**Introduction:** Speech perception performance following cochlear implantation (CI) varies substantially in children. Although cochlear substrate prior to implantation is a presumed factor in implant outcomes this has never been directly demonstrated. Objective: To use intraoperative round window (RW) electrocochleography (ECoG) at the time of implantation as a quantitative measure of residual cochlear physiology and to correlate the results with speech perception outcomes in a pediatric population.

**Methods:** The physiological metric used was the “total response” defined as the sum of responses across a series of frequencies (250, 500, 750, 1000, 2000 and 4000 Hz) at 90 dB nHL (97-107 dB SPL). Stimuli were delivered through insert earphones and recordings were made with a clinical ABR machine. Speech perception was evaluated after at least 9 months of implant use with the phonetically balanced kindergarten (PB-k) open set speech perception test. Because this test requires the subjects to be age and developmentally advanced, the population studied had only a few children implanted under the age of two. The PB-k scores were compared to ECoG total response and other clinical and bioaudiometric variables using multiple linear regression analysis in order to construct a parsimonious model for predicting speech outcomes in implanted children.

**Results:** Postoperative PB-k scores were significantly correlated with ECoG total response ($r^2=0.34$, $p=0.004$). Other significant predictors of speech perception performance in univariate analyses included residual hearing, duration of CI use and age at testing. When all four of these predictors were combined in a multiple linear regression, only the ECoG total response remained significant. Hierarchical multiple linear regression identified a model for speech perception performance that included pre-operative PTA, duration of CI use, and ECoG total response that was able to predict about half of the variance in PB-k scores (adjusted $r^2=0.49$, $p=0.002$).

**Conclusion:** Intraoperative ECoG recordings show a strong correlation between cochlear physiology and speech performance in children, which has long been assumed but not previously measured. Among other uses, the ability to account for a high degree of variance with a relatively simple measure can have a benefit in many studies, because in the face of a large variance in outcomes a prohibitively large N may be required to show a significant effect.

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2University Of North Carolina At Chapel Hill, Department Of Otolaryngology/Head And Neck Surgery, Chapel Hill, NC USA; 3Ohio State University, Department of Otolaryngology - Head & Neck Surgery, Columbus, OH USA
Electric Charge Requirements of Pediatric Nucleus Recipients with Normal and Abnormal Inner Ear Anatomy

H. K. Slager, AuD¹, T. A. Zwolan, Ph.D.¹

¹University of Michigan, Otolaryngology, Ann Arbor, MI USA

Topic: Basic Research

Keywords: Anatomy, Sound Processing, Speech Coding

Introduction: Little data exists regarding average psychophysical responses and the stability of these responses over time in children with normal or abnormal inner ear anatomy. One longitudinal study reported that pediatric programming levels vary significantly across programming centers. This highlights the need to collect data to aid clinicians in programming difficult to test populations. Objective: The aim of this study was to calculate mean electric charge requirements and charge variability over time in children with normal and abnormal inner ear anatomy.

Methods: This study was a retrospective review of pediatric Nucleus device recipients at a large tertiary care clinic who underwent surgery prior to 60 months of age. Subjects included children with normal or abnormal inner ear anatomy (Enlarged vestibular aqueduct (EVA), hypoplastic cochleae, incomplete partition type I or II, common cavity, and narrow internal auditory canals). Psychophysical measurements analyzed were threshold (T) and comfort (C) levels obtained at approximately 6 and 24 months post-activation. Threshold and comfort levels were converted to units of charge per phase (nC). Mean charge requirement and variability over time was calculated for each anatomical subgroup. Mean charge requirement for each subgroup was compared to data for children with normal anatomy and comparisons were made across anatomical subgroups. Typical mapping parameters (strategy, pulse width, pulse rate, maxima), number of useable electrodes, sound field detection thresholds, and demographic information (pre-operative hearing thresholds, communication mode) for each subgroup were also analyzed and compared.

Results: Mean electric charge requirements and variability over time for pediatric Nucleus device recipients with normal cochleae, EVA, hypoplastic cochleae, incomplete partition type I and II, common cavity, and narrow internal auditory canals will be presented. Data analytics will include comparison of electric charge requirements of each anatomical subgroup versus normal cochlear anatomy, and comparison of electric charge requirements across anatomical subgroups. Typical mapping parameters and demographic information will be presented for each anatomical subgroup.

Conclusion: The determination of programming levels (T/C levels) can be difficult to accomplish in some patients, particularly in young children and children with abnormal cochlear anatomy. Furthermore, little data is available to aid clinicians in setting mapping parameters for children with abnormal cochlear anatomy. This study provides mean threshold and comfort levels for a large group of pediatric Nucleus cochlear implant recipients with normal or abnormal cochlear anatomy. This information is valuable because it provides data that may aid audiologists in the clinical management of these challenging groups of patients. More investigation is needed to correlate electric charge requirement with performance outcomes.

Cochlear Americas¹, MedEl Corporation², Advanced Bionics Corporation³
Introduction: Currently there is no guideline regarding bone conduction amplification for children with unilateral aural atresia. Research has suggested that delayed treatment for hearing loss can result in speech and language impairments. The purpose of this study was to examine the relationship between bone conduction amplification use and speech and language delays in children with aural atresia.

Methods: Male and female subjects, 16 total, were included in this study if they were between 3 and 6 years of age and had unilateral or bilateral conductive hearing loss due to aural atresia. All subjects underwent an audiology exam, which included an analysis of pure tone air and bone conduction, with speech thresholds for each ear when possible using picture identification word recognition and tympanogram, and a speech and language evaluation using the Preschool Language Scale 4 to assess language skills and the Expressive and Receptive One-Word Picture Vocabulary Tests (EOWPVT, ROWPVT) for vocabulary skills. A parent or legal guardian completed the Children’s Outcomes Worksheet.

Results: We found that subjects who were fit before the age of one show better compliance with use of bone conduction amplification and exhibited fewer delays in speech and language abilities. Interestingly, among those with speech and language delays those with right-sided atresia had significantly more severe delays.

Conclusions: Findings from this study highlight a relationship between side of atresia, time of first fit with bone conduction device, compliance in device use, and speech and language abilities in children with atresia. In an effort to obtain a larger sample size we are expanding the study to include additional subjects from another southern California speech and hearing center.
The Role of Hand-Dominance on Speech Intelligibility Performances in Patients with Unilateral Cochlear Implantation

C. H. Raine, MD,BS,MS,FRCS , A. Goomany1 , M. S. Miah1

1Yorkshire Auditory Implant Service, Bradford, West Yorkshire United Kingdom

Topic: Rehabilitation/Educational Aspects

Keywords: Speech and Language Development with CI

Introduction: Hand-dominance may define which ear is responsible for transmission of speech, musical and cognitive information. Efficacy of cochlear implantation (CI) is usually based on assessment of speech intelligibility performances. This can be influenced by a number of factors including patients age, aetiology of deafness, duration of deafness and cognitive function. Cerebral dominance has been suggested as an important factor determining the side of implant surgery. Hand-dominance laterality is an indirect determinant of cerebral dominance. Literature is very limited on the role of hand-dominance on efficacy of unilateral CI surgery. Objective: To evaluate the role of hand-dominance on the efficacy of CI in relation to the side of implantation based on outcomes of speech intelligibility performances.

Methods: Post-lingually deafened patients with unilateral CI were studied. Data was collated from electronic records and CI audit database. Patients were selected according to defined criteria. For uniformity, speech intelligibility performances were assessed pre and post-operatively using the Bamford-Kowal-Bench (BKB) sentences. For the purpose of this study, BKB scores at 12 months post-operatively were analyzed. Statistical analysis was conducted using the Statistical Package for the Social Sciences (version 22.0.0).

Results: 294 patients met the study inclusion criteria with a median age of 54 years (range 16 - 89 years). 217 (73.8%) patients were right handed, 51 (17.3%) were left handed and 26 (8.8%) were excluded based on hand-dominance alone (could not be assessed or mixed-handedness). Overall, 67% of patients had CI on the dominant hand side and 33% on the non-dominant side for various reasons including patient preference and clinical decision due to previous middle ear/mastoid surgery on the dominant side. The mean post-operative BKB scores were 78% (right-sided CI, right-dominant), 83% (left-sided CI, left-dominant), 69% (left-sided CI, right-dominant) and 76% (right-sided CI, left-dominant). However, there was no statistically significant difference between the groups (Kruskall-Wallis H=6.93, Chi-square p=0.074163, p>0.05). Interestingly, there is significant difference in post-operative BKB scores between dominant sided versus non-dominant sided CI in male patients (n=91, 87% vs n=51, 71%, p=0.0381) in contrast to female patients (n=89, 74% vs n=37, 81%, p=0.0843), respectively. On univariate and multivariate analysis no significant difference noted between dominant and non-dominant sides of implantation (p=0.079 and p=0.471, respectively).

Conclusions: Hand-dominance is an important factor for decision making with regards to the side of CI from patient’s perspective. However, from this study, it does not appear to affect the efficacy of CI assessed using the BKB sentences for speech intelligibility performances. These findings may be of some use in the management of children identified for unilateral CI surgery.
ACI2014
Auditory Brainstem Development in Children Receiving Different Devices In A Simultaneous Bilateral Implant Procedure
Stephanie. Jewell, BS 1 Blake. C. Papsin, MD,BS,MS 1,2, Sharon. L. Cushing, MD,BS,MS 1,2, Karen. A. Gordon, BS,MS,Ph.D 1,2,3

1 Hospital For Sick Children, 2 University of Toronto, 3 University of Toronto

Keywords Objective Measures

Introduction: Simultaneous bilateral cochlear implantation has been shown to support symmetric development of the auditory brainstem when the same device is used bilaterally.

Objective: In the present study, we asked whether auditory brainstem development would be affected by implantation of two different electrode arrays: a pre-curved array and a straight array with the same receiver stimulator.

Methods: Twenty-eight children were implanted with a pre-curved array in one ear and a straight array from the same manufacturer in the other in the same surgery. Electrically evoked auditory brainstem responses (EABRs) were collected at three time-points: the first week post-activation, 3 to 6 months post-activation, and 9 to 12 months post-activation. EABRs were evoked by biphasic single pulses delivered at 11Hz from the apical electrode (#20) and measured at a midline cephalic location (Cz) referenced to each earlobe in separate recording channels. Stimuli were provided at levels which were comfortably loud and evoked equal amplitude wave eV amplitudes (peak to trough) from each side. Wave eV latencies and amplitudes were marked and analyzed using repeated measures ANOVAs for time, device and ear effects. Results: Stimulus protocols resulted in consistent EABR wave eV amplitudes which did not significantly differ between devices (p<0.05) or change over time (p>0.05). EABR eV latency, on the other hand, significantly decreased between initial measures (p<0.05) and follow up measures with no effects of device or which ear was implanted with the straight array (p>0.05).

Conclusion: Despite the use of two different devices, children receiving bilateral cochlear implants simultaneously show symmetric auditory brainstem development during initial stages of implant use. Further analysis of this group will determine whether brainstem development varies with residual hearing and surgical approach.
Etiology of Single Sided Deafness in Children with Congenital and Acquired Unilateral Deafness

R. L. Beck, Dr. med.¹, S. Arndt, Prof. Dr.¹, A. Aschendorff, Prof. Dr.¹, F. Hassepa, Dr. med.¹, T. Wesarg, Dr. ing.¹, R. Laszig, Prof. Dr. Dr. h.c.¹

¹Medical Center - University Of Freiburg, Department Of Oto-Rhino-Laryngology, Freiburg, Germany

Topic: Surgery/Medical

Keywords: New Indications, Young and Very Young Children, Inner Ear Malformation

Introduction: Cochlear implantation in adults affected by single sided deafness or asymmetric hearing loss is on its way to become a standard of care due to the positive outcome documented. The effect of treatment of the same disorder in children is still very unclear. The incidence of single sided deafness in children is estimated between 0.04 to 5 % dependent on the age of hearing loss (congenital or peri-/postlingual) and the spectrum of causative mechanisms is decisively different compared to adults. Previous studies found a deficiency of the auditory nerve (hypoplasia or aplasia) in up to 18% of patients with bilateral deafness. The aim of this study was to evaluate the etiology in children with congenital and acquired SSD.

Methods: 42 children presenting at a tertiary referral center 2009-2014 with congenital (n=20) or acquired (n=22) unilateral deafness have been evaluated for cochlear implantation by electrophysiology (BERA, electrocochleography, promontory test where applicable), audiometry and imaging (MRI, CT). Rehabilitation by cochlear implantation has been performed, where agreed on by the legal guardians after extensive counseling and if medically reasonable.

Results: The age at time of presentation varied greatly and ranged from 2-15.6 years for children with congenital unilateral deafness and 4.9-18 years for acquired SSD (time of deafness 0.3-10 years). This is noteworthy as we should be able to detect children with congenital unilateral deafness reasonably early by NHS. 13 out of 20 congenitally deaf children show a hypoplastic or aplastic cochlear nerve and were not deemed to be good candidates for rehabilitation by CI, CMV-infections where described in 3 children. The causative agents were much more diverse in 22 children with acquired deafness: In 5 cases, a EVA-syndrome could be found, 4 suffered from labyrinthitis, 3 from mumps. 4 out of 4 guardians of eligible congenital deaf children opted for CI (all have been implanted), 19 of 20 eligible children with acquired deafness opted for CI (12 have been implanted; others are in the process to be implanted).

Conclusion: Analysis of CT and MRI scans is essential to diagnose the cause of unilateral deafness. This holds true especially for children with congenital unilateral deafness as a very high percentage show cochlear nerve deficiency. If rehabilitation by cochlear implant is an option to be considered, diagnosis and counseling have to occur at an earlier age to yield optimal results.
Introduction: In the past, CI in certain inner ear anomalies was used to be a contraindication, it has been determined that these group of children benefit from CI. However, surgical risk factors and outcome of the children need to be counseled with the parents.

Objective: To differentiate various inner ear anomalies with the aid of CT and MRI. Selection of electrode array and planning surgery. To manage possible surgical complications.

Methods: The inner ear anomalies encountered were large vestibular aquaduct (LVA), incomplete partition type I (IP-I) incomplete partition type II (IP-II), hypoplastic cochlea. Temporal CT and MRI were studied to identify the anomalies.

Results: In IP-I patients we encountered severe gusher, in IP-II patients and LVA patients we encountered oozing of CSF. The presence of these group of anomalies introduce additional risks of surgery and potential complications. Therefore, it is important to diagnose the anomaly. At the same time, the benefit of CI in these group of patients limited.

Conclusion: Our experience, in inner ear anomalies surgical results, complications and hearing outcomes will be discussed. The selection of electrode, CSF management, facial nerve course need to be planned before surgery.
Session 2: Combining Electric and Acoustic Stimulation: Binaural Hearing and/or Hearing Preservation

ACI2014

Bimodal Stimulation in Infants: Is There a Benefit to Language Development?

A. C. Moberly¹, S. Nittrouer¹

¹Ohio State University, Otolaryngology, Columbus, OH USA

Topic: Rehabilitation/Educational Aspects

Keywords: Children and Recommended Rehabilitation, Speech and Language Development with CI

Introduction: Simultaneous bilateral cochlear implantation is increasingly being performed in infants with profound sensorineural hearing loss, with the assumption that bilateral electric hearing will optimize language outcomes. However, many of these children likely have some low-frequency residual hearing that may benefit from a period of bimodal stimulation (cochlear implant with contralateral hearing aid). This presentation will review for clinicians the theoretical underpinnings of language development that may benefit from bimodal stimulation. Language development data from an ongoing longitudinal study of children who received cochlear implants will be presented.

Methods: Fifty-five children who received cochlear implants while under the age of 3 years were included. Language development data were examined for these children, now having just finished second grade (age 8 ½ years). Twenty-six of these children experienced at least one year of bimodal stimulation around the time of receiving their implants. All children were assessed using measures of phonological processing, working memory, vocabulary knowledge, word reading, reading comprehension, grammar abilities, and nonword recognition. Results were compared between the children who experienced a period of bimodal stimulation around the time of implantation (Bimodal) and those who did not (CI-only).

Results: The Bimodal group had better average scores than the CI-only group for all language measures assessed. The groups were found to be equal on average socioeconomic status and age of identification of hearing loss. Average age of receiving first implant was slightly later for the Bimodal group. Pre-implant pure tone average (PTA) was slightly better for children with Bimodal experience (97 dB HL) versus CI-only (107 dB HL); however, further analysis showed no effect of pre-implant PTA on language measures.

Conclusion: A period of bimodal stimulation for infants receiving cochlear implants appears to provide an advantage for language development, even on measures of language collected after second grade. This advantage is likely due to the fact that bimodal stimulation provides more refined spectral signals, even if only in the low frequencies. This spectral structure most likely facilitates development of well-defined phonological categories, which is essential to acquisition of higher-order language abilities. These findings, along with an understanding of the theoretical underpinnings of language development, suggest the need for further examination of the benefits of a period of bimodal stimulation for children receiving cochlear implants.
Changes in Perceived Listening Effort and Difficulty with Bimodal Stimulation

H. W. Siburt, Ph.D., AuD

1University Of South Florida, Communication Sciences And Disorders/Behavioral And Community Sciences, Tampa, FLORIDA USA

Topic: Audiology

Keywords: Bimodal Hearing, Contralateral Hearing Aid Use, Outcomes

Introduction: This double blind study investigated the effects of hearing aid programming in bimodal listeners.

Objective: The purpose of this study was to explore the effectiveness of bimodal programming methods in adult cochlear implant recipients, and determine if programming the hearing aid with a low frequency emphasis changes one's speech in noise, music and prosody perception.

Methods: This study included 10 adults with bilateral sensorineural hearing loss, who are unilateral cochlear implant recipients. All participants were experienced cochlear implant users (> 6 months). Participants attended four study sessions each one month apart. During those sessions outcome testing was them completed including the CNC, BKB-SIN, AZ-Bio, the UW-CAMP, and the Florida Affect Battery prosody subtests. Effort and difficulty ratings are conducted after each test in all listening conditions throughout the study using a visual analog scale. Following outcome testing a hearing aid was provided fit with one of the two study programming methods. The experimental fitting protocols used in this study are NAL-NL2 and a Low Frequency emphasized program based on NAL-N2 with a 1000Hz upper frequency cut off.

Results: Effort: Analysis of effort ratings was completed using a mixed-effects linear model. There were no associations between effort and listening condition indicated on the BKB-SIN, CNC, AZ-BIO and UW-CAMP. Significant differences in effort were seen on the FAB. Listening condition was significantly associated with effort on the EPD subset of the FAB. There were no associations between difficulty and listening condition indicated on the BKB-SIN, CNC, and the AZBIO. Listening condition was marginally associated with difficulty on the UW-CAMP. Listening condition was marginally associated with difficulty on the NEPD subset of the FAB.

Conclusion: Results indicate significant bimodal benefit over the CI only condition in music and prosody perception as well as a significant reduction in effort and difficulty. Bimodal benefit was observed with objective measures of speech in noise, music and prosody. Additionally, the amount of perceived effort and difficulty decreased significantly in the bimodal condition for all subjects on the prosody measures. Furthermore, study results suggest a significant bimodal benefit for individuals with only minimal measureable hearing thresholds. Although the current study was conducted using adult participants results are applicable to all ages of cochlear implant recipients. This reduction when compared to listening with the cochlear implant alone reflects the importance electro-acoustic simulation in areas outside of our traditional speech perception measures. Determining clinical devices recommendations and programming methods to reduce listening effort and difficulty allow reallocation of those efforts to learning and critical developmental tasks in the pediatric population.
Benefit of Wireless Hearing Assistance Technologies Designed to Function with the Hearing Aid and Implant Sound Processor of Bimodal Users

M. Morais-Duke, AuD¹, J. Wolfe¹

¹Hearts For Hearing, Audiology, Oklahoma City, OK USA

Topic: Audiology

Keywords: Bimodal Hearing

Introduction: Many cochlear implant recipients use a sound processor on the implanted ear and a hearing aid on the opposite ear (i.e., bimodal users). Although bimodal use can improve performance in difficult situations, many bimodal recipients still struggle in challenging situations. Hearing assistance technology (HAT) has been shown to improve performance in these difficult situations, but until now, it has been quite problematic to use HAT to simultaneously deliver audio signals of interest to both the hearing aid and the implant sound processor. Objective: This study evaluated the potential benefits of wireless HAT systems designed to deliver audio signals directly to a contemporary cochlear implant sound processor and a power behind-the-ear hearing via proprietary 2.4 GHz digital wireless radio frequency (RF) transmission.

Methods: Ten bimodal cochlear implant recipients participated in this study. Speech recognition was evaluated over a mobile telephone, in a noisy classroom, and over a television while subjects used their hearing aids and cochlear implants alone and also as they used these devices along with wireless HAT. Speech recognition in the classroom was evaluated with AzBio Sentences presented at 65 dBA at the location of the subject. A wireless digital RF remote microphone was placed eight inches directly in front of the loudspeaker used to deliver the sentences. Classroom noise was presented from four loudspeakers located in the corners of the room. Sentence recognition was evaluated in quiet and at multiple noise levels, 50, 55, 60, 65, 70, 75, and 80 dBA. Speech recognition over a mobile telephone was evaluated with one full list of recorded CNC words per condition. Word recognition was evaluated both in quiet and in the presence of a 60 dBA classroom noise signal. Speech recognition over the television was evaluated with the audio-visual version of the City University of New York sentences. The level of the sentences was 65 dBA at the subject location. Sentence recognition was measured in quiet and in the presence of classroom noise at 60 dBA. In each of the aforementioned conditions, speech recognition was evaluated with use of the participant’s hearing aid and cochlear implant alone and also with use of wireless HAT. Furthermore, a battery of subjective questionnaires was administered to evaluate the potential benefit of use of these hearing assistance technologies in real world settings. The questionnaires included the APHAB, the SSQ, and survey designed by the examiners in this study.

Results: The bimodal users in this study realized a significant improvement in speech recognition in quiet and in noise with use of the HAT.

Conclusion: Use of wireless HAT results in improvement of subjective and objective speech recognition in quiet and in noise of bimodal users in challenging listening situations.
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Cortical Benefits of Bimodal Hearing in Children with Asymmetric Hearing Loss
M. Polonenko, BS,MCISc1,2, S. Jiwani1,2, B. Papsin1,3, K. Gordon1,2,3

1Hospital For Sick Children, Otolaryngology, Toronto, Ontario Canada; 2University of Toronto, Institute Of Medical Science, Toronto, Ontario Canada; 3University of Toronto, Otolaryngology - Head And Neck Surgery, Toronto, Ontario Canada

Topic: Audiology
Keywords: Bimodal Hearing, Objective Measures, Outcomes

Introduction: Unilateral cochlear implant (CI) use promotes speech and language development in children, but does not preserve normal activity patterns in the developing auditory cortex. While these children were traditionally left deprived of sound in the opposite non-implanted ear, many who have accessible acoustic hearing on that side now use a hearing aid in order to hear from both ears. Although this combined electric and acoustic (i.e., bimodal) hearing can restore bilateral stimulation, we are asking whether bimodal hearing can prevent the abnormal reorganization seen in unilateral CI users and restore normal-like patterns of cortical activity. Therefore, we aim to determine whether wearing a CI and a hearing aid can promote normal-like cortical development of bilateral pathways in children with asymmetric hearing loss.

Methods: Eight children with asymmetric hearing loss received bimodal input for 2.0 ± 0.4 years. Etiology of hearing loss included one child with a diagnosis of bacterial meningitis, two with cochleovestibular abnormality, one with mastoiditis, and four of unknown origin. We recorded electroencephalographic measures of cortical activity across 64-cephalic electrodes evoked by 250Hz acoustic clicks and biphasic electric pulses in 36ms trains presented at a rate of 1Hz. To assess whether bimodal stimulation promotes normal-like cortical activity patterns, we are using a beamformer imaging tool developed in our laboratory to suppress the CI artifact and localize underlying neural activity (dipoles) of the cortical waveforms.

Results: Preliminary results indicate that bimodal stimulation evokes a variety of waveforms of different morphologies when evoked by electric versus acoustic stimulation. Differences in the strength and location of dipole activity will be measured, and the hemispheric lateralization and aural preferences will be calculated for electric and acoustic stimulation.

Conclusion: Evoked cortical activity patterns will illustrate whether bimodal stimulation in children with asymmetric hearing loss can promote auditory cortical development in the bilateral auditory pathways. COI: Cochlear Corporation

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The Use of an Integrated Electric-Acoustic Sound Processor in Children with Low Frequency Residual Hearing

S. Neumann, AuD1, J. Wolfe1

1Hearts For Hearing, Audiology, Oklahoma City, OK USA

Topic: Technology

Keywords: EAS, Cochlear Implant Hardware

Introduction: The acoustic cues of speech, spoken from a whisper to a shout, occur over a range of frequencies (i.e. 250-8000 Hz) and intensities that fluctuate from softer than 50 dB SPL to as loud as 80 dB SPL (Pearsons et al., 1977). The primary goal of any auditory sensory device is to provide an audible and comfortable speech signal to the individual wearing the device. The benefits of utilizing low frequency hearing in combination with electric stimulation through an integrated sound processor have been well documented within the literature for adults. Having access to an integrated sound processor in the pediatric population may not only improve the overall speech and hearing performance associated with electric-acoustic (EAS) hearing, but it may also improve wearing compliance. The benefits of binaural low frequency hearing may include improved localization, speech understanding in complex listening environments as well as reverberation (Dunn et al., 2010; Gifford et al., 2010; Gifford et al., 2014, 2013). Historically, fitting options for EAS hearing have been limited and often cumbersome for the pediatric population requiring amplification of residual low frequency hearing through a conventional in the ear hearing aid in combination with the external cochlear implant sound processor. Objective: The objective of this study was to evaluate the performance and wearing satisfaction of pediatric recipients who utilize an integrated sound processor.

Methods: Eight pediatric subjects aged 7 to 16 years old (mean = 9 years old) who presented with functional low frequency hearing were fitted with an integrated EAS sound processor. To assess the importance of low frequency hearing, test metrics included evaluation of AzBio sentences in quiet (50 and 60 dBA presentation levels) and in noise (+5 dB and +10 dB SNR) with electric only hearing and with use of EAS stimulation. The CHILD, LIFE, and SSQ questionnaires were also administered to evaluate subjective benefit in everyday life.

Results: Results indicate statistically significant improvements in speech perception and subjective satisfaction while utilizing the integrated EAS sound processor relative to use of electric-only hearing.

Conclusion: EAS, as delivered by the integrated sound processor, is a viable option for pediatric recipients who possess residual low-frequency hearing.
Evaluation of the Hybrid Cochlear Implant System: Clinical Trial Results
W. H. Shapiro, AuD

New York University School Of Medicine, NYU Cochlear Implant Center, New York, NY USA

Topic: Technology

Keywords: EAS

Introduction: Results of a multicenter clinical trial evaluating the hybrid cochlear implant (CI) system in the United States will be presented. The first of its kind, FDA approved, hybrid cochlear implant system facilitates high-frequency electric stimulation through the hybrid implant, while amplifying low-frequency acoustic information through an integrated electric – acoustic sound processor. Objective: The objective of this multicenter pivotal study was to evaluate the safety and effectiveness of the hybrid cochlear implant system for the treatment of sensorineural hearing loss, characterized by a normal to moderate range in the low frequencies and a severe to profound loss in the high frequencies.

Methods: Fifty subjects were implanted with the hybrid cochlear implant system across 10 implanting centers in the United States. To assess the importance of maintaining low frequency hearing while restoring access to high frequency hearing, test metrics included: CNC Words, AzBio Sentences in noise (+5 dB SNR), music perception and subjective measures on satisfaction. Additionally, for the first time in a multi-center cochlear implant study, hearing thresholds were monitored longitudinally.

Results: Results indicate statistically significant pre- to postoperative improvements in speech perception and subjective satisfaction while in the everyday listening condition. Music perception performance remained unchanged from the preoperative condition of best fit hearing aids indicating that the low frequency cues for music perception were preserved. Audiometrically, a majority of subjects (90%) maintained levels of measurable hearing. For subjects who were able to utilize the integrated sound processor, a significant increase in speech perception performance was observed when acoustic information was combined with electric stimulation. For those who did not utilize the integrated sound processor, speech perception performance significantly exceeded the preoperative condition with hearing aids.

Conclusion: Electric-acoustic stimulation, as delivered by a hybrid cochlear implant system, is a viable option for individuals with residual low-frequency hearing and severe to profound high-frequency hearing loss. Results indicate that a cochlear implant electrode array can be inserted within the cochlea while maintaining useful levels of acoustic low-frequency hearing in a majority of individuals.

COI: Cochlear Americas

Introduction: Loss of residual hearing post implantation involve trauma to macroscopic elements of the cochlea and program cell death of sensory cells

Objective: To dissect molecular mechanisms involved in loss of residual hearing post CI and identify therapeutic actions

Methods: In-vitro and animal model of cochlear implantation were used to evaluate mechanisms involved in apoptosis of hair cells and support cells post implantation

Results: Multiple pathways are involved in cell death of sensory cells. These pathways are different in support cells as compared to hair cells.

Conclusion: Preservation of residual hearing is possible by developing appropriate drug therapies that interfere with program cell death pathways.
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Benefit of a Wireless Hearing Assistance Technology for Understanding Speech over the Television

J. A. Wolfe, Ph.D.¹, M. Morais-Duke, AuD¹

¹Hearts For Hearing, Audiology, Oklahoma City, OK USA

Introduction: Cochlear implant recipients often report difficulty understanding speech from the television. There are no published studies that have examined the benefit of using a wireless hearing assistance technology (HAT) designed to improve speech understanding over the television. Objective: This study assessed the ability of implant recipients to understand speech from a television with and without a proprietary HAT designed for use with the television. This HAT device wirelessly transmits the audio signal from the television directly to a receiver integrated into the recipient's sound processor via proprietary 2.4 GHz digital wireless radio frequency (RF) transmission.

Methods: The recognition of speech from a television was evaluated for 15 unilateral and bilateral cochlear implant users. Performance was assessed while they used their sound processor alone and also as they used their sound processor with a wireless HAT device designed to directly transmit the audio signal of the television directly to the participants' sound processor. Sentence recognition was assessed in two conditions: 1) the sound processor alone with everyday processing enabled, and 2) the sound processor and use of a digital wireless RF HAT system designed for use with the television. The accessory mixing ratio of the processor was set to 1:1 for both conditions. The settings of the HAT device were set to the manufacturer's default parameters. All assessments were completed in a living room-type environment. The speech signal was presented from a High Definition LED 37-inch television located directly in front of the subjects (0-degree azimuth). Classroom noise was presented from four loudspeakers located in the corners of the room. The level of the speech signal was 65 dBA at the location of the subject. Sentence recognition was evaluated in quiet and in the presence of the competing noise signal. Two full lists (12 sentences each) of audio-visual version of City University of New York (CUNY) sentences were presented in each test condition. This study included four conditions: 1) Use of the cochlear implant sound processor alone in quiet 2) Use of the cochlear implant sound processor and the HAT device in quiet 3) Use of the cochlear implant sound processor alone in noise 4) Use of the cochlear implant sound processor and the HAT device in noise

Results: Repeated measures analysis of variance was used to analyze the data collected in this study. This analysis indicated that speech recognition in quiet and in noise was significantly better with use of the wireless HAT system when compared to performance with the cochlear implant sound processor alone.

Conclusion: Use of a proprietary HAT technology featuring 2.4 GHz digital wireless radio frequency (RF) transmission and designed for television use results in significant improvement in sentence recognition in quiet and in noise.
Introduction: Cochlear implant recipients frequently experience difficulty understanding speech in noise. Use of remote microphone hearing assistance technology may improve implant recipients’ performance in noisy environments. Objective: This study assessed the ability of implant recipients to understand speech in quiet and in noise with a proprietary remote microphone technology that features 2.4 GHz digital wireless radio frequency (RF) transmission and that was developed for use with a commercially available cochlear implant sound processor.

Methods: Speech recognition of 15 cochlear implant users was evaluated while they used their sound processor alone and also as they used their sound processor with a digital wireless microphone, a system that uses digital RF transmission to wirelessly deliver a signal of interest captured at the microphone directly to a 2.4 GHz antenna integrated into the sound processor. Sentence recognition was assessed in two conditions: 1) the sound processor alone with everyday processing enabled, and 2) the sound processor (with everyday processing enabled) and a digital wireless RF remote microphone system. The accessory mixing was set to 1:1 for both conditions. The settings of the digital wireless RF remote microphone system were set to the manufacturer’s default parameters. All assessments were completed in a classroom environment (25’3” by 24’8” by 9’). The speech signal was presented from a loudspeaker located directly in front of the subjects (0-degree azimuth). Classroom noise was presented from four loudspeakers located in the corners of the room. The wireless remote microphone was placed 8 inches away from the center of the diaphragm of the loudspeaker used to present the sentences. The level of the speech signal was 85 dBA at the wireless remote microphone and 65 dBA at the location of the subject. Sentence recognition was evaluated in quiet and at multiple noise levels, 50, 55, 60, 65, 70, 75, and 80 dBA. The aforementioned noise levels were the same at the remote microphone and at the location of the subject. One full list of AzBio sentences was presented in each test condition.

Results: Repeated measures analysis of variance was used to analyze the data collected in this study. This analysis indicated that subjects experienced a substantial decrease in sentence recognition in the presence of competing noise. However, speech recognition in quiet and in noise was significantly better with use of the wireless remote microphone system when compared to performance with the cochlear implant sound processor alone.

Conclusion: Use of a proprietary remote microphone technology featuring 2.4 GHz digital wireless radio frequency (RF) transmission and designed for a commercial cochlear implant sound processor results in significant improvement in sentence recognition in quiet and in noise in a classroom environment.
Adaptive Directional Microphone Benefit for Speech Understanding in Noise for Advanced Bionics Recipients

J. Gilden¹, M. L. McDonald¹, S. Taxman¹

¹Houston Ear Research Foundation, Houston, TX USA

Topic: Audiology

Keywords: Outcomes, Fitting

Introduction: Speech understanding in background noise is a challenge for cochlear implant recipients. Use of a proprietary advanced adaptive directional microphone (ADM) system that can be activated when the user needs to hear a talker face-to-face in noisy situations is a new option available to some implant recipients. The new ADM technology emphasizes sounds in front of the listener while reducing noise at the side and back. This study is a part of an ongoing multi-center clinical study to determine the benefits of this proprietary ADM in adult cochlear implant recipients. Objective: To demonstrate the benefits of a proprietary ADM technology for understanding speech in noise when the speaker is directly in front of the listener.

Methods: A within-subjects design evaluates speech understanding in noise with and without the ADM. AzBio sentences were presented at 0-degree azimuth and continuous speech spectrum noise was presented at 180-degree azimuth. Using their everyday listening program, subject AzBio sentence score was obtained first in quiet. Then subjects were tested in noise to determine a signal-to-noise ratio (SNR) that yielded approximately half of the score obtained in quiet. Subjects were tested again using the same SNR with the ADM turned on. AzBio sentence scores in noise are compared between the everyday and ADM conditions to determine the benefit of the ADM for understanding a speaker face-to-face in noise.

Results: Initial data reveal significant benefit of the ADM for speech understanding in noise. Benefit is evident in unilateral and bilateral implant recipients as well as in bimodal listeners. Benefit is irrespective of baseline performance.

Conclusion: The proprietary ADM affords listeners significant improvements in speech understanding in noise. It offers another integrated option to help implant users manage hearing challenges encountered in their daily lives.
Benefit of a Wireless Telephone Accessory Device for Understanding Speech over the Telephone in Quiet and in Noise

M. Morais-Duke, AuD¹, J. Wolfe¹

¹Hearts For Hearing, Audiology, Oklahoma City, OK USA

Topic: Audiology

Keywords: Assistive Listening Devices

Introduction: Cochlear implant recipients frequently encounter difficulty understanding speech over the telephone. There are no published studies examining the benefit cochlear implant recipients may receive when using wireless hearing assistance technology (HAT) for telephone use. Objective: This study assessed the ability of implant recipients to understand recorded speech over the telephone in quiet and in noise with a proprietary wireless HAT designed for telephone use. This wireless HAT serves as an interface to transmit signals to and from Bluetooth-enabled mobile telephones and delivers audio signals to and from the recipient’s sound processor via proprietary 2.4 GHz digital wireless radio frequency (RF) transmission.

Methods: The speech recognition of 15 unilateral and bilateral cochlear implant users was evaluated while they used a mobile telephone with their sound processor alone and also as they used their sound processor with a digital wireless HAT, a system that uses digital RF transmission to wirelessly deliver audio signals of interest from mobile telephones directly to a 2.4 GHz antenna integrated into the sound processor. Sentence recognition was assessed in six conditions: 1) In quiet with the sound processor alone with the telephone receiver held next to the microphone of the participant’s sound processor 2) In quiet with the sound processor alone with the telephone receiver held next to the participant’s sound processor with the telecoil enabled 3) In quiet with the audio signal from the telephone delivered to the participant’s sound processor via digital RF transmission via the wireless HAT device 4) In noise with the sound processor alone with the telephone receiver held next to the microphone of the participant’s sound processor 5) In noise with the sound processor alone with the telephone receiver held next to the participant’s sound processor with the telecoil enabled 6) In noise with the audio signal from the telephone delivered to the participant’s sound processor via digital RF transmission via the wireless HAT device.

All assessments were completed in an office-type environment. The speech signal was presented from a mobile telephone at the participant’s most comfortable listening level. Classroom noise was presented at 60 dBA from four loudspeakers located in the corners of the room. One full list of CNC words was presented in each test condition.

Results: Repeated measures analysis of variance was used to analyze the data collected in this study. This analysis indicated that speech recognition in quiet and in noise improved significantly with the use of the wireless HAT device. Bilateral implant recipients particularly showed a considerable improvement in word recognition with use of the wireless HAT device.

Conclusion: Use of a proprietary wireless HAT device resulted in a significant improvement in word recognition over the mobile telephone both in quiet and in noise.

COI: Cochlear¹
Technology for Improving Speech Understanding in Noise in Cochlear Implant Recipients
S. Agrawal, Ph.D.¹

¹Advanced Bionics, LLC, Valencia, CA USA

Topic: Technology

Keywords: Cochlear Implant Hardware, Sound Coding, Speech Coding Strategies

Introduction: While most Cochlear Implant (CI) recipients can hear remarkably well in quiet, understanding speech in real world situations with multiple sound sources can be a significant challenge. One approach for improving hearing in noisy situations is to improve the signal-to-noise ratio (SNR) by either reducing the level of interfering sounds, enhancing the speech signal, or a combination of both. Objective: This study evaluated the advantage offered by the following Advanced Bionics technology options for understanding speech in noise as compared to a conventional omnidirectional microphone (omni-mic): (1) a microphone that is placed near the opening of the ear canal (T-mic), thus providing access to the advantages offered by the pinna, (2) a proprietary speech enhancement strategy (SES) that reduces gain in spectral channels with steady state input, thereby reducing noise and enhancing speech, and (3) an adaptive directional microphone (ADM) that reduces input from the back hemifield thereby enhancing the input from the front hemifield.

Methods: Adult CI recipients with a range of baseline speech performance participated in the study. Baseline performance in quiet was measured using Consonant-Nucleus-Consonant (CNC) words and AzBio sentences in quiet. All participants had been implanted with a CI device that allowed access to various combinations of the three technology options. Five test conditions were compared: (a) omni-mic only, (b) omni-mic + SES (c) T-mic + SES (d) ADM alone, and (e) ADM + SES. Speech performance was evaluated rigorously in several different noise types. Target signals were presented from 0° and noise from 90°, 180° and 270°. Adaptive SNR (Hearing in Noise Test [HINT]) as well as fixed SNR testing methods were used. In addition, subjective ratings were obtained to reflect the perceived difficulty of the listening tasks in the various conditions.

Results: Improvements in speech understanding were observed with the evaluated technology options and their combinations as compared to the omnidirectional microphone alone in the following order: ADM + SES > ADM > T-mic + SES > omni-mic + SES > omni-mic only. Benefit was evident irrespective of the baseline performance. Improvements also were noted in the perceived difficulty of the listening task. Performance with certain SNR boosting options varied based on the noise type. Clinical recommendations will be offered for using the technologies based on the listening environment.

Conclusion: CI recipients have access to technology options that can help them hear significantly better in noisy situations. These options not only improve the ability to understand speech but also impact listening effort. Clinicians should consider programming/activating these technologies to improve CI recipients’ communication in real world environments.

COI: Advanced Bionics, LLC ¹
Value of Data Logging in Pediatric Cochlear Implant Recipients
E. Tournis, Au.D.

Ann & Robert H. Lurie Children's Hospital of Chicago, Chicago, IL USA

Topic: Audiology
Keywords: Fitting, Objective Measures, Outcomes

Introduction: The amount of time a cochlear implant sound processor has been worn as well as the amount of exposure to auditory information are two key contributors to a child's success with a cochlear implant. Historically, this information was obtained via anecdotal report from parents and caregivers. However with the advent of new cochlear implant processors this information is now available in the programming software via data logging. Data logging enables audiologists to obtain objective information regarding the use patterns of their cochlear implant recipients. The processor stores information regarding usage including the number of hours the device is powered on, the amount of time and number of times the processor is turned on but the coil is off the head, and the environment the device is used in (quiet, speech in quiet, speech in noise, music, etc.) Objective: The primary purpose of this study was a review of the database of our large metropolitan pediatric Cochlear Implant Center to determine typical wearing patterns for specific age groups. In addition, analysis regarding the amount of speech exposure and accessory/FM usage will be completed.

Methods: Retrospective study of 50 pediatric implant recipients using a cochlear implant system containing data logging. Demographic information, presence of co-occurring disabilities, auditory performance, and data logging data will be extracted from the medical record and programming software. Data logs will be analyzed regarding average use time, number of "coil offs", speech exposure and accessory/FM usage. Trends in regards to growth of auditory skills will be examined.

Results: This data will be presented along with any patterns observed according to chronological age, age at implantation, presence of additional disabilities. Additionally, the details provided by data logging will be analyzed to determine if there are any trends related to auditory skill development.

Conclusion: In conclusion data logging enables audiologists to obtain objective information regarding the use patterns of their cochlear implant recipients. This additional information provides additional insight into patient progress and is useful as a counseling tool for parents.

COI: Cochlear Americas¹
Benefit of a Speech Enhancement Strategy and a Digital Adaptive Remote Microphone System for Understanding Speech in Quiet and in Noise

M. Morais-Duke, AuD¹, J. Wolfe¹

¹Hearts For Hearing, Audiology, Oklahoma City, OK USA

Topic: Audiology

Keywords: Assistive Listening Devices

Introduction: Understanding speech in many real-world listening situations can be challenging for cochlear implant recipients. Innovative sound-processing algorithms and assistive technologies offer implant recipients the opportunity to communicate more effectively in noisy environments. Objective: This study assessed the ability of 11 implant recipients to understand speech in a noisy environment with a speech-enhancement sound processing strategy alone, a digital adaptive remote microphone system alone, and both technologies together. The primary objective was to evaluate the potential benefit of a speech enhancement signal processing scheme and a personal remote microphone system on speech recognition in noise.

Methods: This study included 11 participants who were unilateral or bilateral CII/HiRes 90K implant recipients. All subjects were fitted with a Naida CI Q70 processor, a T-Mic 2, and an integrated Roger 17 receiver on the implanted ear(s). Sound processor programs were created using their everyday sound processing strategy and a speech-enhancement sound processing strategy. Each of these programs was configured with 100% T-Mic2 microphone only input and also as a 50/50 audio mixing ratio, with the T-Mic2 and the Roger 17 serving as the two input sources. The programs with the 50/50 mixing ratio were used during the test conditions incorporating the digital adaptive remote microphone system. Sentence perception in quiet and in noise was evaluated using four sound-processing programs: Speech-enhancement strategy OFF, digital adaptive remote microphone system OFF Speech-enhancement strategy ON, digital adaptive remote microphone system OFF Speech-enhancement strategy OFF, digital adaptive remote microphone system ON Speech-enhancement strategy ON, digital adaptive remote microphone system ON Speech was presented from a loudspeaker located in front of the listener (0-degree azimuth). The level of the speech signal was 85 dBA at the microphone of the adaptive digital remote microphone system and 65 dBA at the location of the participant. Classroom noise was presented from four loudspeakers (45-, 135-, 225-, and 315-degree azimuth) at 50, 55, 60, 65, 70, 75, and 80 dBA. For each test condition, one list of AzBio sentences was presented. For conditions involving the digital adaptive remote microphone system, the receiver gain was left in the default mode.

Results: Repeated measures analysis of variance was used to analyze the data collected in this study. This statistical analysis indicated that use of the speech-enhancement strategy and digital adaptive remote microphone system alone and together improved the ability to understand sentences in quiet and in the presence of classroom noise.

Conclusion: A speech-enhancement strategy and digital adaptive remote microphone system alone and together can improve speech recognition of cochlear implant users both in quiet and in noisy environments.
Using Phoneme Perception Error Information to Modify Cochlear Implant Programming

J. R. Madell, Ph.D.  
J. Hewitt, Au.D  
L. Hewitt

Pediatric Audiology Consulting, Audiology, Brooklyn, NY USA  
Project Talk, Encinitas, CA USA

Introduction: The goal of cochlear implantation is to improve speech perception. While standard programming techniques provide significant improvement, many CI users continue to have specific phoneme perception errors which can be corrected by modifying CI I programming. A technique will be described which evaluates an individual’s phoneme perception errors and uses error information to modify the cochlear implant program.

Methods: A medial consonant test is performed and errors recorded. Phoneme errors are analyzed and the frequency band of each phoneme that is misheard is recorded using a frequency allocation table. A determination is made about which frequency bands are not providing adequate information. The cochlear implant program is analyzed evaluating the frequencies covered by each electrode and a determination is made about which electrodes need to have levels modified. The CI program is modified and performance is re-evaluated to determine if perception errors have been corrected. 103 subjects age from 2yrs 5 months to 49 yrs 6 months were evaluated.

Results: All patient phoneme errors were reviewed. Errors were placed into one of three categories: errors completely corrected after MAPping changes; errors not corrected after MAPping changes that did, however, result in an appropriate approximation of the test phoneme; and errors that, even after MAPping changes, resulted in neither a correction in phoneme perception nor an appropriate approximation for the phoneme. Before any changes were made to their CI MAPs, the 103 subjects had a total of 1516 phoneme perception errors. The phoneme correction rate was 66.03% when all approximations of a phoneme were counted as incorrect. However, when appropriate approximations were counted in the corrections, the correction rate increased to 81.46%. Although more than half of the phoneme errors were corrected, a portion of the initial errors persisted.

Conclusion: The data collected on the phonemes indicates that the correction of phoneme perception errors relies heavily on the manipulation of the formants that correspond to the targeted phoneme including increases, decreases, increases and decreases in tandem. Data suggest the necessity of formant specific changes. Information gained from testing before changes are made provides information as to which formants will need adjustment. This study suggests that changes in electrical stimulation levels of those electrodes which correspond to the specific formants of incorrectly perceived phonemes will improve speech perception and remediate errors. In addition, this study suggests that the audiologist must consider the full combination of increases, decreases, increases and decreases applied in tandem, electrode deactivation, electrode activation, and pulse width changes to provide the greatest remediation.
ACI2014
Does Method of Presentation Impact Pediatric Word Recognition Scores: Monitored Live Voice Versus Recorded Speech Materials?
A. Biever,Au.D.¹

¹Rocky Mountain Ear Center, Englewood, CO USA

Topic: Audiology

Keywords: Outcomes

Introduction: In the adult literature, administering recorded speech materials is recommended for best practices speech audiometry. In fact, research has shown that the use of monitored live voice (MLV) for adult word recognition can yield discrepancies up to 80-percentage points as compared to scores obtained with recorded stimuli (Roeser and Clark, 2008). In the pediatric population, the use of recorded speech materials is also recommended and will similarly improve test-retest reliability, however, many clinicians continue to report preference for MLV for assessing speech perception. Objective: To determine whether there is a difference in children’s performance on word and sentences assessed using live voice and recorded speech measures.

Methods: This study utilized a combination of retrospective and prospective data explored within subject performance for recorded versus monitored-live-voice presentation methods on pediatric word and sentence measures. Eighteen pediatric cochlear implant recipients between the ages of 4 and 17 were administered recorded and monitored-live-voice word and/or sentence measures at 60 dBA during a single test session. The difference score was calculated for word and sentence measures allowing a comparison across conditions. Due to the retrospective nature of the design presentation order was not randomized.

Results: On average, the recorded word scores were 12-percentage points lower than those obtained via MLV, regardless of whether the recorded words were administered first or second. There was a significant difference between recorded word and MLV word scores as revealed by repeated measures analysis of variance F(1,17)=44.785, p<0.001.

Conclusion: Further prospective studies are needed to determine whether these trends continue with randomization in a larger population. Nevertheless, the results of this project suggest that the use of MLV for the assessment of speech perception in the pediatric Audiology clinic will overinflate children’s performance and runs the risk of failing to identify poorer or at-risk performance.
Relationship Between Sensation Level and Optimal Speech Perception Performance in Normal Hearing and Hard-of-Hearing Infants

K. M. Uhler, MA,Ph.D.¹, S. Claycomb,AuD¹, S. Elam,AuD¹, A. Biever,AuD², T. Fredrickson¹

¹University Of Colorado Denver, Otolaryngology And Audiology, Aurora, CO USA ; ²Rocky Mountain Ear Center, Denver, CO USA

Topic: Audiology

Keywords: Outcomes , Objective Measures

Introduction: Infants with hearing loss (HL) are often identified within the first few months of life and fit with amplification. Currently little is known about the auditory perceptual development of infants/toddlers with HL and there is a need for a normed clinical tool to examine speech perception for infants with HL and normal hearing (NH). The investigation of speech perception in early amplified infants/toddlers is relatively new since EHDI or UNHS. Visual reinforcement infant speech discrimination (VRISD) has been used to learn much of what we know about development of speech perception in NH children and is being applied for the deaf and hard-of-hearing (DHH) population. This study examined one aspect of assessing infant speech perception: the optimal sensation level (dB SL).

Objective: To determine the dB SL that maximizes performance in both NH and HH listeners using VRISD for two sound contrasts (/a-/i/ and /ba-/da/). A second objective was to examine if a different presentation level is necessary for different speech sound contrasts when assessing infant speech perception using the VRISD paradigm.

Methods: VRISD utilizes a conditioned head turn paradigm, VRISD, was used to examine infants’ ability to discriminate the two speech sounds. Prior to initiation of VRISD testing, thresholds were established using VRA and the same-recorded speech stimuli (/a/, /i/, /b/, and /d/) in order to calculate sensation level (dB SL) of the stimuli. The SL was calculated by subtracting the threshold obtained for each speech sound from 50, 60, and 70 dBA.

Results: There were 22 NH participants and 13 HH participants (7 with hearing aids and 3 with cochlear implants). Generalized estimating equation (GEE) model demonstrated a significant effect for both contrast /a-/i/ and /ba-/da/ (p=.006) and level (50, 60, and 70 dBA) (p=.001), but there was not a significant interaction between the two. There was a greater probability of mastery as level increased; this probability was greater for the /a-/i/ contrast when compared to /ba-/da/ contrast. After controlling for level, the /a-/i/ contrast was associated with an 8 times greater likelihood of mastery than /ba-/da/ (odds ratio=8).

Conclusion: This study demonstrated that NH infants required a greater intensity level than adults to discriminate speech sounds similar to Nozza, (1987). The dB SL required for infants with hearing loss was smaller. These findings illustrate the importance of assessing different intensity levels to study an infant’s ability to discriminate speech contrasts. Contrast selection should be carefully considered due to the difference in ease of discrimination of /a-/i/ versus /ba-/da/.

V. D. Driscoll, MA, A. E. Welhaven, J. Oleson, K. I. Kirk

University Of Iowa, Department Of Otolaryngology–Head And Neck Surgery, Iowa City, IA USA; University Of Illinois At Urbana-Champaign, Department Of Speech And Hearing Science, Champaign, IL USA; University Of Iowa, Department Of Biostatistics, Iowa City, IA USA

Topic: Rehabilitation/Educational Aspects

Keywords: Children and Recommended Rehabilitation, Social Situation of implanted children

Introduction: Clinical testing of children’s speech understanding is often conducted in quiet, sound-treated booth. Such test conditions do not accurately reflect the listening demands of real-world conditions. Often, listeners can combine visual information found in speech, such as lip and facial movements, to aid in perceptual accuracy. It has been suggested that younger children receive less benefit from the addition of visual speech cues compared to older children. In a study by Diamond et al., (2013), age effects were found for children with normal hearing (NH) who completed the MLST-C™ in seven signal-to-noise ratios (SNR) ranging from -10 to 5 dB. Presentation format was also found to affect performance. Similar measures have not yet been evaluated with children who have cochlear implants (CIs).

Method: Nineteen pediatric CI users (4-16 years) and 35 NH children (5-12 years) completed testing on the MLST-C™, repeating sentences presented in either Audio only (A) or Audio-visual (AV) presentation in five SNRs: -10, -5, 0, 5, 10 dB. Participants repeated sentences presented by male and female talkers and were scored on accuracy of three keywords. Outcome was evaluated as a function of age, group membership (CI/NH), presentation format (A/AV), SNR and interactions of variables.

Results: Group, SNR, presentation format, and age were all found to be significant predictors in the logistic regression model as well as interactions of SNR*group, age*group and SNR*age. Children with normal hearing were significantly more accurate than those with CIs across all SNR levels; older children within each group showed better performance and were able to demonstrate greater performance accuracy in difficult listening conditions. For example, using SNR= 0 and an age of 10 years, the odds of a NH child scoring correctly in the AV format is 3.4 times higher than just A while a child with a CI has an odds that is only 1.13 times higher in AV than A.

Conclusion: Children with CIs are at a disadvantage in noisy listening conditions and do not consistently utilize the cues available to them via lip-reading, as observed in the smaller improvement compared to NH peers. Utilizing these cues may require direction, as they may not know to pair them for additional listening information. Effects of device configuration (unilateral, bilateral, bimodal and hybrid) will be discussed as it relates to performance.
**Redefining the Borders: The Benefits of Stretching the Criteria for Pediatric CI**

Y. Abrahams, BA, BHealthSc, MClInAud¹, A. Davis¹²

¹The Shepherd Centre, Newtown, NSW Australia; ²Macquarie University, Macquarie Park, NSW Australia

**Keywords:** Speech and Language Development with CI, Children and Recommended Rehabilitation

**Introduction:** Over the past 10 years there has been a significant shift in the audiological and functional listening criteria that would suggest a child will have improved access to sound with a CI. In an integrated CI program that is embedded in a comprehensive early intervention service the opportunity exists to closely monitor the progress of children with different levels of hearing and different hearing devices, and how the ever improving outcomes for children with CIs has driven shifts in candidacy criteria. Objective: This retrospective study reviews the changing criteria in a pediatric CI program over the past 3 years, and the impact on speech, language and listening outcomes. Additionally, medical, audiological and psychosocial outcomes are reviewed and compared to those of children using traditional amplification.

**Methods:** A retrospective review was conducted to identify the candidacy criteria, medical, surgical and long term listening speech and language outcomes with respect to listening, speech, language and the family factors for 148 implant procedures over 3 years. This review provided clarity on the current criteria for pediatric cochlear implant evaluation in 2014.

**Results:** Audiological criteria have been gradually shifting over the past 3 years. Children with more residual hearing are now being considered appropriate candidates for implantation and are showing improved post-operative listening skills and when compared to children using traditional amplification. Surgical and medical aspects of cochlear implantation have not shown any significant change in the impact on the individual or their post-operative residual hearing. Other characteristics are emerging as likely outcomes such as reduced listening effort and improved confidence.

**Conclusion:** Rather than being the sole qualifying criteria, a child’s audiological results are just one component of the information driving a family to consider CI. The value of the description ‘borderline’ needs to be reconsidered as it is defined differently by different clinicians and at different points in history, and this has proved only to add confusion for families and professionals. Instead the focus needs to be on functional listening and access to sound, and professionals need to keep abreast of the shifting criteria for CI with respect to possible outcomes in order to ensure candidates are obtaining the best access to sound that technology can provide.
Evaluation and Results of Implanted Children When They Have Reach 12 Years of Age
A. Ramos1, J. Falcón González1, n Ramos De Miguel1, S. Borkoski Barreiro1

1Complejo Hospitalario Universitario Insular Materno Infantil De Gran Canaria, ENT, Las Palmas, LAS PALMAS DE GRAN CANARIA Spain

Keywords: Young and Very Young Children, Outcomes, Fitting

Introduction: Children worldwide acquire the basic vocabulary and essential grammar of their mother language during the first four years of life. It is thought that the end of the sensitive phase for language acquisition occurs around twelve to thirteen years of age. Among the benefits of bilateral cochlear implantation is an improved sound localization and better speech understanding in noise. The objective is to evaluate auditory and linguistic results in children implanted when they were 1 to 5 years old, when they have reached 12 years of age. We studied the benefits of sequential bilateral implantation.

Methods: Observational, cross-sectional, descriptive study. 57 implanted children of 12 years of age. Each subject passed a free-field tone audiometry and speech tests in silence and noise. Language proficiency was assessed with the “Bateria de Lenguaje Objetiva y Criterial” (BLOC) in its screening version.

Results: The scores of disyllabic and common sentences tests, with and without noise, are similar for the group implanted when they were 1-2 years old than for the group implanted when they were 3-5 years old. Bilateral implanted children under 2 years of age and with a short inter-implant time obtained statistically significant results in the two bi-syllabic and sentences in quiet (p=0.006) and in noise (p=0.045). As for the language proficiency test, children implanted between the ages 1-2 have better results than those implanted between 3 and 5 years of age (p<0.05).

Conclusion: The disyllabic and sentence tests in quiet and in noise are better in all patients implanted below 2 years of age with respect to those implanted above 3 years of age. For the group of sequentially implanted children, those implanted below 2 years and with an inter implant period smaller or equal to 4 years, results in speech perception of disyllabic words in quiet, and sentences with and without noise are statistically significant with respect to those from children implanted above this age and with an inter-implant period bigger than 4 years Ramos Macías et al. studied 90 children and demonstrated that a simultaneous or short inter implant period bilateral implantation allows the acquisition of binauraity. In more demanding tests, such as the disyllabic words in noise test, sequentially implanted children with an inter-implant time period smaller or equal to 4 years and implanted below 2 years of age show statistically significant better results. Our results show that unilateral and bilateral implanted children whose first implantation was before 2 years of age have better results with respect to children implanted above 3 years of age. Children with prelingual deafness implanted before 2 years of age have higher benefits in language development and proficiency when they reach 12 years of age than those implanted later. Children implanted below 2 years of age and with a short inter-implant time acquire binaurality.
Managing Unilateral Hearing Loss in Infants: Why One Ear is Not Enough
Y. Abrahams, BA,BHlthSc, MCllinAud, A. Davis

1The Shepherd Centre, Newtown, NSW Australia; 2Macquarie University, Macquarie Park, NSW Australia

Topic: Audiology

Keywords: Outcomes, Residual Hearing, Young and Very Young Children

Introduction: The risk of difficulties arising from unilateral hearing impairment is well documented. For audiologists and allied professionals, the immediate challenge is in demonstrating benefit of fitting hearing devices and accessing early intervention services when faced with families with very young paediatric clients.

Objective: This study aims to determine the current state of children with unilateral hearing impairment in a single early intervention service, and reviews device use, age at device fitting, and results on formal assessment.

Methods: Demographic information, formal speech and language assessment results, auditory skills and diagnostic results from regular Auditory-Verbal Therapy sessions recorded on file were reviewed. Parents were interviewed about their perceptions of the information provided at the time of diagnosis and the availability of services, devices and support for children with unilateral hearing impairment. Particular attention was paid to children who received a cochlear implant with unilateral hearing loss in order to articulate the candidacy criteria and likely outcomes of this procedure. Tools and approaches for therapy were also reviewed.

Results: Of the children enrolled in early intervention aged 0-6 years, 16% had a unilateral hearing impairment of some type/degree. Devices used included no device, devices to contralaterally reroute the signal, acoustic hearing aids and cochlear implants. Outcomes across the group were excellent; however parent report of the guidance and information they received was varied. All reported concern about the lack of action following on from such early diagnosis and limitation of options.

Conclusion: In any environment where universal newborn hearing screening continues to identify unilateral hearing loss specific and appropriate management needs to be consistently offered and professionals at all points in the service chain need to understand and articulate the likely impact and need for audiological management, device use and early intervention. Consideration needs to be given to the appropriate therapy tools and techniques and the impact on listening in complex environments that may not be measureable until children reach school age.
Introduction: For profoundly deaf infants, cochlear implantation (CI) is an established treatment to enable acquisition of speech perception and spoken-language skills. While a number of studies have investigated speech discrimination, language, and speech production gains in these infants, little is known about how basic auditory sensitivities develop in these patients. This gap in knowledge is important to address if we are to understand how early atypical auditory experience with a CI impacts development of the auditory system. As a first step toward this goal, auditory abilities of cochlear implanted infants were examined using two psychoacoustic measures previously shown to be related to speech understanding in post-lingually deaf adult CI users. One test assessed spectral resolution while the other assessed temporal resolution. Due to the fact that spectral and temporal resolution mature during the first 6-7 months of life in normal hearing infants, it was hypothesized that a similar trajectory will be seen in cochlear implanted infants. Objective: To compare spectral and temporal resolution in cochlear implanted listeners from two groups: post-lingually deaf long-term adult CI users and prelingually deaf infants with cochlear implants.

Methods: Spectral resolution was assessed using spectral ripple discrimination (SRD). Listeners discriminated broadband noises with amplitude modulated (or “rippled”) spectra which differed in phase by 90 degrees. At two fixed ripple depths (10dB and 20dB), ripple density was varied to obtain the highest density (in ripples per octave) that could be discriminated (the SRD threshold). Temporal resolution was assessed using amplitude modulation detection (AMD). Listeners discriminated broadband noises containing temporal amplitude modulations from unmodulated noises. At two fixed modulation rates (10Hz and 100 or 150Hz) modulation depth was varied to obtain the lowest depth at which unmodulated and modulated noises could be discriminated. Infants and adults were both tested using an identical observer-based psychoacoustic procedure (OPP) that has been widely used in psychoacoustic experiments with infants and toddlers. Stimuli were presented at 65dB in soundfield to CI listeners using their preferred clinical processor and (for bilaterally implanted patients) their first and/or best side only.

Results: Preliminary results show that cochlear implanted infants performed similarly to post-lingually deaf adult CI users on SRD and AMD tasks.

Conclusion: Though preliminary, these findings support the hypothesis that basic spectral and temporal resolution matures early in cochlear implanted infants. Future research will standardize the post-implant interval of testing in infants to 3 and 7 months to see if psychoacoustic measures mature during this timeframe. SRD and AMD thresholds will be compared to later spoken-language abilities measured at 1 year post-implantation.