and surgical precision. To address these challenges, this study introduces two novel robotic systems designed for different purposes: one focuses on compatibility and automated implantation, while the other emphasizes an innovative design for force sensing during insertion.

The first system integrates a 6-degree-of-freedom (6D) motion platform with a semi-autonomous control mechanism, designed to facilitate precise and safe EA insertion. The system features a dual-forceps mechanism that can adapt to various EA types, ensuring versatility and compatibility. By maintaining controlled forces and torques, this system reduces the risk of damage to delicate inner ear structures and reveals the various force patterns of different EAs during insertion.

The second system prioritizes shape adaptability and high-precision force sensing. It incorporates a 6-axis force-sensing pneumatic forceps with fiber Bragg grating (FBG) sensors, offering high-resolution force/torque detection. The forceps feature a curved body shape and decoupled pneumatic actuation, ensuring stable EA handling while maintaining sensing accuracy. Cadaveric studies demonstrate the system's effectiveness in achieving precise and safe EA insertion.

These two robotic systems address different design priorities and collectively offer scalable solutions for high-precision microsurgeries. By integrating advanced motion control, force sensing, and adaptive design features, these innovations bridge technical advancements with clinical perspectives. Future work will focus on further optimizing these systems to enhance their clinical adaptability and expand their applications in cochlear implantation and other microsurgical procedures. While the robotic systems introduced in this study represent significant advancements in the field of cochlear implantation, addressing the barriers related to development costs, clinical translation, and health economics is crucial for their broader adoption and long-term impact on patient care.

T-W 72: STIMULATION RATE VARIABILITY IN COCHLEAR IMPLANTS: A NOVEL APPROACH TO IMPROVING SPEECH INTELLIGIBILITY

Samuel Oghenetega Okei, **John H. L. Hansen**

Cochlear Implant Processing Lab, Center for Robust Speech Systems (CRSS-CILab),
University of Texas at Dallas, Richardson, TX, USA

Cochlear implants are the most successful neural prosthetics in recent history, restoring partial hearing to individuals with severe-to-profound sensorineural hearing loss [1]. While highly valuable, modern cochlear implant devices still face significant limitations, including difficulties with speech localization and intelligibility in noisy environments [1,2]. Users also often struggle with music enjoyment and inconsistent performance [2].

Recent research suggests that increasing the variability of stimulation rates across electrodes and time could potentially improve speech intelligibility. This would allow for more advanced resource allocation and customization to individual users. Proposed studies also depend on the ability to vary stimulation rates, such as the mixed-rate strategy for improved speech localization by Tanvi et al. [3] This study introduces a new user-friendly tool accessible through the CCi-MOBILE platform, enabling researchers to explore this approach. By allowing researchers to vary stimulation rates across electrode channels and time while using ACE or CIS algorithms, this solution opens new directions for investigating strategies that explore new scientific strategies in stimulation rate variation, which is currently lacking in most research platforms that maintain a single stimulation rate across all channels[4].

The proposed hardware/software system supports both real-time and offline stimulation, extending the utility of the CCi-MOBILE research platform to naturalistic and take-home experimentation. This expanded capability allows for more diverse and ecologically valid studies, potentially leading to further advancements in cochlear implant technology and improved outcomes for CI users.

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T-W 73: MONITORING OF THE INNER EAR FUNCTION DURING AND AFTER COCHLEAR IMPLANT INSERTION USING ELECTROCOCHLEOGRAPHY

S. Haumann[1,2], M. Timm[1,2], A. Büchner[1,2], T. Lenarz[1,2], R. Salcher[1,2]

[1]ENT Department, Medical School Hannover
[2]Cluster of Excellence Hearing4All

Introduction: In order to preserve residual hearing during CI insertions, it is desirable to carry out intraoperative monitoring of the cochlea. A promising approach is the measurement of cochlear microphonics (CM) using electrochleography (ECochG). In a previous study with 10 adult CI patients (Haumann et al., 2025), evidence was found that the course of the preoperative audiogram has an influence on the amplitude course of the ECochG stimulus response measured intracochlear. This was determined using a 500 Hz tone burst. This study aims to investigate whether this effect is also visible when stimulated with a multifrequency chirp.

Method: First, both stimuli (500 Hz and chirp) were applied postoperatively to patients with residual hearing, stimulus responses were measured individually on all electrode contacts and the results were compared to each other. Currently n=5 data sets have been collected, further measurements are scheduled. Based on the results, the measurement protocol for intraoperative measurement is adapted and applied during the insertion of hearing-preserving CI electrodes.

Results: The first results show adequate stimulus responses when using both stimuli. When stimulating with chirps, the stimulus responses can be displayed at several frequencies. In these first results a strong relation to the audiogram was detected.

Conclusion: Both stimuli appear to elicit comparable amplitudes. However, so far only patients with similar audiogram shapes have been included in the study. Thus, data sets with more different audiogram shapes are required for a more detailed examination.

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T-W 74: EXAMINING THE IMPACT OF INCOME AND MINORITY STATUS ON ACCESS TO HEARING HEALTH SUPPORT AMONG COCHLEAR IMPLANT USERS

Tanvi Thakkar, Serena Fincher

University of Wisconsin-La Crosse

In recent years, the overall incidence of cochlear implants (CIs) among adults with severe-to-profound bilateral hearing loss has increased significantly from 244 per 100,000 persons in 2015, to 350 per 100,000 persons in 2019 (Nassiri et al., 2023). Despite the rising incidence of qualifying hearing loss, CIs are underutilized, and while recent trends show improved access for the elderly population, there are little documented efforts to improve access for minority and poverty populations. The extent of support for CI patients from minority populations is unclear, with limited data on underserved and black, indigenous, and other people of color (BIPOC) communities, reducing generalizability of outcomes. This data gap hinders our understanding of how individuals from diverse backgrounds experience and benefit from implantation, especially in challenging auditory environments. The main objective of this study was to report and advance the unique challenges faced by hearing-impaired and CI patients from BIPOC, rural, and underserved communities in La Crosse County, WI. We hypothesized that individuals with lower income or those from ethnic minority backgrounds would report fewer opportunities for CI device education, greater barriers to healthcare access, and consequently, fewer perceived benefits from their assistive devices.

Participants included individuals from La Crosse county who had hearing impairment both with and without CI utilization. The study asked participants to complete a 35-question Hearing Health questionnaire, which first asked participants to report basic demographic information, including ethnicity, age, and gender. Other major categories of the survey were aimed at collecting information about 1) income, 2) access to hearing healthcare, including any possible barriers to care, and 3) education about hearing devices.

Preliminary data show that 71% of respondents identified as BIPOC, with only 29% identifying as white. Nearly half (45%) had a high school education or lower, and only 6% held a master's degree or higher. Income levels were generally low, with 44% earning between $30,000 and $49,999 annually and 15% earning below $30,000. Healthcare access was limited, as 40% lacked a primary care provider due to cost (47%) or distance (47%), and fewer than 40% had access to hearing-specific healthcare, with cost, distance, and lack of insurance as key barriers. Additionally, most participants stated that they desire to receive more technical and counseling/psychological support regarding their hearing device(s).
These findings suggest there is a possible inequitable relationship between access to hearing health support and counseling between non-minority individuals compared to those from BIPOC or lower income backgrounds and education level.

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T-W 75: IMPROVING SSD-CI OUTCOMES BY REDUCING INTERAURAL FREQUENCY AND LOUDNESS MISMATCHES THROUGH DEVICE PROGRAMMING

Laura Holden, Rosalie Uchanski, Noël Dwyer, Ruth Reeder, Tim Holden, Jill Firszt

Department of Otolaryngology-Head and Neck Surgery, Washington University School of Medicine, St. Louis, Missouri

Objective: Interaural frequency and loudness mismatches affect outcomes in cochlear implant (CI) recipients with single-sided deafness (SSD). The study's objective was to reduce interaural frequency and loudness mismatches through speech processor programming in SSD-CI participants implanted with a Cochlear Nucleus device.

Methods: Experiment 1 examined interaural frequency mismatch in 20 experienced and 10 newly implanted SSD-CI. Experienced SSD-CI were evaluated using two frequency allocation tables (FATs), their everyday FAT and a modified FAT. The modified FAT was created to better match the tonotopicity of the contralateral ear and in turn, reduce interaural frequency mismatch. Participants were first tested with their everyday FAT. After 6 weeks use, participants were tested with the modified FAT. Lastly, participants compared both FATs at home for several weeks before being tested again with each FAT. Newly implanted SSD-CI were placed in one of two groups at initial activation. Group A was programmed with Cochlear's default FAT and Group B with the modified FAT. Participants were tested after six weeks' use of each FAT and then com-pared both FATs at home for several weeks before being tested a second time with each. Experiment 2 examined interaural loudness mismatch; 15 experienced SSD-CI were evaluated with their everyday program and with a modified loudness program. The modified program was created to obtain audibility of ~20 dB HL from .25 - .6 kHz with the aim of balanced loudness be-tween ears. Participants were first tested with their everyday program and then with the modified program, after 6-weeks use. Participants compared the two programs at home and were tested a second time with both programs. CI audibility, speech recognition in quiet and noise, localization, and perceived hearing abilities were evaluated. Additionally, a loudness judgment test was conducted in Experiment 2.

Results: Experiment 1 showed a significantly lower (better) signal-to-noise ratio (SNR) in the R-SPACETM, a test simulating a noisy restaurant, with the modified FAT compared to the everyday FAT for experienced SSD-CI. Localization scores were not significantly different between FATs; however, perceived ability ratings for localization were higher with the modified FAT compared to the everyday FAT. For newly implanted SSD-CI, there were no significant differences between FATs for any of the test measures. Experiment 2 indicated significantly better audibility and lower SNRs in the R-SPACETM with the modified program compared to the everyday pro-gram. Furthermore, participants' loudness ratings at the CI ear with the modified program (obtained via the loudness judgment test) were similar to loudness ratings at the normal-hearing ear. Preferences for a modified program (either modified FAT or loudness) were encouraging.

Conclusions: Results indicated clinicians can adjust programming parameters to reduce interaural frequency and loudness mismatches and improve SSD-CI outcomes, even for those with years of CI experience. The first few months after CI activation may be too early to compare FATs; however, the modified FAT can be implemented at CI activation with no detriment to CI outcomes.

T-W 76: CORTICAL ENCODING OF TONES VS ACUTE INTRACOCHLEAR STIMULATION IN NORMAL HEARING AND ADULT-DEAFENED RATS: A COMPARATIVE STUDY USING HIGH-DENSITY MICRO-ELECTROCORTICOGRAPHY.

Ariel Edward Hight[1], Michele Insanally[2], Julia Scarpa[3], Yew-Song Cheng[4], Mario A. Svirsky[1,*], and Robert C. Froemke[1,*]

[1]NYU Langone Medical Center
[2]University of Pittsburgh Medical Center
[3]Weill Cornell New York Presbyterian
[4]University of California San Francisco
[*] co-senior authors.

Purpose/Objective: Tonotopy, or cochleotopy, is the primary organizing feature of the primary auditory cortex, a feature conserved across mammalian species [1]. Traditional mapping techniques include repeated microelectrode recordings across the topographical axes of the cortex, asynchronously. Here, we utilize a novel 60-channel surface electrode array (micro-electrocorticography, μECoG), to record sensory evoked responses across the auditory cortex, simultaneously [2]. We ask the question whether central pathways effectively encode acute 8-channel cochlear implant (CI) stimulation and the extent to which encoding of CI stimulation overlaps with encoding pure tones.

Methods/Approach: We recorded cortical surface potentials from primary auditory cortex, evoked by tones in 7 normal-hearing rats and by intracochlear electrodes in 7 adult-deafened rats. For a subset of these animals (N=4), both tone-evoked and electrode-evoked potentials were recorded and compared. Measurements were filtered either minimally (event-related potentials, ERPs) or extracting high-gamma power (HG, 60-150 Hz). Standard measures of cortical encoding were extracted, and responses were further reduced using principal component analysis (PCA) and tensor decomposition analysis (TCA). We also employed linear discriminant analysis (LDA) decoders to determine whether latent features could encode stimulus identity

Results/Findings: Both tone-evoked and electrode-evoked responses revealed clear cochleotopy, largely overlapping in location and orientation. Trial-by-trial variability in stimulus encoding was higher in electrode-evoked compared to tone-evoked responses. PCA and TCA reductions, followed by LDA decoding, indicated that evoked potentials could encode stimulus identity in both normal-hearing and implanted rats. Importantly, reducing the spatial, but not the temporal, aspects of the measurements significantly decreased decoder performance. When training decoders on tone-evoked responses and testing them on electrode-evoked responses, the results showed a preference for specific electrodes, though there was minimal information transfer.

Conclusions/Implications: Cochlear implants impose a remapping of the sense of sound in adult-deafened subjects. One significant dimension of remapping is cochleotopic encoding of sound frequency, in terms of tuning & frequency-place functions. Here, we demonstrate that the acute cochleotopic encoding of CI stimuli is significantly preserved but does not overlap completely with the encoding of tones.

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T-W 78: BILINGUALS' SPEECH PERCEPTION OF NOISE-VOCODED SPEECH

Deena Wechsler-Kashi

Ono Academic College, 1 Academic Boulevard, Kiryat Ono, Israel.

Introduction: A large percentage of the world's population is bilingual. Many Cochlear Implant (CI) recipients are bilingual as well. Speech perception in monolingual listeners remains robust in various adverse listening conditions, such as spectrally-degraded speech (Yang et al., 2022). Understanding the linguistic constraints on the ability to perceive processed speech is important. Noise-vocoded speech has been used to simulate speech perception via an implant. The purpose of this study was to compare speech perception performance of noise-vocoded speech between bilingual and monolingual listeners.

Methods: Two groups of young adults participated in this study (mean age: 24.8 years). One group included 30 Arabic-Hebrew bilingual adults, of whom 13 were early bilinguals (acquiring their second language (L2) before the age of 7) and 17 were late bilinguals. The second group included 15 Hebrew-speaking monolingual adults. Participants listened to monosyllabic words that were vocoded through 12 channels and presented at four different signal-to-noise ratios (SNRs): -2, +3, +8, and +13 dB.

Results: A significant group effect was found in word identification performance ($F(1,41) = 13.350$, $p < 0.01$) across all four SNR conditions. The monolinguals outperformed the bilingual group. However, no significant difference was observed between early and late bilinguals.

Conclusion: The findings indicate a monolingual advantage in perceiving noise-vocoded speech. This advantage might be explained by the monolinguals relying on language knowledge via top-down processes, while attempting to perform the speech perception tasks of noise-vocoded speech under challenging noise-ratio conditions. These results have clinical implications for the rehabilitation of bilingual adults with hearing loss who receive cochlear implants.

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Th-F 1: A BIOLOGICALLY PLAUSIBLE VOCODER FOR AUDITORY PERCEPTION MODELING

Jacob P. de Nobel[1], Thomas H. W. Bäck[1], Jeroen J. Briaire[2], Anna V. Kononova[1], Johan H. M. Frijns[2]

[1]Leiden Institute of Advanced Computer Science (LIACS), Leiden, the Netherlands
[2]Dept. of Otorhinolaryngology, Leiden University Medical Centre (LUMC), Leiden, the Netherlands

This project focuses on developing a biologically plausible vocoder to model auditory perception in both normal-hearing individuals and cochlear implant (CI) users. Unlike conventional vocoders that rely primarily on signal processing techniques, this model integrates neural activity simulations to provide a more accurate representation of auditory perception. By leveraging well-established physiological models of the auditory system, this approach aims to bridge the gap between theoretical modeling and real-world auditory experiences.

For normal hearing simulation, the vocoder is based on the Bruce et al. (Hear Res 2018) model, a computational model of the auditory nerve that simulates neural responses to sound stimuli based on known cochlear and neural processing mechanisms. For CI users, the vocoder utilizes a model by the Leiden University Medical Center (LUMC), which integrates in-house biophysical models (Kalkman et al., Hear Res 2022) and a phenomenological (PHAST) model (van Gendt et al., Hear Res 2020; de Nobel et al., Hear Res 2024). This provides a detailed simulation of the electrical stimulation of auditory nerve fibers by a cochlear implant. This dual-model approach allows for a direct comparison of auditory processing under normal and impaired conditions.

The vocoder processes incoming sound by passing it through these neural models to generate neural activity patterns, which are then used to create neurograms-time-frequency representations of neural firing rates. These neurograms are subsequently mapped onto a Mel spectrogram-like structure, where neurons are binned according to a Mel scale. This is normalized, scaled and subsequently processed using the Griffin-Lim phase correction algorithm to reconstruct the perceived sound, which refines the phase information to generate an intelligible acoustic waveform.

The FADE model (Schadler et. al, JASA 2016)-a Hidden Markov Model (HMM)-based system-is employed to test the validity and accuracy of the vocoder. FADE is designed to simulate auditory discrimination experiments, allowing for an objective and patient-free assessment of how the vocoder's output aligns with real-world measurements. In this initial trial the Digits-in-Noise (DIN) test, a widely used metric for evaluating speech perception in noise was used for evaluation. The validation results indicate that the vocoder accurately simulates CI speech perception, closely matching expected clinical observations and the simulated CI processing exhibits performance trends consistent with real cochlear implant users.

One of the key strengths of this approach is that it provides a self-contained system for developing and testing CI technologies without human subjects. Combining the Bruce, PHAST, and FADE models enables:

1) Realistic normal and CI hearing simulation.
2) Quantifiable evaluation of modeled conditions.
3) Rapid iteration of speech coding strategies before clinical trials. This accelerates CI speech processing research, reduces reliance on human testing, and offers a consistent, reproducible platform for evaluating auditory models. Future work can leverage this system to rapidly prototype new CI technologies.

Th-F 2: THE IMPACT OF ACTIVE COMMUNICATION AND DEVICE USE ON SPEECH OUTCOMES IN ADULT CI USERS

Griet Goovaerts[1], Obaid Qazi[1], Birgit Philips[1], Tom Bertens[1], Andreas Büchner[2], Filiep Vanpoucke[1]

[1]Cochlear Technology Center, Cochlear Ltd, Mechelen, Belgium
[2]Medical University Hannover, Dept. of Otorhinolaryngology, Hannover, Germany

Cochlear implants (CI) provide hearing to children and adults with severe to profound hearing loss. Research has consistently demonstrated a strong positive correlation between device use and speech outcomes. We hypothesize that this correlation is primarily driven by using the device in auditory rich environments and actively contributing to conversations. This study analyses the link be-tween device use, active communication and speech outcomes by employing a novel research feature, own voice detection (OVD), that runs on CochlearTM Nucleus(R) sound processors.

The OVD algorithm is implemented as an extension of the SCANTM sound classifier. When SCANTM detects a "speech" or "speech in noise" environment, OVD further classifies the sound as "own speech" or "external speech. Additionally, it estimates the number of conversational turns. The algorithm is based on a decision tree that combines the features generated by SCAN together with additional features designed to differentiate "own" from "external" speech. The algorithm was validated in a prospective study with paediatric CI recipients, showing strong correlations with human transcriptions. It was subsequently included as research feature on sound processors, where it automatically records the OVD parameters (i.e. duration of own speech, duration of external speech and number of conversational turns) in the datalogs.

To investigate the correlation between the OVD features and speech outcomes, we collected a retrospective dataset of 207 post-lingually deaf adult CI users. The dataset included patient characteristics, datalog features related to device use and active communication, and speech outcomes at 3 months and 1 year after implantation. The relationship between the different features and speech outcome was analysed with correlations and multivariate linear mixed models. Stepwise model selection was performed excluding non-significant predictors until the optimal model was found.

The results show that, while device use was not correlated with age, the features related to OVD var-ied as a function of age at implantation: both the number of conversational turns and the own speech time decreased as users were older, while the detected external speech time increased with age. The final multivariate model to predict speech in quiet outcomes included three significant predictors: time since implantation, time on air (ToA) and time of own speech (ToS). Between these predictors, ToS was a stronger predictor than ToA, which supports the hypothesis that active communication is important in achieving good speech outcomes. In the absence of ToS, the number of conversational turns similarly predicted outcome better than ToA.

In this study, we analyzed outcomes from OVD, an algorithm that characterizes communication in CI recipients directly from the sound processor. Our findings indicate that active communication (measured by the time of own speech and the number of conversational turns) decreases as CI recipients age. This trend likely reflects changes in social environment which lead to less active participation in conversations. Furthermore, the results underscore the importance of device use and active communication in achieving better speech outcomes in adult CI users. This suggest that interventions promoting active engagement in communication could be beneficial. It is important to note however that the results in this retrospective study are limited to correlations between device use and outcome. Future research should focus on determining the direction of causation and on longitudinal studies to confirm these findings and explore the underlying mechanisms.

This work was funded by Cochlear Ltd.

Th-F 4: ESTABLISHING A RELIABLE TEST PROCEDURE FOR MEASURING THE ASSOCIATION OF SPECTRO-TEMPORAL PROCESSING WITH SPEECH ACQUISITION FOR PAEDIATRIC COCHLEAR IMPLANT USERS

C. Leal[1], E. Buchanan-Worster[2], D. Vickers[1]

[1]SOUND Lab, University of Cambridge, Cambridge, United Kingdom
[2]MRC Cognition and Brain Sciences Unit, University of Cambridge, Cambridge, United Kingdom

Purpose/Objective: Spectro-temporal processing abilities are considered important for extracting speech information in complex auditory environments (e.g. noisy or with multiple speakers). Speech sounds are made up of varying spectral and time patterns so better spectrotemporal processing skills enable the listener to differentiate these patterns and thus, distinguish speech from background noise. While assistance of cochlear implants (CIs) should improve spectrotemporal processing, they can't fully replicate typical hearing abilities. Current CI signal processing limits the delivery of low frequency, voice-pitch-related acoustic information needed for suprasegmental perception firstly, because the lower cut off frequencies are typically above 150 Hz and secondly because the signal processing limits delivery of temporal fine structure cues. CIs do deliver temporal-envelope information across a wide range of frequency regions such that recognition of vowels and consonants (segmental perception) may be conveyed well. In the present study, we aim to investigate the link between auditory processing abilities, specifically spectrotemporal processing, and speech/language outcomes in children aged 7-11 with bilateral CIs implanted before age 2; native English speakers, to understand the predictive nature of spectrotemporal processing, and how these factors change together over time. Initially this work has explored the value of producing a paediatric version of the Spectro-Temporal Ripple for Investigating Processor Effective-ness (STRIPES) (Archer-Boyd et al., 2018) task for use in paediatric population (named cSTRIPES). Two additional filtered conditions were prepared for more specific frequency analysis.

Methods/Approach: The cSTRIPES, a paediatric friendly game format of STRIPES was used in the pilot. 17 adults Native English speakers aged between 18-56 years (average age 36.7) with typical hearing levels were tested and all stimuli were vocoded to simulate CI processing (cSTRIPESvoc). Three STRIPES stimuli were used to focus on important speech regions. (1) original broadband STRIPES filtered between 250 Hz to 8 kHz (cSTRIPESvoc-BROAD), (2) Low-frequency important speech range was filtered 250 Hz to 1kHz (cSTRIPESvocLOW; predominantly covering the fundamental frequency (F0) and first for-mant (F1) region, and (3) Mid-frequency important speech range was filtered 1 to 4 kHz (cSTRIPESvocMID; predominantly covering the second formant region (F2). The intention was to determine if different STRIPES stimuli related well to speech-in-noise perception. Speech stimuli used were Children's Coordinate Response Measure (CCRM) (vocoded, in noise) and CHEAR Auditory Perception Test (CAPT) (vocoded, in noise).

Results/Findings: Conducting all three cSTRIPESvoc tests took under 45 minutes, matching expert recommendations. High test-retest reliability was observed for all three cSTRIPESvoc (Pearson correlation >=0.6). The only STRIPES stimulus that had a strong correlation with speech (CCRMvoc, CAPTvoc) was the original STRIPESvocBROAD.

Conclusions/Implications: Frequency segmentation of cSTRIPES was aimed to explore frequency regions' roles in speech perception by using cSTRIPES. However, formant-filtered STRIPES are unlikely to be valuable at the individual level for predicting speech outcomes so we will not include these in the protocol going forwards. Therefore, we will only focus on using broadband STRIPES for pediatric adaptations. We will test children with Cis in the next phase of testing and will present pilot data at the meeting.

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Th-F 5: USE OF ADJECTIVES IN NARRATIVE DISCOURSE IN SCHOOL-AGED CHILDREN WITH HEARING LOSS

Deena Wechsler-Kashi, Galit Ben-Zvi

Ono Academic College, 1 Academic Boulevard, Kiryat Ono, Israel.

Purpose: Prior research has revealed a developmental gap in linguistic abilities between school-aged children with hearing loss and their peers with typical hearing (Sarant et al., 2015). The literature suggests that the adjective category-secondary to nouns and verbs and not mandatory in nature-constitutes a fertile field for research and provides an important window into the development of lexical knowledge throughout the school years. Adjectives are essential for producing literate texts, demonstrate lexical richness, and are highly diverse in Hebrew, making them suitable for assessing the language skills of school-aged children and differentiating between typical and atypical language development. The study aimed to investigate the distribution and use of adjectives in picture-based storytelling among children and adolescents with hearing loss compared to their peers with typical hearing.

Methods: A total of 144 narrative picture-based storytelling samples were produced by 72 Hebrew-speaking children and adolescents, 50 with typical hearing and 22 with hearing loss. Participants were divided into two age groups: 1st-4th graders and 6th-9th graders. Among children with hearing loss, eight were CI users.

All participants produced two narratives based on picture sequences and answered questions about their stories. All adjective types and tokens in each text were identified, counted, classified, and analyzed based on semantic and morphological criteria.

Results: Findings revealed that children with hearing loss exhibited limited development in adjective quantity and diversity with age, producing significantly fewer and less varied adjectives than their hearing peers. Furthermore, there was a significant interaction between group and age indicating that the gap between the two groups widened with age. Qualitative analysis within participants with hearing loss showed an advantage for CI users in adjective types and tokens.

Conclusions: The results highlight a linguistic delay in adjective acquisition in children with hearing loss. Not only does this gap fail to close with age, but it also appears to widen as children grow older, leading to a disadvantage in adjective knowledge and use. These findings have implications for academic outcomes in school-aged children and adolescents with hearing loss.

References:

Sarant, J. Z., Harris, D. C., & Bennet, L. A. (2015). Academic outcomes for school-aged children with severe-profound hearing loss and early unilateral and bilateral cochlear implants. Journal of Speech, Language, and Hearing Research, 58, 1017-1032.

Th-F 6: RELATING INDIVIDUAL BINAURAL CUES TO FREE-FIELD LOCALIZATION PERFORMANCE WITH THE CCI-MOBILE RESEARCH PLATFORM USING A REAL-TIME MIXED RATE CODING STRATEGY

Stephen R. Dennison[1], Agudemu Borjigin[2], Ruth Y. Litovsky[2]

[1]MED-EL (Durham, NC, USA)
[2]University of Wisconsin-Madison (Madison, WI, USA)

Bilateral cochlear implants (BiCIs) do not restore sound localization abilities to the full extent exhibited by typical hearing (TH) listeners, partly because they do not encode interaural time differences (ITD) well. This is mainly because 1) clinical processors are not synchronized, introducing uncontrolled timing variation across ears, and 2) high-rate stimulation is used on a majority of electrodes. While high-rate stimulation is important for speech intelligibility, low-rate stimulation is needed for ITD sensitivity. Although some commercial strategies provide low rates of stimulation, ITD cues are not explicitly preserved. Our lab has been using synchronized research processors and investigating "mixed-rate" strategies, where low-rate stimulation is applied to select electrodes to restore ITD sensitivity without compromising speech understanding. Our recent study showed that a single pair of electrodes with low-rate stimulation is sufficient to improve lateralization if this pair of electrodes has the best ITD sensitivity. This study, like most on synchronized low-rate stimulation, used direct stimulation, delivering signals directly to implants and removing interaural level difference (ILD) cues that BiCI users rely on in free-field conditions when their processors lack ITD cues. Here, we present the first sound localization experiment evaluating synchronized low-rate stimulation in the free field, conducted using a real-time processing research platform (CCi-MOBILE).

New for this project, due to the unique CCi-MOBILE platform, we can measure the binaural cues delivered to the user with their own head cues in real-time. For each of fourteen participants, multiple recordings were obtained for the stimulus presented from each loudspeaker using the CCi-MOBILE microphones positioned on the participants' ears. ITD and ILD cues were calculated from the acoustic stimuli at the level of microphone input. The audio recordings were further processed with each participant's stimulation strategies tested in the localization experiment to construct electrodograms (simulation of the electrical stimulation) for each stimulus presentation. ITD and ILD cues were then calculated for these electrical stimulation sequences, which allowed us to investigate whether the binaural cues delivered in electrical stimulation could predict the perceptual performance.

The analysis of binaural cues demonstrates that the electrical ILDs are much smaller than the acoustic ILDs, consistent with the smaller dynamic range available to CI users with electrical stimulation. There was no difference in ILDs across different coding strategies we tested for localization, but this was likely due to the large variability in ILDs measured from the electrodograms. In contrast, the mixed rate coding strategies preserved ITDs, which better differentiated unique loudspeaker locations than ILDs, suggesting that listeners could achieve improved performance if they accessed these cues. However, the perceptual results showed no significant difference in localization error, indicating that ILDs remain the dominant cue in acute testing, even when low-rate ITDs are available. Though the mixed-rate strategy can reliably deliver ITD cues in the electrical stimulation, these ITD cues may not translate into improved localization performance, likely due to lack of training and the perceptual dominance of ILDs for sound localization. A dedicated training paradigm may be necessary to help BiCI listeners shift their reliance from ILD cues to ITD cues provided by the mixed-rate strategy in free-field conditions.

Th-F 8: COMBINING DEXAMETHASONE WITH DICLOFENAC OR IMMUNOPHILIN INHIBITOR MM284 IN COCHLEAR IMPLANTS: EVALUATING ELECTRICALLY EVOKED ACTION POTENTIALS IN GUINEA PIG

O. de Olano Dieterich[1], W. Behrends[2], S. Strahl[3], G. Paasche[2,4]

[1]MED-EL Research Center, 30625 Hannover, Germany
[2]Department of Otolaryngology, Hannover Medical School, 30625 Hannover, Germany
[3]MED-EL Medical Electronics, 6020 Innsbruck, Austria
[4]Hearing4all Cluster of Excellence, Hannover Medical School, 30625 Hannover, Germany

Introduction: Cochlear implants (CIs) are essential for restoring hearing in individuals with severe to profound hearing loss; however, their long-term efficacy can be hindered by post-implant inflammation and fibrotic tissue formation, leading to spiral ganglion neuron (SGN) degeneration. Electrically evoked compound action potentials (eCAPs) are neural responses to electrical stimulation from CIs, serving as a direct measure of auditory nerve activity. eCAPs are essential for assessing CI functionality, electrode positioning, and cochlear health over time. This study investigates the effects of dexamethasone (DEX) combined with poly-L-lactic acid (PLLA) coatings that release either diclofenac or the immunophilin inhibitor MM284, evaluating their impact on eCAPs in guinea pigs.

Materials and Methods: Twenty-four adult guinea pigs were used, with each animal receiving a unilateral cochlear implant. Animals were randomly assigned to four groups (n=6 per group): a control group, a PLLA group, a diclofenac group, and a MM284 group. All implants contained 5% DEX within the silicone body. Post-implantation, eCAP recordings (days 0,7,14,21, and 28) and impedance measurements were collected. For the eCAP measurements, the clinical system from MED-EL was used consisting of a MAX-Box and the MAESTRO software (version 8.0). eCAP action potentials were recorded using the AutoART task [1].The eCAPs were recorded with a custom made electrode array connected to a MED-EL PULSAR CI100 cochlear implant (MED-EL GmbH, Innsbruck, Austria). The electrode array had four contacts that were evenly spaced over the first 3 mm of the array. Histological analyses at four weeks post-implantation evaluated SGN survival and connective tissue formation. Pre- and post-implantation hearing thresholds were assessed using auditory brainstem response testing.

Results: Impedance measurements were possible for all subjects [2], while eCAP responses were not consistently observed across all animals. An amplitude growth function (AGF) with an r^2 greater than 0.9 was found for 201 of the 480 eCAP measurements. Strong correlations were observed between eCAP parameters (amplitude and slope) and both histological measures (connective tissue density, SGN counts) and functional measures (hearing thresholds).

Conclusion: This study demonstrates a significant correlation between eCAP parameters and cochlear health measures, suggesting that eCAPs could serve as a valuable non-invasive tool for monitoring cochlear health over time. However, impedance measurements proved to be more reliable, as they were achievable for all subjects, while eCAP responses were inconsistent across individuals. These findings highlight the importance of optimizing eCAP measurement techniques to improve the reliability of eCAP AGFs in guinea pig.

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Th-F 9: HEALTH-RELATED QUALITY OF LIFE AMONG COCHLEAR IMPLANT USERS IN CHINESE ADULTS: A NATIONWIDE, CROSS-SECTIONAL, WEB-BASED SURVEY

Huan Jia[1,2], Jiayu Sun[1], Guo Jlia[3], Hao Wu[1,2]

[1]Department of Otolaryngology-Head and Neck Surgery, Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai 200011, China

[2]Shanghai Key Laboratory of Translational Medicine on Ear and Nose diseases. (14DZ2260300）

[3]Shanghai Jiao Tong University School of Medicine, Shanghai 200025, China

Background: With the inclusion of cochlear implants (CIs) in centralized procurement programs, the cost of these devices is expected to decrease significantly. This change is anticipated to expand the potential user base dramatically. Against this backdrop, we conducted a study based on patient-reported outcomes (PROs) to investigate the efficacy, hearing outcomes, and overall satisfaction related to quality of life among adult cochlear implant recipients in China.

Methods: A nationwide, cross-sectional survey was conducted using an online questionnaire. The inclusion criteria were as follows: age of 30 years or older at the time of implantation, CI activation more than 1 year after implantation, and sufficient cognitive ability to complete the questionnaire independently or with family assistance. Participants who submitted ineligible questionnaires (e.g., incomplete items, irrelevant answers) were excluded. The questionnaire covered eight dimensions, including personal and family satisfaction, work and social influences, pre-operative auditory-verbal status, lifestyle habits, knowledge of CIs, surgical and post-operative status, fitting and rehabilitation, and economic factors.

Results: A total of 628 questionnaires were collected, of which 448 were valid, representing approximately 1.3% of the total cochlear implant recipients in China (estimated at 33,400 at the time of survey closure). Participants were distributed across mainland China, and all five commercially available CI brands were represented, with at least 60 participants for each brand. The overall satisfaction score was 7.0 ± 2.3 (on a scale of 10), and the Categories of Auditory Performance (CAP) score was 4.7 ± 2.1. Among the participants, 73% used their CI for more than 12 hours daily, while 20% used it for 8-12 hours daily. CI recipients with pre-operative music listening habits, such as frequent music listening and participation in singing and dancing activities, reported higher post-operative satisfaction. Additionally, recipients who had prior exposure to CI users and a correct understanding of CI efficacy exhibited higher post-operative satisfaction. Regular follow-up visits and the absence of significant complications within six months after surgery were also associated with higher satisfaction levels. Furthermore, satisfaction was primarily reflected in improvements in work and social life, and family satisfaction was significantly correlated with user satisfaction.

Conclusion: The primary factor influencing satisfaction of Chinese adult CI users is the assistance provided by CIs in enhancing work and social life. Improving the correct understanding of CIs and reducing the incidence of post-operative complications can both contribute to higher satisfaction among CI recipients.

Th-F 10: SPEECH PERCEPTION AND ACOUSTIC CUE TRANSMISSION IN QUIET AND NOISE IN COCHLEAR IMPLANT USERS: PRELINGUALLY-IMPLANTED CHILDREN VERSUS POST-LINGUALLY IMPLANTED ADULTS

Destinee M. Halverson[1,2,4], Olga Peskova[1,2], Mariette S. Broncheau[1,2], David L. Horn[1,2,3,4]

[1] Department of Otolaryngology Head and Neck Surgery, University of Washington
[2] Virginia Merrill Bloedel Hearing Research Center, Seattle, WA
[3] Department of Speech and Hearing Sciences, University of Washington
[4] Seattle Children's Hospital, Seattle, WA

Background Although early-implanted children with cochlear implants (CIs) can develop good speech understanding in quiet, clinical outcomes remain highly variable and difficult to predict. Clinical measures of open-set speech perception do not provide detailed assessment of how a child perceives various phonetic features nor do they take into account developmental factors that change throughout childhood. Children with normal hearing and hearing loss alike have greater difficulty understanding speech in the presence of background noise compared to adults, suggesting developmental differences in how they perceive and/or utilize speech cues. One approach to better capture independent cues is to study at the level of consonant phonetic features (voicing, manner and place). Analyzing these cues may help better identify how specific cues of speech, such as temporal or spectral factors, are correlated to speech perception, and why this may be different in children and adults. In our lab, we have previously examined the relationship between spectral resolution, a well-known predictor of speech perception in CI listeners, and acoustic cue transmission in consonants and vowels. Our previous findings suggest developmental differences in acoustic cue transmission between children and adults, particularly in noise. The purpose of this study is to further examine consonant acoustic cue transmission by exploring age related differences among groups of children.

Methods Participants included 12 children (5-8 years at recruitment) implanted prior to age 2, and 10 post-lingually implanted adults. Children are tested annually for three years in an ongoing longitudinal study. Participants were separated into 5 groups by age: 5-6yo, 7yo, 8yo, 9-10yo, adults. Speech perception was measured in two separate tasks. Pediatric AzBio sentences were scored in percent correct in quiet and a multi-talker babble at +5 signal to noise ratio (SNR) conditions. Next, consonant identification was measured using a closed set /a/-consonant-/a/ task in quiet (with a subset of listeners tested in +10 dB SNR multi-talker babble) scored by percent correct, which also provided a confusion matrix of error patterns. These error patterns were systematically analyzed using the sequential information analysis (SINFA) for the three major consonant cues: voicing, manner, and place. The effect of age-group and noise/quiet condition, and their interaction, was assessed for each dependent variable (AzBio, aCa, voicing, manner, place).

Results Performance and cue transmission was significantly worse in noise for all measures. Significant effects of group were found for aCa but not AzBio. For cue transmission, the effect of group and the groupXcondition interaction were significant for place and voicing cues. In all group effects and interactions, the trend was for greater deficit in noise relative to quiet in the 5-7 year olds compared to older groups.

Conclusion These findings fail to support ongoing developmental factors for speech perception and consonant cue transmission in quiet, although the sample size is currently underpowered. However, susceptibility to noise appears to continue to mature during this age range. These developmental effects may not be relevant for clinical measures in quiet, however, likely has significant real-world impact for younger children. Furthermore, developmental trajectories for hearing in noise may affect some acoustic cues more than others. Further data collection is ongoing and will continue to analyze individual acoustic cues for implanted children and adults to aid in understanding developmental differences in speech performance.

Th-F 11: CAN NEURAL HEALTH ESTIMATES EXPLAIN THE VARIABILITY IN PLACE-PITCH SENSITIVITY IMPROVEMENT FROM CURRENT FOCUSING AMONG COCHLEAR IMPLANT USERS?

Niyazi O. Arslan, Xin Luo

Program of Speech and Hearing Science, College of Health Solutions,
Arizona State University, Tempe, AZ 85287, USA

Cochlear implant (CI) users rely on a small number of electrodes to perceive place pitches. In addition, broad electrical fields of stimulation in monopolar (MP) mode reduce stimulation selectivity and spectral resolution. Electrical field-shaping techniques attempt to overcome these constraints: current steering blends electrical fields from two adjacent active electrodes to create intermediate pitch percepts (virtual channels), while current focusing uses intracochlear electrodes for current return to narrow the spread of excitation (e.g., Bonham & Litvak, 2008). Combining both techniques, such as current steering in spanned partial tripolar (pTP) mode or virtual tripole stimulation (Padilla et al., 2017), was proposed to produce a greater number of distinctive virtual channels compared to current steering in MP mode. Yet, benefits of current steering and focusing may fluctuate across stimulation sites and individual ears, partially due to variations in local neural health. The present research examined whether the overall quality of electrode-neural interface, and particularly the neural health near each stimulation site, can predict both the performance in pitch ranking of virtual channels without current focusing and the improvement in pitch-ranking performance with current focusing.

Nine post-lingually deaf adult CI users with a total of 11 implanted ears were tested. Virtual channel ranking (VCR) thresholds were measured using an adaptive procedure at all available stimulation sites in both MP and spanned pTP modes. In spanned pTP mode, 75% of the current on each main electrode was equally returned to both the apical and basal non-adjacent electrodes. Polarity effect on detection thresholds of triphasic pulses, and electrically evoked compound action potential (ECAP) interphase gap (IPG) offset effect, were measured to reflect different aspects of neural health (Brochier et al., 2021), while spanned pTP-mode detection thresholds were measured to evaluate the overall condition of electrode-neural interface at each stimulation site (Bierer, 2010).

Basal electrode pairs exhibited significantly worse VCR thresholds than apical and middle pairs, regardless of stimulation mode. Percentage improvements in VCR threshold from MP to pTP mode were smaller on basal electrode pairs too. However, spanned pTP-mode detection thresholds, polarity effects on detection thresholds, and ECAP IPG offset effects did not significantly differ across electrode pairs. Across electrode pairs, various normalized neural health estimates were not correlated with normalized VCR thresholds in MP or pTP mode or percentage improvements in VCR threshold from MP to pTP mode. Across ears, higher mean pTP-mode detection thresholds tended to correlate with better mean VCR thresholds in MP or pTP mode when two outliers were removed, and larger mean polarity effects on detection thresholds were associated with smaller mean improvements in VCR threshold from MP to pTP mode.

Overall, current steering in spanned pTP mode improved CI users' pitch sensitivity to virtual channels, although the improvements were variable across stimulation sites and ears. Local neural health estimates of peripheral axon degeneration may partially explain the variable benefits of combined current steering and focusing across implanted ears.

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Th-F 12: MACHINE LEARNING MODELS OF HEARING DEMONSTRATE THE LIMITS OF ATTENTIONAL SELECTION OF SPEECH HEARD THROUGH COCHLEAR IMPLANTS

Annesya Banerjee[1,2], Ian Griffith[1,2], Josh McDermott[1,2,3]

[1]Program in Speech and Hearing Bioscience and Technology, Harvard University
[2]Department of Brain and Cognitive Sciences, MIT
[3]McGovern Institute for Brain Research, MIT

Background: Humans with normal hearing abilities are able to attend to target sources in the presence of concurrent sounds, allowing them to communicate in noisy environments. Such abilities are limited for individuals with hearing loss and users of cochlear implants. Attentional deficits could reflect degraded peripheral information, for instance if attentional cues are not encoded with sufficient fidelity. Alternatively, deficits could result from suboptimal decoding of the altered peripheral representations that follow hearing loss and cochlear implantation (as if the central auditory system cannot fully adapt to the altered periphery). To study this issue, we optimized artificial neural network models to recognize speech from a cued talker in multi-talker settings, and asked whether the models could perform the task using simulated cochlear input stimulation.

Method: We optimized deep neural networks to report words spoken by a cued talker in a multi-source mixture. Models were trained using simulated binaural auditory nerve input obtained from either a normal cochlea, a cochlea with degraded temporal coding (simulated via lowering the nerve phase-locking cutoff to 50 Hz), or a simulated cochlear implant. Attentional selection was enabled by stimulus-computable feature-based gains, implemented with learnable logistic functions operating on the time-averaged model activations of a cued talker. Gains could be high for features of the cue, and low for uncued features, as determined by parameters optimized to maximize task performance.

Results: Models with normal nerve input successfully learned to use both spatial and vocal timbre cues to solve the word recognition task. In the presence of competing talkers, these models correctly reported the words of the cued talker and ignored the distractor talker(s), similar to humans with normal hearing abilities. Models with degraded temporal coding performed worse than the normal hearing model, but showed some benefit of target-distractor spatial separation and sex difference. Models with simulated cochlear implant stimulation performed notably worse, showing only modest benefits from target-distractor sex differences, and showing spatial benefits only for very large spatial separation.

Conclusion: Our results suggest that auditory attention deficits in cochlear implant users reflect limitations of peripheral information available from current electrical stimulation strategies.

Th-F 13: FILTERSTRIPES: A FREQUENCY-SPECIFIC VERSION OF THE SPECTRO-TEMPORAL RIPPLE FOR INVESTIGATING PROCESSOR EFFECTIVENESS

Evelien De Groote[1], Deborah A. Vickers[2], Manohar Bance[3], Robert P. Carlyon[1]

[1] Cambridge Hearing Group, MRC Cognition and Brain Sciences Unit, University of Cambridge, 15 Chaucer Road, Cambridge, CB2 7EF, UK
[2] SOUND Lab, Department of Clinical Neurosciences, University of Cambridge, Cambridge, United Kingdom
[3] Department of ENT, Cambridge University Hospitals NHS Foundation Trust, Cambridge, United Kingdom

Purpose: The Spectro-Temporal Ripple for Investigating Processor EffectivenesS (STRIPES) is a psychophysical test for the assessment of spectro-temporal resolution by cochlear-implant (CI) recipients. Participants discriminate between concurrent frequency glides that sweep upward vs. downwards, and the spacing between concurrent glides is varied adaptively to obtain a threshold. STRIPES requires both temporal and spectral processing to perform well and shows a good correlation with speech perception. In its original form, STRIPES uses a broadband stimulus ("fullSTRIPES"), so it is currently not known which frequency region(s) dominate performance in any given CI recipient. We believe this information could help identify reasons for poor speech performance in some CI recipients and to make informed decisions with regards to CI programming. Furthermore, it could provide a means to acutely assess the effects of reprogramming in greater detail.

Methods: We investigated two strategies of presenting STRIPES to a restricted region in the cochlea ("filterSTRIPES") in a group of eight Cochlear CI recipients. None of the participants had any electrodes switched off, and all obtained good self-reported speech perception using the default frequency allocation in their everyday settings. In the Electrode-DeActivation (EDA) strategy, participants were tested with the original broadband stimulus and three experimental MAPs that each had only seven electrodes activated (apex: E22 to E16, mid: E15 to E9, and base: E8 to E2). In the Band-Pass (BP) strategy, the STRIPES stimuli were band-pass filtered (slopes 48 dB/octave) so that their cut-off frequencies matched the passbands of the electrodes that were defined in the EDA strategy (apex: 188 - 1063 Hz, mid: 1063 - 2688 Hz, and base: 2688 to 6938 Hz), and participants used their clinical MAP with all electrodes switched on. All four MAPs (clinical and experimental) were programmed onto a lab-owned Nucleus 7 processor, which had all Audibility and Noise Reduction strategies disabled. STRIPES stimuli were presented through loudspeakers at a level that the participants deemed loud but comfortable. After two practice runs of fullSTRIPES with participants wearing their own processor, thresholds were measured for seven conditions in random order: fullSTRIPES, BP and EDA apexSTRIPES, BP and EDA midSTRIPES, and BP and EDA baseSTRIPES.

Results: The group-average threshold for fullSTRIPES was 4.3, which is comparable to that previously reported. For filterSTRIPES, we found a significant interaction between Strategy and Region, so that performance with EDA was worse compared to BP filterSTRIPES, but only in the mid region. In addition, participants generally did worse at the base compared to other regions.

Implications: These data provide useful baseline information for the expected variation in filterSTRIPES in participants with good speech perception, allowing us in future to identify localised regions of difficulty in poor-performing CI recipients. We will discuss the relationship between filterSTRIPES and objective measures of neural health and spectral spread. In addition, we will present an online application of filterSTRIPES using direct streaming (AUDITO), which shows a strong within-participant correlation with filterSTRIPES obtained in the lab.

This work was funded by a grant from Cochlear Corporation.

Th-F 14: PREDICTING THE ACOUSTIC UNDERPINNINGS OF PHONEMIC CONFUSIONS IN NOISE BASED ON SPREAD OF EXCITATION

Bobby E. Gibbs Ii, Erika D. Rodriguez, Sam M. Herkert

University of Wisconsin, Madison

Understanding how listeners prioritize acoustic cues when speech is degraded can inform signal enhancement strategies. Predicting the cues that best support intelligibility in noise for people with cochlear implants (CIs) is challenging due to individual variability. Here we test the hypothesis that the acoustic information that best predicts phonemic confusions in noise depends on the fidelity of peripheral neural encoding, the CI electrode-to-neural interface. As a first step, the focus is spread of excitation.

Listeners with typical acoustic hearing were presented with phonemes (vowel-consonant-vowel stimuli) in "bubble" noise. The bubbles referred to random time-frequency regions of attenuation in otherwise unintelligible speech. Listening tests targeted 50% correct performance to identify the time-frequency regions most important to intelligibility. Conditions were unprocessed speech and vocoders simulating narrow and broad spread of excitation. SPIRAL vocoders with 16 channels, 50 tonal carriers and slopes of -40 and -12 dB/octave were used to simulate narrow and broad spread of excitation respectively. Sequential information transfer (SINFA)analyses were used to quantify the percentage of transmitted cues for place and manner of articulation and voicing based on phonemic confusion matrices. Additionally, we analyzed how phonemic confusions were related to similarity with bubble noise mixtures based on different speech intelligibility metrics.

Preliminary data shows that at the group level, the transmission of place, manner and voicing cues in noise is more similar when speech is unprocessed. For vocoded speech, larger disparities between the transmission of place of articulation and voicing cues were observed. However, at the individual level, some listeners had more similar transmission of cues for unprocessed and narrow spread of excitation compared to broad spread of excitation. A speech intelligibility metric that weights spectrotemporal modulations based on training with typical hearing listeners (the weighted spectrotemporal modulation index, wstmi) appears well-suited for predicting phonemic confusions in unprocessed but not vocoded speech, at least at the group level. The extended short-time objective intelligibility index (estoi, which does not have preset spectrotemporal modulation weighting) appears better at predicting phonemic confusions for vocoded speech. However, for some listeners, the predictive ability of wstmi and estoi was more similar with unprocessed speech and narrow spread of excitation.

We will examine how well the SINFA and speech intelligibility predictions in bubble noise translate to listeners with CIs. Spread of excitation will be indexed by electrically evoked compound action potential channel interaction functions. The results should help illuminate tailored regions of the speech spectrum that should be targeted for CI processing enhancement or rehabilitation in noise.

Th-F 15: "LOOK OVER HERE!": USING VISUAL CUES TO SUPPORT SPATIAL HEARING IN CHILDREN WITH HEARING LOSS

Anna Ishchuk[1,2], Jaina Negandhi[1], Emily Jesin[1], Rachel Lim[1], Nicholas Bridi[1], Robel Alemu[1,2], Sharon Cushing[1-3], Blake Papsin[1-3], Karen Gordon[1-3]

[1]Archie's Cochlear Implant Laboratory, Hospital for Sick Children, Toronto, ON, Canada
[2]Institute of Medical Sciences, University of Toronto, Toronto, ON, Canada
[3]Department of Otolaryngology, Head and Neck Surgery, Hospital for Sick Children, Toronto, ON, Canada

Objective: This study aims to determine if visual cues can be used to train improved spatial hearing in children who use cochlear implants (CIs).

Background: Children who use bilateral CIs or bimodal hearing devices have poor access to interaural cues essential for spatial hearing, contributing to ongoing cognitive and academic challenges. Vestibular deficits may further limit spatial perception in these children by restricting accurate head and eye movements necessary for sound localization tasks. The study tests the hypothesis that visual cues support increased head and eye movements through training, enhancing sound localization abilities in children with CIs.

Methods: CI users (bilateral CI and bimodal hearing), ages 8-18 years, are compared with normal hearing peers, whose access to interaural cues is distorted by monaural ear plugging. Both groups are further subdivided into audio-visual and audio-repetition training cohorts. During testing, participants sit in a dark sound booth as a speaker generates a broadband noise, presenting stationary and moving stimuli. A light on the speaker allows participants to visually locate the stimuli. Participants in the audio-visual training cohort localize the stimuli across four blocks (audio, audio-visual, audio, and visual). In the audio-repetition cohort, a third audio block replaces the audio-visual block to control for improvements from testing repetition. Naturally occurring head and eye movements are recorded.

Results: To date, 38 participants have been tested: 14 bilateral CI users (9 audio-visual, 5 audio-repetition), 6 bimodal users (5 audio-visual, 1 audio-repetition), and 18 normal hearing participants (10 audio-visual, 8 audio-repetition). Preliminary data reveals trends of improved stationary sound localization across all three hearing groups following audio-visual training. Pre-training localization errors [M(SD) = 25.44(10.6) deg] significantly decreased following audio-visual training [M(SD) = 19.02(7.92) deg] [$t(23) = 3.49$, $p = 0.002$]. Perception of moving sound was measured by fitting a binomial logistic regression to assess the probability of participants reporting the second auditory stimulus as rightward of the first. No significant changes have been observed thus far between the initial slopes of the participant curves [M(SD) = 0.13(0.28)] and the slopes following audio-visual training [M(SD) = 0.20(0.51)] [$t(23) = -0.71811$, $p = 0.48$]. Testing repetition with auditory stimuli also reveals a trend of improved stationary sound localization abilities across all three hearing groups, with pre-training sound localization errors [M(SD) = 29.87(15.03) deg] reducing significantly following repetition [M(SD) = 24.19(13.55) deg] [$t(13) = 3.20$, $p = 0.007$]. No significant changes have been observed in the slopes of the curves for the perception of moving sound pre-repetition [M(SD) = 0.10 (0.27)] and post-repetition [M(SD) = 0.18(0.38)] [$t(13) = -0.578$, $p = 0.57$].

Implications: These findings highlight the potential of audio-visual training to improve sound localization abilities, leading to the possible integration of targeted training into future therapies to delay the developmental consequences of poor spatial hearing.

Th-F 16: PITCH PERCEPTION LIMITATIONS WITH A COCHLEAR IMPLANT AS REVEALED BY VOCAL MIMICRY OF PROSODIC STIMULI BY SINGLE-SIDED DEAF LISTENERS

David M. Landsberger[1,2], Natalia Stupak[1], Benjamin Gordon[1], Sean Lang[2], John J. Galvin III[2]

[1]New York University Grossman School of Medicine, New York, NY USA
[2]House Institute Foundation, Los Angeles, CA USA

Background: Cochlear implants (CIs) are effective for speech recognition but less so for perception of musical pitch and emotional prosody. The transmission of pitch cues with a CI is problematic, but the exact nature of pitch perception with electric hearing remains unknown. Behavioral measures of pitch perception (e.g., pitch scaling, discrimination, etc.) with a CI are challenging and subject to prescribed notions of meaningful pitch cues embedded in the listening tasks. For postlingually deaf CI users, an alternative approach would be to record vocal reproductions of pitch contours heard through the CI and then analyze the recordings in terms of key acoustic features (e.g., fundamental frequency, or F0). Single-sided deaf (SSD) CI users are a unique population for this approach, as vocal reproductions for sounds heard with the acoustic-hearing (AH) ear can serve as a "ruler" with which to compare vocal reproductions of sounds heard with the CI.

Methods: We recorded vocal mimicry of emotional speech (i.e., happy, sad, angry, scared, neutral) in 10 SSD CI users listening with the CI or AH ear; stimuli were provided by Dr. Monita Chatterjee and first described in Cannon and Chatterjee (2019). Stimuli were delivered to the AH ear via headphones or to the CI ear via direct audio input. During testing, a stimulus was played, and participants were asked to repeat the stimulus as accurately as possible. Listeners mimicked timing, pitch, intonation, and sound quality of the stimuli. The software interface allowed listeners to read the sentences so that the focus was on imitation rather than word recognition. In both AH and CI conditions, the participants could hear their vocalizations through their AH ear. Vocal reproductions were recorded and F0 pitch contours were extracted with Praat.

Results: Listeners accurately replicated pitch contours with their AH, though some deviations occurred due to vocal range differences (e.g., male listener mimicking female speech) and differences in ability to mimic pitch. F0 extracted from the CI and AH reproductions were correlated, but the range of F0 in the CI reproductions was smaller, suggesting that F0 range within the CI ear was perceived as smaller. Frequency compression varied across listeners, with two response patterns observed: 1) compressed frequency contours across the entire range, or 2) well-represented at low frequencies (~<200 Hz) with compression at higher frequencies. Only one participant mimicked pitch contours above 300 Hz when listening with the CI. Often frequencies were perceived as lower pitched with the CI than with AH.

Conclusions: These results provide unique insights into how pitch and vocal emotion are conveyed through a CI. Most participants were able to reproduce low frequencies up to 200-300 Hz but not higher. CI signal processing primarily encodes low frequencies via temporal coding (e.g., amplitude modulation) and higher frequencies by spectral representation. The data suggests that CI users have a tendency to interpret temporal information, but not spectral information, as pitch. It is worth noting that the one listener who was able to accurately mimic higher frequencies most likely encoded spectral information as pitch, as no useful temporal cues are expected for those frequencies. The data suggests that CI users are likely able to perceive smaller pitch changes in prosodic speech than available in the acoustic signal. The vocal mimicry task appears to be a promising method with which to investigate pitch and prosody perception in CI users.

Cannon, S. A., & Chatterjee, M. (2019). Voice emotion recognition by children with mild-to-moderate hearing loss. Ear and Hearing, 40(3), 477-492.

Th-F 17: VALIDATING RECONSTRUCTED CONSONANTS PERCEPTUALLY INTEGRATED ACROSS EARS BY LISTENERS WITH NORMAL HEARING AND HEARING LOSS

Allison Leach[1], Corinne Cancila[1], Caroline Grady[1], Magdeline Schwarz[1], Benjamin Estell[2], Yang-Soo Yoon[1]

[1]Department of Communication Sciences and Disorders, Baylor University, Waco, TX, USA
[2]Department of Computer Science, Baylor University, Waco, TX, USA

Objective: Listeners with bilateral hearing loss experience different spectral contents across ears, which requires integrating spectral cues processed independently by each ear within the central auditory system. Common psychoacoustic methods such as pitch fusion and confusion matrices for phoneme recognition do not fully capture integrated spectral contents. This study aims to validate the reverse correlation (RC) approach for reconstructing integrated spectral contents. The hypothesis being tested is that RC can accurately reconstruct perceptually integrated sounds, with unique integrated spectral contents for each user.

Methods: Listeners with normal hearing were tested to validate the accuracy of RC, followed by testing listeners with bilateral hearing loss to assess how varying degrees of hearing loss impact spectral integration. Stimuli included four consonants (/ba, da, pa, ta/). The RC method presented subjects with two sounds: one of the four consonants followed by a random sound generated by RC 1.5 seconds later. Subjects were asked if the sounds were similar or not similar. Regardless of the response, RC generated another random sound and repeated the question over a minimum of 200 trials. The internal representation of the integrated sound was obtained by subtracting the mean of stimuli eliciting a "similar" response from those eliciting a "different" response.

Results: Spectral densities of the original consonants and the RC reconstructed sounds were 80% similar for listeners with normal hearing. However, for listeners with bilateral hearing loss, the first three formant frequencies differed significantly between the two sounds, with unique differences observed for each listener with bilateral hearing loss.

Conclusions: The RC approach successfully captures the spectral contents of consonants perceptually integrated across ears. These results provide a more direct and complete characterization of the integrated spectra, aiding in our understanding of spectral integration in the central auditory system.

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Th-F 18: AUDIOVISUAL SPEECH-EVOKED OSCILLATORY DYNAMICS IN AGING COCHLEAR IMPLANT USERS

James W. Dias, Kara C. Schvartz-Leyzac, Kelly C. Harris

Medical University of South Carolina

INTRODUCTION: Aging cochlear implant (CI) users and non-users can rely on visible speech information to enhance perception of auditory speech, more-so than younger adults. Electrophysiological responses in younger and older adults with normal to mild-to-moderate sensorineural hearing loss are consistent with behavioral data, exhibiting enhanced neural processing of audiovisual speech, compared to auditory speech. Importantly, this enhanced neural processing is exaggerated in older adults. Despite this evidence of enhanced audiovisual speech processing in older non-CI users, little is known about the neural processing of audiovisual speech in aging CI users. Behavioral evidence suggests many CI users demonstrate multisensory benefits in speech perception that exceed those of non-CI users. Examination and comparison of the oscillatory dynamics of auditory, visual, and audiovisual speech-evoked potentials (SEPs) in CI users and age-matched non-CI users may help identify mechanistic differences between groups that can account for group differences in unisensory and multisensory speech processing.

METHODS: We recruited 20 post-lingually deafened CI users between the ages of 49 and 83 years (SD=9.625) and 36 age-matched controls (non-CI users) (51-81 years of age, SD=8.199). All participants had normal or corrected-to-normal sight. The hearing of our controls varied from normal hearing to mild-to-moderate sensorineural hearing loss. SEPs were recorded in all participants while they were passively presented consonant-vowel syllables in three conditions: auditory-only (AO), visual-only (VO), or audiovisual (AV). We employed independent component analysis (ICA) - a computational approach that separates the subcomponents of a multivariate signal - to identify and remove CI and eye-movement artifacts from the summated data, leaving the artifact free speech evoked potential. Continuous data was then epoched from -700 ms to 1000 ms around auditory stimulus onset (for VO trials, stimulus onset was defined as the point in time when the auditory stimulus would have been heard had it been presented with the visual signal). Time-frequency analysis was performed using a wavelet decomposition with Morlet wavelets, executed using EEGLab's "newtimef" function in MATLAB.

RESULTS: The AV SEPs of CI users and age-matched controls demonstrated shorter peak latencies and smaller peak amplitudes than AO SEPs, consistent with past evidence of enhanced neural processing of AV stimuli. The time-frequency analysis found that both CI users and age-matched controls displayed significant positive event-related spectral perturbations (ERSPs) in the theta and alpha bands between 100 and 200 MS post AO and AV stimulus onset. Both groups also exhibited significantly greater pre-stimulus theta and alpha suppression (negative ERSPs) when presented AV stimuli, compared to AO stimuli. Interestingly, CI users, but not age matched controls, demonstrated a significant burst of theta activity around 500 ms post stimulus onset when presented AO and AV stimuli. Between groups, CI users exhibited more theta, alpha, beta, and gamma activity immediately following stimulus onset and up to 150 ms post stimulus onset. CI users exhibited more theta activity around 500 ms post stimulus onset than age-matched controls.

CONCLUSIONS AND IMPLICATIONS: The results suggest that CI users largely engage similar early neurophysiological mechanisms to age-matched non-CI users when processing AO and AV speech. Unlike non-CI users, CI users, demonstrated a burst of theta activity 500 ms post stimulus onset, which may indicate the engagement higher-level mechanisms when processing AO and AV speech. Discussion of the results will consider the involvement of top-down mechanisms, like attention and working memory, when CI users process acoustic speech information transmitted through their device.

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Th-F 19: ADVANCING OPTICAL COCHLEAR IMPLANTS: INSIGHTS FROM ACOUSTIC AND LED-EVOKED INFERIOR COLLICULUS RESPONSES

Niels Albrecht*[1,2,3,4], Fadhel El May*[1,3,4], Elisabeth Koert[1,3,4], Anna Vavakou[1,3,4], Eric Klein[7], Bettina Wolf[1,3,4,5], Patrick Ruther[7,8], Tobias Moser[1,3,4,5,6]

*equally contributing first authors
[1] Institute for Auditory Neuroscience and InnerEarLab, University Medical Center Göttingen, Germany.
[2] Göttingen Promotionskolleg für Medizinstudierende, University Medical Center Göttingen, Germany.
[3] Cluster of Excellence "Multiscale Bioimaging: from Molecular Machines to Networks of Excitable Cells" (MBExC), University of Göttingen, Germany.
[4] Else Kröner Fresenius Center for Optogenetic Therapies, University Medical Center Göttingen, Germany.
[5] Auditory Neuroscience and Synaptic Nanophysiology Group, Max-Planck-Institute for Multidisciplinary Sciences, Göttingen, Germany.
[6] Auditory Neuroscience and Optogenetics laboratory, German Primate Center, Göttingen, Germany.
[7] Department of Microsystems Engineering (IMTEK), University of Freiburg, Freiburg, Germany.
[8] BrainLinks-BrainTools Center, University of Freiburg, Freiburg, Germany.

Worldwide, over 1 million people with severe sensorineural hearing loss use electrical cochlear implants (eCIs) for hearing. Electrical cochlear implants partially restore speech comprehension in most otherwise deaf individuals, yet users still face unsolved challenges primarily routed in insufficient spectral selectivity of electrical stimulation. Promising approaches to overcome these limitations include optogenetic activation of the auditory nerve by optical cochlear implants (oCIs). Prior results showing high spectral selectivity of optical stimulation imply improved channel discriminability of oCIs. However, a thorough comparison of optical and more complex acoustic stimulation is needed to further evaluate the oCI's potential for improved hearing restoration beyond eCIs.

To address this, we conducted multi-unit recordings in the inferior colliculus (IC) of anesthetized Mongolian gerbils using a 32-channel NeuroNexus probe. The recordings were obtained in response to narrowband noise stimulation, acoustic masking, and harmonic sounds. By emulating single-, two- and multi-channel optical experiments, our results provide a framework for interpreting IC responses in the context of optogenetic experiments.

To investigate frequency discriminability a low dimensional signal manifold was identified using principal component analysis. Discriminability of responses was significantly larger for pure tones than for small noise bands (0.25 octaves bandwidth), when measured as the distance in the low-dimensional manifold. In presence of a high frequency masker discriminability remained higher for pure tones than for noise bands.

To investigate channel discriminability, implants based on commercial green LEDs (220 x 270 µm, Cree) have successfully been used in Mongolian gerbils with preceding AAV-mediated expression of the new powerful channelrhodopsin variant ChReef in spiral ganglion neurons (SGNs). This enables IC responses to low-energy oCI stimulation (238.5 ± 235 nJ) at different sites along the tonotopic axis.

We aim to combine LED-evoked with acoustically evoked IC responses to provide insights into the discriminability of optical stimulation channels.

These findings pave the way for a better understanding of optogenetic activation of the auditory system advancing the development of optical cochlear implants.

Th-F 20: DEVELOPMENT OF A NEURAL HEALTH TEST BATTERY FOR TRIALS OF ADVANCED THERAPIES FOR HEARING LOSS

Eleni Genitsaridi[*1], Andrew Soulby[2], Efstratia Papoutselou[1,3,4], Patrick Boyle[5], Charlotte Garcia[6], François Guerit[6], Faizah Mushtaq[1,3,4], Huib Versnel[7], Robert P. Carlyon[6], Douglas E. H. Hartley[1,3,4,8]

[1] Rinri Therapeutics Ltd., Innovation Centre, Sheffield, United Kingdom
[2] St. Thomas' Hearing Implant Centre, St. Thomas' Hospital, London, United Kingdom
[3] National Institute for Health Research (NIHR) Nottingham Biomedical Research Centre (BRC), Nottingham, United Kingdom
[4] Hearing Sciences, Division of Clinical Neuroscience, School of Medicine, University of Nottingham, Nottingham, United Kingdom
[5] Advanced Bionics GmbH, European Research Center, Hannover, Germany
[6] Cambridge Hearing Group, MRC Cognition and Brain Sciences Unit, University of Cambridge, Cambridge, United Kingdom
[7] Department of Otorhinolaryngology and Head & Neck Surgery, UMC Utrecht Brain Center, University Medical Center Utrecht, Utrecht, the Netherlands
[8] Nottingham University Hospitals National Health Service (NHS) Trust, Queen's Medical Centre, Nottingham, United Kingdom

Purpose: Poor auditory neural health contributes to various forms of hearing loss, including presbycusis and auditory neuropathy spectrum disorder, and can reduce the effectiveness of cochlear implants (CIs). Whilst reliable measures of neural health are essential for assessing outcomes of therapies targeting auditory nerve pathologies, a standardized test battery for this purpose has yet to be established. The aim of this study is to refine the battery for assessing auditory neural health, by evaluating 1) the test-retest reliability of three experimental tests thought to provide estimates of neural functionality, and 2) the extent to which these tests reflect the same aspects of neural health.

Methods: Six adults experienced in CI use (more than 1 year) will participate. The three experimental tests being assessed employ CI electrodes to electrically stimulate spiral ganglion neurons (SGNs). These are: i) panoramic electrically evoked compound action potentials (PECAPs), ii) inter-phase gap (IPG) effects, and iii) polarity effects. The first two tests provide objective measures utilizing the CI electrodes to record the response of SGNs to electrical stimulation. PECAPs assess electrically evoked compound action potentials (eCAPs) across every probe and masker electrode combination to estimate the synchronized responsiveness of SGNs. IPG effects are based on evidence that changes in eCAP characteristics when varying the IPG of a biphasic stimulus depend on neural health. The IPG measures focus on effects on eCAP amplitude at maximum delivered current and slope of the eCAP amplitude growth function. Polarity effects are measured behaviorally and are based on the notion that the polarity of the stimulus (cathodic or anodic leading) influences participant-reported comfortable loudness levels in ways indicative of neural health. Test-retest reliability from up to five repeated measurements (conducted on different days) for each of these tests is being assessed with various statistical approaches including intraclass-correlation coefficients and results from fitting generalized linear models to evaluate the consistency of measurements across sessions. In addition, potential associations with established clinical assessments (including electrode impedances, eCAP thresholds, speech perception and electrically evoked auditory brainstem responses) are being explored.

Results: Preliminary results (from testing three out of six participants) suggest that all three measures display high test-retest reliability. For different participant and electrode combinations, the different tests do not always agree on the level of proposed neural functionality, which could be attributed to the ability of each test to detect different aspects of neural health. Completed analyses on reliability and associations between tests will be presented.

Conclusions: Results from this study will contribute to the development of a robust test battery to be used in advanced therapies aiming to improve neural health.

Th-F 21: COMPARISON OF METHODS TO ASSIGN THE MAXIMUM COMFORTABLE LOUDNESS LEVELS ON THE SPEECH RECOGNITION FOR COCHLEAR IMPLANT USERS WITH ASYMMETRIC HEARING LOSS

Margaret E. Richter, **Margaret T. Dillon**

University of North Carolina at Chapel Hill; 170 Manning Dr Campus Box 7070 Chapel Hill, NC 27599

Purpose: One procedure when mapping a cochlear implant (CI) is assigning the maximum comfortable loudness (MCL) level for each channel. The MCL levels can be assigned using behavioral or objective methods. With the behavioral method, the CI user ranks the perceived loudness of the stimulation from an individual electrode or group of electrodes. An objective method that is used to assign MCL levels is the electrically evoked stapedius reflex threshold (eSRT). For the eSRT method, a tympanometer probe is placed in either the contralateral or ipsilateral ear and the CI is stimulated on individual channels until a response is observed. Though some CI users have similar MCL levels between behavioral and eSRT methods, other CI users have remarkable differences between these methods. It is important to achieve a loudness balance between the ears, but it is unclear as to whether there is a preferred method and how this may impact spatial hearing abilities. The present study compared eSRT and behaviorally-measured MCL levels among adult CI users with asymmetric hearing loss and assess the differences in spatial hearing between mapping methods.

Methods: Adults with asymmetric hearing loss (n=14), 10 with unilateral hearing loss (UHL), completed a speech recognition in noise task. The task was completed using the AzBio sentences in a 10-talker masker in three spatial configurations. These configurations were speech and masker from the front, speech from the front and masker 90 degrees to the CI, and speech from the front and masker 90 degrees to the acoustic hearing ear. Participants completed this task first with their familiar settings, behaviorally measured MCL map. The eSRT values were measured by placing the tympanometry probe in either the ipsilateral or contralateral ear and using a probe tone of 226Hz, 678Hz, or 1000 Hz. Stimulation level on individual channels were increased until the eSRT was observed and repeatable. A new map was created with MCLs assigned at the eSRT level and speech recognition testing was repeated acutely.

Results: There were individual differences in the relationship between the behavioral and eSRT MCL levels across participants. Some participants had behaviorally-measured MCL levels that approximated the eSRT MCL levels, while others had behaviorally-measured MCL levels that were higher (louder) than the eSRT MCL levels. Improved speech recognition in noise was observed with the eSRT maps compared to the behaviorally-measured MCL maps.

Conclusions: The individualized mapping of MCL levels may include behavioral and/or objective measures to create an optimal map. For some CI users, these two methods may produce different levels for MCLs. To improve individualized care and patient outcomes, it is important to understand the optimal ways to program unique patient populations, such as those with asymmetric hearing loss as it can impact their spatial hearing abilities.

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Th-F 22: COMPARISON OF SPEECH IN NOISE PROCESSING IN HEARING IMPAIRED POPULATIONS USING [15 O]WATER PET

Phillip E. Gander[1,2,3], Joel I. Berger[3], Bob McMurray[4], Inyong Choi[5], Laura L. Ponto[1], Timothy D. Griffiths[6]

[1]Dept of Radiology, University of Iowa Hospitals and Clinics, IA, USA
[2]Dept of Otolaryngology–Head & neck surgery, University of Iowa Hospital and Clinics, IA, USA.
[3]Dept of Neurosurgery, University of Iowa Hospitals and Clinics, IA, USA.
[4]Dept of Psychological & Brain Sciences, University of Iowa, IA, USA.
[5]Dept of Communication Sciences & Disorders, University of Iowa, IA, USA.
[6]Bioscience Institute, Newcastle University, UK.

One of the most important issues in hearing impairment (HI) is difficulty with speech in noisy real-world environments. Research in normal hearing listeners indicates that auditory cortex is active while abstracting speech objects from noise and provides input to fronto-temporal networks for further perceptual, attentional, and semantic analysis. We want to understand whether these are the same neural mechanisms across hearing impaired listeners with different devices (CI and hearing aid) and configurations, and how these mechanisms relate to successful hearing outcomes.

Previously we demonstrated in a proof-of-concept study that we could robustly and reliably measure brain [15O]Water positron emission tomography (PET) blood flow activity to speech in noise in cochlear implant users at a single subject level. We observed activity in a fronto-temporal network to speech in noise in each single subject. Here we expand our investigation to include a broad range of hearing impairment (CI and hearing aid users) and device configurations to capture variability and activity patterns that may be different to that of a matched control population.

We measured PET blood flow in a group of 42 cochlear implant subjects, 20 hearing aid users, and 20 age-matched normal hearing controls while they performed a word-in-noise identification or noise-control task (matched on RMS sound level). Six runs were performed for each condition. On a given 3-min run for speech in noise (+15 dB SNR), word tokens were presented in multi-talker babble, and at random intervals subjects were prompted to perform a 4-alternative forced choice task. The control condition was a noise level detection task matched for response demands. PET data were analyzed in SPM12 using a flexible factorial model.

We found robust activations in single subjects for the contrast speech in noise vs control noise in auditory cortex and inferior frontal cortex. Group level activation regions of interest in auditory cortex and inferior frontal cortex were significant, along with activations across a network of areas involved in language processing ($p<0.05$, corrected). Group comparisons highlighted differences in the involvement of frontal cortex which may relate to the existence of acoustic hearing. A regression analysis including speech in noise task performance indicated the involvement of brain regions for attention and object analysis.

Our results show that speech in noise processing in different hearing-impaired populations may depend on the availability of residual acoustic hearing, and the use of brain networks for language similar to that of the normal hearing population.

Th-F 23: WHAT IS THE SOURCE OF THE BINAURAL ADVANTAGE FOR MUSIC SOUND QUALITY IN SINGLE-SIDED DEAF COCHLEAR IMPLANT USERS?

Sean Lang[1], David M. Landsberger[1,2], Natalia Stupak[2], John J. Galvin III[1]

[1]House Institute Foundation, Los Angeles, CA, USA;
[2]New York University Grossman School of Medicine, New York, NY, USA

Single-sided deaf (SSD) cochlear implant (CI) users prefer to listen to music with both the acoustic hearing (AH) and CI ears despite the poor sound quality provided by the CI (Landsberger et al., 2020). The sources of this binaural benefit for music listening remain unclear. Is the benefit due to gross binaural restoration (i.e., is any input to the CI ear is beneficial)? Or does there need to be coherent spectral and/or temporal information across the AH and CI ears? To investigate potential sources of the binaural benefit for music sound quality in SSD CI users, we collected sound quality ratings for music excerpts from different genres - pop, rock, and classical - while controlling the spectral and/or temporal information delivered to the CI ear.

A Multiple Stimuli with Hidden Reference and Anchor (MUSHRA) paradigm was used to collect sound quality ratings in SSD CI users with CI-only, AH-only, and CI+AH listening. Participants were presented with a reference stimulus (unmodified audio presented to the AH ear alone), multiple unlabeled test stimuli (which contained the experimental manipulations to the sound presented to the CI ear), and an unlabeled version of the reference audio stimulus. A vocoder-to-the-CI-ear approach was used to control the spectral and temporal information provided in the CI ear. Custom sine-wave vocoders were designed for each SSD CI user such that the carrier frequency matched the center of that CI user's frequency analysis bands. Electrodograms were used to verify that the vocoder manipulations performed as intended, with minimal artifact. Participants were instructed to rate all test stimuli relative to the reference, on a scale from 0 (lowest) to 200 (highest), and to give the test stimulus that was identical to the reference a rating of 100. Participants were also instructed that if the sound quality of a test stimulus was better than the reference, they must give a rating >100; if the sound quality was poorer than the reference, they must give a rating <100.

CI+AH ratings were significantly higher than AH-only ratings when unprocessed music stimuli, vocoder stimuli with spectro-temporal cues, or vocoder stimuli with only spectral cues were delivered to the CI ear, with no significant difference among these conditions. There was substantial inter-subject variability, with some participants exhibiting large binaural benefits and others less so. CI+AH ratings were significantly correlated with CI-only ratings. There was no significant effect of music genre on ratings.

The results suggest that coherent spectral information across ears appears to be a strong component of the binaural benefit for music sound quality in SSD CI users. The correlation between CI-only and CI+AH ratings suggests that poor reception and/or transmission of musical cues by the CI ear may be a limiting factor for binaural benefit; improving CI sound quality may further improve binaural benefit.

Landsberger DM., Vermeire, K Stupak, N, Lavender A., Neukam J, Van de Heyning P, Svirsky MA. (2020). Music is more enjoyable with two ears, even if one of them receives a degraded signal provided by a cochlear implant. Ear Hear, 41(3), 476-490.

Th-F 24: BEHAVIORAL AND PHYSIOLOGICAL RESPONSES TO EMOTIONALLY EVOCATIVE SOUNDS IN ADULTS WITH COCHLEAR IMPLANTS

Prabuddha Bhatarai[1,2], Kelly N. Jahn[1,2]

[1]Department of Speech, Language, and Hearing, The University of Texas at Dallas, Richardson, TX 75080,
[2]Callier Center for Communication Disorders, The University of Texas at Dallas, Dallas, TX 75235

Purpose: The impact of hearing loss extends beyond reduced audibility and can lead to an increase in depressive symptoms, social isolation, and a poor quality of life. Emerging evidence suggests that indi-viduals with hearing loss also experience a reduced range of emotional responses to sound, which can further compound these negative psychosocial consequences. We recently demonstrated that individuals with normal hearing (NH) perceive spectrally degraded environmental sounds as more negative and less arousing than natural (unprocessed) sounds. We therefore expect that CI listeners, who rely on a spectrally degraded signal to hear, may exhibit a reduced range of emotional responses to sound relative to individuals with acoustic hearing. Thus, the primary aim of this study is to characterize behavioral and physiological emotional reactions to sound in CI users.

Methods: Data collection is ongoing. To date, 13 CI users (mean age = 40.08 years, SD = 16.29 years) and 3 NH controls (mean age = 22.33 years, SD = 4.04 years) have participated. Participants listened to 60 emotionally evocative environmental sounds presented in the sound field from 0 degrees azimuth at a calibrated level of 65 dB SPL. Sounds were selected from the International Affective Digitized Sounds-2nd Edition (IADS-2) corpus. Stimuli were selected from the corpus based on their normative valence ratings in order to encompass a wide range of negative, neutral, and positive sounds. Positive and negative sounds were matched in the arousal dimension (i.e., there was no significant difference in normative arousal ratings between negative and positive stimuli). Participants reported their emotional responses to each sound on two dimensions (valence and arousal) using the self-assessment manikin rating scale. Pupillometry was recorded simultaneously during stimulus presentation to monitor sound-evoked chang-es in pupil diameter as an estimate of physiological arousal.

Results: Sounds were grouped into three valence categories (negative, neutral, and positive) based on their normative valence ratings. Behavioral data indicate that the CI users provide significantly higher valence ratings for "negative" sounds ($p = 0.001$) and significantly lower valence ratings for "neutral" sounds ($p = 0.009$) than the NH group. There were no significant between-group differences in valence ratings for positive sounds or for subjective arousal ratings of any sound category (all $ps > 0.05$). Preliminary pupillometry data ($n = 9$ CI users, $n = 3$ NH controls) mirror the behavioral data, showing that CI users exhibit larger sound-evoked pupil dilation in response to negative sounds, but smaller pupil dilation in response to neutral sounds, relative to the NH group.

Conclusions: These preliminary findings suggest that emotionally evocative auditory stimuli may elicit different emotional responses in CI users than in individuals with NH. CI listeners perceive negative sounds as more positive and neutral sounds as more negative compared to NH listeners. Sound-evoked changes in pupil diameter mirror these results, showing heightened physiological arousal in response to negative sounds, but dampened physiological arousal in response to neutral sounds in CI users. Ongoing data collection will allow us to increase the number of participants, balance the sample sizes between groups, and investigate the relationship between behavioral and physiological measures of valence and arousal. A better understanding of emotional responses in CI users will guide improvements in device programming, clinical interventions, and counseling, thereby enhancing emotional experiences and over-all quality of life.

Th-F 25: PITCH PROCESSING OF ELECTRICAL STIMULATION AT THE APEX OF THE COCHLEA

R. P. Carlyon[1], E. de Groote[1], D. Arzounian[1], J. M. Deeks[1], and O. Macherey[2]

[1]Cambridge Hearing Group, MRC Cognition & Brain Sciences Unit, University of Cambridge, UK
[2]Aix-Marseille University, CNRS, Centrale Méditerranée, LMA, Marseille, France

The ability of cochlear-implant (CI) users to derive pitch from the temporal pattern of stimulation is im-paired relative to that of normal-hearing listeners. Here we use idealized stimuli, such as single-pulse-per-period (SPP) pulse trains, to probe the reasons for this limitation. We focus on temporal pitch processing at the apex of the cochlea, both because of evidence that selective apical stimulation can ex-cite a neural pathway that accurately processes fine temporal cues, and because CI processing algorithms such as MEDEL's Fine Structure Processing (FSP) strategy explicitly encode temporal fine structure (TFS) at apical electrodes. The FSP strategy presents a brief pulse burst at the zero crossings of the bandpass filtered waveforms in each frequency channel.

We report that:

(i) Although discrimination of low rates of SPPs is better for stimulation of the most apical electrode of the MEDEL CI compared to a mid-array electrode [1], the "upper limit" (highest rate up to which pitch continues to increase) does not [2].

(ii) A simplified FSP strategy, in which SPPs of rates [100 200 300 400] pps are applied to electrodes 1-4 of the MEDEL device, reveals that listeners do not hear a pitch equal to the fundamental frequency (F0) [3].

(iii) The pitch of SPP pulse trains presented concurrently to different apical electrodes of the MEDEL CI can depend strongly on the relative timing of the pulse trains applied to the different electrodes, but this effect differs markedly between listeners. Preliminary evidence suggests that it is smallest in listeners with good place-pitch discrimination between apical electrodes. This be-tween-channel effect may reduce the effectiveness of FSP-type strategies because reverberation can affect between-channel timing

(iv) An analysis of the pulse trains generated by FSP-type strategies in response to synthetic vowels sometimes shows an alternation between shorter and longer inter-pulse intervals in each channel, with the nature of the alternation depending on a combination of fundamental frequency (F0) and formant frequency. This phenomenon, which arises directly from the zero crossings of the bandpass filtered waveforms, may lead to pitch percepts that differ from F0 [4].

(v) Conveying pitch via SPP pulse trains presented to an apical channel of the Advanced Bionics (AB) CI leads to better melody recognition than via amplitude modulation (AM) of high-rate pulse trains applied to groups of six adjacent apical or basal electrodes, and where the multi-electrode stimulation simulates the output of AB's HiRes processing strategy. Performance with SPP is not impaired by the addition of the AM channels.

We conclude that processing strategies that present a different pattern of TFS on several adjacent apical electrodes are unlikely to provide a robust sensation of pitch that is immune to the effects of room reverberation and formant frequency. However, a modified TFS strategy that explicitly encodes F0 using the same temporal pattern applied to one or more apical electrodes has the potential to convey pitch without a major risk of interference from high-rate AM stimulation of neighboring electrodes.

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Th-F 26: USING ELECTROPHYSIOLOGY TO ASSESS LANGUAGE PROCESSING IN COCHLEAR IMPLANT USING CHILDREN

David P. Corina[1], Elizabeth Perotti[2], Sharon Coffey-Corina[1], Lee M. Miller[3]

[1]Center for Mind and Brain, University of California, Davis
[2]Department of Psychology, University of California, Davis,95618
[3]Department of Neurobiology, Physiology and Behavior, University of California, Davis,95618

Introduction. The use of electrophysiology indices, such as the auditory brainstem response (ABR), in the diagnosis of hearing loss in newborns is routine. However, the use of electrophysiological methods in the assessment of spoken language processing in cochlear implant (CI) using children is rare. We present electrophysiological data from three recent experiments that document the time course of early auditory sensory processing and higher-level lexical recognition.

Method. We recorded cranial EEG (22 channels) during testing and evaluated ERP components in early bilaterally implanted children (n = 70, age range 31-163 mos.) and typically hearing (TH) controls (n = 66, age range 30-150 mos.). Three paradigms are discussed. The first describes a passive speech processing task designed to elicit cortical auditory evoked potential (CAEPs). Two lexical-semantic priming paradigms are described. These complementary studies allow us to examine higher-level audiovisual speech processing and lexical-semantic integration in CI-using children

Results. Significant between group differences are observed in the amplitude of the P1 and N2 CAEPs. While only TH children showed responsivity to phonological information as indexed by a P300 component, largely equivalent results are observed for later occurring N400 components, indicating similar lexical-semantic processing in CI using and TH children.

Conclusion. These data demonstrate the utility of ERPs techniques in understanding the variability of language outcomes in congenitally deaf CI-using children and may lead to more targeted interventions. Electrophysiological approaches may have diagnostic utility in holistic assessments of language outcomes in congenitally deaf cochlear implant users.

Th-F 27: PRINCIPAL COMPONENT-BASED RECONSTRUCTION OF COCHLEAR IMPLANT MAPS

Griet Goovaerts[1], Sean R. Anderson[2], Amir Ansari[1], Tom Bertens[1]

[1] Cochlear Technology Center, Cochlear Ltd., Mechelen, Belgium
[2] Research & Technology Laboratories, Cochlear Ltd., Lone Tree, CO, USA

The number of recipients of cochlear implants (CIs) has grown substantially in the past two decades. Thus, there are data sets containing large numbers of recipients' programming parameters from MAPs, which can be studied to understand patterns across populations of recipients. In this analysis, we evaluated MAPs from different types of CI arrays to identify repeating patterns across recipients which could be leveraged to improve mapping technology's efficiency and accuracy. This analysis focuses on threshold (T) and maximum comfortable (C) levels since these are most often changed by clinicians during a typical fitting session.

Data from more than 10000 implants with 22-type (Slim Straight) and 32-type (Slim Modiolar) CI arrays were included in the analysis. Only MAPs with monopolar, ~900 pulses per second, and standard (25, 37, or 50 µs) pulse width stimulation were considered. For each implant, only the most-used MAP was included. All data where pseudonymized in accordance with applicable privacy regulations. Data were partitioned into model development and validation datasets. This process was sometimes repeated using different partitions (i.e., cross-fold validation) to ensure independence of model development and validation datasets. In the model development stage, datasets were loaded into a principal component analysis. A criterion of 95% variance explained was used to determine the number of principal components (PCs) needed for an accurate representation of the model data. These PC profiles were then extracted and used for reconstruction of T and C profiles. In the validation stage, T- and C-levels were fit using linear regression with the PCs derived in the model development stage used as predictors. The median absolute deviation was used to describe the amount of residual error.

Five PCs were sufficient to explain 95% of the variance in the model development datasets. Within a principal component analysis, PCs are organized by the amount of variability they explain in the model development dataset. Thus, each PC can be interpreted such that it describes characteristic patterns across electrodes that emerge with each array type. There were some characteristic differences between PCs derived from each array type (e.g., with 22-type electrodes showing a flatter profile for the first component), though for the most part they were very similar. Further inspection of the PC patterns showed that similar patterns emerged across different electrode types: differences in profile shift explained most of the variability, followed by differences in tilt and curvature. Linear regression over the PCs were effective at accurately reconstructing T- and C-level profiles from independent datasets.

Results of this work suggest that T- and C-level profiles can be approximated using five dimensions rather than the 22 T- and C-levels required with traditional programming techniques. PCs from large sample sizes could be integrated into technology stacks to improve the speed with which mapping occurs, freeing time of clinicians to work on testing, counseling, and other key roles.

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Th-F 28: A VOCODER-BASED STUDY ON THE EFFECTS OF SIMULATED CURRENT SPREAD ON BINAURAL FUSION

Justin M. Aronoff, **Josephine R. LaPapa, Jordan Deutsch, Karla Rodriguez**

Department of Speech and Hearing Science,
University of Illinois Urbana-Champaign, Champaign, IL, USA

Binaural fusion reflects the ability to fuse signals delivered to the two ears into a single auditory percept. While binaural fusion is affected by changes in interaural coherence (i.e., the statistical similarity of the signal delivered to the two ears) and interaural place matching, studies have demonstrated that cochlear implant users are particularly less sensitive than normal hearing listeners to the detrimental effects that interaural place mismatches have on binaural fusion. This has been hypothesized to reflect the broader spread of excitation that occurs with electrical stimulation. Broader spread of excitation may also provide better temporal information by stimulating more neurons and thus reducing the effects of internal noise, potentially improving sensitivity to interaural coherence. To test these hypothesis, normal hearing listeners were tested with a vocoder where simulated current spread was manipulated.

Twelve normal hearing listeners participated in Experiment 1, which investigated the influence of simulated current spread on binaural fusion in the presence of interaural place mismatches. Stimuli were generated using a bilateral single channel vocoder, with narrow or broad simulated current spread. The center frequency for the single channel varied across ears to manipulate interaural place matching. The envelopes for the vocoder were derived from narrow band segments of speech and were identical for both ears. Participants were presented with an image depicting a head with a small oval in the center. By turning a dial, they could alter the size and number of the oval(s) to indicate perception of a punctate auditory image, a diffuse auditory image, or two separate auditory images, one near each ear. By pushing down and turning the dial, they could also indicate the lateralization of the perceived auditory image.

Twelve normal hearing listeners participated in Experiment 2, which investigated the influence of simulated current spread on binaural fusion in the presence of decreased interaural coherence. The vocoder and task was the same as in Experiment 1, except that the center frequency for the single channel was identical across ears and the interaural coherence of the envelope varied instead.

In Experiment 1, binaural fusion degraded with increased interaural place mismatch, but at a slower rate when the simulated current spread was broader. Critically, increased current spread only had an effect for moderate interaural place mismatches. In Experiment 2, binaural fusion decreased with decreasing interaural coherence. However, the magnitude of simulated current spread had little to no impact on the effects of interaural coherence on binaural fusion.

The results support the hypothesis that increased current spread can, to some extent, mitigate the detrimental effects of interaural place mismatch on binaural fusion, albeit for a limited range of interaural place mismatches. However, the results also suggest that increased current spread does not alter the effects of interaural coherence on binaural fusion.

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Th-F 29: ELECTROACOUSTIC PITCH MATCHING IN COCHLEAR IMPLANT USERS WITH SINGLE-SIDED DEAFNESS

Maya Hatley[1], Nicole Capach[1], René Gifford[2], Ariel Hight[1], Annette Lavender[1], Artur Lorens[3], Rohit Makol[1], Jonathan Neukam[2], Elad Sagi[1], Mario Svirsky[1]*, Mahan Azadpour[1]*

[1]Department of Otolaryngology-HNS, NYU Grossman School of Medicine, New York, NY, USA [2]Department of Hearing and Speech Sciences, Vanderbilt University Medical Center, Nashville, TN, USA [3]Institute of Physiology and Pathology of Hearing, Warsaw, Poland
*Co-Senior Authors

Purpose/Objective: The efficacy of cochlear implants (CIs) is based on the tonotopic organization of the cochlea, where basal stimulation of the cochlea elicits high-pitched percepts and pitch decreases towards the apex. Percepts resulting from stimulating the most apical electrodes are typically higher pitched than those elicited by corresponding acoustic stimulation in a normal ear. This mismatch can lead to decreased sound quality and speech intelligibility with CIs. CI users with single-sided deafness (SSD) offer a unique opportunity to compare CI-elicited pitch to normal-ear percepts. We employed adaptive psychophysical procedures to examine pitch percepts in SSD-CI users as a function of electrode location and time since initial stimulation. We also compared pitch matching scores to accepted frequency-place functions and clinically assigned center frequencies.

Methods/Approach: We studied 42 post-lingually deafened CI users with contralateral nor-mal/near-normal hearing. Participants compared perception of CI electrode stimulation to normal-ear pure tones. In each tested electrode, we conducted four adaptive runs: two 1 up-1 down (with high- and low-frequency starting points), 3 up-1 down, and 1 up-3 down. We collected data on time since initial stimulation and electrode insertion angle. A conservative validity check ensured the 1 up-3 down result was highest and 3 up-1 down lowest. Analyses were performed on both the full dataset and the validated subset.

Results/Findings: This data demonstrated clear tonotopicity, with a strong relationship between electrode insertion angle and pitch perception. On graphical analysis and multivariate logistic regression, no significant effect of time since initial stimulation was observed in either pitch matching scores or the degree of perceived frequency mismatch. Pitch matched scores were consistently higher than clinically assigned center frequencies in the most apical electrodes tested. These pitch matched scores were also consistently lower than predicted by the Stakhovskya and NYU frequency-place functions. In this study, 77% of the original data set survived the validity check, providing a robust dataset for analysis. Furthermore, results remained consistent across the full data set and the validated subset, underscoring the robustness of these findings.

Conclusions/Implications: Our data corroborates several patterns congruent with prior literature, including the presence of basalward frequency mismatch for the most apical electrodes, evidenced by basalward deviation from commonly used spiral ganglion frequency-place functions, and the strong tonotopic relationship between electrode location and pitch perception across this study population. However, unlike some previous studies, our pitch matching data shows marked stability in pitch matching scores and perceived pitch mismatch over time. These findings raise questions about prior studies conducted on this topic (including ours) and highlight the need for further investigation into the short- and long-term stability of pitch perception in CI users, especially those with single-sided deafness. Future studies should explore the relationship between pitch mismatch and speech recognition outcomes over time to optimize CI performance.

Th-F 30: THE CONTRIBUTION OF FREQUENCY-SPECIFIC INTERAURAL LEVEL DIFFERENCES TO SPATIAL SELECTIVE ATTENTION

Benjamin N. Richardson[1], J. M. Kainerstorfer[2], B. G. Shinn-Cunningham[1], C. A. Brown[3]

[1] Neuroscience Institute, Carnegie Mellon University
[2] Department of Biomedical Engineering, Carnegie Mellon University
[3] Department of Communication Science and Disorders, University of Pittsburgh

Purpose/Objective: Binaural processing in bilateral cochlear implant (BiCI) users is restricted to interaural level differences (ILDs). ILDs dominate primarily at frequencies above 1.2 kHz. This motivated Brown (2014) to magnify ILDs in the low frequency region, which led to a significant benefit to spatial selective attention (SSA) in BiCI users. More recently, Richardson et al (2025) showed no significant benefit to SSA when ILD magnification was restricted to the low frequencies, while significant benefit was observed only when ILDs were magnified across the entire usable frequency spectrum. This raises questions about frequency specific ILD magnification. Here, we sought to explore this relationship systematically in normal hearing listeners, probing the effect of ILD magnification when stimuli were low pass filtered.

Methods/Approach: We conducted a word-detection spatial attention task in normal hearing listeners. Listeners were asked to attend to a target stream spatialized to the left or right using ILDs while ignoring a masker stream in the opposite quarterfield. Subjects identified the word "bash" from the set "bash","dash","gash". Stimuli were either broadband or low-pass filtered with a 4th order Butterworth filter at 1.2 kHz. To force listeners to focus attention based on spatial cues, we temporally staggered word onsets to eliminate rhythm cues, and we used the same talker for the target and masker streams to eliminate voice pitch cues. Competing streams were spatially separated using ILDs at 5 deg or 10 deg azimuth, with or without ILD magnification, and either with broadband or low-pass filtered stimuli. In each condition, we calculated target hit and false alarm rates.

Results/Findings: Performance was better with natural ILDs from 10 deg ILDs than 5 deg azimuth, driven both by differences in hit rates and false alarm rates. Performance also improved with ILD magnification at both spatial separations. Performance was also better with broadband stimuli than with low pass filtered stimuli, regardless of spatial separation. These data underscore the importance of high frequency information for spatial segregation with naturally-occurring interaural level differences.

Conclusions/Implications: ILD magnification led to an improvement in task performance regardless of target-masker azimuth or low-pass filtering. This suggests that magnified ILDs aid in SSA even when restricted to frequency regions at which the auditory system does not usually process robust ILDs.

Th-F 32: PERFORMANCE OF RECIPIENTS OF COCHLEAR IMPLANTS AT ADOLESCENCE

R. M. Uchanski[1], L. S. Davidson[1,2], A. E. Geers[3], and B. Spehar[1]

[1]WashU Medicine, Dept of Otolaryngology, Program in Audiology & Communication Sciences, 660 S. Euclid Ave., St. Louis, MO 63110, USA
[2]Central Institute for the Deaf, 825 S. Taylor Avenue, St. Louis, MO 63110, USA
[3]University of Texas – Dallas, 800 W. Campbell Rd, Richardson, TX 75080, USA

Purpose: To provide researchers and clinicians with data on the performance of cochlear implant (CI) recipients, at adolescence, across a wide range of tests.

Methods: Participants are adolescents with severe-to-profound hearing loss, who received their 1st CI at an early age (mean age at 1st CI: 2.1 years) and who wear hearing devices bilaterally (N=14 simCI, N=56 seqCI, N=10 bimodal). Twenty-one adolescents with typical hearing (TH) also participated. Participants were administered a wide range of tests including localization, speech recognition in quiet, speech recognition in noise (co-located, and spatially-separated), and standardized language and reading comprehension measures. While most tests were administered with participants wearing their bilateral devices, some tests were given in unilateral listening conditions. From these tests with unilateral conditions, 'ear-asymmetry' was estimated for each participant.

Results/Findings: For the localization and speech recognition tests, adolescents with CIs perform more poorly than adolescents with typical hearing. E.g., rms error in localization: 20.1 deg for CIs vs 0.8 deg for TH; SNR-50 for sentences in noise (co-located): 4.6 dB for CIs vs -0.6 dB for TH. Reading and language scores are also, on average, poorer for adolescents with CIs compared to their peers with TH, although most CI participants have scores in the 'normal' range for these standardized tests. E.g., mean language scores are 94.0 for CIs vs 107.7 for TH. Analyses are being conducted to examine the unique and combined contributions of audiological characteristics (Age at 1st CI, Duration of Acoustic Experience, 'ear-asymmetry') to these CI participants' performance.

Conclusions/Implications: The differential effects of various audiological factors on long-term speech perception, language and academic outcomes will be discussed in relation to early CI device management.

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Th-F 33: IMPROVING ITD SENSITIVITY OF COCHLEAR IMPLANTED RATS: MICROSECOND PRECISE VERSUS BINAURALLY JITTERED ITD INFORMATION

T. Fleiner[1], C. Wirtz[2], R. Schatzer[2], P. Nopp[2], S. Arndt[3], J. W. Schnupp[4], N. Rosskothen-Kuhl[1, 5]

[1]Neurobiological Research Laboratory, Section for Experimental and Clinical Otology, Department of Otorhinolaryngology, Medical Center – University of Freiburg, Faculty of Medicine, Freiburg, Germany
[2]MED-EL GmbH, Innsbruck, Austria
[3]University of Freiburg, Faculty of Medicine, Department of Otorhinolaryngology, Freiburg, Germany
[4]Chinese University of Hong Kong, Gerald Choa Neuroscience Institute, Sha Tin, Hong Kong, Hongkong
[5]University of Freiburg, Bernstein Center Freiburg and Faculty of Biology, Freiburg, Germany

Sound localization in patients with bilateral cochlear implants (biCI) is a commonly described problem. A major cause is the difficulty patients have in perceiving interaural time differences (ITD), especially if they suffer from prelingual deafness. This led to the hypothesis that a lack of binaural hearing experience during an early critical period might limit the ITD perception in these patients. However, recent work by our research groups has shown that neonatally deafened (ND) rats, bilaterally cochlear im-planted in young adulthood, can be trained to use ITDs for sound lateralization with remarkably low ITD thresholds (~50 μs) even at higher pulse rates if the biCIs deliver informative pulse timing (pt) ITDs from the onset [1, 2]. Limitations in the temporal accuracy of current clinical biCI, which try to encode temporal features of sound in pt, can lead to small deviations (jitter) in the pt pattern. Here we investigate how much jitter the inexperienced auditory system can tolerate in order to develop good ITD sensitivity.

Twelve ND biCI rats were trained to lateralize pulse trains with jittered ITD at 250 pps. Baseline ITD were drawn independently from a set of ±120 μs in 20 μs steps. Binaural jitter values changed per pulse and were randomly drawn from a distribution ranging from ±60 μs in 20 μs steps (1st cohort; n = 7) and from ±120 μs in 40 μs steps (2nd cohort; n = 5). After five weeks of training, both biCI cohorts were tested on their ITD sensitivity with and without jitter (≙ microsecond precise ptITD) on each pulse.

Under both jitter conditions, all biCI rats showed very good ITD sensitivities. Training with ±60 μs jitter resulted in a significantly better ITD sensitivity threshold (just noticeable difference = 20 μs) than without jitter (just noticeable difference = 40 μs) or with ±120 μs jitter (just noticeable difference = 41 μs).

The results indicate that the early-deafened auditory system can develop good ITD sensitivity under binaural electric stimulation even in the presence of jitter on ptITD. Interestingly, small amounts of jitter may even improve the ITD sensitivity in electric hearing. These findings enhance our understanding of ITD processing in the electrically stimulated auditory system, especially after early deafness. Furthermore, these results highlight the importance of fine structure stimulation strategies for biCI patients to improve their spatial hearing and thus lay an important foundation for developing future CI coding strategies.

This work was funded by MED-EL GmbH, Innsbruck, Austria

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Th-F 34: CONTRIBUTIONS OF LOW FREQUENCY ACOUSTIC HEARING TO BINAURAL SENSITIVITY AND SPEECH UNMASKING IN INDIVIDUALS WITH ELECTRIC-ACOUSTIC STIMULATION AND NORMAL HEARING

Mohammad Maarefvand[1], René H. Gifford[4], Spencer Smith[3], Shelly Godar[1], Sara Misurelli[1], Roya Abdi[1], Jonathan D. Neukam[2], Fan-Yin Cheng[3], Olaedo Obinna[3], Ruth Y. Litovsky[1]

[1] Waisman Center, University of Wisconsin-Madison, Madison, WI, USA
[2] Vanderbilt University, Nashville, TN, USA
[3] Department of Speech, Language, and Hearing Sciences, University of Texas at Austin, USA
[4] Hearts for Hearing, Oklahoma City, OK, USA

Objective: There is a rapidly growing population of cochlear implant (CI) recipients with acoustic hearing preservation in the implanted ear(s), affording the opportunity to combine electric hearing in one or both ears, and binaural acoustic stimulation (EAS). Adults with EAS demonstrate significant benefits for speech understanding in noise and spatial hearing tasks as compared to a CI paired only with a contralateral HA (bimodal hearing). The potential for binaural EAS to improve outcomes in children, however, remains poorly understood with published data being highly variable. A hypothesized source of variance is the ability of children to use interaural timing and level differences (ITDs and ILDs, respectively) provided by residual acoustic hearing. Surprisingly few data exist on maturation of low-frequency binaural hearing in children with typical hearing, or the ability to harness binaural hearing for functional benefits such as segregation of speech from noise. This investigation focuses on the developmental trajectory of low-frequency acoustic hearing in individuals with typical hearing, and in children and adults with bin-aural EAS, who are tested prior to and following cochlear implantation.

Methods: ITD and ILD thresholds for pure tones presented at 250 Hz and 500 Hz were assessed. Numbers to date include 26 children (ages 5 to 17) and 29 adults (18 + years). A 3-interval 2-alternative forced choice discrimination task was used, and a two-down-one up adaptive tracking algorithm was implemented, targeting thresholds at 70.7% correct. In addition, binaural intelligibility level difference (BILD) was used to assess speech understanding in noise, comparing conditions in which the speech and noise were either both in phase (N0S0) or in which the phase of the noise was reversed (N0Spi). BILD is defined as the difference in signal-to-noise ratio between (N0Spi) and (N0S0).

Results: Results to date show a maturational trajectory of low-frequency binaural hearing in typical hearing children, such that both ITD and ILD thresholds improve (decrease) with age. In addition, BILD benefit increases with age and is correlated with ITD and ILD thresholds. For EAS participants, pre- and post-CI data are currently being collected, with preliminary observations suggesting considerable variance in binaural hearing outcomes at all time points. This presentation will also include analyses on the stability of adaptive tracks to consider sources of variance in performance.

Conclusions: Sensitivity to ITD and ILD improves with age as children transition into adolescence. Children with better ITD thresholds also experienced greater functional benefits in BILD, regardless of hearing status. This finding highlights the importance of distinguishing between maturation of overall spatial hearing abilities in free field in which head shadow cues are also available, and low-frequency binaural hearing, which is the frequency targeted in binaural EAS intervention.

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Th-F 35: EVALUATING ELECTROPHYSIOLOGICAL AND BEHAVIORAL MEASURES OF NEURAL HEALTH IN COCHLEAR IMPLANT USERS: A COMPUTATIONAL SIMULATION STUDY

Yixuan Zhang[1,2], Daniel Kipping[1,2], Waldo Nogueira[1,2]

[1]Department of Otolaryngology, Hannover Medical School (MHH), Hannover, Germany
[2]Cluster of Excellence Hearing4all, Hannover, Germany

Objective: Neural health refers to the condition and functionality of the auditory nerve fibers (ANFs), essential for transmitting sound signals from the cochlea to the brain. However, neural health cannot be directly measured due to current techno-logical limitations. We utilize a computational model to evaluate different indirect methods for estimating neural health.

Method: Two distinct measures for estimating neural health, (i) threshold levels for focused partial tripolar stimulation and (ii) changes in the electrically evoked compound action potential (eCAP) amplitude growth function for different inter-phase gaps (IPGs), were evaluated in a computational model of an electrically stimulated implanted cochlea [1]. The model combined a 3D finite element method model, a realistic ANF geometry, and a neuron model, including an existing phenomenological single-ANF model and an eCAP model [2]. Our experiments simulated different neural health conditions (healthy, shrunk, and degenerated) to model cochlea dead regions.

Results: Experiment results demonstrated that the threshold levels with partial tripolar stimulation were more sensitive to neural health deficits than monopolar stimulation. The threshold difference between partial tripolar and monopolar stimulation seems to be a promising measure of neural health status. However, results from the eCAP IPG slope and offset effects were not consistently associated with neural health conditions.

Conclusion: Our results suggest that the difference in threshold levels with partial tripolar and monopolar stimulation is a possible method for estimating neural health. Significance: This study enhances the understanding of neural health through a computational model, contributing to new approaches for neural health estimation.

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Th-F 36: AGE-RELATED TEMPORAL PROCESSING DEFICITS ASSESSED VIA FORWARD MASKING IN COCHLEAR-IMPLANT USERS

Chengjie G. Huang, Natalie A. Field, Gianna Delucca, Rebecca Scheerer, Samira Anderson, Matthew J. Goupell

Department of Hearing and Speech Sciences, University of Maryland College Park, 7251 Preinkert Drive, College Park, MD, USA 20742

As people age, one of the main contributors to poor speech perception is auditory temporal processing deficits. Although this has been extensively studied in acoustic listeners, the mechanisms underlying these deficits as well as how they occur in cochlear-implant (CI) users are not well understood. The primary goal of this study is to understand how forward masking, and by extension, temporal processing is affected by aging in CI users. CI users also offer the advantage of bypassing the peripheral auditory system, allowing us to understand the peripheral and central contributions to temporal processing deficits. Similar to acoustic listeners, we hypothesize that forward masking will have a greater effect as age increases, but will co-vary with neural health at the level of the auditory nerve (peripheral) and subcortical processing at the level of inferior colliculus (central).

To understand this relationship, we plan to recruit 20 CI users across the adult lifespan. We evaluated their electrode-to-neural interface (ENI) by measuring electrically-evoked compound action potentials amplitude growth functions (ECAP AGFs) to determine their "best" (steepest slope) and "worst" (shallowest slope) electrodes. Then, we presented using direct stimulation a multi-electrode masker followed by a target chirp stimulus with varying masker-to-target intervals (5, 50, 100, and 200 ms) with 4 electrodes spread across the array centered around their best electrode. While presenting the stimulus, we measured electrically evoked auditory brainstem responses (eABRs) and evaluated averaged eABR Wave V amplitudes and latencies. Separately, we performed a behavioral three-interval two-alternative forced-choice task using the same stimuli to evaluate detection thresholds for release from masking at each MTI.

Our previous results with single pulse direct stimulation suggest that eABR Wave V is correlated with ENI. We expect that ENI (i.e., slope) will decrease as a function of age, and as a result release from masking will also increase as a function of age. We expect that eABR Wave V will correlate with behavioral detection thresholds and there will be a main effects and interactions of age and MTI, and plan to compare these results to our previous findings in normal-hearing listeners across the adult lifespan.

The results from this study demonstrate the underlying contributions of both peripheral and central areas of the auditory system on the temporal processing deficits which are observed with increasing age. By understanding the deficits at each neural locus, we can aim to treat these issues more effectively by improving CI processing. Thus, the findings here can potentially influence future design of CI devices to better individualize treatment for patients in the clinic.

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Th-F 37: CO-PRODUCTION WITH THE SOUTH ASIAN COMMUNITY TO INCREASE INCLUSION AND ENGAGEMENT WITH HEARING RESEARCH

Jane Gallacher, Bhavisha Parmar, Deborah Vickers

SOUND Lab, Department of Clinical Neurosciences, University of Cambridge, Cambridge, UK

Purpose/Objective: This project examines the reported inequalities in access to hearing healthcare for people from minority ethnic backgrounds and is directed towards the South Asian community in the UK to understand views and attitudes towards deafness and hearing loss. Co-production is a process where stakeholders including, in this case, members of the South Asian community as well as professionals in Audiology, Speech and Language Therapy, medics and policy makers are collaborators with the researcher, having joint ownership of and input to the project. Many people from ethnically diverse backgrounds report discrimination and challenges in accessing healthcare. This carries through to healthcare research where minority communities have often not had their voices heard and research is frequently dictated by 'professional opinion' of the needs and priorities of the community. Using National Institute for Health and Care Research (NIHR) co production principles, we have worked with the Scottish South Asian community to design our study from inception through to dis-semination of results.

Methods/Approach: South Asian community focus groups have helped to co-produce, design and publish a survey to understand attitudes of the South Asian community to hearing loss generally as well as hearing assessment and hearing device interventions for hearing loss. The survey identified themes to further engage with the community via interactive solutions workshops which ensured equal voice for all participants. Activities included facilitated discussions, problem mapping/emotional touchpoint exercises and structured group activities to cross-pollinate ideas and reach consensus on solutions.

Results/Findings: Survey results from 60+ members of the South Asian community were used to identify themes for a stakeholders workshop with 15 community leaders, healthcare providers and policymakers. Consensus was reached on 3 novel interventions to improve access to hearing healthcare for the South Asian population.

Conclusions/Implications: Co-production has proven to be a time-consuming part of this project, however, the benefits are clear. Such an approach supports research that is ethical, specific, and appropriate to the local community. Including participants' research priorities ensures that the research that is produced will be relevant, culturally sensitive and appropriate to the specific community. It builds trust between the health researchers and minority community which, in turn, increases engagement and adoption of the out-comes of the study.

This work was funded by Cochlear Limited

Th-F 38: FOCUSSED, BUT BROAD ENOUGH: TOWARDS PSYCHOPHYSICALLY RELEVANT CURRENT FOCUSSING WITH COCHLEAR IMPLANTS

F. Guérit, R. P. Carlyon

Cambridge Hearing Group, MRC Cognition and Brain Sciences Unit, University of Cambridge, 15 Chaucer Road, CB2 7EF Cambridge, United Kingdom.

Background. Cochlear Implant (CI) users struggle when listening to speech under noisy conditions. This has long been attributed to channel interactions: a given neuron not only responds to electrical stimulation from the closest electrode but is also influenced by electrodes located further away. Shaping the stimulation voltage into a very sharp profile (e.g. tripolar as opposed to the more common monopolar stimulation) has been proposed as a solution. The limited success of this approach may arise from:

- the outputs of adjacent CI channels being anyway highly correlated,
- that some neural spread of excitation is necessary for sufficient loudness,
- that, at comfortably loud levels, monopolar and sharp stimulation modes can yield very similar output voltage, at least 3-4 electrodes away from a given stimulation electrode.

We therefore propose a "Hilltop" approach, where the voltage is shaped to be broad near a given stimulation electrode (and recruit enough neurons) but reduced by several orders of magnitude more than 3-4 electrodes away.

Methods. We investigated 1) how much current needs to be injected at each electrode to produce voltage patterns of various widths; 2) what input levels are necessary to achieve comfortable loudness; 3) what sensation of place pitch is elicited; 4) and whether measuring charge summation can reflect and guide the accuracy of the shaping at the level of the auditory nerve. We also investigated the output given by various stimulation modes in physical and computational models of the cochlea.

Results. When loudness-balanced to monopolar stimulation, Hilltop stimuli produce large voltage differences more than 3-4 electrodes away from a given electrode, while keeping a similar sensation for place pitch. Charge summation results differ between monopolar and Hilltop stimulation, with Hilltop stimuli creating very little summation more than 3-4 electrodes away from a given electrode. For some participants, Hilltop stimulation may create sidelobes of excitation of opposite polarity.

Conclusion. Shaping the voltage into a "Hilltop" profile is feasible and may be effective at the level of the auditory nerve, not just at the electrode array. We will discuss the next steps for evaluating its impact on channel interactions with speech as input signal, and how to quickly assess several current-focusing methods in individual listeners.

Th-F 39: COMPARING PHYSIOLOGICAL AND PSYCHOPHYSICAL SPREAD OF EXCITATION: ECAP VERSUS ELECTRIC AND BLUETOOTH PTCS

Charles B. Hem[1], Dietmar M. Wohlbauer[2], Caylin R. McCallick[2], Julie G. Arenberg[1]

[1]Harvard Speech and Hearing Bioscience and Technology,
Massachusetts Eye and Ear Infirmary, Boston, MA, USA
[2]Massachusetts Eye and Ear Infirmary, Boston, MA, USA

Purpose/Objective: Stimulation of overlapping neural regions by adjacent cochlear implant (CI) channels, or channel interaction, is likely one source of poor spectral resolution in CI listeners. Channel interaction can be measured physiologically using spread of excitation (SOE) curves de-rived from electrically evoked compound action potentials (ECAP) and behaviorally using forward-masked psychophysical tuning curves (PTC), but it is uncertain whether the behavioral performance is driven purely by peripheral physiology or the periphery plus central processing. PTCs have traditionally been measured using direct-stimulation in CIs (Direct-PTC), but a recent method (Bluetooth-PTC1) uses audio signals sent via Bluetooth to the CI processor to greatly reduce the measurement time. This study aims to compare SOEs measured using ECAP with Direct-PTCs and Bluetooth-PTCs.

Methods/Approach: ECAP, Direct-PTC, and Bluetooth-PTC were measured at 2 electrodes in 10 experienced (>6 months device experience), adult Advanced Bionics recipients. ECAP was recorded using the PECAP method2 and normalized by max amplitude in each SOE curve. ECAP SOE curves and PTCs were quantified using the slope of best-fit lines on both the apical and basal sides of the curve's tip, which was usually the probe electrode. Electrodes that produced no masking in PTCs or no ECAP response were excluded from fits. Two linear mixed effects models were used to compare Direct-PTC slopes to SOE slopes and Bluetooth-PTC slopes to SOE slopes.

Results/Findings: In this preliminary data, the relationship between PTC slope and SOE slope was not significant: Direct-PTC vs SOE (standardized beta = 0.21, p = 0.10), Bluetooth-PTC vs SOE (standardized beta = -0.08, p = 0.54). Further data collection and ECAP data processing is ongoing.

Conclusions/Implications: The lack of correlation between SOE curves and PTCs in this initial sample suggests that behavioral performance is not driven by physiological spread of excitation in experienced cochlear implant listeners. If these results are consistent once more participants have been tested, then it is possible that either central processing contributes heavily to psycho-physical tuning curves or that the stimuli used in each method measures different qualities of the auditory periphery.

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Th-F 40: MEASURING SPEECH IN NOISE PERCEPTION DURING INFANCY WITH HD-DOT

Addison D. N. Billing[1,2], Robert J. Cooper[2], Deborah A. Vickers[1]

[1] SOUND Lab, Department of Clinical Neurosciences, University of Cambridge, Cambridge, UK
[2] DOT-HUB, Department of Medical Physics and Biomedical Engineering, University College London, London, UK

Understanding how infants process speech in noisy environments is critical, as they frequently encounter complex communication settings from early infancy. This study measured cortical responses of typically hearing infants, aged 6 to 8 months, to varying levels of background noise using high-density diffuse optical tomography (HD-DOT).

We adapted nursery rhyme videos used in a well-established social behaviour paradigm to have different levels of intelligibility, for different stimuli. Infants watched audio-visual videos of women singing nursery rhymes with hand gestures, presented in three different competing babble noise (3 male and 3 female speakers) conditions: no back-ground noise, +8 dB signal-to-noise ratio (SNR), and +4 dB SNR. Our intention was to create an objective psychometric performance measure of speech perception as a function of SNR.

In the no background noise condition (high accessibility of speech), we observed significant bilateral activation in the Inferior Parietal Lobule (IPL), a region crucial for integrating audio-visual social cues. Additionally, the right dorsolateral prefrontal cortex (DLPFC) showed significant activation, suggesting that higher-order cognitive processing is engaged when speech cues are clear and undisturbed. Conversely, in the +8 dB SNR (medium speech access) and +4 dB SNR (low speech access) conditions, DLPFC activation was absent, indicating that this region's engagement may depend on the clarity of auditory signals.

The IPL continued to show bilateral responses across all noise levels, although the strength of the hemodynamic response was inversely related to the amount of back-ground noise, suggesting that while the IPL is sensitive to auditory clarity, it can still respond to lower speech clarity input. Furthermore, the high-accessibility-of speech condition elicited significant activation in the left superior temporal gyrus (STG) and middle temporal gyrus (MTG), regions associated with language processing. This activation diminished with increased background noise, suggesting that these areas are likely more dependent on clear auditory input for optimal engagement.

The robust HD-DOT cortical responses highlight its potential as a tool for psychometric assessments in early childhood. Unlike EEG, HD-DOT is not susceptible to electrical interference, making it particularly suitable for evaluating infants using hearing aids or cochlear implants who are unable to provide reliable feedback. These findings pave the way for HD-DOT to be used in early audiological evaluations, offering insights into infants' auditory processing capabilities and aiding in the development of interventions during a critical period of speech and language acquisition and social development.

Th-F 41: USING SCINSEVS FOR INTRAOPERATIVE DETECTION OF PARTIAL INSERTION AND TIP FOLD-OVER IN A TERTIARY CARE CENTRE

M. Salorio-Corbetto[1,2], R. Chin[1], S. T. Eitutis[1], Y. C. Tam[1], N. Havers[1], M. E. Smith[1], N. P. Donnelly[1], J. Tysome[1], P. Axon[1], D. Borsetto[1], M. L. Bance[1,3]

[1] Cambridge University Hospitals NHS Trust, Cambridge, CB2 0QQ, United Kingdom.
[2] Cambridge Hearing Group, SOUND Lab, University of Cambridge, Department of Clinical Neurosciences, Herchel Smith Building, Cambridge, CB2 0SZ, United Kingdom
[3] Cambridge Hearing Group, SENSE Lab, University of Cambridge, Department of Clinical Neurosciences, Clifford Allbutt Building, Cambridge, CB2 0AH, Cambridge, United Kingdom

Purpose: To establish whether intra-operative Simultaneous Current-Induced Non-stimulating Electrode Voltage measurements' (SCINSEV, clinically known as transimpedance matrices, voltage matrices, or electric field imaging) provided useful feedback to surgeons to reduce the number of patients requiring revision surgery or needing to have electrodes deactivated in programming.

Methods: A review of cases of cochlear-implant surgeries for the period between 1st April 2021 to 31st March 2022 was completed. 216 surgeries took place, involving 173 patients (207 ears). Intraoperative testing was completed for 57.87% of the cases. Post-operative X-rays were used to determine array position, as intra-operative imaging was not available. SCINSEVs and X-rays were reviewed by two observers and any conflicts were resolved by a third one. Comparisons were established across measures to calculate the sensitivity and specificity of surgeon's reports, contact impedances, electrically evoked compound action potentials (ECAP), and SCINSEVs were calculated.

Results: SCINSEVs had the best combination of sensitivity and specificity (0.41 and 0.98) compared with other methods. The real sensitivity of SCINSEVs may be higher as for some cases (15/121, 12.40%) feedback was provided to improve array positioning. These were one case of tip-fold-over (0.83%), 12 cases with extra-cochlear electrodes (9.92%), one case of extra-cochlear location (0.83%), and one case with inconclusive results (0.83%). Seven cases of partial insertion were actioned and resolved (5.79%). It was not possible to further insert the array for five more cases (4.13%), for which the post-operative X-ray confirmed partial insertions. One case of extra-cochlear location and one of tip fold-over were resolved (0.83% in each case). The case with inconclusive results corresponded to a mal-positioned device (0.83%). Overall, 7.43% of ears benefited from intra-operative SCINSEVs, with patients avoiding revision surgery or modifications to programming. The rate of occurrence of tip-fold-over for the SCINSEV tested cohort was 0% and that for the non-tested cohort was 3.30%. The rate of partial insertions was 18.97% (22/116 cases) for the SCINSEV tested cohort and 21.98% (20/91 cases) for the non-tested cohort. SCINSEVs were more difficult to interpret if there were numerous open circuits or in cases with cochlear abnormalities.

Conclusions: SCINSEVs provided useful feedback to surgeons, with improvements to array positioning being achieved for 7.43% ears. It is recommended that in cases with a previous history of a mal-positioned implant or cochlear abnormalities, intraoperative X-ray is available in the event SCINSEVs are inconclusive.

Th-F 42: EVALUATION OF THE RELIABILITY OF THE COCHLEAR IMPLANTS USING LARGE ANIMAL MODEL

Doo-Hee Kim[1,2], Dong-Min Kang[2], Soo-Won Shin[1], Gwang-Jin Choi[1], Jun-Woo Hyun[1], Yoon-Hee Ha[1], Sang-Woo Kim[1], Ho-Seung Lee[1], Kyou-Sik Min[1] and Myung-Hwan Suh[2]

[1]Department of Cochlear Implant Business, TODOC Ltd, Seoul, Republic of Korea
[2]Department of Otorhinolaryngology Head and Neck Surgery, Seoul,
Seoul National University Hospital, Seoul, Republic of Korea

Purpose/Objective: The cochlear implant (CI) is an active implantable medical device that requires rigorous reliability testing. Pigs are commonly used as large animal models in preclinical studies for organ transplantation and the evaluation of implantable medical devices. This study aims to establish a cochlear implant model in large animals and evaluate the device's reliability.

Methods/Approach: Nine minipigs underwent cochlear implantation using TODOC devices. A retroauricular incision was performed, and the implant's body and coil were embedded above the vertex of the head. The electrode was inserted via the round window. After suturing the incision site, a dummy electrode was implanted in the contralateral ear using the same procedure. Following implantation, electrically evoked auditory brainstem response (EABR) measurements were performed under the following conditions: stimulation-Channels 1,2 8, 9, 14 and 15; pulse width (PW) 25 and 50 mus/ph; 40 pps; intensity: 0-255 current level; EABR recording-500 sweeps, 100-5000 Hz. Over a three-month post-operative period, the implantation site was monitored for adverse events, connectivity between the internal and external parts of the cochlear implant, and EABR measurements. After euthanasia, device functionality was assessed.

Results/Findings: Cochlear implantations were successful in all cases. The body and coil were embedded on the skull of the animal and the electrodes were inserted into the cochleae with an average of 21 contacts. One animal required device removal due to an immediate postoperative infection. Others exhibited no serious adverse events during the three-month observation period except electrode dislocation from the cochlea according to time. EABR measurements were successfully recorded in eight animals intraoperatively. The EABR thresholds for stimulation pulse widths of 25, and 50 μs/ph were 822 ± 178 μA and 509 ± 105 μA, respectively. After euthanasia, all implants were extracted and found to be functioning normally.

Conclusions/Implications: A simultaneous bilateral cochlear implantations were done using a large animal model. The model was utilized to evaluate adverse events, device connectivity, electrically evoked responses, and the functionality of the explanted implant, thereby confirming the device's reliability.

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Th-F 43: PREDICTING POST-OPERATIVE COCHLEAR IMPLANT OUTCOMES WITH PRE-OPERATIVE PSYCHOPHYSICS

Emily R. Spitzer, David R Friedmann, Madeleine M. Beyer, David M. Landsberger

New York University Grossman School of Medicine, New York, NY USA

Objective: Cochlear implants (CIs) are an option for individuals with steeply sloping hearing loss who receive insufficient benefit from hearing aids. These patients risk losing residual acoustic hearing, which may contribute to their sense of safety, music enjoyment, and general communication, for a potential improvement in speech perception. However, pre-operative pure tone thresholds and speech scores, two primary metrics of CI candidacy, are unreliable predictors of post-operative outcomes. Pre-operative pure tone thresholds represent the minimum audible sounds but do not describe the ability of a listener to interpret those sounds. Pre-operative speech recognition depends on the audibility of specific speech sounds (i.e., the speech banana) which is typically not relevant post-implantation. We hypothesized that pre-operative assessment of non-linguistic, suprathreshold psychophysical abilities may predict post-operative outcomes better than the current clinical test battery.

Design: We are conducting a pre-operative battery of psychophysical tests with CI candidates with residual acoustic hearing. These tests include measures of spectral processing, temporal processing, localization, and environmental awareness, among others. Presently, the majority of our pre-operative psychophysical data is from the Spectral-temporally Modulated Ripple test (SMRT; Aronoff and Landsberger, 2013) as the project originated with that task. However, we are actively collecting data with the entire test battery.

As of abstract submission, pre-operative psychophysics has been evaluated in 14 participants undergoing CI candidacy evaluation. To establish clinical feasibility, we are also recording test administration time and patient-reported level of difficulty. CNC words and AzBio sentences were assessed pre- and three months post-operatively.

Results: Pre-operative SMRT scores were significantly correlated with post-operative speech perception scores in quiet and in noise, irrespective of post-operative hearing thresholds. Presently, we have insufficient post-operative data from other tests to determine if similar patterns exist, although we feel positive about results thus far. Data will be available before July 2025. A majority of the psychophysical evaluations require less than five minutes, though some may take up to fifteen.

Conclusions: Assessment of suprathreshold psychophysical measures offers a more comprehensive view of auditory health than pure tone thresholds and clinical speech testing alone. The predictive value and clinical feasibility of SMRT support its utility as a counseling tool for CI candidates. While the SMRT is an informative test, it is plausible that other tests may be similar or more effective. Data addressing this question will be presented.

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Th-F 44: THE CONTRIBUTION OF VESTIBULAR AND BALANCE FUNCTION ON DEVELOPMENTAL OUTCOMES OF CHILDREN WITH BILATERAL COCHLEAR IMPLANTS

Melissa Hazen[1,2], Sharon L. Cushing[1,3], Karen A. Gordon[1,2]

[1]Institute of Medical Science, University of Toronto
[2]Department of Neurosciences and Mental Health, The Hospital for Sick Children (SickKids)
[3]Department of Otolaryngology - Head & Neck Surgery, SickKids

Objectives: This study aimed to determine the contribution of vestibular and balance deficits on developmental variability in children using bilateral cochlear implants. While prior research has identified cognitive and academic deficits in cochlear implant users, the additional influence of vestibular and balance impairments on these outcomes remains unclear. It was hypothesized that cognitive and academic impairments in children with hearing loss are predicted by hearing history and marginalization with an additive role of vestibular and balance impairments.

Design: Study participants were 96 children (4.65 - 17.85 years of age) who were grouped as: (1) typically developing (TD) (n=30, mean age (SD) = 11.40 (2.86) years), (2) bilateral cochlear implant (BCI) users (n=66, mean age (SD) = 11.54 (3.47) years). Vestibular function was measured using cervical vestibular evoked myogenic potentials (cVEMP) and the video head impulse test (vHIT), and balance was measured using the Bruininks-Oseretsky Test of Motor Proficiency balance subtest (BOT). Hearing was tested using pure tone audiometry to confirm normal hearing. Three developmental domains were assessed using specific tests: 1) working memory (Dot Matrix, Corsi Block, and Digit Span tests); 2) academic performance (Weschler Individual Achievement Test (WIAT)); 3) language abilities (Clinical Evaluation of Language Fundamentals (CELF)). Hearing history included duration of deafness and onset of hearing loss per ear, and age at diagnosis. Socioeconomic marginalization was indexed (ON-MARG linking to postal codes). Linear regressions examined the effects of age, group, vestibular and balance function, etiology, and marginalization on developmental outcomes. Principal component analysis (PCA) was used to identify relationships between predictors. Linear regression was used to assess effects of these predictors on outcomes.

Results: Accounting for effects of age in both groups, children with bilateral cochlear implants (BCIs) performed significantly worse than their typically developing peers in language ($t(82) = -3.65$, $p<0.01$), visuospatial working memory ($t(82) = -3.41$, $p<0.01$), math ($t(81) = -3.49$, $p<0.01$), and word reading ($t(73) = -2.01$, $p<0.05$). PC1 (Hearing History) was positively associated with higher math scores ($t(46) = 2.27$, $p<0.03$) and PC2 (Hearing Experience & Marginalization) was positively associated with language ($t(46) = 3.19$, $p<0.01$), Digit Span ($t(46) = 2.26$, $p<0.03$), Word Reading ($t(46) = 3.62$, $p<0.01$), Pseudoword Reading ($t(46) = 2.65$, $p<0.02$), and Math ($t(46) = 4.62$, $p<0.01$). PC3 (Social & Demographics) was associated with higher Word Reading scores ($t(46) = 2.11$, $p<0.05$). PC4 (Vestibular & Balance) showed no significant associations with any outcomes.

Conclusions: Although all children experience improvements in cognitive and academic skills with age, and negative effects of marginalization, children with bilateral cochlear implants continue to exhibit persistent gaps in visuospatial working memory, math, reading, and language compared to their typically developing peers. These differences cannot be fully explained by vestibular and balance function, etiology, or hearing history. This emphasizes the importance of individualized support and early access to sound.

Th-F 45: IMPACT OF LINKED SOUND PROCESSING ON THE ENCODING OF BINAURAL CUES IN BILATERAL COCHLEAR IMPLANTS

G. Palo[1], O. Qazi[1], T. Bertens[1], F. Vanpoucke[1], J. Wouters[2,3]

[1]Cochlear Technology Centre, Mechelen, Belgium
[2]ExpORL, Dept. Neurosciences, KU Leuven
[3]Leuven Brain Institute, KU Leuven

Bilateral cochlear implantation is a crucial intervention for individuals with severe-to-profound bilateral hearing loss. While cochlear implants (CIs) have proven effective for speech understanding, there is still significant potential to enhance their performance in noisy environments and improve sound localization [1, 2]. In bilateral CI (BiCI) users, the independent sound processing between the left and right implants causes distortions of interaural time differences (ITDs) and interaural level differences (ILDs) [3]. The widely used Advanced Combination Encoder (ACE) strategy selects the highest N amplitudes from the M available channels. While this approach improves speech intelligibility in noise, the independent selection of channels between the two implants can alter binaural cues [3]. Additionally, the independent functioning of the Automatic Gain Control (AGC) can distort ILD cues [4]. Previous studies [4, 5] have investigated the aspects of linking channel selection and AGC independently, showing promise in improving speech understanding in noise. However, achieving full restoration of binaural cues requires a comprehensive investigation and synchronization of key CI processing components.

This simulation study aims to systematically characterize the entire CI processing pathway, quantifying the degree of distortion of binaural cues introduced by each processing stage, such as AGC, channel selection, and Logarithmic Growth Function (LGF), under both linked and unlinked conditions. ILDs and ITDs will be evaluated for each individual frequency band as well as in a broadband manner, through the weighted sum of the frequency-specific values. The degree of distortion of ILD and ITD information will be assessed using measured Head-Related Transfer Functions (HRTFs) in both quiet and more challenging acoustic conditions, including stationary noise and reverberation. The distortion in ITD and ILD values across various frequencies and azimuth angles will be measured at each CI processing stage relative to the baseline 'unlinked' condition using (1) direct comparison, (2) Root Mean Square (RMS) difference, and (3) Jensen-Shannon divergence.

We hypothesize that linking channel selection and AGC will have a great positive impact on the encoding of both ITD and ILD cues. In the unlinked condition, the head shadow effect attenuates high-frequency signal components on one side, causing lower-frequency channels to be more selected on the contralateral side, resulting in misleading cues. Similarly, independent AGCs may cause one device to enter compression while the contralateral one remains inactive, leading to inaccurate level cues.

The results of the study will offer a more comprehensive understanding of binaural cues and the impact of various CI processing stages, providing a foundation for improving the design of sound coding strategies that can better support binaural hearing in bilateral CI users.

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Th-F 46: STIMULATING AND RECORDING CORTICAL POTENTIALS DIRECTLY VIA ADVANCED BIONICS' COCHLEAR IMPLANT SYSTEM

Chen Chen[1], Don Bell-Souder[2], Tony Spahr[1], Anu Sharma[2]

[1]Advanced Bionics, LLC (28515 Westinghouse Pl, Valencia, CA 91355)
[2]Brain and Behavior Laboratory, University of Colorado Boulder (University of Colorado at Boulder 2501 Kittredge Loop Road, 409 UCB Boulder, CO 80309-0409)

Purpose/Objective: The objective of this study is two folds: 1) to demonstrate that it is feasible to stimulate and record cortical auditory evoked potentials directly via Advanced Bionics (AB) 's cochlear implant (CI) system via back telemetry and 2) to validate the signal by comparison with simultaneously recorded commercial scalp EEG system. Motivation: The cortical auditory evoked potential (CAEP) has proven to be a physiological measurement to objectively monitor auditory cortex development in normal hearing children and effects of CI implantation (1 - 5), and has recently been shown to have high correlation with behavioral thresholds (6) hence potential for objective CI programming. Obtaining such signals has not been widely used clinically due to extensive external equipment and complex operations. Previously we demonstrated CI recordings could be done using acoustic stimulation (7 - 8), this study is the first time that we show CI recordings with CI stimulation. Some of the work in this presentation is available and published in (9).

Methods/Approach: We recorded the electrically-stimulated cortical auditory evoked potentials (eCAEP) in adult bilaterally implanted AB users. Stimulation and recording were done using AB's BEEP (Bionic Ear Evoked Potential) research software. In this study, we used BEEP to present direct stimulation to one CI and then record eCAEP using both CIs simultaneously. The eCAEP was also simultaneously recorded using a commercial EEG system, and the waveforms recorded by the two systems were compared to each other.

Results/Findings: eCAEP response was observed in all participants in the contralateral recording CI, and the CI recorded eCAEPs were comparable to scalp recorded eCAEPs (with cross-correlation r=0.83 for the grand averages, individual mean cross-correlations ranged from 0.13 to 0.70). Obligatory evoked potential peaks (the P1, N1 and P2) showed no significant latency difference between the two systems. The eCAEP waveforms recorded via the CI mostly converge in a stable distinct P1-N1-P2 waveform by as early as 130 sweeps (less than 5 minutes).

Conclusions/Implications: This study shows the feasibility of stimulating and recording the eCAEP directly through AB's CI system, using user's existing implant, in less than 5 min of time, without requiring external EEG system. This makes it possible to incorporate cortical potential measurements into CI's clinical practice in the future to guide CI fitting and track auditory cortex development in response to CI use. More future studies need to be done to continue build up scientific evidence for CAEPs and other central auditory potentials' applications for CI clinical use.

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Th-F 47: A BEHAVIORAL MEASURE OF NEURAL ADAPTATION

O. Macherey[1], J. Chatron[1], S. Roman[2], R. P. Carlyon[3]

[1]Aix-Marseille University, CNRS, Centrale Méditerranée, LMA, Marseille, France
[2]Dept. of Pediatric Otolaryngology and Neck Surgery, Aix-Marseille University, France
[3] Cambridge Hearing Group, MRC Cognition and Brain Sciences Unit, University of Cambridge, UK

The time constants of rapid- and short-term adaptation are too short to be tracked using perceptual measures such as the sequential loudness judgements used to index adaptation with long ï¾minutes) time constants. Furthermore, although recovery from adaptation might be reflected psychophysically in the reduction in forward masking with increases in masker-probe gap, this phenomenon can alternatively be modelled in terms of a central integration window. As a result, evidence for peri-stimulus adaptation rests primarily on (electro-) physiological measures of the AN or brainstem response throughout acoustic and electrical stimuli. Because the effects of adaptation depend on some incompletely known combination of processes at multiple stages of the auditory system, it would be desirable to have a behavioral measure of the effects of adaptation or at least on how those effects interact with stimulus characteristics.

The present study aims to provide an albeit indirect measure of the effect of pulse rate on adaptation by measuring the interaction between pulse rate and duration on perceived loudness. Specifically, we predict that if adaptation is greater for high than for low pulse rates, then the difference in level between equally loud low- and high-rate stimuli should decrease with increasing duration. This hypothesis is tested in experiment 1 with normal-hearing (NH) listeners and pulse-like acoustic stimuli, and in experiment 2 with trains of electrical pulses presented to cochlear-implant (CI) listeners.

In experiment 1, eight NH listeners loudness-balanced harmonic complexes that had been bandpass-filtered between 7800-10,800 Hz. The complexes had durations of 40, 120, or 400 ms and a fundamental frequency of 50 Hz. They were generated either in sine phase, in alternating phase, or were 2nd- or 3rd-order pulse-spreading harmonic complexes, and resembled pulse trains with rates of 50, 100, 200, or 450 pulses per second (pps) respectively. In experiment 2, thirteen CI listeners loudness-balanced 100- and 2000-pps pulse trains, presented to a single electrode, at durations of 40, 120, and 400 ms. Both experiments showed that lower-rate stimuli needed a higher level to match the loudness of higher-rate stimuli, but that this effect decreased with increasing duration. In experiment 2, this duration effect was only observed in trials where the 2000-pps train was presented before the 100-pps train, consistent with participants comparing the end of the first stimulus in each trial to the start of the second.

To conclude, the results of both experiments are consistent with rate-dependent neural adaptation. Theoretical and clinical implications will be discussed.

Th-F 48: ACCOUNTING FOR AGE DIFFERENCES IN SPECTRAL AND TEMPORAL MODULATION PERCEPTION WITH A COCHLEAR IMPLANT

D. L. Horn[1,2], D. M Halverson[1], B. O. Peskova[1], M. S. Broncheau[1], L. A Werner[2], J. T. Rubinstein[1,2]

[1]Virginia Merrill Bloedel Hearing Research Center, Seattle WA
[1]University of Washington Department of Otolaryngology, Head and Neck Surgery
[2]University of Washington Department of Speech and Hearing Sciences

Background: For infants and toddlers with hearing loss, there are no suprathreshold tests of auditory acuity available to determine cochlear implant candidacy or device efficacy. This limits precise, patient specific, optimization of auditory input at the earliest possible age. Measures of spectral and temporal modulation perception have shown promise as nonlinguistic indicators of device efficacy in post-lingually-implanted adults and prelingually-implanted school-age children. However, children up to 9-10 years old, even those with normal hearing (NH), perform poorly on these tasks compared to adults calling into question the validity of these measures in assessment of auditory acuity in much younger CI users. In this study we seek to characterize spectral and temporal modulation perception in pre-lingually implanted children from 5-10 years of age compared to post-lingually implanted adults. We hypothesize that sensitivity to modulation at low density/rate will mature gradually whereas listeners' ability to perceive dense spectral or fast temporal modulation will be equivalent across ages.

Methods: Twenty two participants were recruited including 11 post-lingually implanted adults (aged 50s-70s) with at least 1 year of CI experience. Prelingually-implanted children (n=11) included 5-8 year-olds with bilateral severe-profound hearing loss who received a CI prior to 18-months-old. Children were tested annually in an ongoing longitudinal study. Spectral modulation sensitivity (SMS) was measured as the smallest modulation depth (dB) for which the listener could discriminate 0.5 from 20 ripples per octave (RPO). Temporal modulation sensitivity (TMS) was measured as the minimal depth at which the listener could detect 10 Hz modulation. Spectral and temporal resolution were assessed as the maximum ripple density/modulation rate the listener could perceive when depth was fixed relative to the listeners' SMS or TMS. All testing was at 70dBA in sound-field, using a single CI in the preferred ear, employing a 3-AFC adaptive staircase procedure. Linear mixed-models were employed to assess the effect of age group on the 4 dependent measures.

Results: Significant and near significant effects of age group were found for TMS and SMS respectively with similar trajectories: immature sensitivity in 5-6 year olds relative to the other groups. There is little evidence for maturation from 7-10 years-old. In contrast there were no effects of age group on spectral or temporal resolution.

Conclusions: These findings support the study hypotheses and suggest that developmental factors beyond spectral and temporal resolution confound performance on spectral and temporal modulation tasks, in young listeners under 7 years old. This may limit the potential of standard spectral ripple or temporal modulation tasks to evaluate candidacy and device efficacy in young children.

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Th-F 49: DYNAMIC SELECTION OF ELECTRODE FIRING SEQUENCES FROM MODEL-BASED ESTIMATES OF NEURAL RESPONSES

Erin L. Bratu[1], Andrea J. DeFreese[1], Katelyn A. Berg[2], René H. Gifford[3], Jack H. Noble[1]

[1]Vanderbilt University, Nashville, TN, USA
[2]Vanderbilt University Medical Center, Nashville, TN, USA
[3]Hearts for Hearing, Oklahoma City, OK, USA

Objective: Building on our previously developed electroanatomical model (EAM) of the implanted cochlea [1], which integrates CT images and telemetry data to customize anatomical and electrical properties, we propose a novel signal coding strategy for cochlear implants (CIs). Our approach combines our EAM with an established computational auditory nerve fiber (ANF) model [2] to simulate patient-specific neural responses to electrical stimuli, enabling us to predict the number and spatial distribution of recruited ANFs as a function of stimulus current for each electrode. Using these simulations, we have developed an "n-of-m" strategy that dynamically selects the electrode firing order based on patient-specific neural activation patterns using computational modeling to target the most excitable auditory nerve fiber (ANF) populations. In this study, we present an initial performance comparison between our proposed strategy, standard Advanced Combination Encoder (ACE), and Continuous Interleaved Sampling (CIS) approaches to test our hypothesis that targeting the most excitable ANF populations can improve speech recognition for CI users.

Approach: Three adult CI users evaluated five programs: standard ACE (approximating their everyday program), CIS (as a control for familiarity effects), and three variants of our Neural-Optimized ACE (N-ACE) strategy. The first N-ACE variant added a channel reordering step to standard ACE processing, while the other two variants used alternate n values of 6 (N-ACE6) and 12 (N-ACE12), respectively. This additional reordering step identifies the firing order that maximizes ANF recruitment in each frame by combining single-pulse activation estimates with a model of ANF refractory states. For each program, participants completed word (CNC) and sentence recognition in noise (BKB-SIN) acutely after programming. All programs were implemented via the Nucleus MATLAB Toolbox and streamed through a Nucleus 6 processor to control for hardware differences.

Results: For word recognition, all N-ACE variant scores ranged from equal to 16% better than standard ACE, though none reached clinical significance. CIS scores were the lowest of all programs, ranging from equal to 16% lower than standard ACE. For sentence recognition in noise, performance varied across participants. Two participants demonstrated better performance with increasing n values (N-ACE6 to N-ACE12: 2.75-3.75 dB SNR improvement). Only N-ACE12 showed consistent improvements (1-2.5 dB SNR) over standard ACE. However, no differences between standard ACE and other evaluated programs exceeded clinical significance thresholds.

Conclusions: Initial results are promising for our proposed neural-optimized channel selection signal coding strategy, particularly given the minimal adaptation time participants were given with each program. Ongoing work includes additional testing with a greater number of participants and refinement of the optimization objective function, e.g., by incorporating patient-specific neural health and refractory period estimates.

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Th-F 50: ELECTROPHYSIOLOGY BASED SURGICAL SENSITIVITY COMPARISON BETWEEN MANUAL AND ROBOT-ASSISTED CI

Sidharta Gupta[1,3], Dyan Ramekers[1,2], Tinne Vandenbroeke[1,2], Emilie Heuninck[1,2] Griet Mertens[1,2], Vincent Van Rompaey[1,2], Marc Lammers[1,2]

[1]Dept. Translational Neurosciences, University of Antwerp
[2]Antwerp University Hospital
[3]MED-EL GmbH, Innsbruck

Minimizing trauma during cochlear implantation (CI) requires surgeons to work at the limits of their visuo-tactile feedback, particularly during the electrode insertion. Surgical techniques have been implemented to minimize insertion trauma but despite this, more than 50% of subjects lose at least 10 dB in residual hearing across frequencies, presumably due to cochlear trauma, unfavorable geometry [1] and fibrosis [2]. With more patients with residual hearing being implanted, understanding how the inner ear reacts to the electrode array is vital. Electrophysiology based monitoring presents a promising prospect for providing feedback to the surgeons during the current "black box" electrode insertion process.

The primary objective of this single center natural experiment study is to gain a better understanding of the underlying physical mechanisms and compare manual and robot-assisted electrode insertion to derive a sensitivity metric.

In this study, electrocochleography and simultaneous impedance measurements were recorded in manual and robot-assisted CI by two experienced CI surgeons using Maestro 9.0.4 based Research software (MED-EL GmbH, Innsbruck, Austria). Sixteen patients were implanted with manual electrode insertion and 10 patients were implanted with robot-assistance using Otodrive (CAScination AG, Bern, Switzerland). Continuous alternating polarity intra-cochlear electrocochleography was recorded in all patients as a response to acoustic stimuli 40 dB above the patient's pre-operative audiometric threshold at 500 Hz. In 5 patients in the manual group and all patients in the robot-assisted group, continuous impedance was simultaneously measured at the electro-cochleography recording electrode. Insertion events of start, insertion resistance, electrode release, completion of full insertion and electrode fixation were noted in time relative to recording onset (t0). Immediately after electrode fixation and during packaging, electrode sweep - alternating polarity electrocochleography measurements on all electrode contacts as a response to the same acoustic stimuli - was performed at stimuli amplitude as during insertion at 500 Hz.

We will present data on these measurements, first categorizing the different events and then comparing them between the two groups to formulate an Electrocochleography Sensitivity Index. This sensitivity index shall classify the invasiveness of electrode insertion and shed light on manual vs robot-assisted insertions. Such a metric shall be useful in providing real-time intra-operative objective feedback and assisting clinicians in understanding recurring surgical events and their impact on cochlear health.

Th-F 51: SENSITIVITY ANALYSIS OF SPEECH ENHANCEMENT FOR COCHLEAR IMPLANT (CI) USERS IN NOISY REVERBERANT ENVIRONMENTS

Sohini Saha, Leslie M. Collins, Boyla O. Mainsah

Department of Electrical and Computer Engineering, Duke University, Durham, NC, USA

Cochlear implant (CI) users face significantly greater challenges in understanding speech in reverberant and noisy environments compared to individuals with normal hearing [1]. While existing CIs incorporate noise reduction techniques, such as beamforming and signal-to-noise-based noise reduction, these techniques do not explicitly address reverberation. This limitation arises because noise reduction and reverberation suppression address fundamentally different acoustic signal characteristics. Additive non-speech noise, such as environmental sounds, differs significantly from speech, while babble noise shares some acoustic similarities with the target speaker but still remains distinct. In contrast, reverberation consists of attenuated and delayed copies of the target speaker's speech, often blending with preceding phonemes. Reverberation is more diffuse as sound reflections arrive from multiple directions, making it challenging to suppress effectively.

One widely used speech enhancement technique is time-frequency (T-F) masking, which applies a matrix of gain values to T-F representations of speech to suppress acoustic distortions. Since the ideal mask is not available in real time, it must be estimated using features extracted from the current degraded speech signal. Most of the current research focuses on leveraging machine learning (ML) models to predict the T-F mask based on these features. The spectro-temporal structure of speech varies significantly across different acoustic environments, posing challenges for the generalization of mask estimation algorithms to unseen conditions with combined noise and reverberation. Algorithms that address noise and reverberation typically perform better with acoustic features extracted from multi-microphones as they leverage spatial information to address the diffuse nature of reverberation, e.g. Gaultier & Goehring (2024) [2].

Conventional time-frequency (TF) algorithms used in speech enhancement do not inherently exploit the predictable structure of speech, posing a challenge for mask estimation models to learn an effective mask due to the significant variability in the spectro-temporal characteristics of speech. Phonemes are typically concentrated in specific frequency ranges, with vowels predominantly in the low-frequency spectrum and fricatives in the high-frequency range. Phoneme knowledge has been shown to enhance speech processing in noisy environments, though primarily in non-CI applications. Wang et al. (2016) utilized phonemes for speech separation in automatic speech recognition systems [3]. Chazan et al. (2017) proposed a mixture of experts-based deep learning approach leveraging phonemic information to handle various types of noise [4]. Building on this concept, Chu et al. (2022) introduced phoneme-based mask estimation to improve speech intelligibility for CI users in reverberant environments, leveraging phonemic structure to distinguish target speech from reverberant reflections better [5]. However, since noise and reverberation exhibit distinct characteristics, a mask estimation model trained exclusively on reverberant conditions may lack robustness in noisy reverberant scenarios.

In this work, we conduct a sensitivity analysis to investigate whether a single channel mask-estimation approach can handle both noise reduction and dereverberation or if specialized models are needed for each condition. Our experiments will assess speech intelligibility in varying combinations of reverberant rooms and noise types. To assess performance, the trained models will be used to estimate masks from speech utterances from unseen test datasets.

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Th-F 52: DELAY COMPENSATION BETWEEN ACOUSTIC AND ELECTRIC INPUTS CAN PARTIALLY RESTORE DEGRADED ITD CODING TO BINAURAL-BIMODAL (ACOUSTIC-ELECTRIC) STIMULATION

Maike Vollmer[1,2], Merle Berents[1], Andreas Schulz[2], Frank W. Ohl[2]

[1]Department of Otorhinolaryngology-HNS, University Hospital Magdeburg,
Leipziger Straße 44, 39120 Magdeburg, Germany
[2]Systems Physiology of Learning, Leibniz Institute for Neurobiology,
Brenneckestraße 6, 39118 Magdeburg, Germany,

Unilateral cochlear implants (CIs) provide functional benefits of binaural hearing in subjects with single-sided deafness (SSD-CI users). Nevertheless, directional hearing in SSD-CI users is typically poorer than that in normal hearing subjects and in subjects using bilateral CIs. This finding indicates suboptimal neural integration of unilateral CI stimulation and contralateral acoustic hearing (binaural-bimodal stimulation).

To identify the deficits of binaural-bimodal processing, we compared phenomenological aspects (tuning curves) and functional efficacy (Fisher information) of interaural time difference (ITD) coding of single neurons in the inferior colliculus of normal-hearing gerbils in response to bimodal stimulation and to two kinds of unimodal stimulation, namely bilateral acoustic and bilateral electric stimulation. To maintain acoustic sensitivity of the implanted ears and, thus, to allow within-neuron comparisons of responses across the three kinds of stimulation, electric stimuli were delivered to the round window.
ITD tuning metrics (e.g., best ITD, maximum slope) were widely dispersed in response to bimodal stimulation. At least for low pulse rates, ITD discrimination thresholds and ITD coding efficacy (Fisher information) were largely similar for both unimodal acoustic and unimodal electric stimulation, but were significantly degraded in response to bimodal stimulation. Artificially compensating for the delay between the acoustic and the electric inputs shifted the averaged bimodal ITD tuning functions towards the physiological range of ITDs and increased the Fisher information for ITD coding in neuronal populations. Despite this increase in average Fisher information, maximum Fisher information in response to bimodal ITDs remained lower than that to unimodal acoustic or unimodal electric ITDs.

Our results suggest that compensating the delay differences between acoustic and electric inputs can improve neural ITD coding in auditory midbrain and might, thus, be a suitable strategy for improving directional hearing in SSD-CI users. Nevertheless, differences in the firing patterns of the auditory nerve to acoustic and electric stimulation still pose a problem for attaining the degree of interaural correlation necessary to optimally integrate bimodal ITDs in binaural brain circuits.

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Th-F 53: VISUAL AMPLITUDE ENVELOPE BENEFITS SPEECH PERCEPTION IN COCHLEAR IMPLANT USERS: A PILOT FNIRS AND ECAP STUDY

Yi Yuan[1], Zi Gao[2], Yingying Wang[3], Shuman He[2]

[1]Department of Audiology, San José State University
[2]Department of Otolaryngology – Head and Neck Surgery, The Ohio State University
[3]Department of Special Education and Communication Disorders, University of Nebraska - Lincoln

Background: Cochlear implant (CI) users experience difficulties in speech perception, particularly in noisy environments. In adverse listening conditions, a common compensatory strategy in CI listeners is to use visual cues to assist speech perception (Stropahl & Debener, 2017). However, it is unknown whether the benefit of visual cues in CI users, measured at both the behavioral and the cortical levels, is dependent on listening environment or peripheral neural health. Previous studies have demonstrated that visual analog of the speech amplitude envelope can improve speech perception in normal hearing listeners at intermediate background noise levels (Yuan et al., 2021). The current pilot study serves to compare audiovisual benefits across noise levels and to preliminarily evaluate the associations between cortical activities and peripheral neural health.

Methods: To date, 12 subjects (twelve ears, age range = 60.2-85.7) have been recruited and tested for this study. All subjects were implanted with a Cochlear™ Nucleus® device in the test ear with full electrode insertions. Peripheral neural health was measured using two indices derived from electrically evoked compound action potential (eCAP) recordings: the interphase gap effect on the maximum slope of the amplitude growth function (IPGEslope), and the phase locking value (PLV) of 400 single sweeps presented at the maximal comfort level. IPGEslope and PLV represent neural survival and synchrony of the cochlear nerve, respectively (Gao et al., 2024). In a separate session, sentence-level speech perception performance was measured using Harvard sentences (IEEE, 1969) presented in auditory-only (AO), visual-only (VO) or audiovisual (AV) mode in both quiet and multi-talker babble noises with signal-to-noise ratios (SNR) of +5 dB and +10 dB. The extracted target amplitude envelopes were synchronized with the radius of a sphere and presented as visual stimuli on a desktop monitor. Sentence recognition accuracy was compared between results measured in AO and AV modalities. Behavioral speech perception was measured concurrently with cortical activities, recorded using functional near-infrared spectroscopy (fNIRS).

Results: A linear mixed-effect model (LMM) on speech perception scores showed that the visual analog of amplitude envelope cues improved speech perception in the SNR 10 condition, but not the SNR 5 or quiet conditions. An LMM on beta values, proxies of activation strength derived from fNIRS recordings using generalized-linear models, revealed that the results measured in the SNR10 condition showed the weakest overall cortical activation in the AO condition but the greatest AV super-additivity [i.e., AV - (AO + VO)] in auditory and visual regions of interest (ROI) among the three testing conditions. An LMM on cortical connectivity between visual and auditory ROIs demonstrated higher functional connectivity to the visual region in the SNR 10 than the SNR 5 condition in the left auditory cortex, supramarginal gyrus, and Broca's area, but this trend was not observed in the right hemisphere. Spearman correlations between eCAP measurements and beta values revealed the trends of IPGEslope and PLV being negatively associated with activities in left supramarginal gyrus and in bilateral visual regions were observed in the SNR 10 condition, albeit statistically non-significant.

Conclusion: Both behavioral and neuroimaging results suggest that the benefit of the visual amplitude envelope on speech perception is generalizable to CI users at intermediate SNR levels. Combining peripheral neural health measurements with neuroimaging is feasible in CI users and valuable in bridging the gap between research on peripheral and central neural correlates.

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Th-F 55: ELECTRICAL MODEL OF THE GUINEA PIG HEAD FOR IN-SILICO ANALYIS OF NEURAL STIMULATION BY COCHLEAR IMPLANTS

Michael Handler[1,2], Peter Baumhoff[3], Wiebke Konerding[3], Björn Michael Vey[1], Andrej Kral[3], Daniel Baumgarten[1]

[1]Biomedical Engineering Group, Department of Mechatronics, University of Innsbruck, Innsbruck, Austria
[2]Institute of Electrical and Biomedical Engineering, UMIT TIROL, Hall in Tirol, Austria
[3]Department of Experimental Otology, Hannover Medical School, Hannover, Germany

Purpose/Objective: Personalized medicine is increasingly shaping biomedical research, including cochlear implants (CIs), where patient-specific adaptation plays an increasing role. Optimizing stimulation strategies relies on assumptions about excitation sites, current-spread patterns, and stimulation parameters, which cannot be directly verified in humans. To address this, studies use computer (in-silico) models of human cochleae and in-vivo animal research. In-silico models predict excitation patterns and the impact of individual anatomical influences on stimulation outcomes. Validation is only possible via recorded telemetry data (e.g., thresholds) and indirect measures (e.g., speech comprehension). However, only animal models enable direct analysis of auditory processing from the cochlea to the brain. Still, distinguishing global patterns of cochlear excitation from downstream effects remains challenging. Species-specific auditory differences further complicate translation to human data. To combine the advantages of both the in-vivo and the in-silico approach, we present an in-silico model of the guinea pig for simulation of cochlear stimulation at single-fiber level.

Methods/Approach: Computer models derived from imaging data of guinea pig heads with implanted species-adapted custom 6 contact CIs (MED-EL GmbH, Austria) were created based on µCT scans using an adapted workflow previously described for human inner ear models [1, 2]. For simulating neural activation of cochlear nerve fibers, an established neural model was adopted [3, 4]. Model verification was performed by comparing recorded telemetry data with the outcome of corresponding simulations.

Results/Findings: The computer models generated in this work could reproduce data obtained in corresponding in-vivo experiments and allowed for a more detailed analysis of neural responses, evoked by different stimulation strategies.

Conclusions/Implications: By refining the model with animal in-vivo data and comparing it to human models, we aim to improve translatability, enhance experimental precision, and reduce the number of required animal studies. Specifically, this model will allow us to investigate how pulse shape and duration influence intracochlear excitation patterns, how adverse effects such as facial nerve stimulation can be minimized, and how local neuronal damage impacts overall excitability. Thereby, the model provides valuable tools for improving existing stimulation solutions and diagnostic possibilities as well as inventing new strategies for optimal stimulation outcome.

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Th-F 56: INVESTIGATING THE EFFECT OF ENVELOPE SAMPLING AT LOW STIMULATION RATES ON SPEECH PERCEPTION AND POWER CONSUMPTION WITH COCHLEAR IMPLANTS

Lidea Shahidi[1], Robert P. Carlyon[1], Deborah A. Vickers[2], Tobias Goehring[1]

[1]Cambridge Hearing Group, MRC Cognition and Brain Sciences Unit,
University of Cambridge, Cambridge, UK
[2]Cambridge Hearing Group, Department of Clinical Neurosciences,
University of Cambridge, Cambridge, UK

Cochlear-implant (CI) processing strategies transform an acoustic signal into a pattern of electrical pulses transmitted across the electrode array. One such processing strategy, the temporal integrator processing strategy (TIPS), uses a model of temporal masking to identify and remove stimulation pulses that are unlikely to be perceived. Although speech perception outcomes with TIPS have been mixed, with studies finding significant group-level improvements (Lamping et al. 2020) or no change (Shahidi et al. 2025) in speech intelligibility, these evaluations suggest that TIPS could remove a substantial proportion of the stimulation pattern (up to 75%) without a detriment to speech intelligibility. Such a substantial reduction in the number of stimulation pulses would considerably reduce the power required by the CI, which could extend the already limited daily device use time, improve the comfort and form-factor of the device, provide power for computationally expensive front-end algorithms, and facilitate the development of fully implantable devices. Although the potential power savings conferred by TIPS could greatly improve quality of life for CI recipients, it must be determine whether similar power savings could be achieved with a simpler adjustment to the processing strategy, namely by reducing the channel stimulation rate. Some studies of speech perception at reduced channel stimulation rates suggest that speech perception can be maintained with channel stimulation rates that are lower than the participants' clinical stimulation rate (Friesen et al. 2005; Weber et al. 2007; Brochier et al. 2017), with one study indicating that stimulation rates could be reduced to 50 pulses per second (pps) before phoneme recognition was significantly impacted (Fu and Shannon, 2002). Given the variability in the effect of stimulation rate on speech perception, it is possible that the lowest tolerable rate and therefore the maximum potential power savings may vary with each CI recipient. To determine whether TIPS-driven sampling of stimulation pulses provides any benefit to speech perception or power consumption over uniform stimulation rates, this study compares speech perception with TIPS and equivalent low stimulation rates.

Two double-blind within-subject experiments were conducted to determine 1) the listener-specific rate at which speech intelligibility worsens with decreasing pulse rate (termed the "Low Rate") and 2) whether TIPS, when presented with an overall pulse rate equivalent to the Low Rate, provides any benefits in terms of speech intelligibility. In both experiments, threshold levels (T-levels) and most-comfortable levels (C-levels) were measured for each condition and loudness was balanced across conditions prior to speech testing. The same twelve CI recipients participated in both experiments and all were recipients of Cochlear™ devices. Experiment 1 measured speech intelligibility across seven channel stimulation rates: 80, 110, 160, 240, 350, 500, and 900 pps. At each rate, consonant recognition for vowel-consonant-vowel (VCV) utterances and speech reception thresholds (SRTs) for open-set sentences in multi-talker babble noise were measured. Measures were taken acutely and no acclimatisation was provided. For each participant, the Low Rate was identified as the first rate demonstrating reduced speech recognition performance on the consonant discrimination task. Experiment 2 then measured speech intelligibility with the Low Rate, TIPS, and the participants' clinical rate. Ten minutes of acclimatisation was provided for each condition, followed by the measurement of consonant recognition for VCV utterances, vowel recognition for CVC words, and SRTs for open-set sentences in multi-talker babble noise. Results from the ongoing experiments will reveal participants' performance profiles for low rates and whether TIPS-driven sampling of stimulation pulses benefits speech intelligibility over the equivalent uniform stimulation rate.

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Th-F 57: FOCUSED STIMULATION ENHANCES MUSIC SOUND QUALITY IN COCHLEAR IMPLANT RECIPIENTS: FINDINGS FROM A FEASIBILITY STUDY

Naomi B.H. Croghan[1], Zachary M. Smith[2], Jennifer H. Torres[1], Sara I. Duran[1], Wendy B. Potts[1], David C. Kelsall[3], Allison Biever[3], Richard K. Gurgel[4], Kate Johnson[4], Christopher J. Long[1]

[1]Cochlear Americas, Lone Tree, CO, USA
[2]Cochlear Ltd., Sydney, NSW, Australia
[3]Rocky Mountain Ear Center, Englewood, CO, USA
[4]University of Utah Health, Salt Lake City, UT, USA

Introduction: Music appreciation remains a significant challenge for many cochlear implant recipients. A key barrier to delivering sufficient spectral and temporal detail required for good music perception is the intracochlear current spread associated with standard monopolar stimulation with electrodes far from the target auditory neurons. This study explores whether focused stimulation, paired with a perimodiolar electrode array, improves the interface between the stimulating electrode and auditory neurons, enhancing the perceived sound quality of music.

Methods: Twelve adults with post-lingual sensorineural hearing loss participated in this study and received a percutaneous cochlear implant with a perimodiolar electrode array. Participants were fitted with focused maps using multipolar stimulation and monopolar maps using standard procedures. After sequential take-home intervals using each mode of stimulation, participants rated overall sound quality for music samples from four different genres (classical, country, jazz, and rock). Music quality was measured using A/B paired comparisons in which the monopolar and focused stimulation programs were presented in succession. The order of program presentation was randomized and blinded.

Results: Music sound quality was rated significantly better for focused stimulation over monopolar stimulation across the study cohort. The focused program was selected more frequently, with a positive degree of preference. Some participants' preferences were influenced by their prior listening experience, but over half of the cohort showed a robust preference for focused stimulation regardless of take-home experience.

Conclusions: These early findings demonstrate that focused stimulation delivered superior music sound quality over monopolar stimulation in adult cochlear implant recipients using a percutaneous investigational device with a perimodiolar electrode array. This technology may offer promising improvements in areas of hearing performance that have been historically limited by the resolution of the electrode-neural interface.

Th-F 58: PSYCHOPHYSICAL TUNING CURVES FOR CHILDREN AND ADULTS WITH AND WITHOUT COCHLEAR IMPLANTS

S. C. Aker[1,2], C. Hem[1,2], C. R. McCallick[1], J. G. Arenberg[1,2]

[1]Mass Eye and Ear, Boston, MA, USA
[2]Harvard Medical School, Boston, MA, USA

Introduction: Frequency selectivity outcomes in cochlear implant (CI) users can be variable and often reduced when compared to people without cochlear implants. The cause is likely interaction between channels at the electrode neuron interface as well as a reduced number of healthy auditory nerves. Recent data has suggested that young, pediatric CI recipients may have more lower thresholds and better frequency selectivity than older CI users, which could indicate healthier auditory nerves.

Methods: Psychophysical tuning curves (PTCs) with a forward masking paradigm have been obtained from 17 participants, including 8 adult CI users (mean age 58 years, range 23-68 years), 3 pediatric CI users (9, 11 and 13 years), 3 adult normal-hearing (NH) controls (23, 30 and 58 years) and 3 pediatric NH controls (7, 8, and 11 years). All CI users use AB systems. Stimuli were presented to CI users via Bluetooth or to NH listeners via insert earphones. The 20 ms probe was centered at the frequency equivalent of electrode 8 and its level set to its the masking threshold in 25 dB SPL of an on-frequency, 100 ms masker. The masker was presented after a 5 ms interval. The masker was then increased to 37 dB SPL, and the corresponding masker frequency above and below the probe frequency was determined.

Results: Frequency selectivity was measured with the 1 dB bandwidth of the resulting PTCs. Pediatric CI users show a mean bandwidth of 0.18 +- 0.037 electrodes while adult CI users show a mean bandwidth of 0.25 +- 0.081 electrodes. Pediatric NH controls show a mean bandwidth of 0.098 +- 0.036 electrodes while adult NH controls show a mean bandwidth of 0.081 +- 0.060 electrodes.

Conclusions: Results show a slight improvement in mean 1 dB bandwidth of the pediatric CI users versus the adult CI users, but a smaller increase between pediatric NH controls versus adult NH controls. These results could encourage the use of CI stimulation strategies that take advantage of this improved neural health, such as focused stimulation [1].

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Th-F 59: ANALYZING ELECTROANATOMICAL MODELING TECHNIQUES FOR IMAGE-GUIDED COCHLEAR IMPLANT PROGRAMMING

Jared A. Rybarczyk, Erin L. Bratu, Jack H. Noble
Vanderbilt University, Nashville, TN, United States

Introduction: Image guided cochlear implant programming (IGCIP) is an approach that relies on image-based models of neural stimulation to determine patient-customized programming strategies [1]. A previous modelling pipeline relies on the finite difference method (FDM) to serve as a volume conduction model [2,3], while other groups have relied on the finite element method (FEM) or the boundary element method (BEM) for this purpose [4,5]. Each modeling approach has advantages, with FDM and BEM models tending to be easier to create customized meshes for new patients while FEM may allow more precise representations of the fine scale structures of the inner ear such as the Scala Media and Reissner's Membrane. All methods have a tradeoff between model resolution and field-of view (FOV) with accuracy and efficiency. In this work, we will compare predictions from FDM and FEM models constructed for live patients at various resolutions and FOV for the task of IGCIP in terms of: (a) accuracy in prediction of voltage distributions elicited by cochlear implant electrodes across the auditory nerve fibers; and (b) computational efficiency in terms of required run time.

Methods: For a set of 7 individuals, we relied on our previous pipeline to construct high resolution tissue class volumetric maps, representing the patient specific distribution of air, bone, soft tissue, neural tissue, electrolytic fluid, auditory nerve fiber bundles, and electrodes using the patient's pre- and post-operative CT images [3]. Using the existing custom FDM solver we computed FDM solutions of voltage distributions predicted in the auditory nerve fibers for each individual based on their unique anatomy and electrode position. Construction of the corresponding model meshes for the FEM and BEM models is being done using the Gmsh library [6]. Results from these methods will be reported at the conference.

Results: Based on previously used FDM models, we observe that limiting the FOV over which nodes are placed leads to faster computation with only minor (~2% on average) differences in resulting predicted voltage distribution in the spiral ganglion. Reducing the resolution of the FDM nodal distribution by 2, 4, and 8 times results in 1.7, 4.4, and 5.1% differences in predictions when compared to full resolution models.

Conclusion: Assessing which numerical PDE solving technique provides the best balance between accuracy, reliability, and computational efficiency will enable optimizing IGCIP pipelines. We report performance of FDM models and are currently in the process of performing tests on FEM/BEM models, which will be presented in full at the conference.

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Th-F 60: OPTICAL DETECTION OF BASILAR MEMBRANE DAMAGE

Joaquín Cury, Olivia Griffith, Jordan Villa, Xiaodong Tan, Claus-Peter Richter

Department of Otolaryngology, Northwestern University,
Feinberg School of Medicine, Chicago, Illinois, U.S.A.

BACKGROUND: Hearing impairment is the most common sensory deficit, affecting over 1.5 billion people worldwide. More than 430 million experience disabling hearing loss that demands rehabilitation. For severe-to-profound hearing loss untreatable with medication or hearing aids, cochlear implants (CIs) can restore some auditory perception. A CI's external sound processor converts sound into electrical signals sent to an implanted electrode array in the cochlea, stimulating the auditory nerve.

Despite their success, CI surgeries pose challenges. Inserting the electrode array can misalign or damage the cochlea, causing inflammation and additional hearing loss in up to 40% of implantations. Existing monitoring techniques rely mainly on the surgeon's tactile feedback, with no direct real-time visualization. This increases the risk of structural damage, underscoring the need for better preservation methods to maintain residual hearing and improve CI outcomes. Advances including robotic insertion, optical coherence tomography, and micro-cameras show promise, nevertheless there is still no clinical tool to visualize and continuously assess the cochlea's structural integrity during electrode insertion.

Optical-based label-free methods, such as birefringence, allow the assessment of tissue organization without the need for staining. Birefringence arises from the interaction of polarized light with anisotropic tissues, where differences in refractive indices create a slow and fast axis within the structures. In the cochlea, the basilar membrane shows birefringence due to the radial arrangement of collagen fibers, which extend from the osseous spiral lamina to the spiral ligament, perpendicular to the cochlear lumen. These fibers contribute to the mechanical properties of the membrane, which are essential for the cochlea's tonotopic frequency mapping.

In this study, we aim to evaluate whether birefringence is a sensitive and reliable marker for tissue damage, with a particular focus on the cochlea. To investigate this, we performed both qualitative and quantitative birefringence assessments on various tissues, including cornea, connective tissue, and cochlea from mouse, all exposed to laser-induced damage. These measurements explore the potential of birefringence for monitoring tissue health and its use in real-time evaluation during CI electrode insertion.

METHODS: In our study, we performed qualitative and quantitative birefringence measurements on unstained cornea, connective tissue and cochlear sections from male and female mice, sectioned at 10-20 micrometers. We obtained qualitative birefringence data using a conventional transmission-mode birefringence microscope, followed by quantitative analysis with an LC-PolScope microscope. We analysed normal cochlear samples and those exposed to various damage conditions, including laser light exposure (Omniguide CO_2 laser).

RESULTS AND CONCLUSIONS: The technique demonstrated promising results in our study, indicating its potential for assessing cochlear damage with a high sensitivity and resolution. This method has been previously employed by other research groups to evaluate the resolution of normal cochlear sections. In this context, we have shown its implementation in a clinical scenario involving cochlear damage. Further improvements will focus on evaluating these quantitative measurements in back-reflection mode.

Th-F 61: A COMBINATIONAL APPROACH USING LOMBARD EFFECT PERTURBATION AND ENHANCEMENT AS A FRONT-END SOLUTION FOR SPEECH INTELLIGIBILITY IN NOISE

Juliana N. Saba, Nursadul Mamun, John H. L. Hansen

Cochlear Implant Processing Laboratory, Center for Robust Speech Systems, Department of Electrical and Computer Engineering, The University of Texas at Dallas, Richardson, TX, USA

Recently, an alternative approach to speech enhancement was proposed to mimic Lombard Effect (LE) demonstrating significant speech-in-noise improvements for cochlear implant (CI) listeners [1-2]. In this study, the effect of signal quality on speech intelligibility is evaluated using perturbation combined and varied with a machine-learning-based speech enhancement approach [3] to simulate how perturbation would operate using a non-ideal (noisy) input (i.e., feasibility of a real-time solution).

Speech intelligibility, speech quality, and paired preference tasks using IEEE sentences for quiet, 10, and 5 dB babble noise were tested with 5 CI users in an online, self-paced experiment via CCi-Cloud (a part of CCi-MOBILE, developed by UT-Dallas). A total of 5 processing conditions were evaluated: unprocessed control, perturbation, and perturbation and enhancement combined prior to additive noise (-pre), as well as perturbation and enhancement combined and the reverse order after additive noise (-post). LE perturbation using the LOM-4+ strategy [2] acoustically mimics and exaggerates a presumed ideal (clean) input using a 4-stage traditional signal processing approach. The enhancement strategy, DCCTN (Deep Complex Convolution Transformer with Frequency Transformation), uses a U-Net architecture with additional features optimizing the magnitude and phase of the signal. Routines were processed in and passed between MATLAB and Python in an offline manner.

Average intelligibility for the perturbed-enhanced (pre-) and the enhanced-perturbed (-post) approaches in the 5 dB SNR condition, representative of ideal and non-ideal input signals respectively, were significantly higher than the control at both 10 dB and 5 dB SNR, demonstrating a restoration of speech-in-noise deficits at a higher SNR. While the performance of the perturbed-enhanced (-post) approach, simulating a real-time (non-ideal) solution, was found to be comparable, CI users preferred this combination to the enhanced-perturbed (-post) approach.

These results suggest that the perturbed signal, which is distinctly different than an enhanced signal, is susceptible to a non-ideal input yet still has the potential to improve speech-in-noise intelligibility and may provide larger benefits when enhanced.

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Th-F 62: MONITORING OF DAILY IMPEDANCE FLUCTUATIONS IN EXPERIENCED CI USERS

J. Pesch[1], M. Leblans[2], L. Beckers[1], F. Vanpoucke[1], A. Zarowski[2], K. Galvin[3], W. Wang[1], T. Bertens[1]

[1]Cochlear Technology Centre Belgium, Mechelen, Belgium
[2]European Institute For ORL, GZA Sint-Augustinus, Antwerp, Belgium
[3] HEARnet, University of Melbourne, Melbourne, Australia

In current clinical routine for cochlear implants, information about the status of the implanted electrodes is obtained during clinical visits by means of measuring the electrode impedance. As such, knowledge is lacking about the normal or abnormal daily variability of impedances while users are in their home environment. This knowledge is crucial for the application of electrode impedances in cochlear implant users as a biomarker for changes in cochlear health and/or the report of clinical events such as changes in sound quality, vertigo, tinnitus or the loss of residual acoustic hearing. The aim of this study was to collect and describe daily impedance fluctuations at the electrode contacts and in the tissue for experienced adult CI-recipients and to collect information on the health of the user via self-assessments.

Data collection was performed using a newly developed wireless measurement system on a mobile device in the recipient's home environment. The mobile app allowed the measurement of the total electrode impedance as complex impedances (ie. Impedance measurements add different timepoints of the stimulation pulse) to enable the separation of the total impedance into its subcomponents: access resistance and polarization impedance. The app can also measure transimpedance matrices and bipolar 4-point impedances to further examine near-field and far-field effects around the electrodes and in the tissue. A total of 45 experienced Nucleus CI users performed measurements of impedances and transimpedances five times per day (early morning, breakfast, lunch, evening, before powering off) for a period of 14 days followed by a period of six weeks with two measurements per day (morning, evening). To assess the clinical parameters, speech perception was monitored with a Digit-Triplet test, next to device usage logs. Data about use of medication, medical and hearing conditions of the subjects, and clinically relevant events occurring during the observation period were collected via questionnaires.

The total impedance data showed daily fluctuations with a range of more than 2kOhm in 11/45 subjects. The fluctuations of the access resistance and polarization impedance showed different cyclic daily patterns but also distinct periods of stronger fluctuations. Some changes were correlated with the device use, esp. for the polarization impedance and for changes over night. The tissue impedance (far-field) showed slower and more monotonic changes. The standard device logs were used to independently characterize impedance changes and identify unexpected strong fluctuations. The speech test results and questionnaires did not indicate any major clinical or perceptual effects during the observation period. Most of these reported events were mild or not ear related. A more detailed time-series analysis of the impedance and transimpedance data in combination with the clinical data is ongoing.

This study showed that fluctuations of electrode complex impedances can also occur in absence of events that show up in speech results or questionnaires and that impedance patterns are patient dependent. The characterization of the impedance data will help to define what normality is for an individual recipient and will help clinicians to interpret the impedance data. The results will also be useful as a baseline to further develop detection and prediction models for impedances as a biomarker.

Th-F 64: FACTORS INFLUENCING HEARING PRESERVATION AND SPEECH UNDERSTANDING: A PREDICTIVE MODELLING APPROACH

Annette Günther, Thomas Lenarz, Andreas Büchner

Department of Otolaryngology, Hannover Medical School, Hannover, Germany

Purpose: Currently, hearing outcomes with cochlear implants (CI) vary significantly between patients and cannot be reliably predicted. The reasons for these individual differences are diverse and remain insufficiently understood. They include factors such as age at implantation [1], preoperative hearing scores [2], individual cochlear anatomy, and insertion angle [3]. This project, therefore, investigates factors influencing hearing preservation and speech understanding with CI and develops models for outcome prediction.

Methods: The project analyzed data from 230 CI patients (aged 18 to 88 years) implanted at Hannover Medical School between 2009 and 2024. The target variables to predict were the postoperative Freiburg monosyllabic score one year after implantation and the pre- to postoperative change in air conduction thresholds (averaged over 125-1,500 Hz), defined as hearing preservation. The change in thresholds was scaled into three groups: <=15 dB good, >15 dB to <=30 dB moderate, and >30 dB low or no preservation [4].

The postoperative speech understanding and hearing preservation were modeled using the following data:

- Demographic data: Progression and duration of hearing loss, gender, and age.
- Preoperative tone and speech audiometry data: Low-frequency air-conduction thresholds and speech understanding (Freiburg Monosyllabic Test).
- Geometry- and surgery-related data: Use of assisted insertion systems, and insertion angle.

The dataset underwent extensive preprocessing to improve data quality. This included data cleaning, standardization, and imputation of missing values based on a detailed review of patient records and semi-automated procedures. After data preprocessing and exploratory analysis for feature selection, various models (e.g. logistic regression, decision tree, random forest) were trained and optimized using cross-validation. Finally, the performance of the models was evaluated on a separate test dataset.

Results: The analysis indicates that various factors influence hearing outcomes of CI patients. Key factors include age at implantation, preoperative maximum monosyllabic score, and insertion angle, all of which play a significant role in predicting hearing preservation and speech understanding with CI. Among the models, the random forest algorithm shows that insertion angle is the most influential factor, contributing 21% to the prediction of hearing preservation.

Conclusions: Both patient-related and surgical factors are predictive for hearing success with CI, which is in line with previous studies [1-3]. These findings can be useful for understanding individual differences among CI patients and improving cochlear implantation outcomes on a patient-specific basis. Further research is necessary to examine additional factors and optimize the predictive models.

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Th-F 65: ANATOMICAL FREQUENCY MAPS STRICTLY BASED ON THE GREENWOOD FUNCTION MAY BE SUBOPTIMAL FOR BIMODAL CI USERS

Nicole Hope Capach[1], Elad Sagi[1], René H. Gifford[2*], Mario A. Svirsky[1*]

[1] New York University Grossman School of Medicine, New York, NY, USA
[2] Hearts for Hearing, Oklahoma City, OK, USA
*Co-senior authors

Background and Objectives: The Greenwood function with Stakhovskaya correction has long been considered the gold standard for estimating the anatomical frequency at specific points in the human cochlea. However, recent research suggests that while this function is accurate for stimuli presented at threshold levels, it may not be optimal for suprathreshold levels. This study reanalyzes data from two unique studies by Gifford et al. to evaluate the effectiveness of various frequency allocation tables (FATs) in bimodal cochlear implant (CI) users, who use a CI in one ear and a hearing aid in the other ear.

Methods: We reexamined data from Gifford et al. (2017, 2022), which assessed speech perception in bimodal CI users using different FATs. These studies are unique in several ways: they obtained CT scans to determine the angular insertion depth of the most apical active electrode for 19 of the subjects, they evaluated speech perception with multiple FATs, and six of the subjects received extensive real-world experience using several of these FATs. We categorized subjects into three groups: "chronic" (N=6), who had extensive exposure to various FATs; "acute" (N=9), who were tested with many FATs but were previously only exposed to the standard FAT; and "hybrid" users of the hybrid-L cochlear implant (N=4). We analyzed which FATs resulted in top speech perception-or within 5-percentage points of the top-for three listening conditions: CI only, bimodal CI plus contralateral hearing aid, and CI plus two hearing aids.

Results: The strict Greenwood-Stakhovskaya SG frequency map never resulted in optimal performance for any of the 19 subjects under any of the three listening conditions. Its recommended starting frequency was consistently too high. The NYU level-corrected SG map, which accounts for differences in frequency-place functions when stimuli is at a comfortably loud level vs. at threshold, was optimal for 4 of the 6 chronic subjects and 4 of the 9 acute subjects. The standard clinical FAT was optimal for 2 of the 6 chronic subjects and 7 of the 9 acute subjects, likely due to their exclusive prior exposure to the standard FAT. Results will also be reported by subject category and listening condition.

Discussion: These findings indicate that the NYU level-corrected frequency-place function may offer a better approach to individualized FAT selection than the strict Greenwood-Stakhovskaya function. The NYU function appears to align more closely with optimal speech perception outcomes across various listening conditions, suggesting its potential for improving CI fitting procedures.

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Th-F 66: LOUDNESS GROWTH WITH PULSE PHASE DURATION: EFFECT OF STIMULATION MODE

Emily Spitzer[1], David Landsberger[1,2], David Bakhos[2,3], Mathew Robier[4], Bradford Backus[5], John Galvin[2,3]

[1]New York University, New York NY USA
[2]House Institute Foundation, Los Angeles CA USA
[3]University of Tours, Tours France
[4]Audilab, France
[5]Cochlear Corporation, London

In cochlear implants (CIs), loudness often grows more quickly with increasing pulse amplitude (PA) than with increasing pulse phase duration (PPD). However, differences in loudness growth with increasing PA or PPD can vary across stimulation sites and/or CI listeners (Zhou et al., 2020, 2021) and may reflect some aspect of neural health. We quantified this difference in loudness growth as "charge integration efficiency" (CIE), defined as the log difference in dynamic range (DR) in charge with increasing PPD or PA. We found substantial variability in CIE across stimulation sites and across CI listeners. In our previous studies, loudness growth was measured with broad monopolar stimulation. Focused stimulation has been previously associated with greater across-site variability in thresholds (e.g., Bierer, 2010). It is unclear how the across-site variability in CIE may differ between relatively broad and focused stimulation. In this study, CIE was measured for electrodes equally spaced along the cochlea for relatively broad or focused stimulation modes. We hypothesized we would observe greater across-site variability with focused than broad stimulation modes, which might provide greater specificity as a neural health metric. We also hypothesized that CIE across stimulation sites would be similar across modes.

Methodology was similar to that used by Zhou et al. (2020, 2021). DR was measured by increasing PA or PPD relative to a common threshold anchor until achieving maximum acceptable loudness. Cochlear device users were tested with monopolar (MP1+2) or bipolar (BP+2) stimulation modes using biphasic pulses. Oticon Medical device users were tested with monopolar (MP) stimulation mode with biphasic pulses (similar to Cochlear devices) or with distributed all-polar (DAP) with capacitive discharge.

Significantly more charge was required for relatively focused than for broad stimulation to achieve DR, whether with increasing PA or PPD. For both device types and stimulation modes, there was substantial variability in CIE across stimulation sites and CI listeners. Inconsistent with our hypothesis, the across-site variability and the across-site mean in CIE was greater with broad than with focused stimulation. Also inconsistent with our hypothesis, CIE with broad stimulation was not predictive of CIE with focused stimulation across stimulation sites. The data suggests a complicated relationship among current spread, probabilistic neural firing, and the temporal window for neural charge integration.

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Th-F 69: TAKE-HOME COCHLEAR IMPLANT PROCESSOR WITH SPECTRAL AND TEMPORAL ENHANCED PROCESSING (STEP)

D. Kovačić[1], C. J. James[2]

[1] Dept. of Physics, University of Split-Faculty of Science, Split, Croatia
[2]Cochlear France SAS, Toulouse, France

Cochlear implant users have varying capacities to use temporal and spectral cues, for example, for voice pitch and vocal tract length1. Sound coders used in CIs generally have fixed parameters such that the extent or availability of these cues cannot be individually tuned. Even when using experimental coders in the lab, live processing often has to be interrupted when parameters are changed or only a limited set of parameters can be trialed. The possibility to hand over control of certain sound coding parameters to the user would fulfill some of the requirements of personalized medicine.

To address these limitations, we developed a take-home CI processor based on the University of Texas CCi-MOBILE platform2. Real-time Spectral and Temporal Enhanced Processing3 (STEP) was implemented in an Android smartphone application. In this first version, the CI user is able to switch between ACE, the standard clinical advanced com-bination encoder, and STEP. In addition, the modulation bandwidth can be varied continuously, for example, to control temporal voice-pitch cues.

We will report representative electrode-o-grams showing the effects of varying sound coding parameters. The first author will also share his real-world experiences listening through the device. Finally, we show how the system may allow CI users further control over spectral parameters, such as varying the assignment of specific frequencies to electrodes (i.e., FATs). The system will be demonstrated at the conference.

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Th-F 70: RESTING-STATE FUNCTIONAL CONNECTIVITY IN COCHLEAR IMPLANT USERS: A FNIRS STUDY

Yingying Wang[1, 2], Yuan Yi[3], Shuman He[3], Michelle Hughes[4], Hongying Dai[5]

[1]Neuroimaging for Language, Literacy and Learning (NL3) Lab, Department of Special Education and Communication Disorders (SECD), University of Nebraska-Lincoln (UNL), NE
[2] Center for Brain, Biology, and Behavior (CB3), UNL, NE
[3] Human Auditory Evoked Potential Laboratory, Department of Otolaryngology-Head and Neck Surgery, The Ohio State University, OH
[4]Cochlear Implant Research Lab, SECD, UNL, NE
[5]Department of Biostatistics, College of Public Health, University of Nebraska Medical Center (UNMC), NE

Purpose: Cochlear implants (CIs) are the primary treatment for individuals with severe-to-profound sensorineural hearing loss. Unlike getting a pair of new glasses, the brain needs more time to reorganize in response to auditory input following implantation. Cross-modal plasticity post-CI is still not well understood. The primary goal of this research is to identify differences in resting-state functional connectivity (RSFC) be-tween CI users and sex- and age-matched hearing peers using functional near-infrared spectroscopy (fNIRS).

Methods: This study included 18 CI users (72.0±10.3 years old, 10 males, 14 collected at The Ohio State University (OSU) and 16 normal-hearing adults (68.0±8.4 years old, 6 males, 16 collected at the University of Nebraska-Lincoln (UNL). All participants underwent fNIRS scanning. During the resting-state fNIRS data collection period, participants were directed to relax and focus their eyes on a white cross on a black screen to minimize head motions. The recording time was 15 minutes. The Consonant-Nucleus-Consonant (CNC) test was administered in quiet and noise at +5 dB signal-to-noise ratio (SNR) to all 14 CI users at the OSU. All fNIRS data were first preprocessed to remove motion artifacts and superficial physiological artifacts using Satori. Then, RSFC was computed using Pearson correlations between each pair of channels. Two-sample t-tests were used to determine group differences between CI and control groups. All statistical tests were two-tailed, and the significance level was set at 0.05, corrected for multiple comparisons.

Results: RSFC between the left supramarginal gyrus and the left middle occipital gyrus was stronger in CI users than in their hearing peers, indicating the enhanced cross-modal RSFC between the speech-related brain region and visual cortex in CI users. CI users may rely on visual support to compensate for degraded auditory inputs. Moreover, RSFC between the left supramarginal gyrus and the left middle frontal gyrus was significantly correlated with CNC scores at +5 dB SNR ($r = 0.62$, 95% CI [0.13, 0.86], $p < 0.05$), but not with CNC scores in quiet.

Conclusions: The stronger functional connection between the speech-related brain region and frontal cortex supports the notion that executive function could benefit speech perception in noisy environments. These functional connectivity patterns might be helpful for optimizing auditory rehabilitation strategies.

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Th-F 71: ELECTROPHYSIOLOGICAL ASSESSMENT OF TEMPORAL ENVELOPE MODULATION ENCODING FOR THE FITTING OF COCHLEAR IMPLANTS

Elise Verwaerde[1], Julian Schott[1,2], David Wouter[1], Robin Gransier[1], Marc Moonen[2], Jan Wouters[1]

[1]ExpORL, Dept. of Neurosciences, KU Leuven, Herestraat 49/721, 3000 Leuven, Belgium
[2]STADIUS, Dept. of Electrical Engineering, KU Leuven, Kasteelpark Arenberg 10/2440, 3001 Leuven, Belgium

Several auditory potentials have been investigated in the past to objectively determine electrical stimulation parameters in cochlear implant (CI) users, however, only with limited success. One of the main reasons is that in-place clinical and previously explored methods use low-rate pulse trains to evoke the neural responses. In everyday stimulation the CI operates at pulse rates of 900-1000 pulses per second (pps). One potential measure that can be used for objective determination of stimulation parameters is the electrically evoked auditory steady-state response (eASSR). eASSRs are phase-locked responses from (sub)cortical regions of the auditory pathway and can be evoked with amplitude-modulated (AM) stimuli. Previous research shows that this measure represents temporal envelope modulation (TEM) encoding across the auditory pathway and can be measured with speech-like stimuli. Newly developed methods enable the measurement of these neural responses, evoked with high pulse rate stimuli and a clinical stimulation paradigm [900 pps and a monopolar stimulation configuration], despite the challenges posed by the stimulation artifacts that corrupt the EEG. Current approaches primarily focus on individual electrodes, yet CIs activate tonotopically organized neural ensembles of the auditory nerve through high-rate pulse trains that convey TEMs derived from acoustic inputs. Sensorineural hearing loss, however, induces degenerative changes in these neural ensembles that vary across the tonotopic map, contributing to variability in CI outcomes. When neural degeneration affects specific electrode sites, the accurate encoding of temporal modulations may be compromised. While behavioral growth function patterns across electrodes tend to be consistent, the neural encoding of TEMs exhibits substantial variability across electrodes. A systematic analysis of these neural encoding patterns is necessary to enhance CI outcomes and improve electrode placement strategies.

The goal of this study is to characterize neural TEM encoding at the level of the individual CI user and objectively determine modulation encoding across the CI array. We probe the envelope-based speech processing across the auditory pathway using 40 Hz-eASSRs derived from EEG-based objective measures in adult CI users. Twenty unilateral adult CI users with a CochlearTM Nucleus Implant participated in this study. AM stimuli were presented at 900 pps and in monopolar mode on one up to six intracochlear electrodes for one of two stimulation paradigms, a continuous and intermittent (multi-channel) stimulation paradigm. EEG was recorded with a custom BioSemi hyper-rate sampling system with a sampling frequency of 262 kHz to optimize modeling of stimulation artifacts.

Results were obtained for both stimulation paradigms within participants across EEG sessions with a correlation of .88 ($p<0.0001$). Most electrophysiological thresholds derived from the TEM growth functions were within the lowest quartile of the dynamic range and correlated with behaviorally determined thresholds (.76 ($p<0.0001$)). Furthermore, there is limited overlap in neural populations activated by individual CI electrodes during multi-channel measurements. Amplitude magnitudes indicate no integration of the stimulus over two alternating electrodes. In a follow-up study we will measure eASSRs simultaneously to a set of up to four electrodes to probe TEM encoding across the array. This study demonstrates that eASSR responses can be used to derive stimulation parameters from artifact-free growth functions in adult CI users. It seeks to develop a method to characterize neural information transmission from the ENI up to the auditory cortex, thereby advancing the precision and effectiveness of CI programming.

This work was partly funded by Cochlear Technology Centre Belgium and the Flanders Innovation & Entrepreneurship Agency through the VLAIO research grant [HBC.2019.2373; HBC.2020.2308], and partly by an SB Ph.D. grant from the Research Foundation Flanders (FWO) awarded to EV [1SF5123N].

Th-F 72: THE USE OF MICRO-COMPUTED TOMOGRAPHY IMAGES TO INVESTIGATE THE RELATIONSHIP BETWEEN THE INTERNAL AUDITORY CANAL SHAPE AND THE CLASS OF THE COCHLEA.

N. Mntungwa[1], T. Hanekom[2], R. Human-Baron[1]

[1]Department of Anatomy, School of Medicine, Faculty of Health Sciences, University of Pretoria, South Africa.
[2]Department of Electric, Electronic and Computer Engineering, Faculty of Engineering, Built Environment and Information Technology, University of Pretoria, South Africa.

Purpose/Objective: The objective of this study was to investigate whether a correlation exists between the internal acoustic canal shape and cochlear class. Additionally, the parameters used to determine the internal acoustic canal shape were used as the basis for incorporating the internal acoustic canal into three-dimensional computational models.

Methods/Approach: Retrospectively collected micro-computer tomography (μCT) scans of human temporal bones were used to collect morphological data of the internal auditory canal and the cochlea. The scans were scaled, rotated into the cochlear view and sixteen landmarks were plotted and digitised in ImageJ (Rasband) Descriptive and comparative statistics were used to describe the data obtained. Repeatability was assessed through intra- and inter-observer agreement using intra class correlation. Correlation was calculated through the Pearson's Chi-Square test to determine correlation between the variables.

Results/Findings: No evidence of a correlation between the shape of the IAC and the class of the cochlear was found (p-value = 0.336). The funnel- shaped IAC was the most prevalent shape while the sloping cochlea was the common cochlear class. Good inter- and intra-class correlation was observed between CT and μCT images.

Conclusions/Implications: This study provided the first comprehensive look at the relationship between the variations that exist in the internal acoustic canal and cochlear taxonomy.

Th-F 74: THE EVOLVING CONTRIBUTION OF EARLY AND LATER GESTURES TO SUBSEQUENT VOCABULARY OUTCOMES IN MANDARIN-SPEAKING CHILDREN WITH COCHLEAR IMPLANTS

Jianfen Luo[1], Lei Xu[1], Min Wang[1], Jinming Li[1], Linda J. Spencer[2], Shuman He[3], Ling-Yu Guo[4]

[1]Department of Otolaryngology-Head and Neck Surgery, Shandong Provincial ENT Hospital
[2]Department of Communication Disorders, New Mexico State University
[3]Department of Otolaryngology-Head and Neck Surgery, The Ohio State University
[4]Department of Communicative Disorders and Sciences, University at Buffalo

Rationale: Children with cochlear implants (CIs) tend to have difficulty developing vocabulary skills (Lund, 2016). For example, Geers et al. (2009) found that nearly 50% of children with CIs fell behind their typical peers on receptive vocabulary and 42% on expressive vocabulary at school entry. Effective early intervention may improve vocabulary outcomes for children w with CIs.

Children with typical hearing use gestures to express their communication intentions before producing spoken words. Research has shown that gestures predict later vocabulary outcomes (e.g., Rowe et al., 2012). Although gestures facilitate spoken language development, some early intervention programs for children with CIs do not explicitly target gesture skills, citing concerns that gestural (visual) communication may interfere with spoken language development (Kaipa et al., 2016). Contrary to these concerns, Bavin et al. (2018) found that early gesture skills (e.g., pointing to a dog) positively predicted expressive vocabulary size in English-speaking children with CIs at 12 to 15 months after implantation. However, their study did not examine the role of later gesture skills (e.g., pretending to wipe with a towel) in vocabulary outcomes.

In the present study, we extended Bavin et al. (2018) by examining the contribution of early and later gesture skills to subsequent expressive vocabulary size in Mandarin-speaking children with CIs. Specifically, we asked two research questions. First, are children's early and later gesture skills during the first 6 months after CI activation positively correlated with their expressive vocabulary size at 12 months after CI activation? Second, does the contribution of early and later gesture skills to later expressive vocabulary size change over time?

Method: Participants were 50 Mandarin-speaking children with CIs who received implantation before 30 months of age. At the day of CI activation and 3, 6, and 12 months after CI activation, parents endorsed the early and later gestures their children were able to produce using the infant form of The Chinese Communicative Development Inventory - Putonghua (Tardif et al., 2008). They also endorsed the words their children were able to say using the form of Early Vocabulary Inventory - Infants (Hao et al., 2008). Early and later gesture scores and expressive vocabulary size were computed for each time point.

Results and Discussion: Correlation analyses showed that, with age of CI activation being controlled, early gesture scores at 3 months after CI activation and both early and later gesture scores at 6 months after CI activation were positively correlated with children's expressive vocabulary size at 12 months after CI activation ($rs = .35\text{-}.36$, $ps<0.05$). Regression analyses using the stepwise method further revealed that, with the age of CI activation and expressive vocabulary size being controlled, early gesture scores at 3 months after CI activation were a stronger predictor than later gesture scores in accounting for children's expressive vocabulary size at 12 months after CI activation. In contrast, later gesture scores at 6 months after CI activation were a stronger predictor than early gesture scores in accounting for children's vocabulary size at 12 months after CI activation.

Our findings suggest that gesture skills that Mandarin-speaking children with CIs developed during the first 6 months after CI activation were positively associated with their subsequent vocabulary outcomes. The contribution of early and later gestures to vocabulary development varied over time. Targeting specific types of gestures at different developmental stages may be one strategy for maximizing vocabulary outcomes in children with CIs.

Th-F 75: CLINICAL EVALUATION OF FREQUENCY ALLOCATION FOR BIMODAL COCHLEAR IMPLANT USERS

Megan Eitel, **Nicole Capach, Maya Hatley, Mario Svirsky**

New York University Grossman School of Medicine, New York, NY

Purpose: To evaluate the effects of an alternative frequency allocation table (FAT) on sound quality, device satisfaction, and speech perception in experienced bimodal cochlear implant users.

Standard cochlear implant programming typically employs a default FAT with a low-frequency boundary of 188 Hz (Cochlear devices). However, emerging evidence suggests a potential anatomical mismatch between this standard low-frequency boundary and its corresponding cochlear place of stimulation. This mismatch may be addressed by implementing a higher low-frequency boundary.

This study compares outcomes between the standard FAT (188 Hz low-frequency boundary) and an experimental FAT (438 Hz low-frequency boundary). Participants undergo three behavioral testing sessions, completing speech perception assessments in both bimodal (hearing aid plus cochlear implant) and cochlear implant-only conditions with both FATs. Following each of the first two sessions, participants complete a one-month adaptation period with the newly programmed map (438 Hz after visit 1, 188 Hz after visit 2). Upon study completion, participants may choose to retain their preferred FAT. Electrode array placement is verified through CT imaging in eligible participants.

This ongoing investigation has implications for optimizing programming strategies in experienced cochlear implant users. Superior outcomes or user preference for the non-standard FAT would suggest that anatomical frequency mismatch remains relevant even after extended device use. In such cases, minimizing this mismatch through alternative FAT strategies could enhance both satisfaction and auditory performance in long-term cochlear implant users.

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Th-F 76: COCHLEAR MALFORMATIONS IMPACT THE RELATIONSHIP BETWEEN CURRENT SPREAD AND NEURAL RESPONSE AT THE ELECTRODE-INTERFACE IN CHILDREN WITH COCHLEAR IMPLANTS

C. J. Sabourin[1], S. G. Lomber[1], J. Negandhi[2,3], S. L. Cushing[2,3,4], B. C. Papsin[2,3,4], K. A. Gordon[2,3,4,5]

[1] Department of Biological and Biomedical Engineering, McGill University, Montreal, Canada,
[2] Department of Otolaryngology-Head and Neck Surgery, The Hospital for Sick Children, Toronto, Canada.
[3]Archie's Cochlear Implant Laboratory, Hospital for Sick Children, Toronto, Canada.
[4]Department of Otolaryngology-Head and Neck Surgery, University of Toronto, Toronto, Canada.
[5]Department of Communication Disorders, Hospital for Sick Children, Toronto, Canada.

Purpose: The objective of this study was to evaluate the impact of inner ear malformations on the ability of cochlear implants (CI) to deliver current to the auditory nerve. CI electrodes each target sites along the auditory nerve to represent sound level, frequency, and timing. However, CI current paths may be affected by malformation of the cochlea, hindering stimulation of auditory neurons and/or causing stimulation of overlapping populations of auditory neurons which distort auditory cues. Although many children with abnormal cochleae have received CIs, their devices can be difficult to program, and their outcomes can be variable. This study aimed to test the hypotheses that children with abnormal inner ear shape show: 1) wider CI current spread, 2) reduced neural responsivity, and 3) higher programmed electrical stimulation parameters and, 4) poorer behavioural outcomes than peers with normal inner ear structure.

Methods: CI stimulation parameters, electrophysiological recordings, transimpedance measurements, as well as audiometry and speech perception tests, if available, were assessed for a large cohort of children with bilateral CIs with either typically developed inner ears (n=184) and inner ear malformations (n = 27). A mixed effects modelling analysis was conducted. Child-specific models of voltage spread in the inner ear were developed by optimizing the tissue properties of 3-D models of the implanted cochlea to accurately reproduce the spread of current in the child's cochlea as measured by the transimpedance measurements.

Results: Wider current spread was observed in children with malformed cochleae compared to those with typical cochleae, particularly in the mid (mean(SE) = 1.43(0.43), $p < 0.05$) and apical regions of the electrode array (mean(SE) = 1.18(0.53), $p < 0.05$). This increased spread was associated with higher auditory nerve electrophysiological thresholds and lower amplitude growth function slopes in the malformed cochlea (mean(SE) = 0.83(0.59), $p < 0.05$ for thresholds; mean(SE) -0.76(0.39), $p < 0.05$ for slopes), but no such relationship was observed in the typical inner ear ($p = 0.21$ for thresholds; $p = 0.42$ for slopes). Higher CI electrical stimulation levels were required for electrodes with wider current spread in both groups. For the malformed cochlea, C-levels (mean(SE) = 5.50(0.77), $p < 0.001$) and T-levels (mean(SE) = 5.55(0.49), $p < 0.001$) were significantly elevated, while in the typical cochlea, C-levels (mean(SE) = 3.31(0.82), $p < 0.001$) and T-levels (mean(SE) = 4.73(0.38), $p < 0.001$) were also increased. Behavioral outcomes were more variable in children with inner ear malformations. Child-specific models of voltage distribution highlighted that the spread of current to the auditory nerve is highly influenced by individual differences in the intracochlear environment.

Conclusion: Abnormal spread of current from a CI occurs in children with inner ear malformations. Programming protocols should be tailored accordingly to optimize auditory nerve stimulation to support hearing development.

Th-F 77: SEMI-OBJECTIVE COCHLEAR IMPLANT FITTING WITH ELECTRICALLY EVOKED AUDITORY STEADY-STATE RESPONSES RESULTS IN GOOD SPEECH PERCEPTION

Julian Schott[1,2], Elise Verwaerde[1], Robin Gransier[1], Marc Moonen[2], Jan Wouters[1]

[1] ExpORL, Department of Neurosciences, KU Leuven
[2] STADIUS, Department of Electrical Engineering, KU Leuven

Cochlear implant (CI) fitting, i.e., the tuning of the stimulation parameters of the CI, is performed in an interactive procedure between the CI recipient and a healthcare professional. Effective communication between both parties is essential to ensure time efficiency and achieve optimal fitting results, such as improved speech perception with the CI. Although there are more than one million CI recipients worldwide, all of whom require regular fitting sessions throughout their hearing restoration journey, identifying the fitting parameters that lead to optimal CI performance remains challenging. The variability in CI recipients, and 'fitting philosophies' of different healthcare professionals have so far prevented the definition of a systematic fitting protocol with reliable results in CI performance. Consequently, there is a great interest in using neural responses to systematically determine and verify CI stimulation parameters, even more so in populations where communication is challenging, such as children.

Electrically evoked auditory steady-state responses (EASSRs) are neural responses following continuous CI stimulation. They are particularly interesting, as they can be used to quantify the responsiveness of the auditory pathway to the temporal envelope modulations of the CI stimulation [Luke et al. (2015) - 10.1016/j.heares.2015.02.006], which has shown to be correlated with speech perception in noise conditions of CI recipients [Gransier et al. (2020) - 10.1097/AUD.0000000000000783].

Recent advances in CI stimulation artifact removal have enabled the use of EASSRs, evoked with clinically relevant stimulation parameters, for objective fitting [Schott et al. (2023) - 10.1109/TBME.2023. 3316838]. In this study, we present a semi-objective fitting protocol that utilizes EASSRs to determine the threshold stimulation levels of CI recipients. We applied the protocol to eight CI recipients and analyzed the results using various performance indicators. Furthermore, we created CI maps (a structure, summarizing CI stimulation parameters) based on the determined 'EASSR thresholds' and tested speech perception in both quiet and noisy conditions. Preliminary results indicate that, even without any training period, the CI recipients performed equally well with the systematically and objectively created maps compared to their optimized daily CI maps.

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Th-F 78: LEVERAGING INTERAURAL TIME DIFFERENCES FOR IMPROVED SPEECH LOCALIZATION IN COCHLEAR IMPLANT USERS USING CCI-MOBILE

Samuel Oghenetega Okei, **John H. L. Hansen**

University of Texas at Dallas, Cochlear Implant Processing Lab, Center for Robust Speech Systems (CRSS-CILab), Richardson, TX, USA

There is growing interest in advancing the scientific understanding of and technology needed for speech localization research for cochlear implant users [1] [2]. Research suggests that cochlear implant users experience a degradation in their ability to localize sound compared to normal-hearing individuals [2]. This is attributed to an inability to capture interaural time differences, with any remaining speech localization capabilities being attributed to the retention of interaural level differences [2]. The assumption is that finding a way to better leverage ITD cues is the solution necessary to improve speech localization in cochlear implant users.

This study aims to develop a system for use with the CCi-MOBILE research platform that enables researchers to electrically introduce and control ITDs on an input audio stream [3]. This system allows researchers to introduce ITD delays in microseconds on a per-channel basis, as well as leverage other CCi-MOBILE's technological capabilities to introduce individual user-defined stimulation rates per channel to explore CI listener perception in ITD research. Our solution also supports electrode place matching through the cochlear implant user's map, providing researchers with the needed flexibility and customizability to apply different ITDs on each channel to explore new questions within this research space [2] [4]. The goal is to improve speech localization abilities in cochlear implant users by leveraging ITD cues, which are known to be important for sound localization in normal-hearing individuals [1].

To validate this system both electrical system verification and CI user validation experiments are carried out. Verification tests focus on confirming the expected signal output when ITDs are introduced, while validations compare the speech localization accuracy observed when using this new system to the existing speech localization ability available with commercial CIs. Results from both tests will be presented and subject tests show promise indicating an ability to introduce and control ITDs within the CCi-MOBILE.

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CIAP 2025 Attendee List

Victor	Adenis	victor_adenis@meei.harvard.edu
Sumit	Agrawal	sumit.agrawal@lhsc.on.ca
Martijn	Agterberg	martijnagterberg@gmail.com
Scott	Aker	scottaker6@gmail.com
Niels	Albrecht	niels.albrecht@stud.uni-goettingen.de
Obada	AlQasem	oalqasem@umd.edu
Jonas	Althoff	Althoff.jonas@mh-hannover.de
Sean	Anderson	seanderson@cochlear.com
Nick	Apollo	Nicholas.Apollo@advancedbionics.com
Julie	Arenberg	julie_arenberg@meei.harvard.edu
Justin	Aronoff	jaronoff@illinois.edu
Niyazi	Arslan	narslan@asu.edu
Dorothée	Arzounian	dorothee.arzounian@mrc-cbu.cam.ac.uk
Marie-Luise	Augsten	marie-luise.augsten@oeaw.ac.at
Seba	Ausili	s.ausili@miami.edu
Test	Award	marketing@granlibakken.com
Mahan	Azadpour	mahan.azadpour@nyulangone.org
Gizem	Babaoglu	gizem.babaoglu.demiroz@vumc.org
Siwei	Bai	siwei.bai@tum.de
Annesya	Banerjee	annesya_banerjee@g.harvard.edu
Hanne	Bartels	hanne.bartels@sickkids.ca
Deniz	Baskent	d.baskent@rug.nl
Dietmar	Basta	dietmar.basta@rz.hu-berlin.de
Uwe	Baumann	uwe.baumann@ukffm.de
Peter	Baumhoff	baumhoff.peter@mh-hannover.de
Prajna	Beladakere Krishnamurthy	prajnab2@illinois.edu
Heval	Benav	heval.benav@medel.com
Katie	Berg	katelyn.a.berg@gmail.com
Joshua	Bernstein	jgbern@yahoo.com
Madeleine	Beyer	madeleine@womeninsound.com
Prabuddha	Bhatarai	prabuddha.bhatarai@utdallas.edu
Addison	Billing	ab2712@cam.ac.uk
Anhelina	Bilokon	abilokon@umd.edu
Agudemu	Borjigin	dagu@wisc.edu
Patrick	Boyle	patrick.boyle@advancedbionics.com
Erin	Bratu	erin.l.bratu@vanderbilt.edu
Jeroen	Briaire	j.j.briaire@lumc.nl
Ioana	Brill	ioana.brill@rub.de

Stefan	Brill	stefan.brill@medel.de
Ian	Bruce	ibruce@ieee.org
Craig	Buchman	buchmanc@wustl.edu
Andreas	Büchner	buechner.andreas@mh-hannover.de
Nadine	Buczak	buczak.nadine@mh-hannover.de
Emily	Burg	emily.burg@vumc.org
Cherith	Campbell-Bell	cherith.campbellbell@rinri-therapeutics.com
Corinne	Cancila	corinne_cancila1@baylor.edu
Nicole	Capach	nicole.capach@nyulangone.org
Bob	Carlyon	bob.carlyon@mrc-cbu.cam.ac.uk
Laurel	Carney	Laurel_Carney@URMC.rochester.edu
Carmen Marie	Castañeda González	carmen.castaneda@tum.de
Josef	Chalupper	josef.chalupper@advancedbionics.com
Xiuhua	Chao	xiuhuachao@gmail.com
Monita	Chatterjee	monita.chatterjee@boystown.org
Chen	Chen	Chen.Chen@advancedbionics.com
Gwangjin	Choi	gjchoi@to-doc.com
Aristeidis	Choustoulakis	a.choustoulakis@lumc.nl
Yoojin	Chung	yoojin.chung@gmail.com
Miranda	Cleary	micleary@umd.edu
Debbie	Colesa	djmorris@umich.edu
David	Corina	dpcorina@ucdavis.edu
Justin	Cottrell	justin.cottrell@yale.edu
Naomi	Croghan	ncroghan@cochlear.com
Albert	Croner	albert.croner@tum.de
Joaquin	Cury	joaquin.cury@northwestern.edu
Nimesha	Dantanarayana	ndantanaraya@wisc.edu
Lisa	Davidson	davidsonls@wustl.edu
Evelien	De Groote	evelien.degroote@mrc-cbu.cam.ac.uk
Onhintz	de Olano Dieterich	onhintz.deolanodieterich@medel.com
Lucrèce	de Villars	lucrecedevillars@gmail.com
Andie	DeFreese	andrea.j.defreese@vanderbilt.edu
Alexey	Demyanchuk	demyanchuk.alexey@mh-hannover.de
Stephen	Dennison	stephen.dennison@medel.com
James	Dias	diasj@musc.edu
Meg	Dillon	mdillon@med.unc.edu
Andrew	Dimitrijevic	andrew.dimitrijevic@sunnybrook.ca
hilal	Dogan	Hilal.Dogan@nottingham.ac.uk
Sara	Duran	sduran@cochlear.com
Bob	Dwyer	robert.dwyer@advancedbionics.com
Megan	Eitel	eitelmm@gmail.com

Wafae	El Guerouani	wafae.elguerouani@gmail.com
Wayne	Ellis	info@audiologycentral.co.uk
Jenna	Felder	jenna.felder@medel.com
Natalie	Field	nfield@umd.edu
Charles	Finley	charliefinley.1@gmail.com
Tim	Fleiner	tim.fleiner@uniklinik-freiburg.de
David	Friedmann	drfriedmann@gmail.com
Johan	Frijns	j.h.m.frijns@lumc.nl
Robert	Froemke	robert.froemke@med.nyu.edu
Qian-jie	Fu	qfu@mednet.ucla.edu
Juan-Daniel	Galeano-Otalvaro	juandaniel.galeanootalvaro@kuleuven.be
Jane	Gallacher	jg2075@cam.ac.uk
John	Galvin	jgalvin@hifla.org
Phillip	Gander	phillip-gander@uiowa.edu
Zi	Gao	zi.gao@osumc.edu
Charlotte	Garcia	charlotte.garcia@mrc-cbu.cam.ac.uk
Aditi	Gargeshwari	gargeshwari2@wisc.edu
Carolyn	Garnham	carolyn.garnham@medel.com
Lutz	Gärtner	gaertner.lutz@mh-hannover.de
Etienne	Gaudrain	etienne.gaudrain@cnrs.fr
Clement	Gaultier	clement.gaultier@pasteur.fr
Eleni	Genitsaridi	eleni.genitsaridi@rinri-therapeutics.com
Marlies	Geys	marlies.geys@usz.ch
Bobby	Gibbs	bgibbs5@wisc.edu
Melanie	Gilbert	melanie.gilbert@ucsf.edu
Katelyn	Glassman	Katelyn.Glassman@medel.com
Pedro	Goncalves Gomes	pedro.goncalvesgomes@medel.com
German	Gonzalez	german.gonzalez@advancedbionics.com
Karen	Gordon	karen.gordon@utoronto.ca
Matthew	Goupell	goupell@umd.edu
Caroline	Grady	cbgrady@icloud.com
Andreas	Griessner	andreas.griessner@uibk.ac.at
Francois	Guerit	Francois.Guerit@mrc-cbu.cam.ac.uk
Annette	Günther	koch.annette@mh-hannover.de
Jia	Guo	1506739587@sjtu.edu.cn
Yoonhee	Ha	yhha@to-doc.com
Destinee	Halverson	dhalve@uw.edu
Volkmar	Hamacher	volkmar.hamacher@advancedbionics.com
Michael	Handler	michael.handler@uibk.ac.at
Stefan	Hans	Stefan.Hans@medel.de
John	Hansen	john.hansen@utdallas.edu

Eleanor	Harding	e.e.harding@rug.nl
Kelly	Harris	harriskc@musc.edu
Douglas	Hartley	douglas.hartley@nottingham.ac.uk
Maya	Hatley	maya.hatley@nyulangone.org
Sabine	Haumann	Haumann.Sabine@mh-hannover.de
Melissa	Hazen	melissa.hazen@sickkids.ca
Shuman	He	shuman.he@osumc.edu
Charles	Hem	charleshem@g.harvard.edu
Ariel	Hight	ariel.hight@nyulangone.org
Laura	Holden	laurakholden@wustl.edu
David	Horn	david.horn@seattlechildrens.org
Chengjie	Huang	chuang88@umd.edu
Michelle	Hughes	mhughes3@unl.edu
Rene	Human-Baron	rene.baron@up.ac.za
Clifford	Hume	Hume@uw.edu
Raabid	Hussain	rhussain@cochlear.com
Junewoo	Hyun	hjw3152@to-doc.com
Anna	Ishchuk	anna.ishchuk@sickkids.ca
Jussi	Jaatinen	jussi.o.jaatinen@helsinki.fi
Marine	Jambois	marinelegwood@gmail.com
Wendy	James	wsjames@uw.edu
Huan	Jia	huan_jia_orl@163.com
Michael	Johns	mikejohns15@gmail.com
Swarali	Joshi	swarali.joshi@utdallas.edu
Sang Beom	Jun	juns@to-doc.com
Randy	Kalkman	r.k.kalkman@lumc.nl
Simon	Kennedy	kennedy.simon@gmail.com
Spea	Ker	brandon.ewan@gmail.com
Matthijs	Killian	matthijskillian@hotmail.com
Doo Hee	Kim	dhkim@to-doc.com
Sangwoo	Kim	tkddn8632@to-doc.com
Liat	Kishon Rabin	lrabin@tauex.tau.ac.il
Wiebke	Konerding	konerding.wiebke@mh-hannover.de
Damir	Kovacic	Damir.Kovacic@pmfst.hr
Andrej	Kral	kral.andrej@mh-hannover.de
Heather	Kreft	plumx002@umn.edu
Harish	Krishnamoorthi	hkrishnamoorthi@cochlear.com
Matthias	Kuhl	matthias.kuhl@imtek.uni-freiburg.de
Aditya	Kulkarni	aditya.kulkarni@boystown.org
Bernhard	Laback	Bernhard.Laback@oeaw.ac.at
David	Landsberger	david.landsberger@nyulangone.org

Sean	Lang	slang@hifla.org
Nienke	Langerak	n.c.langerak@lumc.nl
Taylor	Lawson	taylor.lawson@utdallas.edu
Allison	Leach	allison_leach1@baylor.edu
Carolina	Leal	cl841@cam.ac.uk
Kara	Leyzac	leyzac@musc.edu
Will Yuhang	Li	li2746@wisc.edu
Mackenzie	Lighterink	mackenzie.a.lighterink@vanderbilt.edu
Rachel	Lim	rachel.lim@sickkids.ca
Ruth	Litovsky	ruth.litovsky@wisc.edu
Wai Sun	Liu	wsl34@cam.ac.uk
Christopher	Long	clong@cochlear.com
Valerie	Looi	valerie@spiraltx.com
Xin	Luo	xluo38@asu.edu
Richard	Lyon	dicklyon@google.com
Mohammad	Maarefvand	maarefvand@wisc.edu
Bert	Maat	a.maat@umcg.nl
Olivier	Macherey	macherey@lma.cnrs-mrs.fr
Boyla	Mainsah	boyla.mainsah@duke.edu
Devon	Major	devon.major@boystown.org
Coline	Marché	coline.marche@gmail.com
Michael	Marzalek	mike@mikemarz.com
Paul	Mayo	paulmayo@umd.edu
Caylin	McCallick	cmccallick@meei.harvard.edu
Carolyn	McClaskey	mcclaske@musc.edu
Gabriel	McDerment	gjm9891@nyu.edu
Ashish	Mehta	ashish.mehta@advancedbionics.com
John	Middlebrooks	j.midd@uci.edu
Kyou-Sik	Min	ceo@to-doc.com
Filip	Miscevic	filip.miscevic@mail.utoronto.ca
Shimin	Mo	shimin.mo@mail.utoronto.ca
Aaron	Moberly	aaron.c.moberly@vumc.org
Behnam	Molaee	bmolaee@cochlear.com
Abbie	Mollison	amolliso@purdue.edu
Fuzzy	Murray	fuzzymurray@granlibakken.com
Anil	Nagathil	anil.nagathil@rub.de
Hideko	Nakajima	heidi_nakajima@meei.harvard.edu
Jonathan	Neukam	jd.neukam@vumc.org
Christopher	Nguyen	ckn140030@utdallas.edu
Peter	Nopp	peter.nopp@medel.com
Terry	Nunn	Terry.Nunn@gstt.nhs.uk

Samantha	O'Connell	samantha.oconnell@nirx.net
Heonjeong	OH	heonjeong36@gmail.com
Ode	Ojowu	Ode.Ojowu@advancedbionics.com
Samuel	Okei	Soo200001@utdallas.edu
Argelio	Olivera	Argelio.Olivera@advancedbionics.com
Andrew	Oxenham	oxenham@umn.edu
Itunu	Oyebamiji	itunumo2@illinois.edu
Gianpaolo	Palo	gpalo@cochlear.com
Chhayakanta	Patro	cpatro@towson.edu
Ellen	Peng	ellen.peng@boystown.org
Richard	Penninger	richard.penninger@medel.com
Ronen	Perez	perezro@zahav.net.il
Joerg	Pesch	jpesch@cochlear.com
Sandeep	Phatak	s.a.phatak@gmail.com
Sandra	Prentiss	s.prentiss@med.miami.edu
Abigail	Proctor	aproctor5@lamar.edu
Tobias	Rader	Tobias.Rader@med.uni-muenchen.de
Suhrud	Rajguru	s.rajguru@miami.edu
Dyan	Ramekers	D.Ramekers@umcutrecht.nl
Valluri	Rao	vvrmrao@gmail.com
Yehoash	Raphael	yoash@umich.edu
Lina	Reiss	reiss@ohsu.edu
Matthew	Richardson	mlrichar@uci.edu
Claus-Peter	Richter	cri529@northwestern.edu
Gretta	Richter	margaret_richter@med.unc.edu
Tania	Rinaldi Barkat	tania.barkat@unibas.ch
Calvin	Roberts	cal.roberts@arpa-h.gov
Eric	Rodriguez	rodri796@purdue.edu
Nicole	Rosskothen-Kuhl	nicole.rosskothen-kuhl@uniklinik-freiburg.de
Floris	Rotteveel	florisrotteveel@hotmail.com
Jay	Rubinstein	rubinj@uw.edu
Jared	Rybarczyk	jared.a.rybarczyk@vanderbilt.edu
Carina	Sabourin	carina.sabourin@sickkids.ca
Elad	Sagi	elad.sagi@nyulangone.org
Sohini	Saha	sohini.saha@duke.edu
Marina	Salorio-Corbetto	ms878@cam.ac.uk
Reinhold	Schatzer	reinhold.schatzer@medel.com
Erik	Schebsdat	erik.schebsdat@medel.de
Rachel	Scheperle	rachel-scheperle@uiowa.edu
Jan	Schnupp	jschnupp@cuhk.edu.hk
Julian	Schott	Julian.Schott@kuleuven.be

Magdeline	Schwarz	mmschwarz8@gmail.com
Konrad	Schwarz	konrad.schwarz@medel.com
Maureen	Shader	mshader@purdue.edu
Lidea	Shahidi	lidea.shahidi@mrc-cbu.cam.ac.uk
Bob	Shannon	robertvshannon@gmail.com
Soowon	Shin	swshin@to-doc.com
Leanne	Sijgers	leanne.sijgers@usz.ch
Jeffery	Skidmore	jeffrey.skidmore@medel.com
Richard	Smith	richard-smith@uiowa.edu
Ghislain	Sofack	ghislain.sofack@uniklinik-freiburg.de
Andrey	Soulby	a.soulby@nhs.net
Tony	Spahr	Tony.Spahr@advancedbionics.com
Emily	Spitzer	emily.spitzer@nyulangone.org
Thomas	Stainsby	tstainsby@cochlear.com
Brent	Sterckx	brent.sterckx@kuleuven.be
Josh	Stohl	josh.stohl@medel.com
H. Christiaan	Stronks	h.c.stronks@lumc.nl
Natalia	Stupak	natalia.stupak@nyulangone.org
Myung-Whan	Suh	drmung@naver.com
Lukas	Suveg	lsuveg@wisc.edu
Mario	Svirsky	mario.svirsky@nyulangone.org
Brett	Swanson	bswanson@cochlear.com
Marko	Takanen	marko.takanen@medel.com
Viral	Tejani	viral.tejani@UHhospitals.org
Tanvi	Thakkar	tthakkar@uwlax.edu
Leo	Thieme	leo.thieme@medel.com
Jochen	Tillein	Jochen.Tillein2@medel.com
Nicole	Tomassi	ntomassi@meei.harvard.edu
Ritva	Torppa	ritva.torppa@helsinki.fi
Jennifer	Torres	jtorres@cochlear.com
Rosalie	Uchanski	r.uchanski@wustl.edu
Luna	Valentin	lvalent@stanford.edu
Anne	van Alphen	a.van_alphen@lumc.nl
Anna	Vavakou	anna.vavakou@med.uni-goettingen.de
Ilja	Venema	i.m.venema@lumc.nl
Elise	Verwaerde	elise.verwaerde@kuleuven.be
Debi	Vickers	dav1000@cam.ac.uk
Louis	Villejoubert	lv362@cam.ac.uk
Julianna	Voelker	jvoelker@hjf.org
Maike	Vollmer	maike.vollmer@med.ovgu.de
Minh	Vu	minh.q.vu@vanderbilt.edu

Yingying	Wang	yingying.wang@unl.edu
Greg	Watkins	gwatkins@coch
Deena	Wechsler-Kashi	deenawk@gmail.com
Tobias	Weißgerber	tobias.weissgerber@unimedizin-ffm.de
Edward	Wersocki	edwersocki@gmail.com
Harley	Wheeler	wheel488@umn.edu
Nicholas	Winterling	nicholas.winterling@gmail.com
Jennifer	Wittman	jennifer.k.wittman@gmail.com
Dietmar	Wohlbauer	dm.wohlbauer@gmail.com
Tina	Worman	worman@uw.edu
Jan	Wouters	jan.wouters@kuleuven.be
Xinyi	Yao	xinyixy.yao@mail.utoronto.ca
Yang-Soo	Yoon	yang-soo_yoon@baylor.edu
Hazem	Younis	hfy190000@utdallas.edu
Yi	Yuan	yi.yuan@sjsu.edu
Ladan	Zamaninezhad	ladan.zamaninezhad@medel.com
Katharina	Zenke	katharina.zenke@medel.com
John	Zhang	johnz@mit.edu
Jun	Zhang	johnny.jun.zhang@gmail.com
Qinjie	Zhang	spzuo99@hotmail.com
Yixuan	Zhang	zhang.yixuan@mh-hannover.de
Yue	Zhang	yuezhang@cochlear.com
Jun	Zhang	johnny.jun.zhang@gmail.com
Stefan	Zirn	stefan.zirn@hs-offenburg.de