Speech Recognition and Comfort Using Hearing Instruments with Adaptive Directional Characteristics in Asymmetric Listening Conditions.

Emma Mackenzie; Mark E. Lutman

Links: Abstract | HTML | PDF (1.02 M)

Objective: Hearing instruments with adaptive directional microphone systems attempt to maximize speech-to-noise ratio (SNR) and thereby improve speech recognition in noisy backgrounds. When instruments with adaptive systems are fitted bilaterally, there is the potential for adverse effects as they operate independently and may give confusing cues or disturbing effects. The present study compared speech recognition performance in 16 listeners fitted bilaterally with the Phonak Claro hearing instrument using omni-directional, fixed directional, and adaptive directional microphone settings as well as mixed microphone settings (an omni-directional microphone on one side and an adaptive directional microphone on the other).

Design: Under anechoic conditions, speech was always presented from a loudspeaker directly in front of the listener (0 degree azimuth) whereas noise was presented from one or two loudspeakers arranged either symmetrically (0, 180, 90 + 270 degrees) or asymmetrically (170 + 240 degrees and 120 + 190 degrees) in the horizontal plane. Adaptive sentence recognition in noise measurement was supplemented by quality ratings.

Results: With symmetrical omni-directional settings (Omni/Omni), performance was poorer than a control group of 14 listeners with normal hearing tested unaided: Aided listeners required 4.3 dB more favorable SNR for criterion performance. In all loudspeaker arrangements in which directional characteristics could be exploited, performance with symmetrical adaptive microphones (Adapt/Adapt) was similar to the control group. The mixed microphone settings did not appear to confer any particular disadvantage for speech recognition from their asymmetric nature, always giving scores significantly better than Omni/Omni. Quality rating scores were consistent with speech recognition performance, showing benefits in terms of clarity and comfort for the Adapt/Adapt and Fixed/Fixed microphone conditions over the Omni/Omni and mixed microphone conditions wherever directional characteristics could be used. Similarly, the mixed microphone conditions were rated more comfortable and quieter for the noise than Omni/Omni.

Conclusions: It is concluded that bilateral hearing instruments with adaptive directional microphones confer benefits in terms of speech recognition in noise and sound quality. Independence of the two adaptive control systems does not appear to cause untoward effects.

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Evaluation of Streamlined Programming Procedures for the Nucleus Cochlear Implant with the Contour Electrode Array.

Kerrie Plant; Mary-Ann Law; Lesley Whitford; Michelle Knight; Sylvia Tari; Jaime Leigh; Karen Pedley; Esti Nel

Links: Abstract | HTML | PDF (2.25 M)

Abstract:
Objective: The objective of this study was to evaluate streamlined programming procedures for the Nucleus cochlear implant system with the Contour electrode array.

Design: Phase 1 involved an examination of the clinical MAPs for the first 103 recipients implanted with the Contour electrode array in the Melbourne Cochlear Implant Clinic, to examine the ability to predict the entire MAP based on a smaller number of clinically determined T- and/or C-levels. In phase 2, a subset of the streamlined procedures was selected and clinically evaluated, using speech perception and subjective preference measures. In the first study, the clinical MAP was compared with a MAP based on interpolating across three behavioral T-levels and three behavioral C-levels in a group of newly implanted subjects. The second study investigated the use of a single interpolated profile as the basis to creating the entire MAP. Initial evaluation compared the clinical MAP with two streamlined MAPs, one in which the C-level profile was derived from interpolation across a subset of T-levels and one in which the T-level profile was derived from interpolation across a subset of C-levels. In this case, the interpolated profile was based on five behavioral measures. Subsequently, the use of either three or a single T-level measure as the basis for the interpolated T-level profile was evaluated. Initial evaluation compared the clinical MAP with two streamlined MAPs, one in which the C-level profile was derived from interpolation across a subset of T-levels and one in which the T-level profile was derived from interpolation across a subset of C-levels. In this case, the interpolated profile was based on five behavioral measures. Subsequently, the use of either three or a single T-level measure as the basis for the interpolated T-level profile was evaluated. Initial evaluation compared the clinical MAP with two streamlined MAPs, one in which the C-level profile was derived from interpolation across a subset of T-levels and one in which the T-level profile was derived from interpolation across a subset of C-levels. In this case, the interpolated profile was based on five behavioral measures. Subsequently, the use of either three or a single T-level measure as the basis for the interpolated T-level profile was evaluated.

Results: The Phase 1 analysis showed that as expected, larger differences were observed between the clinical and derived MAP levels as interpolation was applied across fewer measured electrodes and that the use of a single interpolated profile to create the entire MAP resulted in the greatest deviation. No significant group mean difference was found in speech perception scores for newly implanted subjects when mapped with the clinical versus the streamlined MAP based on three behavioral T- and three behavioral C-level measures. For some individual subjects, scores were higher with the streamlined MAP. Subjective reports from the comparative performance questionnaire were consistent with these findings. No significant group mean difference in speech perception scores was found in comparing the clinical MAP with the streamlined MAPs based on a single interpolated T- or C-level profile created from five behavioral measures. Individual effects were observed; however, there was no consistent finding across subjects. The use of three rather than five behavioral T-level measures in the procedure did not result in significantly lower group mean scores; however, significantly poorer scores were obtained for three of the 10 individual subjects. The use of a MAP based on a single behavioral measure did result in poorer speech perception scores when compared with the MAP based on five behavioral T-level measures. These findings were consistent with subjective results from the performance questionnaires administered to determine preference for program across a range of listening situations.

Conclusions: Two streamlined programming procedures are recommended for use in the clinical setting: (1) interpolating across three measured T-levels and three measured C-levels and (2) interpolating across five measured T- or C-levels and using the interpolated profile for fitting of the alternative profile.

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How Does the Sound Pressure Generated by Circumaural, Supra-aural, and Insert Earphones Differ for Adult and Infant Ears?

Susan E. Voss; Barbara S. Herrmann

Links: Abstract | HTML | PDF (1.53 M)

Abstract:
Objective: To determine how the ear canal sound pressure levels generated by circumaural, supra-aural, and insert earphones differ when coupled to the normal adult and infant ear.

Design: The ratio between the sound pressure generated in an adult ear and an infant ear was calculated for three types of earphones: a circumaural earphone (Natus Medical, ALGO with Flexicoupler[TM]), a supra-aural earphone (Telephonics, TDH-49 with MXAR cushion), and an insert earphone placed in the ear canal (Etymo[up down arrow]tic Research, ER-3A). The calculations are based on (1) previously published measurements of ear canal impedances in adult and infant (ages 1, 3, 6, 12, and 24 months) ears (Keefe et al., 1993, Acoustic Society of America, 94:2617-2638), (2) measurements of the Thevenin equivalent for each earphone configuration, and (3) acoustic models of the ear canal and external ear.

Results: Sound-pressure levels depend on the ear canal location at which they are measured. For pressures at the earphone: (1) Circumaural and supra-aural earphones produce changes between infant and adult ears that are less than 3 dB at all frequencies, and (2) insert earphones produce infant pressures that are up to 15 dB greater than adult pressures. For pressures at the tympanic membrane: (1) Circumaural and supra-aural earphones produce infant pressures that are within 2 dB of adult ears at frequencies below 2000 Hz and that are 5 to 7 dB smaller in infant ears than adult ears above 2000 Hz, and (2) insert earphones produce pressures that are 5 to 8 dB larger in infant ears than adult ears across all audiometric frequencies.

Conclusions: Sound pressures generated by all earphone types (circumaural, supra-aural, and insert) depend on the dimensions of the ear canal and on the impedance of the ear at the tympanic membrane (e.g., infant versus adult). Specific conclusions depend on the location along the ear canal at which the changes between adult and infant ears are referenced (i.e., the earphone output location or the tympanic membrane). With circumaural and supra-aural earphones, the relatively large volume of air within the cuff of the earphone dominates the acoustic load that these earphones must drive, and differences in sound pressure generated in infant and adult ears are generally smaller than those with the insert earphone in which the changes in ear canal dimensions and impedance at the tympanic membrane have a bigger effect on the load the earphone must drive.

Estimating Noise-Induced Permanent Threshold Shift from Audiometric Shape: The ISO-1999 Model.

Robert A. Dobie

Links: Abstract | HTML | PDF (418 K)

Abstract:
Objective: To describe the relation between audiometric shape and noise-induced permanent threshold shift averaged across the speech frequencies (N5123).

Design: Using an international standard (ISO-1999), 270 audiograms were created, representing both sexes and a variety of ages, exposure levels, and percentiles. Bulge depth (BD) was defined as the difference between pure-tone average for 2, 3, and 4 kHz and PTA for 1 and 6 kHz.
Results: N5123 was well-predicted by quadratic functions of BD, which accounted for 72 to 95% of the variance in N5123.

Conclusions: Estimates of N5123, based on BD, can be helpful in medical-legal diagnosis and allocation of hearing loss.

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Rapid Word-Learning in Normal-Hearing and Hearing-Impaired Children: Effects of Age, Receptive Vocabulary, and High-Frequency Amplification.

A L. Pittman; D E. Lewis; B M. Hoover; P G. Stelmachowicz

Links: Abstract | HTML | PDF (1.17 M)

Abstract:
Objective: This study examined rapid word-learning in 5- to 14-year-old children with normal and impaired hearing. The effects of age and receptive vocabulary were examined as well as those of high-frequency amplification. Novel words were low-pass filtered at 4 kHz (typical of current amplification devices) and at 9 kHz. It was hypothesized that (1) the children with normal hearing would learn more words than the children with hearing loss, (2) word-learning would increase with age and receptive vocabulary for both groups, and (3) both groups would benefit from a broader frequency bandwidth.

Design: Sixty children with normal hearing and 37 children with moderate sensorineural hearing losses participated in this study. Each child viewed a 4-minute animated slideshow containing 8 nonsense words created using the 24 English consonant phonemes (3 consonants per word). Each word was repeated 3 times. Half of the 8 words were low-pass filtered at 4 kHz and half were filtered at 9 kHz. After viewing the story twice, each child was asked to identify the words from among pictures in the slide show. Before testing, a measure of current receptive vocabulary was obtained using the Peabody Picture Vocabulary Test (PPVT-III).

Results: The PPVT-III scores of the hearing-impaired children were consistently poorer than those of the normal-hearing children across the age range tested. A similar pattern of results was observed for word-learning in that the performance of the hearing-impaired children was significantly poorer than that of the normal-hearing children. Further analysis of the PPVT and word-learning scores suggested that although word-learning was reduced in the hearing-impaired children, their performance was consistent with their receptive vocabularies. Additionally, no correlation was found between overall performance and the age of identification, age of amplification, or years of amplification in the children with hearing loss. Results also revealed a small increase in performance for both groups in the extended bandwidth condition but the difference was not significant at the traditional p = 0.05 level.

Conclusions: The ability to learn words rapidly appears to be poorer in children with hearing loss over a wide range of ages. These results coincide with the consistently poorer receptive vocabularies for these children. Neither the word-learning or receptive-vocabulary measures were related to the amplification histories of these children. Finally, providing an extended high-frequency bandwidth did not significantly improve rapid word-learning for either group with these stimuli.

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GIN (Gaps-In-Noise) Test Performance in Subjects with Confirmed Central Auditory Nervous System Involvement.
Frank E. Musiek; Jennifer B. Shinn; Robert Jirsa; Doris-Eva Bamiou; Jane A. Baran; Elena Zaida

Abstract:
Objective: The purpose of the present study was to investigate the value of a new gap detection procedure called Gaps-In-Noise (GIN) for assessment of temporal resolution in a clinical population.

Design: The test consists of 0 to 3 silent intervals ranging from 2 to 20 msec embedded in 6-sec segments of white noise. The location, number, and duration of the gaps per noise segment vary throughout the test for a total of 60 gaps presented in each of four lists. The GIN procedure was administered to 50 normal-hearing listeners (group I) and 18 subjects with confirmed neurological involvement of the central auditory nervous system (group II).

Results: Results showed mean approximated gap detection thresholds of 4.8 msec for the left ear and 4.9 msec for the right ear for group I. In comparison, results for group II demonstrated a statistically significant increase in gap detection thresholds, with approximated thresholds of 7.8 msec and 8.5 msec being noted for the left and right ears, respectively. Significant mean differences were also observed in the overall performance scores (i.e., the identification of the presence of the gaps within the noise segments) of the two groups of subjects. Finally, psychometric functions, although similar for short and long duration gaps, were highly different for gaps in the 4- to 10-msec range for the two groups.

Conclusions: A variety of psychoacoustic procedures are available to assess temporal resolution; however, the clinical use of these procedures is minimal at best. Results of the present study show that the GIN test holds promise as a clinically useful tool in the assessment of temporal resolution in the clinical arena.

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A Validation and Potential Clinical Application of Multivariate Analyses of Distortion-Product Otoacoustic Emission Data.
Michael P. Gorga; Darcia M. Dierking; Tiffany A. Johnson; Kathryn L. Beauchaine; Cassie A. Garner; Stephen T. Neely

Abstract:
Objective: To test the generalizability of multivariate analyses of distortion-product otoacoustic emission (DPOAE) data. Previously published multivariate solutions were applied to a new set of data to determine if test-performance improvements, evident in previous reports, are retained. An additional objective was to provide an alternative approach for making multivariate dichotomous decisions of hearing status in the clinic, based on DPOAE measurements.

Design: DPOAE level and noise were obtained in 345 ears of 187 subjects. Approximately one third of the subjects had normal hearing, whereas the remainder had hearing loss, ranging from 25 to more than 120 dB HL. DPOAE data were collected at each of nine frequencies. After data collection, clinical decision theory, in combination with univariate (DPOAE level and signal-to-noise ratio [SNR]) and multivariate (logistic regression) analyses, was used to construct relative operating characteristic (ROC) curves and to generate ROC curve areas. In addition, test performance was assessed by fixing the false-alarm rate and
comparing different approaches to analyses in terms of their failure rates as a function of magnitude of hearing loss. The DPOAE test results were compared with either single-frequency or multifrequency gold standards. The multivariate solutions were taken from previously published work (Dorn et al., 1999; Gorga, et al., 1999).

Results: DPOAE level and SNR resulted in roughly equivalent test performance (ROC curve areas and failure rates among ears with hearing loss), although DPOAE level performed better for frequencies above 1 kHz, and SNR performed better for frequencies at 0.75 and 1 kHz. Multivariate analyses resulted in better test performance for nearly all conditions, compared with the univariate approaches that used either DPOAE level or SNR. The improvements in test performance were greatest for the frequencies at which the univariate analyses performed poorest (0.75 kHz, 1 kHz, and 8 kHz). Less difference was observed between univariate and multivariate approaches when multifrequency gold standards were used; however, even for the multifrequency cases, multivariate analyses generally resulted in better performance. An approach that might facilitate the interpretation of multifrequency DPOAE measurements in the clinic is described.

Conclusions: Previously described multivariate analyses were robust in that they improved test performance when applied to an entirely new set of DPOAE data. This, in turn, suggests that the previously described multivariate solutions may have clinical utility in that they are expected to improve test performance at no additional cost in terms of data-acquisition or data-analysis time. In addition to demonstrating that these solutions generalized to new data, an alternative approach to interpreting multifrequency DPOAE measurements is provided that includes the advantages of using multivariate analyses. This new metric may be useful when DPOAEs are used for screening purposes.

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perimodiolar electrode design. Further research is needed to elucidate their individual contributions to those outcomes.

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Threshold Prediction Using the Auditory Steady-State Response and the Tone Burst Auditory Brain Stem Response: A Within-Subject Comparison.
Tiffany A. Johnson; Carolyn J. Brown

Links: Abstract | HTML | PDF (2.24 M)

Abstract:
Objective: The purpose of this study was to evaluate the accuracy with which auditory steady-state response (ASSR) and tone burst auditory brain stem response (ABR) thresholds predict behavioral thresholds, using a within-subjects design. Because the spectra of the stimuli used to evoke the ABR and the ASSR differ, it was hypothesized that the predictive accuracy also would differ, particularly in subjects with steeply sloping hearing losses.

Design: ASSR and ABR thresholds were recorded in a group of 14 adults with normal hearing, 10 adults with flat, sensorineural hearing losses, and 10 adults with steeply sloping, high-frequency, sensorineural hearing losses. Evoked-potential thresholds were recorded at 1, 1.5, and 2 kHz and were compared with behavioral, pure-tone thresholds. The predictive accuracy of two ABR protocols was evaluated: Blackman-gated tone bursts and linear-gated tone bursts presented in a background of notched noise. Two ASSR stimulation protocols also were evaluated: 100% amplitude-modulated (AM) sinusoids and 100% AM plus 25% frequency-modulated (FM) sinusoids.

Results: The results suggested there was no difference in the accuracy with which either ABR protocol predicted behavioral threshold, nor was there any difference in the predictive accuracy of the two ASSR protocols. On average, ABR thresholds were recorded 3 dB closer to behavioral threshold than ASSR thresholds. However, in the subjects with the most steeply sloping hearing losses, ABR thresholds were recorded as much as 25 dB below behavioral threshold, whereas ASSR thresholds were never recorded more than 5 dB below behavioral threshold, which may reflect more spread of excitation for the ABR than for the ASSR. In contrast, the ASSR overestimated behavioral threshold in two subjects with normal hearing, where the ABR provided a more accurate prediction of behavioral threshold.

Conclusions: Both the ABR and the ASSR provided reasonably accurate predictions of behavioral threshold across the three subject groups. There was no evidence that the predictive accuracy of the ABR evoked using Blackman-gated tone bursts differed from the predictive accuracy observed when linear-gated tone bursts were presented in conjunction with notched noise. Similarly, there was no evidence that the predictive accuracy of the AM ASSR differed from the AM/FM ASSR. In general, ABR thresholds were recorded at levels closer to behavioral threshold than the ASSR. For certain individuals with steeply sloping hearing losses, the ASSR may be a more accurate predictor of behavioral thresholds; however, the ABR may be a more appropriate choice when predicting behavioral thresholds in a population where the incidence of normal hearing is expected to be high.

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**Abstract:**

Objective: The purpose of this investigation was to examine the nature and frequency of deviant speech and voice physiology in children who are hard of hearing (HH).

Design: Ten HH children (age, 5 to 15 yrs) participated. Their hearing losses ranged in severity from moderate to severe. The following speech/voice physiological measures were examined: frequency of occurrence of negative intraoral air pressure (-Po), magnitude of Po, phonatory air flow, nasal air flow, voice onset time (VOT), and fundamental frequency (F0). Findings were compared with data previously collected from 56 children with normal hearing and 7 children with cochlear implants (Higgins, McCleary, Carney, & Schulte, 2003).

Results: Five of the 10 HH children exhibited deviant speech/voice behaviors. Only one showed deviancy on more than one measure. In addition, 8 HH children had some borderline-deviant speech behavior. The frequency and degree of speech/voice deviancy for the children in the present study was far less than what we previously had observed for children who underwent cochlear implantation after 5 yrs of age (Higgins et al., 2003). This was the case even for a child with a cochlear implant from our earlier study who eventually achieved speech perception scores that were as good as or better than some of the HH children in the present investigation.

Conclusions: Deviant speech/voice physiology occurs to a limited extent for some HH children. Of the measures that we examined, those related to vocal fold tension and vocal fold articulation appeared to be most sensitive to the effects of diminished auditory input and feedback that occurs for HH children. Data from this and other studies suggest that abnormally high F0 occurs for about 20% of HH children and may be associated with poor speech perception skills. Future studies should examine whether earlier implantation can help deaf children to produce speech that is at least as normal as that of HH children.

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use, reduced ability to monitor the environment as the result of hearing protector use, concerns about future quality of life, and concerns about future employability. Mostly, there was an agreement between the perceptions of workers, supervisors, and hearing conservation program managers regarding difficulties associated with hearing loss and consequent needs. These findings suggest that noise-exposed workers with hearing loss face many of the same problems reported in the literature by noise-exposed workers with normal hearing, with additional concerns primarily about job safety as the result of a reduced ability to hear environmental sounds, warning signals, and so forth.

Conclusions: The study outlines potential challenges regarding job safety and hearing conservation practices for noise-exposed, hearing-impaired workers. Awareness of these issues is a necessary first step toward providing appropriate protective measures for noise-exposed, hearing-impaired workers.

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**Item 12 of 12**

**Hearing Aid Patients in Private Practice and Public Health (Veterans Affairs) Clinics: Are They Different?**


Robyn M. Cox; Genevieve C. Alexander; Ginger A. Gray

**Links:** Abstract | HTML | PDF (1.4 M)

**Abstract:**

Objective: In hearing aid research, it is commonplace to combine data across subjects whose hearing aids were provided in different service delivery models. There is reason to question whether these types of patients are always similar enough to justify this practice. To explore this matter, this investigation evaluated similarities and differences in self-report data obtained from hearing aid patients derived from public health (Veterans Affairs, VA) and private practice (PP) settings.

Design: The study was a multisite, cross-sectional survey in which 230 hearing aid patients from VA and PP audiology clinic settings provided self-report data on a collection of questionnaires both before and after the hearing aid fitting. Subjects were all older adults with mild to moderately severe hearing loss. About half of them had previous experience wearing hearing aids. All subjects were fitted with wide-dynamic-range-compression instruments and received similar treatment protocols.

Results: Numerous statistically significant differences were observed between the VA and PP subject groups. Before the fitting, VA patients reported higher expectations from the hearing aids and more severe unaided problems compared with PP patients with similar audiograms. Three wks after the fitting, VA patients reported more satisfaction with their hearing aids. On some measures VA patients reported more benefit, but different measures of benefit did not give completely consistent results. Both groups reported using the hearing aids an average of approximately 8 hrs per day. VA patients reported age-normal physical and mental health, but PP patients tended to report better than typical health for their age group.

Conclusions: These data indicate that hearing aid patients seen in the VA public health hearing services are systematically different in self-report domains from those seen in private practice services. It is therefore risky to casually combine data from these two types of subjects or to generalize research results from one group to the other. Further, compared with PP patients, VA patients consistently reported more favorable hearing aid fitting outcomes. Additional study is indicated to explore the determinants of this result and its generalizability to other public health service delivery systems such as those in other countries. Moreover, efforts should be made to assess the potential for transferring positive elements from the VA system to the PP service delivery system, if possible.

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