Quarterly Abstract Update

July – September 2007

Part B: L-Z

68 Litvak L. M.; Spahr A. J.; Saoji A. A.; & Fridman G. Y.; (2007); "Relationship between perception of spectral ripple and speech recognition in cochlear implant and vocoder listeners"; J Acoust Soc Am. 122(2):982-991 12

69 Liu B.; Gao X. L.; Yin H. X.; Luo S. Q.; & Lu J.; (2007); "A detailed 3D model of the guinea pig cochlea"; Brain Struct Funct. 212(2):223-230 13

70 Lobo A. P.; Loizou P. C.; Kehtarnavaz N.; Torlak M.; Hoi L.; Sharma A.; Gilley P.; Peddigari V.; & Ramanna L.; (2007); "A PDA-based research platform for cochlear implants"; Neural Engineering. 3rd International IEEE/EMBS Conference 13

71 Luo X. & Fu Q. J.; (2007); "Frequency modulation detection with simultaneous amplitude modulation by cochlear implant users"; J Acoust Soc Am. 122(2):1046-1054 14

72 Malone B. J.; Scott B. H.; & Semple M. N.; (2007); "Dynamic amplitude coding in the auditory cortex of awake Rhesus Macaques"; Journal of Neurophysiology. 98(3):1451-1474 14

73 Marschark M.; Rhoten C.; & Fabich M.; (2007); "Effects of cochlear implants on children's reading and academic achievement"; The Journal of Deaf Studies and Deaf Education. 12(3):269-282 15

74 Marschark M.; Archbold S.; Grimes M.; & O'Donoghue G.; (2007); "On Language, education, and cochlear implants"; The Journal of Deaf Studies and Deaf Education. 12(3):257 15

75 Mens L. H. M.; (2007); "Advances in cochlear implant telemetry: Evoked neural responses, electrical field imaging, and technical integrity"; Trends in Amplification. 11(3):143-159 15

76 Miller J. M.; Le Prell C. G.; Prieskorn D. M.; Wys N. L.; & Altschuler R. A.; (2007); "Delayed neurotrophin treatment following deafness rescues spiral ganglion cells from death and promotes regrowth of auditory nerve peripheral processes: Effects of brain-derived neurotrophic factor and fibroblast growth factor."; J Neurosci Res. 85(9):1959-1969 16

77 Mitchell T. V. & Maslin M. T.; (2007); "How vision matters for individuals with hearing loss"; Int J Audiol. 46(9):500-511 16

78 Mlynski R.; Volkenstein S.; Hansen S.; Brors D.; Ebmeyer J.; & Dazert S.; (2007); "Interaction of cochlear nucleus explants with semiconductor materials"; Laryngoscope. 117(7):1216-1222 17

79 Moeller M. P.; Hoover B.; Putman C.; Arbataitis K.; Bohnenkamp G.; Peterson B.; Wood S.; Lewis D.; Pittman A.; & Stelmachowicz P.; (2007); "Vocalizations of infants with hearing loss compared with infants with normal hearing: Part I - phonetic development"; Ear Hear. 28(5):605-627 17

91 Psillas G.; Kyriafinis G.; Constantinidis J.; & Vital V.; (2007); "Far-advanced otosclerosis and cochlear implantation"; B-ENT. 3(2):67-71 26

92 Raine C. H.; Lee C. A.; Strachan D. R.; Totten C. T.; & Khan S.; (2007); "Skin flap thickness in cochlear implant patients - a prospective study"; Cochlear Implants Int. 8(3):148-157 27

93 Raveh E.; Buller N.; Badrana O.; & Attias J.; (2007); "Auditory neuropathy: clinical characteristics and therapeutic approach"; Am J Otolaryngol. 28(5):302-308 27

94 Roehm P.; Hoffer M.; & Balaban C. D.; (2007); "Gentamicin uptake in the chinchilla inner ear"; Hear Res. 230(1-2):43-52 28

95 Roland P. S.; Wright C. G.; & Isaacson B.; (2007); "Cochlear implant electrode insertion: The round window revisited."; Laryngoscope. 117(8):1397-1402 29

96 Ruffin C. V.; Tyler R. S.; Witt S. A.; Dunn C. C.; Gantz B. J.; & Rubinstein J. T.; (2007); "Long-term performance of Clarion 1.0 cochlear implant users"; Laryngoscope. 117(7):1183-1190 29

97 Sagi E.; Fitzgerald M. B.; & Svirsky M. A.; (2007); "What matched comparisons can and cannot tell us: The case of cochlear implants"; Ear Hear. 28(4):571-579 30

98 Sainz M.; Garcia-Valdecasas J.; Garofano M.; & Ballesteros J. M.; (2007); "Otosclerosis: Mid-term results of cochlear implantation"; Audiol Neurootol. 12(6):401-406 31

99 Sakata M.; Hareyama M.; Heil T. A.; Henson M. M.; Henson O. W.; Webber R. L.; Nair M. K.; & Smith D. W.; (2007); "High-resolution in situ imaging of cochlear implant electrode arrays in cat temporal bones using Tuned Aperture Computed Tomography (TACT)"; Ear Hear. 28(4):435-443 31

100 Sakata M.; Hareyama M.; Heil T. A.; Henson M. M.; Henson O. W.; Nair M. K.; & Smith D. W.; (2007); "Optimization of TACT imaging protocols for in situ visualization of cochlear electrode arrays in cat temporal bones"; Ear Hear. 28(4):444-450 32

101 Seki Y.; Samejima N.; & Komatsuzaki A.; (2007); "Auditory brainstem implants: Current state and future directions with special reference to the subtonsillar approach for implantation"; Acta Neurochir.Suppl. 97(Pt 2):431-435 33

102 Sharma A.; Gilley P. M.; Dorman M. F.; & Baldwin R.; (2007); "Deprivation-induced cortical reorganization in children with cochlear implants"; Int J Audiol. 46(9):494-499 33

103 Sims D. G.; (2007); "Does Auditory Processing Disorder Literature Apply to Learners With Hearing Loss?"; The Journal of Deaf Studies and Deaf Education. 12(3):407-408 34

104 Skarzynski H.; Lorens A.; Piotrowska A.; & Anderson I.; (2007); "Partial deafness cochlear implantation in children"; Int J Pediatr Otorhinolaryngol. 71(9):1407-1413 34

105 Sly D. J.; Heffer L. F.; White M. W.; Shepherd R. K.; Birch M. G.; Minter R. L.; Nelson N. E.; Wise A. K.; & O'Leary S. J.; (2007); "Deafness alters auditory nerve fibre responses to cochlear implant stimulation"; Eur J Neurosci. 26(2):510-522 34

106 Sohmer H.; (2007); "Assessment of plasticity in the auditory pathway in cochlear implant patients with preservation of residual low frequency hearing"; Clin Neurophysiol. 118(8):1655-1657 35

107 Stickney G. S.; Assmann P. F.; Chang J.; & Zeng F. G.; (2007); "Effects of cochlear implant processing and fundamental frequency on the intelligibility of competing sentences"; J Acoust Soc Am. 122(2):1069-1078 35

108 Strenge H. & Muller-Deile J.; (2007); "Auditory feedback does not influence random number generation: Evidence from profoundly deaf adults with cochlear implant"; J Clin Exp Neuropsychol. 29(6):642-647 36

109 Suaning G. J.; Schuettler M.; Ordonez J. S.; & Lovell N. H.; (2007); "Fabrication of multi-layer, high-density micro-electrode arrays for neural stimulation and bio-signal recording"; Sch.of Eng4 36

110 Sucher C. M. & McDermott H. J.; (2007); "Pitch ranking of complex tones by normally hearing subjects and cochlear implant users"; Hear Res. 230(1-2):80-87 36

111 Tait M. E.; Nikolopoulos T. P.; Wells P.; & White A.; (2007); "The use and reliability of Tait video analysis in assessing preverbal language skills in profoundly deaf and normally hearing children under 12 months of age"; International Journal of Pediatric.Otorhinolaryngology. 71(9):1377-1382 37

112 Todd C. A.; Naghdy F.; & Svehla M. J.; (2007); "Force application during cochlear implant insertion: An analysis for improvement of surgeon technique"; IEEE Trans Biomed Eng. 54(7):1247-1255 38

113 Tomblin J. B.; Barker B. A.; & Hubbs S.; (2007); "Developmental constraints on language development in children with cochlear implants"; Int J Audiol. 46(9):512-523 38

126 Xu Y. & Collins L. M.; (2007); "Predictions of psychophysical measurements for sinusoidal amplitude modulated (SAM) pulse-train stimuli from a stochastic model"; IEEE Trans Biomed Eng. 54(8):1389-1398 45

127 Yucel E. & Sennaroglu G.; (2007); "Is psychological status a determinant of speech perception outcomes in highly selected good adolescent cochlear implant users?"; Int J Pediatr Otorhinolaryngol. 71(9):1415-1422 45

128 Zhang F.; Miller C. A.; Robinson B. K.; Abbas P. J.; & Hu N.; (2007); "Changes across time in spike rate and spike amplitude of auditory nerve fibers stimulated by electric pulse trains"; J Assoc Res Otolaryngol. 8(3):356-372 46

60. **"Effects of short- and long-term changes in auditory feedback on vowel and sibilant contrasts".** Lane, H.; Matthies, M. L.; Guenther, F. H.; Denny, M.; Perkell, J. S.; Stockmann, E.; Tiede, M.; Vick, J.; Zandipour, M.; (2007); Journal of Speech, Language, and Hearing Research. 50(4):913-927

Purpose: To assess the effects of short- and long-term changes in auditory feedback on vowel and sibilant contrasts and to evaluate hypotheses arising from a model of speech motor planning. Method: The perception and production of vowel and sibilant contrasts were measured in 8 postlingually deafened adults prior to activation of their cochlear implant speech processors, 1 month postactivation, and 1 year postactivation. Measures were taken postactivation both with and without auditory feedback. Contrast measures were also made for a group of speakers with reportedly normal hearing speaking with masked and unmasked auditory feedback. Results: Vowel and sibilant contrasts, measured in the absence of auditory feedback after 1 month of prosthesis use, were diminished compared with their values measured before prosthesis. Contrasts measured in the absence of auditory feedback after 1 year's experience with the prosthesis were increased compared with their values after 1 month's experience. In both time samples, contrasts were enhanced when auditory feedback was restored. Conclusion: The provision of prosthetic hearing to postlingually deafened adults impaired their phonemic contrasts at first, as their auditory feedback had novel characteristics. Once auditory feedback became recalibrated with prosthesis use, it could, in turn, revise feedforward commands that control the contrasts in its absence.

61. **"Scalar localization of the electrode array after cochlear implantation: Clinical experience using 6-slice multidetector computed tomography".** Lane, J. I.; Witte, R. J.; Driscoll, C. L.; Shallop, J. K.; Beatty, C. W.; Primak, A. N.; (2007); Otol Neurotol. 28(5):658-662

Objective: To use the improved resolution available with 64-slice multidetector computed tomography (MDCT) in vivo to localize the cochlear implant electrode array within the basal turn. Study Design: Sixty-four-slice MDCT examinations of the temporal bones were retrospectively reviewed in 17 patients. Twenty-three implants were evaluated. Setting: Tertiary referral facility. Patients: All patients with previous cochlear implantation evaluated at our center between January 2004 and March 2006 were offered a computed tomographic examination as part of the study. In addition, preoperative computed tomographic examinations in patients being evaluated for a second bilateral device were included. Intervention: Sixty-four-slice MDCT examination of the temporal bones. Main Outcome Measure: Localization of the electrode array within the basal turn from multiplanar reconstructions of the cochlea. Results: Twenty-three implants were imaged in 17 patients. We were able to localize the electrode array within the scala tympani within the basal turn in 10 implants. In 3 implants, the electrode array was localized to the scala vestibuli. Migration of the electrode array from scala tympani to scala vestibuli was observed in three implants. Of the 7 implants in which

localization of the electrode array was indeterminate, all had disease entities that obscured the definition of the normal cochlear anatomy. Conclusions: Sixty-four-slice MDCT with multiplanar reconstructions of the postoperative cochlea after cochlear implantation allows for accurate localization of the electrode array within the basal turn where normal cochlear anatomy is not obscured by the underlying disease process. Correlating the position of the electrode in the basal turn with surgical technique and implant design could be helpful in improving outcomes.

62. **"Cochlear implantation in children with CHARGE syndrome: Therapeutic decisions and outcomes".** Lanson, B. G.; Green, J. E.; Roland, J. T.; Lalwani, A. K.; Waltzman, S. B.; (2007); Laryngoscope. 117(7):1260-1266

Objectives: Ear anomalies and deafness are associated with CHARGE syndrome, which also presents with a cluster of features including coloboma of the eye, heart defects, atresia of the choanae, developmental retardation, and genitourinary abnormalities. The aim of this study is to explore the viability of cochlear implantation in children with CHARGE syndrome and to assess the outcome. Study Design: Retrospective chart review. Methods: Eleven children presenting with severe to profound sensorineural hearing loss associated with CHARGE syndrome were the subjects of this study. Routine audiometric measurements and the Infant Toddler Meaningful Auditory Integration Scale (IT-MAIS) were performed pre- and postoperatively. In addition, the degree of the subjects' cochlear deformity were measured and correlated to outcome. Results: All patients had varying degrees of ear anomalies, seven patients suffered from coloboma of the eyes, two had heart defects, five exhibited choanal atresia, eleven showed developmental retardation, and six had genitourinary abnormalities. Ten of the children underwent cochlear implantation with complete insertion of the electrode array without complication and were followed over a 3-month to a 7-year period. The eleventh child was not implanted because of severe retardation. All of the implanted children showed varying, but limited degrees, of auditory benefit as measured by routine audiometry and the IT-MAIS. Conclusions: Careful treatment planning for children with sensorineural hearing loss and CHARGE syndrome can lead to varying, but limited degrees, of auditory benefit with no increase in surgical complications. Although the implant enhanced the children's 'connectivity' to the environment, it did not promote the development of oral language skills in this population.

63. **"Does music perception have an impact on quality of life following cochlear implantation?".** Lassaletta, L.; Castro, A.; Bastarrica, M.; Perez-Mora, R.; Madero, R.; De Sarria, J.; Gavilan, J.; (2007); Acta Otolaryngol. 127(7):682-686

Conclusion: Despite the decrease in listening habits, about half of the patients still enjoy music post implantation. Better quality of sound through the implant improves music enjoyment and contributes to achievement of better postoperative quality of life (QOL). Objectives: To evaluate music perception and enjoyment in

cochlear implant (CI) users, and to assess their influence on QOL. Materials and Methods: Sixty-five post-lingually deaf CI recipients were enrolled in this study. A musical questionnaire evaluated musical background, listening habits, and quality of musical sound through the CI. The validated Glasgow Benefit Inventory (GBI) was used to quantify changes in QOL. Results: Fifty-two patients answered the questionnaires. Listening habits (music enjoyment and hours spent listening to music per week) significantly decreased following implantation when compared with the same parameters before deafness. Nevertheless, 52% of the patients enjoyed music post implantation. The quality of musical sound was rated >50 (0-100 scale) for the adjective pairs 'like-dislike', 'sounds like music-doesn't sound like music' and 'natural-mechanical' by most users. Med-el device users obtained better scores in the adjective pair 'sounds like music-doesn't sound like music' than Cochlear device users. Recipients rating higher scores for quality of sound enjoyed music post implantation and had higher total GBI scores than those rating lower scores.

64. **"Anatomy of the round window and hook region of the cochlea with implications for cochlear implantation and other endocochlear surgical procedures".** Li, P. M.; Wang, H.; Northrop, C.; Merchant, S. N.; Nadol, J. B.; (2007); Otol Neurotol. 28(5):641-648

Hypothesis: The goal of this study was to create a three-dimensional model of the anatomy of the hook region to identify the optimal site for cochleostomy in cochlear implant surgery. Background: The anatomy of the hook region is complex, and spatial relationships can be difficult to evaluate using two-dimensional histological slides or cadaveric temporal bones. Methods: The right temporal bone of a 14-year-old adolescent boy was used to create a three-dimensional model. Sections containing the round window membrane (RWM) and surrounding cochlear structures were stained, digitized, and imported into a general purpose three-dimensional rendering and analysis software program (Amira, version 4.1). Three-dimensional models of the RWM, basilar membrane, osseous spiral lamina, spiral ligament, cochlear aqueduct, inferior cochlea vein, scala media, ductus reuniens, scala vestibuli, scala tympani, and surrounding bone were generated. The relationship between these structures and the RWM and adjacent otic capsule was evaluated. Histological sections from a different temporal bone were also analyzed. This temporal bone was sectioned in a plane perpendicular to the axis corresponding to the surgical view of the RWM, seen through the facial recess. Results: The anteroinferior margin of the RWM or adjacent otic capsule was identified as the site for a cochleostomy that will avoid damage to critical cochlear structures and allow implantation directly into the scala tympani. The model can be downloaded from: https://research.meei.harvard.edu/otopathology/3dmodels. Conclusion: This three-dimensional model has implications for surgical procedures to the inner ear that aim to minimize insertional trauma.

65. **"Spatially distinct functional output regions within the central nucleus of the inferior colliculus: Implications for an auditory midbrain implant".** Lim, H. H. & Anderson, D. J.; (2007); Journal of Neuroscience. 27(32):8733-8743

The inferior colliculus central nucleus (ICC) has potential as a new site for an auditory prosthesis [i.e., auditory midbrain implant (AMI)] for deaf patients who cannot benefit from cochlear implants (CIs). We have previously shown that ICC stimulation achieves lower thresholds, greater dynamic ranges, and more localized, frequency-specific primary auditory cortex (A1) activation than CI stimulation. However, we also observed that stimulation location along the caudorostral (isofrequency) dimension of the ICC affects thresholds and frequency specificity in A1, suggesting possible differences in functional (output) organization within the ICC. In this study, we electrically stimulated different regions along the isofrequency laminas of the ICC and recorded the corresponding A1 activity in ketamine-anesthetized guinea pigs using multisite probes to systematically assess ICC stimulation location effects. Our results indicate that stimulation of more rostral and somewhat ventral regions within an ICC lamina achieves lower thresholds, smaller discriminable level steps, and larger evoked potentials in A1. We also observed longer first spike latencies, which correlated with reduced spiking precision, when stimulating in more caudal and dorsal ICC regions. These findings suggest that at least two spatially distinct functional output regions exist along an ICC lamina: a caudaldorsal region and a rostralventral region. The AMI will be implanted along the tonotopic axis of the ICC to achieve frequency-specific activation. However, stimulation location along the ICC laminas affects response properties that have shown to be important for speech perception performance, and needs to be considered when implanting future AMI patients.

66. **"Development of a communicative performance scale for pediatric cochlear implantation".** Lin, F. R.; Ceh, K.; Bervinchak, D.; Riley, A.; Miech, R.; Niparko, J. K.; (2007); Ear Hear. 28(5):703-712

Objective: Verbal communicative competence is the main objective after early cochlear implantation in deaf children. However, there are currently no validated instruments to assess a child's real-world communicative abilities. We adopted a rigorous methodological approach to systematically develop the Functioning after Pediatric Cochlear Implantation instrument (FAPCI), a family-centered communicative performance scale based on a conceptual model of functioning established by the World Health Organization. Design: Qualitative instrument development was based on a systematic review of the literature, focus groups, and semistructured interviews with the parents of 2- to 5-yr-old children with cochlear implants and deafness experts. Further refinement and testing of the psychometric validity of the draft instrument was conducted using factor analysis and a cross-sectional sample of 75 parents of children with cochlear implants. Nonparametric and parametric regressions were then performed to investigate the association of FAPCI scores with duration of cochlear implant use to provide preliminary evidence for the instrument's nomological validity. Results: The final

23-item, parent-proxy FAPCI instrument represents a unidimensional scale of the real-world communicative performance of 2- to 5-yr-old children with cochlear implants. The scale demonstrated excellent reliability (Cronbach's alpha >or=0.86), and there was strong evidence supporting the instrument's nomological validity. FAPCI scores were positively associated with duration of implant use ($p < .001$), and 4 yr of implant use were required before maximal FAPCI scores were achieved. Conclusions: Verbal communication is a critical developmental domain that allows for optimal future emotional, cognitive, and behavioral growth. The FAPCI instrument is the first validated instrument ever designed to assess real-world communicative performance of a child with a cochlear implant. The systematic approach taken to development may enable FAPCI to be sensitive to other communication-related disorders commonly seen in childhood or to serve as a model for the development of other disorder-specific instruments.

67. **"Loudness growth observed under partially tripolar stimulation: Model and data from cochlear implant listeners".** Litvak, L. M.; Spahr, A. J.; Emadi, G.; (2007); J Acoust Soc Am. 122(2):967-981

Most cochlear implant strategies utilize monopolar stimulation, likely inducing relatively broad activation of the auditory neurons. The spread of activity may be narrowed with a tripolar stimulation scheme, wherein compensating current of opposite polarity is simultaneously delivered to two adjacent electrodes. In this study, a model and cochlear implant subjects were used to examine loudness growth for varying amounts of tripolar compensation, parameterized by a coefficient sigma, ranging from 0 (monopolar) to 1 (full tripolar). In both the model and the subjects, current required for threshold activation could be approximated by I(sigma)=Ithr(0)(1-sigmaK), with fitted constants Ithr(0) and K. Three of the subjects had a "positioner," intended to place their electrode arrays closer to their neural tissue. The values of K were smaller for the positioner users and for a "close" electrode-to-tissue distance in the model. Above threshold, equal-loudness contours for some subjects deviated significantly from a linear scale-up of the threshold approximations. The patterns of deviation were similar to those observed in the model for conditions in which most of the neurons near the center electrode were excited.

68. **"Relationship between perception of spectral ripple and speech recognition in cochlear implant and vocoder listeners".** Litvak, L. M.; Spahr, A. J.; Saoji, A. A.; Fridman, G. Y.; (2007); J Acoust Soc Am. 122(2):982-991

Spectral resolution has been reported to be closely related to vowel and consonant recognition in cochlear implant (CI) listeners. One measure of spectral resolution is spectral modulation threshold (SMT), which is defined as the smallest detectable spectral contrast in the spectral ripple stimulus. SMT may be determined by the activation pattern associated with electrical stimulation. In the present study, broad activation patterns were simulated using a multi-band vocoder to determine if similar impairments in speech understanding scores could

be produced in normal-hearing listeners. Tokens were first decomposed into 15 logarithmically spaced bands and then re-synthesized by multiplying the envelope of each band by matched filtered noise. Various amounts of current spread were simulated by adjusting the drop-off of the noise spectrum away from the peak (40-5 dB octave). The average SMT (0.25 and 0.5 cycles octave) increased from 6.3 to 22.5 dB, while average vowel identification scores dropped from 86% to 19% and consonant identification scores dropped from 93% to 59%. In each condition, the impairments in speech understanding were generally similar to those found in CI listeners with similar SMTs, suggesting that variability in spread of neural activation largely accounts for the variability in speech perception of CI listeners.

69. **"A detailed 3D model of the guinea pig cochlea".** Liu, B.; Gao, X. L.; Yin, H. X.; Luo, S. Q.; Lu, J.; (2007); Brain Struct Funct. 212(2):223-230

Several partial models of cochlear subparts are available. However, a complete 3D model of an intact cochlea based on actual histological sections has not been reported. Hence, the aim of this study was to develop a novel 3D model of the guinea pig cochlea and conduct post-processes on this reconstructed model. We used a combination of histochemical processing and the method of acquiring section data from the visible human project (VHP) to obtain a set of ideal raw images of cochlear sections. After semi-automatic registration and accurate manual segmentation with professional image processing software, one set of aligned data and six sets of segmented data were generated. Finally, the segmented structures were reconstructed by 3D Slicer (a professional imaging process and analysis tool). Further, post-processes including 3D visualization and a virtual endoscope were completed to improve visualization and simulate the course of the cochlear implant through the scala tympani. The 3D cochlea model contains the main six structures: (1) the inner wall, (2) modiolus and spiral lamina, (3) cochlea nerve and spiral ganglion, (4) spiral ligament and inferior wall of cochlear duct, (5) Reissner's membrane and (6) tectorial membrane. Based on the results, we concluded that ideal raw images of cochlear sections can be acquired by combining the processes of conventional histochemistry and photographing while slicing. After several vital image processing and analysis steps, this could further generate a vivid 3D model of the intact cochlea complete with internal details. This novel 3D model has great potential in teaching, basic medical research and in several clinical applications.

70. **"A PDA-based research platform for cochlear implants".** Lobo, A. P.; Loizou, P. C.; Kehtarnavaz, N.; Torlak, M.; Hoi, L.; Sharma, A.; Gilley, P.; Peddigari, V.; Ramanna, L.; (2007); Dept.of Electr.Eng4

Currently researchers interested in developing new signal processing algorithms for commercially available cochlear implants must rely on coding these algorithms in low-level assembly language. We propose a personal digital assistant (PDA) based research platform for developing and testing in real-time new signal processing strategies for cochlear implants. Software development can be done

either in C or in LabVIEW. The C implementation can be further optimized using Intel's primitive routines. In this paper, we report on the real-time implementation of a 16-channel noise-band vocoder algorithm, which is a similar algorithm used in commercially available implant processors. We further report on EEG recordings on the PDA acquired through a compact-flash data acquisition card.

71. **"Frequency modulation detection with simultaneous amplitude modulation by cochlear implant users".** Luo, X. & Fu, Q. J.; (2007); J Acoust Soc Am. 122(2):1046-1054

To better represent fine structure cues in cochlear implants (CIs), recent research has proposed varying the stimulation rate based on slowly varying frequency modulation (FM) information. The present study investigated the abilities of CI users to detect FM with simultaneous amplitude modulation (AM). FM detection thresholds (FMDTs) for 10-Hz sinusoidal FM and upward frequency sweeps were measured as a function of standard frequency (75-1000 Hz). Three AM conditions were tested, including (1) No AM, (2) 20-Hz Sinusoidal AM (SAM) with modulation depths of 10%, 20%, or 30%, and (3) Noise AM (NAM), in which the amplitude was randomly and uniformly varied over a range of 1, 2, or 3 dB, relative to the reference amplitude. Results showed that FMDTs worsened with increasing standard frequencies, and were lower for sinusoidal FM than for upward frequency sweeps. Simultaneous AM significantly interfered with FM detection; FMDTs were significantly poorer with simultaneous NAM than with SAM. Besides, sinusoidal FMDTs significantly worsened when the starting phase of simultaneous SAM was randomized. These results suggest that FM and AM in CI partly share a common loudness-based coding mechanism and the feasibility of "FM+AM" strategies for CI speech processing may be limited.

72. **"Dynamic amplitude coding in the auditory cortex of awake Rhesus Macaques".** Malone, B. J.; Scott, B. H.; Semple, M. N.; (2007); Journal of Neurophysiology. 98(3):1451-1474

In many animals, the information most important for processing communication sounds, including speech, consists of temporal envelope cues below ~20 Hz. Physiological studies, however, have typically emphasized the upper limits of modulation encoding. Responses to sinusoidal AM (SAM) are generally summarized by modulation transfer functions (MTFs), which emphasize tuning to modulation frequency rather than the representation of the instantaneous stimulus amplitude. Unfortunately, MTFs fail to capture important but nonlinear aspects of amplitude coding in the central auditory system. We focus on an alternative data representation, the modulation period histogram (MPH), which depicts the spike train folded on the modulation period of the SAM stimulus. At low modulation frequencies, the fluctuations of stimulus amplitude in decibels are robustly encoded by the cycle-by-cycle response dynamics evident in the MPH. We show that all of the parameters that define a SAM stimuluscarrier frequency, carrier level, modulation frequency, and modulation depthare reflected in the shape of

cortical MPHs. In many neurons that are nonmonotonically tuned for sound amplitude, the representation of modulation frequency is typically sacrificed to preserve the mapping between the instantaneous discharge rate and the instantaneous stimulus amplitude, resulting in two response modes per modulation cycle. This behavior, as well as the relatively poor tuning of cortical MTFs, suggests that auditory cortical neurons are not well suited for operating as a "modulation filterbank." Instead, our results suggest that <20 Hz, the processing of modulated signals is better described as envelope shape discrimination rather than modulation frequency extraction.

73. **"Effects of cochlear implants on children's reading and academic achievement".** Marschark, M.; Rhoten, C.; Fabich, M.; (2007); The Journal of Deaf Studies and Deaf Education. 12(3):269-282

This article presents a critical analysis of empirical studies assessing literacy and other domains of academic achievement among children with cochlear implants. A variety of recent studies have demonstrated benefits to hearing, language, and speech from implants, leading to assumptions that early implantation and longer periods of implant should be associated with higher reading and academic achievement. This review, however, reveals that although there are clear benefits of cochlear implantation to achievement in young deaf children, empirical results have been somewhat variable. Examination of the literature with regard to reading achievement suggests that the lack of consistent findings might be the result of frequent failures to control potentially confounding variables such as age of implantation, language skills prior to implantation, reading ability prior to implantation, and consistency of implant use. Studies of academic achievement beyond reading are relatively rare, and the extent to which performance in such domains is mediated by reading abilities or directly influenced by hearing, language, and speech remains unclear. Considerations of methodological shortcomings in existing research as well as theoretical and practical questions yet to be addressed provide direction for future research.

74. **"On Language, education, and cochlear implants".** Marschark, M.; Archbold, S.; Grimes, M.; O'Donoghue, G.; (2007); The Journal of Deaf Studies and Deaf Education. 12(3):257

Abstract unavailable.

75. **"Advances in cochlear implant telemetry: Evoked neural responses, electrical field imaging, and technical integrity".** Mens, L. H. M.; (2007); Trends in Amplification. 11(3):143-159

During the last decade, cochlear implantation has evolved into a well-established treatment of deafness, predominantly because of many improvements in speech processing and the controlled excitation of the auditory nerve. Cochlear implants

now also feature telemetry, which is highly useful to monitor the proper functioning of the implanted electronics and electrode contacts. Telemetry can also support the clinical management in young children and difficult cases where neural unresponsiveness is suspected. This article will review recent advances in the telemetry of the electrically evoked compound action potential that have made these measurements simple and routine procedures in most cases. The distribution of the electrical stimulus itself sampled by "electrical field imaging" reveals general patterns of current flow in the normal cochlea and gross abnormalities in individual patients; models have been developed to derive more subtle insights from an individual electrical field imaging. Finally, some thoughts are given to the extended application of telemetry, for example, in monitoring the neural responses or in combination with other treatments of the deaf ear.

76. **"Delayed neurotrophin treatment following deafness rescues spiral ganglion cells from death and promotes regrowth of auditory nerve peripheral processes: Effects of brain-derived neurotrophic factor and fibroblast growth factor.".** Miller, J. M.; Le Prell, C. G.; Prieskorn, D. M.; Wys, N. L.; Altschuler, R. A.; (2007); J Neurosci Res. 85(9):1959-1969

The extent to which neurotrophic factors are able to not only rescue the auditory nerve from deafferentation-induced degeneration but also promote process regrowth is of basic and clinical interest, as regrowth may enhance the therapeutic efficacy of cochlear prostheses. The use of neurotrophic factors is also relevant to interventions to promote regrowth and repair at other sites of nerve trauma. Therefore, auditory nerve survival and peripheral process regrowth were assessed in the guinea pig cochlea following chronic infusion of BDNF + FGF(1) into scala tympani, with treatment initiated 4 days, 3 weeks, or 6 weeks after deafferentation from deafening. Survival of auditory nerve somata (spiral ganglion neurons) was assessed from midmodiolar sections. Peripheral process regrowth was assessed using pan-Trk immunostaining to selectively label afferent fibers. Significantly enhanced survival was seen in each of the treatment groups compared to controls receiving artificial perilymph. A large increase in peripheral processes was found with BDNF + FGF(1) treatment after a 3-week delay compared to the artificial perilymph controls and a smaller enhancement after a 6-week delay. Neurotrophic factor treatment therefore has the potential to improve the benefits of cochlear implants by maintaining a larger excitable population of neurons and inducing neural regrowth.

77. **"How vision matters for individuals with hearing loss".** Mitchell, T. V. & Maslin, M. T.; (2007); Int J Audiol. 46(9):500-511

Hearing loss has obvious implications for communication and auditory functioning. A less obvious implication of hearing loss is its effect on the remaining sensory systems, particularly vision. This paper will review research demonstrating that deafness affects the development of specific visual functions and their neural substrates, including motion processing, face processing, and attention to

peripheral space. Implications of this cross-modal plasticity are discussed in a review of studies with cochlear implant recipients. This latter work suggests that visual speech perception skills that develop during periods of deafness have positive implications for later perception of auditory speech. These effects are discussed in light of multimodal processing and perceptual learning.

78. **"Interaction of cochlear nucleus explants with semiconductor materials".** Mlynski, R.; Volkenstein, S.; Hansen, S.; Brors, D.; Ebmeyer, J.; Dazert, S.; (2007); Laryngoscope. 117(7):1216-1222

Objective/Hypothesis: Implantable hearing devices such as cochlear implants and auditory brainstem implants deliver auditory information through electrical stimulation of auditory neurons. The combination of microelectronic electrodes with auditory nerve cells may lead to further improvement of the hearing quality with these devices. Whereas several kinds of neurons are known to grow on semiconductor substrates, interactions of cochlear nucleus (CN) neurons with such materials have yet to be described. Materials and Methods: To investigate survival and growth behavior of CN neurons on different semiconductor materials. CN explants from postnatal day 10 Sprague-Dawley rats were cultured for 96 hours in Neurobasal medium on polished and unpolished silicon wafers (p-type Si [100] and p-type Si3N4[100]) as well as plastic surface. These surfaces had been coated with poly-L-lysine and laminin. Neuronal outgrowth was examined using image analysis software after immunohistologic staining for neurofilament. Neurite length and directional changes were quantified. Additionally, neurite morphology and adhesion to the semiconductor material was evaluated by scanning electron microscopy. Results: Although proper adhesion of CN explants was seen, no neurite growth could be detected on unpolished silicon wafers (Si and Si3N4). Compared with the other test conditions, polished, laminin-coated Si3N4 wafers showed best biocompatibility regarding neurite length and number per explant. CN explants developed a mean of eight neurons with an average length of 236 mum in 96 hours of culture on these wafers. Conclusion: The results of this study demonstrate the general possibility of CN neuron growth in culture on semiconductors in vitro. The differences in neuron length and number per explant indicate that the growth of CN neurons is influenced by the semiconductor substrate as well as extracellular matrix proteins, with laminin-coated p-type Si3N4[100] being a preferable material for future hybrid experiments on auditory-neuron semiconductor chips.

79. **"Vocalizations of infants with hearing loss compared with infants with normal hearing: Part I - phonetic development".** Moeller, M. P.; Hoover, B.; Putman, C.; Arbataitis, K.; Bohnenkamp, G.; Peterson, B.; Wood, S.; Lewis, D.; Pittman, A.; Stelmachowicz, P.; (2007); Ear Hear. 28(5):605-627

Objective: Infants with hearing loss are known to be slower to develop spoken vocabulary than peers with normal hearing. Previous research demonstrates that they differ from normal-hearing children in several aspects of prelinguistic vocal

development. Less is known about the vocalizations of early-identified infants with access to current hearing technologies. This longitudinal study documents changes in prelinguistic vocalizations in early-identified infants with varying degrees of hearing loss, compared with a group of infants with normal hearing. It was hypothesized that infants with hearing loss would demonstrate phonetic delays and that selected aspects of phonetic learning may be differentially affected by restricted auditory access. Design: The vocalizations and early verbalizations of 21 infants with normal hearing and 12 early-identified infants with hearing loss were compared over a period of 14 mo (from 10 to 24 mo of age). Thirty-minute mother-child interaction sessions were video recorded at 6- to 8-wk intervals in a laboratory playroom setting. Syllable complexity changes and consonantal development were quantified from vocalizations and early verbalizations. Early behaviors were related to speech production measures at 36 mo of age. Participants with hearing loss were recruited from local audiology clinics and early intervention programs. Participants with normal hearing were recruited through day care centers and pediatrician offices. Results: Relative to age-matched, normal-hearing peers, children with hearing loss were delayed in the onset of consistent canonical babble. However, certain children with moderately-severe losses babbled on time, and infants with cochlear implants babbled within 2 to 6 mo of implantation. The infants with hearing loss had smaller consonantal inventories and were slower to increase syllable shape complexity than age-matched normal-hearing peers. The overall pattern of results suggested that consonant development in infants with hearing loss was delayed but not qualitatively different from children with normal hearing. Delays appeared to be less pronounced than suggested by previous research. However, fricative/affricate development progressed slowly in infants with hearing loss and divergence from the patterns of normal-hearing children was observed. Six children (2 with normal hearing; 4 with hearing loss) were identified as atypical, based on their rates of development. At 24 mo of age, these children persisted in producing a high proportion (0.59) of vocalizations lacking consonants, which was negatively correlated with Goldman-Fristoe scores at 36 mo ($r = -0.60$). Conclusions: Results suggest that early-identified children are delayed in consonant and syllable structure development, which may influence early word learning rates. Fricative/affricate development appears to be challenging for some infants with hearing loss. This may be related to the effects of sensorineural hearing loss on high-frequency information, restricted bandwidth provided by amplification, and reduced audibility in contexts of noise and reverberation. Delayed fricative use may have implications for morphological development. Atypically slow rates of change in syllable development may indicate that a child is at risk for delayed speech development.

80. **"[Cochlear implant: Hearing and language in pre-lingual deaf children.]".** Moret, A. L.; Bevilacqua, M. C.; Costa, O. A.; (2007); Pro Fono. 19(3):295-304

Background: cochlear implant in children, speech perception and oral language, hearing and oral language performance in children with pre-lingual profound sensory-neural hearing impairment, users of cochlear implant. AIM: to study the hearing and oral language performance of children with pre-lingual bilateral profound sensory neural hearing impairment, users of multi-channel cochlear implant considering the following aspects: age of the child when the research was carried out, time of hearing sensorial privation, time of cochlear implant use, type of cochlear implant, type of speech coding strategy used, familial permeability level in relation to the therapeutic process and cognitive style of the child. Method: participants of this study were 60 children who were assessed according to hearing and language categories. All of the variables were statistically analyzed. Psycho-social aspects, considering the child's cognitive style and the family's permeability level were also assessed. Results: regarding the hearing and language performance with the use of cochlear implant, the intermediate and advanced hearing categories were accomplished by more than half of the children. The statistically significant aspects in the performance of hearing and oral language were: the age of the child upon evaluation, time of hearing sensorial privation, time of cochlear implant use, type of implant, speech sounds coding strategy and familial permeability. Conclusion: the cochlear implant as a treatment for children with pre-lingual sensory-neural hearing impairment is highly effective, although complex, owing to the interaction of variables which interfere in the implanted child's performance. Further studies are needed for the understanding of the implantation complexity in young children.

81. **"Perception of suprasegmental features of speech by children with cochlear implants and children with hearing aids".** Most, T. & Peled, M.; (2007); The Journal of Deaf Studies and Deaf Education. 12(3):350-361

This study assessed perception of suprasegmental features of speech by 30 prelingual children with sensorineural hearing loss. Ten children had cochlear implants (CIs), and 20 children wore hearing aids (HA): 10 with severe hearing loss and 10 with profound hearing loss. Perception of intonation, syllable stress, word emphasis, and word pattern was assessed. Results revealed that the two HA groups significantly outperformed the CI group in perceiving both intonation and stress. Within each group, word pattern was perceived best, and then intonation and emphasis, with syllable stress perceived poorest. No significant correlation emerged between age at implantation and perception of the various suprasegmental features, possibly due to participants' relatively late age at implantation. Results indicated that CI use did not show an advantage over HA use in the perception of suprasegmental features of speech. Future research should continue to explore variables that might improve this perception.

82. **"Effects of cochlear implantation on gustatory function".** Mueller, C. A.; Khatib, S.; Temmel, A. F. P.; Baumgartner, W.-D.; Hummel, T.; (2007); Annals of Otology, Rhinology and Laryngology. 116(7):498-501

Objectives: Because of the anatomic position of the chorda tympani in the tympanic cavity, the nerve is at risk during cochlear implantation. The aim of this study was to assess changes in taste sensitivity and in self-ratings of gustatory function after surgery. Methods: Twenty-four patients (mean age, 54 years) who underwent cochlear implantation were investigated. Taste function was tested with a validated test for regional quantitative assessment of sweet, sour, salty, and bitter tastes on each side of the tongue before and 4 days after surgery. Results: The mean taste score was 10.0 (SD, 4.0) before and 8.0 (SD, 4.1) after surgery on the side of the tongue ipsilateral to the operated ear ($p = .004$). However, only 1 patient reported subjective taste loss due to surgery. Taste testing of the side of the tongue contralateral to the operated ear yielded a score of 10.0 (SD, 4.1) before and 10.9 (SD, 4.5) after surgery ($p = .037$). Self-ratings of gustatory function did not change significantly as a consequence of the procedure. Conclusions: Our results indicate that cochlear implantation is a relatively safe procedure regarding taste function. Preoperative testing of gustatory function is recommended, at least in those patients who already have undergone operation on the contralateral ear.

83. **"Bilateral cochlear implantation: An evidence-based medicine evaluation".** Murphy, J. & O'Donoghue, G.; (2007); Laryngoscope. 117(8):1412-1418

Objectives/hypothesis: The aim of this study was to evaluate the extent and quality of evidence reported on the outcomes of bilateral cochlear implantation and thereby to inform opinion about future patient management. Study design: Retrospective literature review. Methods: A detailed search of the medical literature was performed using the Medline, Embase, and CINAHL databases starting from the date of their conception. The quality of evidence in each article was assessed according to the categories of evidence as defined by the Oxford Centre for Evidence-based Medicine, Levels of Evidence (May 2001). Results: A total of 37 studies were included; 28 (76%) Investigated adult participants only, 7 (19%) Investigated child participants, and 2 (5%) Contained both groups. Of the studies presented, 9 (24%) Studies contained level 2b evidence, 2 (6%) Level 3b, 16 (43%) Level 4, and 10 (27%) Level 5 evidence. No studies were identified as representing evidence level 1. Adult bilateral recipients demonstrated an increase in sentence recognition of 21% correct over their first implanted ear ($P < .001$) And mean bilateral localization errors of 24 degrees against a monaural error of 67 degrees ($P < .005$). Conclusions: The available evidence indicates that bilateral cochlear implantation confers material benefits not achievable with unilateral implantation, specifically in terms of sound localization and understanding of speech in noise. Well-designed prospective studies of sufficient size are now

needed to precisely quantify these benefits, to validate outcome measures, especially in children, and to define the criteria for intervention.

84. **"Will they catch up? The role of age at cochlear implantation in the spoken language development of children with severe to profound hearing loss".** Nicholas, J. G. & Geers, A. E.; (2007); Journal of Speech, Language, and Hearing Research. 50(4):1048-1062

Purpose: The authors examined the benefits of younger cochlear implantation, longer cochlear implant use, and greater pre-implant aided hearing to spoken language at 3.5 and 4.5 years of age. Method: Language samples were obtained at ages 3.5 and 4.5 years from 76 children who received an implant by their 3rd birthday. Hierarchical linear modeling was used to identify characteristics associated with spoken language outcomes at the 2 test ages. The Preschool Language Scale (I. L. Zimmerman, V. G. Steiner, & R. E. Pond, 1992) was used to compare the participants' skills with those of hearing age-mates at age 4.5 years. Results: Expected language scores increased with younger age at implant and lower pre-implant thresholds, even when compared at the same duration of implant use. Expected Preschool Language Scale scores of the children who received the implant at the youngest ages reached those of hearing age-mates by 4.5 years, but those children implanted after 24 months of age did not catch up with hearing peers. Conclusion: Children who received a cochlear implant before a substantial delay in spoken language developed (i.e., between 12 and 16 months) were more likely to achieve age-appropriate spoken language. These results favor cochlear implantation before 24 months of age, especially for children with aided pure-tone average thresholds greater than 65 dB prior to surgery.

85. **"Standard cochlear implantation of adults with residual low-frequency hearing: Implications for combined electro-acoustic stimulation".** Novak, M. A.; Black, J. M.; Koch, D. B.; (2007); Otol Neurotol. 28(5):609-614

Objective: This study compared preoperative and postoperative cochlear implant benefit in subjects with steeply sloping high-frequency hearing losses (HLs) who were implanted with standard long cochlear implant electrodes to: 1) determine the effect of etiology, 2) compare outcomes in studies exploring the use of combined electrical and acoustic stimulation, and 3) compare outcomes in patients implanted using standard criteria. Study Design: Retrospective case review. Setting: Tertiary referral center. Patients: Nine adults with steeply sloping high-frequency congenital (n=2) or acquired (n=7) bilateral sensorineural HL. All pure-tone audiograms fit the criteria for trials of a short electrode aimed at preserving low-frequency acoustic hearing. Intervention: Subjects received full insertion of a standard cochlear implant long electrode in the poorer ear. Main Outcome Measures: Preoperative versus postoperative audiograms, word and sentence recognition in quiet and noise. Results: Patients with progressive acquired HLs experienced significantly improved speech understanding in quiet and in noise with the cochlear implant, especially when combined with hearing aid use in the

contralateral ear. Patients with congenital HLs experienced little or no improvement in the implanted ear when tested with the implant alone, but achieved some benefit when the implant was combined with a hearing aid in the nonimplanted ear. Conclusion: Based on this small sample, patients with acquired steeply sloping high-frequency HLs obtain significant benefit from cochlear implantation with standard long electrodes. In progressive losses, full insertion of a long electrode would be preferable to a short electrode because acoustic hearing may diminish over time. In contrast, patients with congenital losses may not benefit from long electrodes, and might be better served by implanting a short electrode, thereby allowing use of low-frequency acoustic stimulation.

86. **"Functional magnetic resonance imaging of hearing-impaired children under sedation before cochlear implantation".** Patel, A. M.; Cahill, L. D.; Ret, J.; Schmithorst, V.; Choo, D.; Holland, S.; (2007); Archives of Otolaryngology - Head and Neck Surgery. 133(7):677-683

Objective: To investigate functional magnetic resonance imaging (fMRI) in pediatric cochlear implantation candidates with residual hearing who are under sedation for evaluation of auditory function. Design: During fMRI, subjects heard a random sequence of tones (250-4000 Hz) presented 10 dB above hearing thresholds. Tones were interleaved with silence in a block-periodic fMRI design with 30-second on-off intervals. Twenty-four axial sections (5 mm thick) covering most of the brain were obtained every 3 seconds for a total acquisition time of 5.5 minutes. Setting Single tertiary academic medical institution. Patients: Severely to profoundly hearing-impaired children (n = 10; mean age, 49.1 months). During fMRI, subjects were awake (n = 2) or sedated with pentobarbital sodium if their weight was 10 kg or greater (n = 4) or chloral hydrate if their weight was less than 10 kg (n = 4). Main Outcome Measures: Detection of brain activation by fMRI in the primary auditory cortex (A1) in hearing-impaired patients under sedation, and correlation of A1 activation with hearing levels measured after cochlear implantation. Results: In most subjects, fMRI detected significant levels of activation in the A1 region before cochlear implantation. The improvement in hearing threshold after cochlear implantation correlated strongly (linear regression coefficient, R = 0.88) with the amount of activation in the A1 region detected by fMRI before cochlear implantation. Conclusions: Functional MRI can be considered a means of assessing residual function in the A1 region in sedated hearing-impaired toddlers. With improvements in acquisition, processing, and sedation methods, fMRI may be translated into a prognostic indicator for outcome after cochlear implantation in infants.

87. **"Optical coherence tomography as an orientation guide in cochlear implant surgery?".** Pau, H. W.; Lankenau, E.; Just, T.; Behrend, D.; Huttmann, G.; (2007); Acta Otolaryngol. 127(9):907-913

Conclusion: With optical coherence tomography (OCT) it is basically possible to reveal parts of the cochlear morphology without opening its enveloping

membranes. Thus, it may serve as a helpful guide for the surgeon to localize the scala tympani precisely before opening the fluid-filled inner ear to insert the electrode array. Objective: To improve anatomical orientation in cochlear implant surgery before definitively opening the fluid-filled inner ear. The question was whether a new imaging technique, OCT, might provide information about the site of the underlying inner ear structures (scala tympani, scala vestibuli) and could, consequently, guide the surgeon towards the scala tympani. Material and Methods: In a preliminary study, OCT was carried out on human temporal bone preparations, in which a cochleostomy ('fenestration') was performed leaving the endosteum and the fluid-filled inner ear intact. OCT was applied via a prototype of a specially equipped operating microscope. The mode of OCT used in this context was spectral-domain (SD)-OCT. Results: On scans, which can be read analogous to B-mode sonography, OCT provides information about structures on the inner surface of the partly exposed but still intact membranous cochlear lining - such as scala tympani or scala vestibuli.

88. **"Temporal bone investigations on landmarks for conventional or endosteal insertion of cochlear electrodes".** Pau, H. W.; Just, T.; Dommerich, S.; Behrend, D.; (2007); Acta Oto-Laryngologica. 127(9):920-926

Conclusion. Our anatomical findings place special emphasis on the requirement to follow an infero-anterior approach to the round window, to expose the scala tympani safely for 'normal' cochlear implantation. It is also known how easily the basilar membrane may be accidentally damaged, despite exercising considerable caution in the approach used. With regard to an 'endosteal electrode' it can be stated that there are no really specific indicators to locate the spiral ligament, or each of the scalae, on the lateral aspect of the tissue layer encasing the cochlea. For the concept of an endosteal electrode, however, the soft tissue layer of the lateral aspect of the cochlea is considered to be sufficiently thick to serve as a physical barrier between the electrode and the inner ear fluid. Objectives. To re-evaluate surgical techniques of gaining access to the scala tympani for cochlear implantation (cochleostomy, 'fenestration'). There are two reasons for this study. First, recent publications show that in a significant number of patients the electrode array was unintentionally inserted into the 'wrong' scala (sc. vestibuli). Second, dealing with an alternative concept proposed by Lehnhardt for patients with residual hearing ('endosteal electrode'), the anatomical site of the spiral ligament should be known. In a study on human temporal bones the topography of the middle and inner ear is revised with regard to the presence of anatomical or surgical landmarks that may guide the surgeon. Materials and methods. Anatomical examinations were performed on 10 temporal bones (5 fresh specimens and 5 fixed in formalin), in which the bone of the promontory was carefully milled. The consistency of identification and the relative location of specific surgical indicators or landmarks such as 'blue lines' and 'gray lines' were evaluated for 10 temporal bones. Furthermore, the projection of the lateral attachment of the basilar membrane on the promontory was determined with regard to round window anatomy. Results. In all cases, a major blue line indicated

the lateral aspect of the basal cochlear turn while milling the promontorial bone. In a limited number of cases (20%), an additional gray line potentially indicated the spiral ligament before the last shell of bone was removed. In 80% of the cases it was possible to remove the bony layer and leave the endosteum intact as a precondition for a potential endosteal electrode insertion. In addition, through the examination of these models, the relative anatomical location of structures, such as the scala vestibuli, scala tympani, spiral ligament, and basilar membrane, is reviewed.

89. **"Importance of age and postimplantation experience on speech perception measures in children with sequential bilateral cochlear implants".** Peters, B. R.; Litovsky, R.; Parkinson, A.; Lake, J.; (2007); Otol Neurotol. 28(5):649-657

Objectives: Clinical trials in which children received bilateral cochlear implants in sequential operations were conducted to analyze the extent to which bilateral implantation offers benefits on a number of measures. The present investigation was particularly focused on measuring the effects of age at implantation and experience after activation of the second implant on speech perception performance. Study Design: Thirty children aged 3 to 13 years were recipients of 2 cochlear implants, received in sequential operations, a minimum of 6 months apart. All children received their first implant before 5 years of age and had acquired speech perception capabilities with the first device. They were divided into 3 age groups on the basis of age at time of second ear implantation: Group I, 3 to 5 years; Group II, 5.1 to 8 years; and Group III, 8.1 to 13 years. Speech perception measures in quiet included the Multisyllabic Lexical Neighborhood Test (MLNT) for Group I, the Lexical Neighborhood Test (LNT) for Groups II and III, and the Hearing In Noise Test for Children (HINT-C) sentences in quiet for Group III. Speech perception in noise was assessed using the Children's Realistic Intelligibility and Speech Perception (CRISP) test. Testing was performed preoperatively and again postactivation of the second implant at 3, 6, and 12 months (CRISP at 3 and 9 mo) in both the unilateral and bilateral conditions in a repeated-measures study design. Two-way repeated-measures analysis of variance was used to analyze statistical significance among device configurations and performance over time. Setting: US Multicenter. Results: Results for speech perception in quiet show that children implanted sequentially acquire open-set speech perception in the second ear relatively quickly (within 6 mo). However, children younger than 8 years do so more rapidly and to a higher level of speech perception ability at 12 months than older children (mean second ear MLNT/LNT scores at 12 months: Group I, 83.9%; range, 71-96%; Group II, 59.5%; range, 40-88%; Group III, 32%; range, 12-56%). The second-ear mean HINT-C score for Group III children remained far less than that of the first ear even after 12 months of device use (44 versus 89%; t, 6.48; $p<0.001$; critical value, 0.025). Speech intelligibility for spondees in noise was significantly better under bilateral conditions than with either ear alone when all children were analyzed as a single group and for Group III children. At the 9-month test interval, performance in the

bilateral configuration was significantly better for all noise conditions (13.2% better for noise at first cochlear implant, 6.8% better for the noise front and noise at second cochlear implant conditions, t=2.32, p=0.024, critical level=0.05 for noise front; t=3.75, p<0.0001, critical level=0.05 for noise at first implant; t=2.73, p = 0.008, critical level=0.05 for noise at second implant side). The bilateral benefit in noise increased with time from 3 to 9 months after activation of the second implant. This bilateral advantage is greatest when noise is directed toward the first implanted ear, indicating that the head shadow effect is the most effective binaural mechanism. The bilateral condition produced small improvements in speech perception in quiet and for individual Group I and Group II patient results in noise that, in view of the relatively small number of subjects tested, do not reach statistical significance. Conclusion: Sequential bilateral cochlear implantation in children of diverse ages has the potential to improve speech perception abilities in the second implanted ear and to provide access to the use of binaural mechanisms such as the head shadow effect. The improvement unfolds over time and continues to grow during the 6 to 12 months after activation of the second implant. Younger children in this study achieved higher open-set speech perception scores in the second ear, but older children still demonstrate bilateral benefit in noise. Determining the long-term impact and cost-effectiveness that results from such potential capabilities in bilaterally implanted children requires additional study with larger groups of subjects and more prolonged monitoring.

90. **"Relation between neural response telemetry thresholds, T- and C-levels, and loudness judgments in 12 adult nucleus 24 cochlear implant recipients".** Potts, L. G.; Skinner, M. W.; Gotter, B. D.; Strube, M. J.; Brenner, C. A.; (2007); Ear Hear. 28(4):495-511

Objective: The primary purpose of this study was to determine if the contour of visual (vNRT) or predicted (tNRT) neural response telemetry (NRT) thresholds across electrodes could predict the contour of behaviorally programmed T-levels (minimum stimulation) and/or C-levels (maximum stimulation) across electrodes for well-fit MAPs. The secondary purpose was to determine the relation between NRT thresholds and loudness judgments obtained at the subject's MAP rate (250, 900, 1200, or 1800 pulses per second [pps]) and the NRT stimulus rate (80 pps). Design: Twelve adult Nucleus 24 cochlear implant recipients participated in the study. The T- and C-levels from a preferred MAP, which had been worn for a minimum of 3 mo, were used in this study. Electrically evoked compound action potentials were measured on 11 active electrodes with NRT software (v3.0). Ascending loudness judgments from first hearing to maximum acceptable loudness were completed on these electrodes with the subject's preferred MAP rate stimulus, using the R126 (v.2.0) software and with an 80 pps rate stimulus, using the NRT software (v3.0). All measures were repeated approximately 1 mo later to determine their reliability. Results: The reliability of the behavioral and objective measures was very high from the first to the second half of the study. The mean tNRT thresholds had a lower reliability (r = 0.73) than vNRT thresholds (r = 0.91). The loudness judgment dynamic range was notably different between

rates. The NRT rate (80 pps) stimulus resulted in the narrowest dynamic range followed by increasingly wider dynamic range as the MAP rate increased. The NRT thresholds had a stronger correlation with loudness judgments made with the NRT rate stimulus than with the MAP rate stimulus. The group mean NRT thresholds were significantly correlated with C-levels (vNRT r = 0.69) (tNRT r = 0.66) but not T-levels. The relation between NRT thresholds and T- and C-levels varied for different MAP rates, with the NRT thresholds being closest to the C-levels for the 250 pps MAP rate. Each subject's vNRT thresholds and MAP levels were examined by fitting a third-order polynomial to the data. This analysis revealed significant variability demonstrating that no one fit predicts T- and C-levels well for all subjects. Conclusions: The results of this study provide important insight into the relation between NRT thresholds and loudness judgments for different stimulation rates and T- and C-levels at various MAP rates. The loudness judgment dynamic range and MAP dynamic range (T- and C-levels) varied notably for different stimulation rates. As a result, the relation of NRT thresholds to these measures also varied with stimulation rate. Overall, the mean vNRT thresholds fell higher in the loudness judgment dynamic range than the tNRT thresholds. Mean NRT thresholds fell between the judgments of medium soft and maximum acceptable loudness for all stimulation rates. Mean vNRT thresholds fell above C-levels, whereas almost half of tNRT thresholds fell just below C-levels. However, the relation between NRT thresholds and C-levels varied substantially for different MAP stimulation levels. In addition, there is substantial individual variability in the relation between NRT thresholds and MAP levels that is not reflected in the group data. The prediction of the contour of T- and C-levels from the contour of NRT thresholds across electrodes would not be appropriate for half of the subjects. Therefore, great care should be taken when applying a fitting rule that incorporates NRT thresholds without considering these individual differences. For adults who can provide appropriate loudness judgments and threshold responses it appears to be most efficient to primarily use behavioral measures to create MAPs.

91. **"Far-advanced otosclerosis and cochlear implantation".** Psillas, G.; Kyriafinis, G.; Constantinidis, J.; Vital, V.; (2007); B-ENT. 3(2):67-71

Problems/Objectives: To report the radiographic and surgical findings, speech perception performance, and complications of cochlear implantation for patients who were affected by far-advanced otosclerosis. Methodology: Five patients, 2 males and 3 females, with a family history of otosclerosis and who previously underwent stapedectomy to improve hearing were included in this study. CT scans of all ears were graded according to Rotteveel's grading system. All patients underwent cochlear implantation according to standard procedures. A control group of 10 non-otosclerotic postlingual implanted adults matched for age was used. Results: On CT scanning, one patient had solely fenestral disease (type 1), 3 patients had localized retrofenestral disease (type 2), and 1 had diffuse retrofenestral disease with loss of the normal architecture of the cochlea (type 3). In all otosclerotic patients, the electrode array was fully inserted. However, in two

patients (type 2 and 3) a thickened otic capsule was present and required more drilling than normal. One patient (type 3) experienced postoperatively facial nerve stimulation with normal fitting parameters. Otosclerotic patients showed excellent speech perception after implantation and obtained similar results to those achieved by the non-otosclerotic patients. Conclusions: Patients suffering from far-advanced otosclerosis may benefit from cochlear implantation and achieve speech performance scores comparable to non-otosclerotic implantees. Regarding surgery and facial nerve stimulation, attention should be taken to these cases in which the extension of otosclerosis is more severe on CT scanning (type 2 and mainly 3). Postoperative facial nerve stimulation can be managed successfully by resetting the current levels for comfort level.

92. **"Skin flap thickness in cochlear implant patients - a prospective study".** Raine, C. H.; Lee, C. A.; Strachan, D. R.; Totten, C. T.; Khan, S.; (2007); Cochlear Implants Int. 8(3):148-157

The thickness and quality of the skin overlying a cochlear implant is important for its integrity. It should be thick enough to protect the implant and prevent flap breakdown yet should not be so thick that it impedes the electronic signal or causes difficulty wearing the coil because of loss of the magnetic coupling. The principle of this study was to devise a method to assess the thickness of skin over a cochlear implant receiver stimulator package and prospectively measure this thickness during the first year following surgery. All patients studied were implanted with MED-EL COMBI 40+ implants. The first cohort consisted of 35 adults; the second 23 children. Various methods of measurement were assessed. In this study the principle of the Hall Effect electrode was used to measure the magnetic flux density of the magnet within the receiver stimulator package. Following standardization, results showed that skin thickness significantly thinned in the adult group before stabilizing. This was less obvious in children, probably due to the effect of the skin thickening as the child grows. Knowledge of skin thickness has implications relating to the functioning of an implant and avoiding potential flap related complications.

93. **"Auditory neuropathy: clinical characteristics and therapeutic approach".** Raveh, E.; Buller, N.; Badrana, O.; Attias, J.; (2007); Am J Otolaryngol. 28(5):302-308

Purpose: Auditory neuropathy is characterized by congenital sensorineural hearing loss associated with absent or impaired auditory brainstem evoked responses and preservation of outer hair cell activity. This study describes the recent experience of our tertiary pediatric center with auditory neuropathy (AN). Methods: The files of all children diagnosed with AN at our center from 2000 to 2005 were reviewed for background data, associated factors, laboratory and audiometry findings, management, and outcome. Results: Mean age at diagnosis was 13 months. Factors known to be associated with AN were found in 18 children, namely, prematurity, hyperbilirubinemia, parental consanguinity, or

positive family history. Conception by in vitro fertilization was an additional factor not previously reported. The hearing loss was mostly moderate to severe, and bilateral in all patients but one. Otoacoustic emissions and/or cochlear microphonics were demonstrated in all cases. Hearing improved spontaneously in 4 patients. Management with a hearing aid was successful in 1 of 19 patients. Twelve patients received cochlear implants with good outcome. Conclusion: Because neonates with AN have normal otoacoustic emissions and/or cochlear microphonics, screening tests for high-risk neonates should be complemented by auditory brainstem evoked responses to avoid false-negative findings. Because AN is considered a retrocochlear lesion, with normal outer hair cell function, rehabilitation with hearing aids is problematic. Although the level of pathology is apparently at the cochlear nerve, cochlear implantation is often a good solution for failures of conventional rehabilitation. However, our finding of spontaneous improvement in a small subgroup raises questions regarding implantation before age 1 year.

94. **"Gentamicin uptake in the chinchilla inner ear".** Roehm, P.; Hoffer, M.; Balaban, C. D.; (2007); Hear Res. 230(1-2):43-52

Studies of transtympanic gentamicin have focused on clinical use and outcomes. This study presents evidence of bilateral uptake and retention of gentamicin in certain inner ear cells and structures following transtympanic gentamicin application. Middle ear application of gentamicin was performed by either minipump (Alza model, 2002) or transtympanic injection in a chinchilla model. Histological sections of decalcified temporal bones were stained to identify the distribution of gentamicin. Using both anti-gentamicin immunohistochemistry and autoradiography of tracer amounts of tritiated gentamicin, Scarpa's and spiral ganglion cells, stria vascularis, and vestibular dark cells of the injected ear were found to have higher levels of gentamicin and retain it within cell bodies while staining levels fell to background levels in the rest of the injected ear over the course of 14 days. There was no evidence of an apical to basal gradient of anti-gentamicin staining within the spiral ganglion. Contralateral inner ear cells showed light anti-gentamicin staining. Cell bodies in the ipsilateral dorsal cochlear nucleus bordering the cochlear aqueduct (CA) showed a lateral to medial gradient of gentamicin staining, suggesting the CA as a potential site of transfer of gentamicin to the contralateral ear. Direct effects of aminoglycosides on ganglion cells may have implications on both the success of cochlear implantation in patients deafened following systemic aminoglycoside therapy and on the advisability of clinical practices of transtympanic gentamicin therapy and ototopic aminoglycoside treatment.

95. **"Cochlear implant electrode insertion: The round window revisited.".** Roland, P. S.; Wright, C. G.; Isaacson, B.; (2007); Laryngoscope. 117(8):1397-1402

Objective: To examine aspects of round window (RW) anatomy that are relevant to its use as a portal for atraumatic insertion of cochlear implant electrodes. Study Design: Anatomic study using human cadaveric temporal bones. Methods: A series of 30 temporal bones was dissected to permit microscopic study of the RW region. Results: The bony overhangs of the RW niche limit visibility of the RW membrane during surgery. Measurements of RW membrane area visible through a facial recess opening before and after drilling the overhangs in 15 temporal bones showed that RW membrane visibility is typically increased by a factor of 1.5 to 3 times after drilling and by as much as 13 times when the opening of the RW niche is relatively small. Observations from within the scala tympani in 15 cochlear dissections showed substantial variability in size of the RW opening available for electrode insertion. Area measurements of the portion of the RW covered by the vertical segment of the RW membrane ranged from 0.8 to 1.75 mm^2 in these specimens. In addition, irregularities in contour of the RW margin may make insertion challenging, which may necessitate drilling the anterior-inferior margin of the RW. Drilling in this region should be approached with care because of the close proximity of the cochlear aqueduct opening. Conclusion: RW insertion can be performed in a manner that is potentially less traumatic than the standard cochleostomy insertion. It may therefore be advantageous in cases in which hearing preservation is the goal.

96. **"Long-term performance of Clarion 1.0 cochlear implant users".** Ruffin, C. V.; Tyler, R. S.; Witt, S. A.; Dunn, C. C.; Gantz, B. J.; Rubinstein, J. T.; (2007); Laryngoscope. 117(7):1183-1190

Objective/Hypothesis: To evaluate the long-term performance of adult Clarion 1.0 cochlear implant users. Study Design: This was a retrospective, longitudinal study evaluating word discrimination in quiet for 31 adult cochlear implant patients with preimplantation sentence scores of less than 10%. Methods: The length of the study was 135 months with a mean follow-up length of 93 (median, 96) months. For the duration of the study, all subjects used the Clarion 1.0 cochlear implant with speech processors programmed for the use of the continuous interleaved sampling strategy. Results: There was no significant growth or decline in speech perception after 24 months postimplantation unless adverse medical events were experienced. Age at implantation was significantly and substantially negatively correlated (-11% word score per decade, r = 0.68) with most recent score, maximum score, time to maximum score, range of performance, 24- to 130-month mean score, and for any longitudinal data point tested: 3 to 6 months, 6 months, 1 year, 2 years, 5 years, and 10 years. There were no age-related declines in performance. There were no observed correlations between duration of deafness and any of the variables listed above. Conclusions: The lack of correlation between duration of deafness and performance in a cohort without residual

hearing suggests the presence of a strong correlation between age and speech performance with a cochlear implant. That the cochlear implant is a safe therapy for the treatment of profound deafness is supported by the stability of scores through the 10-year study period as well as a zero rate of device failures or explantation.

97. **"What matched comparisons can and cannot tell us: The case of cochlear implants".** Sagi, E.; Fitzgerald, M. B.; Svirsky, M. A.; (2007); Ear Hear. 28(4):571-579

Objectives: To examine the conclusions and possible misinterpretations that may or may not be drawn from the "outcome-matching method," a study design recently used in the cochlear implant literature. In this method, subject groups are matched not only on potentially confounding variables but also on an outcome measure that is closely related to the outcome measure under analysis. For example, subjects may be matched according to their speech perception scores in quiet, and their speech perception in noise is compared. Design: The present study includes two components, a simulation study and a questionnaire. In the simulation study, the outcome-matching method was applied to pseudo-randomly generated data. Simulated speech perception scores in quiet and in noise were generated for two comparison groups, in two imaginary worlds. In both worlds, comparison group A performed only slightly worse in noise than in quiet, whereas comparison group B performed significantly worse in noise than in quiet. In Imaginary World 1, comparison group A had better speech perception scores than comparison group B. In Imaginary World 2, comparison group B had better speech perception scores than comparison group A. The outcome-matching method was applied to these data twice in each imaginary world: 1) matching scores in quiet and comparing in noise, and 2) matching scores in noise and comparing in quiet. This procedure was repeated 10,000 times. The second part of the study was conducted to address the level of misinterpretation that could arise from the outcome-matching method. A questionnaire was administered to 54 students in a senior level course on speech and hearing to assess their opinions about speech perception with two different models of cochlear implant devices. The students were instructed to fill out the questionnaire before and after reading a paper that used the outcome-matching method to examine speech perception in noise and in quiet with those two cochlear implant devices. Results: When pseudorandom scores were matched in quiet, comparison group A's scores in noise were significantly better than comparison group B's scores. Results were different when scores were matched in noise: in this case, comparison group B's scores in quiet were significantly better than comparison group A's scores. Thus, the choice of outcome measure used for matching determined the result of the comparison. Additionally, results of the comparisons were identical regardless of whether they were conducted using data from Imaginary World 1 (where comparison group A is better) or from Imaginary World 2 (where comparison group B is better). After reading the paper that used the outcome-matching method, students' opinions about the two cochlear implants underwent a significant change even though,

according to the simulation study, this opinion change was not warranted by the data. Conclusions: The outcome-matching method can provide important information about differences within a comparison group, but it cannot be used to determine whether a given device or clinical intervention is better than another one. Care must be used when interpreting the results of a study using the outcome-matching method.

98. **"Otosclerosis: Mid-term results of cochlear implantation".** Sainz, M.; Garcia-Valdecasas, J.; Garofano, M.; Ballesteros, J. M.; (2007); Audiol Neurootol. 12(6):401-406

Introduction: Constant histological changes in otosclerosis lead to progressive hearing loss which may end up in a profound hearing loss and then be treated by means of cochlear implants. These progressive changes could be followed by changes in cochlear implants fitting and speech discrimination results over the years. Objectives: The aim of the study is to correlate the progressive histological changes to the cochlear implant clinical outcomes (fitting and speech discrimination results). Also main complications (facial nerve stimulation and difficulties at insertion) and new complications will be discussed. Design: A 5-year prospective case-control study was performed in order to compare cochlear implant results in otosclerosis patients to those in a matched-pair control group. Materials and Methods: Fifteen otosclerosis patients were followed throughout the study. Preoperatively temporal bone high-resolution computed tomography, electrically evoked auditory brainstem responses and speech discrimination tests were performed in order to select the patients to be implanted. Results: Not only difficulties with electrode guide insertion were reported, but also difficulties with fitting over the years, due to increasing difficulties to spread the electrical stimuli, which provokes increasing thresholds, maximum comfort levels and charges needed to stimulate hearing cells in basal and medial turn electrodes ($p < 0.05$), which required deactivating some basal and medial turn electrodes in order to improve cochlear implant effectiveness. The results demonstrated no statistical differences in speech discrimination in otosclerosis patients compared to the control group ($p > 0.05$). Several complications were reported: facial nerve stimulation (7.14%) and sudden episodes of tinnitus and headaches (14.28%). Conclusions: Although progressive histological changes in otosclerosis lead to increasing thresholds, maximum comfort levels and charges needed to stimulate hearing cells, speech discrimination results support the cochlear implantation in otosclerosis.

99. **"High-resolution in situ imaging of cochlear implant electrode arrays in cat temporal bones using Tuned Aperture Computed Tomography (TACT)".** Sakata, M.; Hareyama, M.; Heil, T. A.; Henson, M. M.; Henson, O. W.; Webber, R. L.; Nair, M. K.; Smith, D. W.; (2007); Ear Hear. 28(4):435-443

Objective: To determine the suitability of Tuned Aperture Computed Tomography (TACT) to generate high-resolution images of intracochlear electrode arrays, in

situ, with sufficient anatomic and electrode detail to relate the location of individual electrode contacts to important anatomic landmarks in cat cadaveric temporal bones. The ultimate objective is to develop an imaging technology whereby variations in electrode location, relative to the target neural tissues, can be accurately determined and related to variations in performance with the cochlear implant. Design: Cat temporal bones were implanted with an experimental scala tympani electrode array and an external fiducial landmark. A series of conventional 2D digital radiographs were collected from a variety of x-ray source projection angles and served as for generation of 3D volume renderings using the TACT software toolbox. The 3D renderings were then reoriented and resliced interactively to view the cochlear and electrode features of interest. Results: Significant electrode and anatomical details could be visualized including the course of the electrode wires (<40 microm diameter), the location of all electrode contacts and the outline of the scala tympani. Conclusions: TACT generates high-resolution 3D images from 2D conventional radiographs. With TACT, the 3D renderings can be interactively reoriented and resectioned to permit visualization of any cochlear or electrode feature. In the present study, this aspect of TACT affords the opportunity to view of the location of each electrode contact relative to the adjacent cochlear features, such as the scalar walls. Because TACT uses conventional radiographic images to generate the volume renderings, the quality and resolution of the resulting 2D images do not suffer from artifacts characteristic of CT. These findings suggest that TACT may be a powerful tool for understanding the contribution of electrode placement to perceptual performance with the cochlear implant.

100. **"Optimization of TACT imaging protocols for in situ visualization of cochlear electrode arrays in cat temporal bones".** Sakata, M.; Hareyama, M.; Heil, T. A.; Henson, M. M.; Henson, O. W.; Nair, M. K.; Smith, D. W.; (2007); Ear Hear. 28(4):444-450

Objective: To explore the effect of the number of two-dimensional (2D) images and x-ray projection angles on the resolution of reconstructed three-dimensional (3D) volumes of intracochlear electrode arrays in cadaveric cat temporal bones using Tuned Aperture Computed Tomography (TACT). Design: Multiple 2D radiographs (basis images (BI)) of implanted cadaveric cat temporal bones were acquired using a range of projection angles, and imported into the TACT workbench. 3D volumes were reconstructed using varying numbers of BIs. Contrast resolution in the image was determined by comparing the contrast ratio (using maximum and minimum grayscale values) in specified anatomic areas of interest. Results: Systematically increasing the number of BIs used in the reconstruction process resulted in a systematic increase in contrast resolution. Likewise, increasing the range of effective projection angles, as also the number of such angles used in the TACT computation also increased the contrast resolution of the resulting images. Conclusions: Precise determination of the location of cochlear implant electrodes in situ is critical to understanding the factors influencing efficacy of electrical stimulation of the deaf ear. Renderings

generated with the TACT algorithm produce 3D images permitting visualization of implant electrode features and anatomic details with resolution sufficient to accurately localize electrode contacts within scala tympani. The quality of resulting images, evaluated as a function of image contrast, improved with a larger number of BIs in the reconstruction. Wider projection angles also improved image detail in addition to generating thinner slices. Any loss in contrast was compensated for by the number of BIs. TACT can thus be optimized to provide useful data to help characterize the location of intracochlear electrode arrays.

101. **"Auditory brainstem implants: Current state and future directions with special reference to the subtonsillar approach for implantation".** Seki, Y.; Samejima, N.; Komatsuzaki, A.; (2007); Acta Neurochir.Suppl. 97(Pt 2):431-435

In this article, the authors describe the current state of the auditory brainstem implant (ABI), comparing it to that of the cochlear implant (CI). The CI restores hearing by stimulating the cochlear nerve in the cochlea in patients whose deafness has been caused by inner ear disease; the ABI restores hearing by stimulating the cochlear nucleus of the brainstem in patients who are deaf because of bilateral cochlear nerve dysfunction. Up to now, about 500 patients worldwide have undergone ABI and had their hearing restored, most of whom suffer from neurofibromatosis type 2. Hearing performance, however, is not as good as that offered by the cochlear implant. To improve the quality of hearing, new techniques such as advanced coding strategies and penetrating electrodes, are now being introduced.

102. **"Deprivation-induced cortical reorganization in children with cochlear implants".** Sharma, A.; Gilley, P. M.; Dorman, M. F.; Baldwin, R.; (2007); Int J Audiol. 46(9):494-499

A basic finding in developmental neurophysiology is that some areas of the cortex cortical areas will reorganize following a period of stimulus deprivation. In this review, we discuss mainly electroencephalography (EEG) studies of normal and deprivation-induced abnormal development of the central auditory pathways in children and in animal models. We describe age cut-off for sensitive periods for central auditory development in congenitally deaf children who are fitted with a cochlear implant. We speculate on mechanisms of decoupling and reorganization which may underlie the end of the sensitive period. Finally, we describe new magentoencephalography (MEG) evidence of somatosensory cross-modal plasticity following long-term auditory deprivation.

103. **"Does Auditory Processing Disorder Literature Apply to Learners With Hearing Loss?".** Sims, D. G.; (2007); The Journal of Deaf Studies and Deaf Education. 12(3):407-408

Examining the utility of some of these procedures with students who have mild-to-severe hearing losses and/or those using a cochlear implant because significant improvements in reading and classroom attention may be positively impacted.

104. **"Partial deafness cochlear implantation in children".** Skarzynski, H.; Lorens, A.; Piotrowska, A.; Anderson, I.; (2007); Int J Pediatr Otorhinolaryngol. 71(9):1407-1413

Objective: Partial deafness cochlear implantation and electric-acoustic stimulation have proven to be a useful method of treating adults with a ski-slope type hearing loss. Good hearing preservation and speech perception outcomes have been reported. This study aims to assess partial deafness cochlear implantation in children. Method: Nine children, ranging in age from 4.2 to 12 years, received a cochlear implant following the round window surgical technique for partial deafness cochlear implantation. Hearing preservation was assessed by pure-tone audiometry and speech perception outcomes were measured using monosyllable word tests in quiet and noise. Data are available for most children up to a period of 1 year. Results: Hearing could be preserved partially in all cases, however, one child does not have sufficient preservation to make use of electric-acoustic stimulation. The eight children with sufficiently preserved hearing either use the natural low frequency hearing in combination with a cochlear implant to hear or use the DUET combined hearing system. Speech perception tests showed improvement in quiet and noise over time. Conclusion: Results suggest that partial deafness cochlear implantation is a viable treatment method in children. However, surgery should only be conducted by an experienced surgeon and parents need to be carefully counselled about the risks and benefits of partial deafness cochlear implantation.

105. **"Deafness alters auditory nerve fibre responses to cochlear implant stimulation".** Sly, D. J.; Heffer, L. F.; White, M. W.; Shepherd, R. K.; Birch, M. G.; Minter, R. L.; Nelson, N. E.; Wise, A. K.; O'Leary, S. J.; (2007); Eur J Neurosci. 26(2):510-522

Here we characterized the relationship between duration of sensorineural hearing loss and the response of the auditory nerve to electrical stimulus rate. Electrophysiological recordings were made from undeafened guinea pigs and those ototoxically deafened for either 5 weeks or 6 months. Auditory neuron survival decreased significantly with the duration of deafness. Extracellular recordings were made from auditory nerve fibres responding to biphasic, charge-balanced current pulses delivered at rates of 20 and 200 pulses/s via a monopolar scala tympani stimulating electrode. The response to 20 pulses/s electrical

stimulation of the deafened cochlea exhibited a decrease in spike latency, unaltered temporal jitter and unaltered dynamic range (of nerve firing rate against stimulus current), and a reduction in threshold after 6 months of deafness. The response to a 200-pulse/s stimulus was similar except that the dynamic range was greater than with 20 pulses/s and was also greater in deafened animals than in undeafened animals. Deafness and pulse rate are related; in deaf animals spike recovery appears to be complete between successive stimulus pulses at a low rate (20 pulses/s), but incomplete between pulses at a moderate pulse rate (200 pulses/s). These results suggest that changes in the function of individual auditory nerve fibres after deafness may affect clinical responses during high-rate stimulation such as that used in contemporary speech processing strategies, but not during lower rate stimulation such as that used to record evoked potentials.

106. **"Assessment of plasticity in the auditory pathway in cochlear implant patients with preservation of residual low frequency hearing".** Sohmer, H.; (2007); Clin Neurophysiol. 118(8):1655-1657

Abstract unavailable.

107. **"Effects of cochlear implant processing and fundamental frequency on the intelligibility of competing sentences".** Stickney, G. S.; Assmann, P. F.; Chang, J.; Zeng, F. G.; (2007); J Acoust Soc Am. 122(2):1069-1078

Speech perception in the presence of another competing voice is one of the most challenging tasks for cochlear implant users. Several studies have shown that (1) the fundamental frequency (F0) is a useful cue for segregating competing speech sounds and (2) the F0 is better represented by the temporal fine structure than by the temporal envelope. However, current cochlear implant speech processing algorithms emphasize temporal envelope information and discard the temporal fine structure. In this study, speech recognition was measured as a function of the F0 separation of the target and competing sentence in normal-hearing and cochlear implant listeners. For the normal-hearing listeners, the combined sentences were processed through either a standard implant simulation or a new algorithm which additionally extracts a slowed-down version of the temporal fine structure (called Frequency-Amplitude-Modulation-Encoding). The results showed no benefit of increasing F0 separation for the cochlear implant or simulation groups. In contrast, the new algorithm resulted in gradual improvements with increasing F0 separation, similar to that found with unprocessed sentences. These results emphasize the importance of temporal fine structure for speech perception and demonstrate a potential remedy for difficulty in the perceptual segregation of competing speech sounds.

108. **"Auditory feedback does not influence random number generation: Evidence from profoundly deaf adults with cochlear implant".** Strenge, H. & Muller-Deile, J.; (2007); J Clin Exp Neuropsychol. 29(6):642-647

Oral random number generation is a widely used neuropsychological task engaging a number of overlapping neural systems of attention, number representation, response generation, and working memory. Although phonological processing is known to be essential for random number generation no information exists on the significance of the auditory feedback of hearing one's own voice on task performance. We therefore examined the influence of auditory feedback in 15 profoundly deaf adults with cochlear implants in a device-on/off experiment. No significant effects of occluding auditory feedback on random number generation were noted, thus supporting an internal response-monitoring model independent of auditory condition.

109. **"Fabrication of multi-layer, high-density micro-electrode arrays for neural stimulation and bio-signal recording".** Suaning, G. J.; Schuettler, M.; Ordonez, J. S.; Lovell, N. H.; (2007); Sch.of Eng4

The electrode-tissue interface is of principal importance in neuroprosthesis. Indeed the successes of the cochlear implant and other therapeutic devices are directly attributable to the design and fabrication techniques of their interfaces with neural tissue, that is, the electrode or electrode array. Traditional fabrication techniques are often labor-intensive and do not lend themselves to automation thereby increasing the cost of the electrode, and owing to fabrication variability, potentially compromising the reliability of the devices incorporating them. Exacerbating the difficulties in electrode fabrication further is the fact that only a handful of materials have been demonstrated to be biologically inert. These same materials are often among the most difficult to utilize in the fabrication of neural electrodes. In the present paper, a new methodology for automated fabrication of high-density electrode arrays is presented. Using exclusively biologically-inert raw materials, laser machining techniques combined with multiple layer structuring is shown to achieve feature sizes of the order of 25 mum. As an illustrative example, a 98 electrode array for interfacing with surviving retinal tissue through a visual prosthesis for the blind is presented. Overall dimensions of the array are of the order of 8.7 * 9.4 mm, consistent with approximately 25 degrees of visual field.

110. **"Pitch ranking of complex tones by normally hearing subjects and cochlear implant users".** Sucher, C. M. & McDermott, H. J.; (2007); Hear Res. 230(1-2):80-87

The ability of 10 normally hearing (NH) adults and eight cochlear implant (CI) users to pitch-rank pairs of complex tones was assessed. The acoustically presented stimuli differed in fundamental frequency (F0) by either one or six semitones (F0 range: 98 to 740 Hz). The NH group obtained significantly higher

mean scores for both experiments: (NH: one semitone - 81.2%, six semitones - 89.0%; CI: one semitone - 49.0%, six semitones - 60.2%; p<0.001). Prior musical experience was found to be associated with higher pitch-ranking scores for the NH subjects. Those with musical experience ratings <3 obtained significantly lower scores for both interval sizes (p<0.001) than those with higher ratings. Nevertheless, the scores obtained by the musically inexperienced, NH adults were significantly higher than those obtained by the CI group for both the one-semitone (p=0.022) and six-semitone (p=0.018) intervals. These results suggest that the pitch information CI users obtain from their implant systems is less accurate than that obtained by NH listeners when listening to the same complex sounds. Furthermore, the relatively poor pitch-ranking ability of at least some CI users may be associated with a more-limited experience of music in general.

111. **"The use and reliability of Tait video analysis in assessing preverbal language skills in profoundly deaf and normally hearing children under 12 months of age".** Tait, M. E.; Nikolopoulos, T. P.; Wells, P.; White, A.; (2007); International Journal of Pediatric.Otorhinolaryngology. 71(9):1377-1382

Background: Assessment measures in evaluating preverbal skills and their progress in very young deaf children are lacking. However, their importance is highlighted by the recent trend of implanting children under 1 year of age. Tait video analysis is a technique for assessing preverbal communication behaviours in very young children with hearing impairment and has been found to be strongly related to speech discrimination and intelligibility outcomes post-implantation. Aim: To assess feasibility and inter-user reliability of Tait video analysis in assessing preverbal communication skills in children under 1 year of age. Material and methods: Ten children (five profoundly deaf and five normally hearing) under 1 year of age were assessed by Tait video analysis. Three observers analysed the samples independently, according to the established protocol. Results: There was complete agreement on 305 judgements and 8 discrepancies between observers over all the measures. Four of the discrepancies occurred in the samples of deaf children and four in the normally hearing samples. Statistical analysis revealed that the correlation coefficients between the different observers were extremely high ranging from 0.94 to 1 (perfect agreement). All of them were found to be statistically significant ($p < 0.01$). Conclusion: The very high rate of inter-observer reliability suggests that the video recordings of children under 12 months can be scored consistently, and Tait video analysis is therefore a valid method of monitoring the development of vocal and auditory preverbal skills in very young deaf children, either following cochlear implantation or using acoustic hearing aids.

112. **"Force application during cochlear implant insertion: An analysis for improvement of surgeon technique".** Todd, C. A.; Naghdy, F.; Svehla, M. J.; (2007); IEEE Trans Biomed Eng. 54(7):1247-1255

Highly invasive surgical procedures, such as the implantation of a prosthetic device, require correct force delivery to achieve desirable outcomes and minimize trauma induced during the operation. Improvement in surgeon technique can reduce the chances of excessive force application and lead to optimal placement of the electrode array. The fundamental factors that affect the degree of success for cochlear implant recipients are identified through empirical methods. Insertion studies are performed to assess force administration and electrode trajectories during implantations of the Nucleus 24 Contour and Nucleus 24 Contour Advance electrodes into a synthetic model of the human Scala Tympani, using associated methods. Results confirm that the Advance Off- Stylet insertion of the soft-tipped Contour Advance electrode gives an overall reduction in insertion force. Analysis of force delivery and electrode positioning during cochlear implantation can help identify and control key factors for improvement of insertion method. Based on the findings, suggestions are made to enhance surgeon technique.

113. **"Developmental constraints on language development in children with cochlear implants".** Tomblin, J. B.; Barker, B. A.; Hubbs, S.; (2007); Int J Audiol. 46(9):512-523

Research on pediatric cochlear implantation has frequently shown that speech perception, speech production, and language outcomes are better for children who are implanted earlier in life than later. These findings are often explained on the grounds that earlier implantation takes advantage of a critical or sensitive period. This paper reviews the literature concerning sensitive periods within the framework of speech and language development. It particularly emphasizes two alternate mechanisms proposed for these periods: an experience-independent mechanism, and an experience-dependent mechanism. Based on this literature review we proposed that research in the field of pediatric cochlear implantation needs to carefully define what kind of evidence is needed to reflect a sensitive period for speech and language learning. The field also needs to consider designing studies that allow the viability of these two mechanisms to be tested. An example of such a study is provided within.

114. **"Ten-year follow-up of a consecutive series of children with multichannel cochlear implants".** Uziel, A. S.; Sillon, M.; Vieu, A.; Artieres, F.; Piron, J. P.; Daures, J. P.; Mondain, M.; (2007); Otol Neurotol. 28(5):615-628

Objectives: To assess a group of children who consecutively received implants more than 10 years after implantation with regard to speech perception, speech intelligibility, receptive language level, and academic/occupational status. Study Design: A prospective longitudinal study. Setting: Pediatric referral center for

cochlear implantation. Patients: Eighty-two prelingually deafened children received the Nucleus multichannel cochlear implant. Interventions: Cochlear implantation with Cochlear Nucleus CI22 implant. Main Outcome Measures: The main outcome measures were open-set Phonetically Balanced Kindergarten word test, discrimination of sentences in noise, connective discourse tracking (CDT) using voice and telephone, speech intelligibility rating (SIR), vocabulary knowledge measured using the Peabody Picture Vocabulary Test (Revised), academic performance on French language, foreign language, and mathematics, and academic/occupational status. Results: After 10 years of implant experience, 79 children (96%) reported that they always wear the device; 79% (65 of 82 children) could use the telephone. The mean scores were 72% for the Phonetically Balanced Kindergarten word test, 44% for word recognition in noise, 55.3 words per minute for the CDT, and 33 words per minute for the CDT via telephone. Thirty-three children (40%) developed speech intelligible to the average listener (SIR 5), and 22 (27%) developed speech intelligible to a listener with little experience of deaf person's speech (SIR 4). The measures of vocabulary showed that most (76%) of children who received implants scored below the median value of their normally hearing peers. The age at implantation was the most important factor that may influence the postimplant outcomes. Regarding educational/vocational status, 6 subjects attend universities, 3 already have a professional activity, 14 are currently at high school level, 32 are at junior high school level, 6 additional children are enrolled in a special unit for children with disability, and 3 children are still attending elementary schools. Seventeen are in further noncompulsory education studying a range of subjects at vocational level. Conclusion: This long-term report shows that many profoundly hearing-impaired children using cochlear implants can develop functional levels of speech perception and production, attain age-appropriate oral language, develop competency level in a language other than their primary language, and achieve satisfactory academic performance.

115. **"Clinical results of AutoNRT, a completely automatic ECAP recording system for cochlear implants".** van Dijk, B.; Botros, A. M.; Battmer, R. D.; Begall, K.; Dillier, N.; Hey, M.; Lai, W. K.; Lenarz, T.; Laszig, R.; Morsnowski, A.; Muller-Deile, J.; Psarros, C.; Shallop, J.; Weber, B.; Wesarg, T.; Zarowski, A.; Offeciers, E.; (2007); Ear Hear. 28(4):558-570

Objective: AutoNRT is the completely automatic electrically evoked compound action potential (ECAP) measuring algorithm in the recently released Nucleus Freedom cochlear implant system. AutoNRT allows clinicians to automatically record T-NRT profiles that in turn can be used as a guide for initial fitting. The algorithm consists of a pattern recognition part that judges if the traces contain an ECAP and an intelligent flow that optimizes the measurement parameters and finds the ECAP threshold (T-NRT). The objective of this study was to determine how accurate, reliable, and fast the automatic measurements are. Design: Data on more than 400 electrodes were collected as part of the multicenter clinical trial of the Nucleus Freedom cochlear implant system. T-NRT values determined by the

algorithm were compared with T-NRT determinations on the same data by different human observers. Also, the time the measurements took was analyzed. Results: In 90% of the cases, the absolute difference between the AutoNRT and the human observer determined T-NRT was less than 9 CL; the median absolute difference was 3 CL. A second experiment, in which a group of human observers were asked to analyze NRT data, showed high variability in T-NRT; in some cases, two experienced clinicians disagreed by more than 30 current levels. Compared with the group, AutoNRT performed as well as the "average" clinician, with the advantage that the AutoNRT threshold determinations are objective. Analysis of the timing data showed an average intraoperative measurement time of less than 20 sec per electrode with a standard deviation of 5 sec, suggesting that the total array of 22 electrodes can be measured intraoperatively in about 7 minutes on average. Conclusions: AutoNRT provides comparable accuracy to an average clinician but with the added benefit of significant time savings over manual recordings. This makes it a valuable tool for clinical measurement of ECAP threshold in cochlear implant recipients.

116. **"Reading comprehension of deaf children with cochlear implants".** Vermeulen, A. M.; van Bon, W.; Schreuder, R.; Knoors, H.; Snik, A.; (2007); The Journal of Deaf Studies and Deaf Education. 12(3):283-302

The reading comprehension and visual word recognition in 50 deaf children and adolescents with at least 3 years of cochlear implant (CI) use were evaluated. Their skills were contrasted with reference data of 500 deaf children without CIs. The reading comprehension level in children with CIs was expected to surpass that in deaf children without implants, partly via improved visual word recognition. Reading comprehension scores of children with implants were significantly better than those of deaf children without implants, although the performance in implant users was substantially lagging behind that in hearing children. Visual word recognition was better in children with CIs than in children without implants, in secondary education only. No difference in visual word recognition was found between the children with CIs and the hearing children, whereas the deaf children without implants showed a slightly poorer performance. The difference in reading comprehension performance of the deaf children with and without CIs remained present when visual word recognition was controlled for. This indicates that other reading-related skills were also contributing to the improved reading comprehension skills of deaf children with CIs.

117. **"Positional vertigo and cochlear implantation".** Viccaro, M.; Mancini, P.; La Gamma, R.; De Seta, E.; Covelli, E.; Filipo, R.; (2007); Otol Neurotol. 28(6):764-767

Objective: To identify patients developing positional vertigo after cochlear implantation. Study Design: Prospective study on a cohort of patients undergoing cochlear implantation. Setting: Academic tertiary referral center. Patients: The study included 70 consecutive patients who underwent vestibular evaluation

before and after cochlear implantation. Intervention: Medical record review. Main Outcome Measure: Recorded vestibular symptoms after cochlear implantation. Patients with positional vertigo were considered case subjects, whereas those without vestibular symptoms were considered case controls. Results: Benign paroxysmal positional vertigo (BPPV) occurred in 8 patients (on the cochlear implant [CI] side in 7 patients, and in the other ear in 1). One patient had BPPV of the lateral semicircular canal on the implanted side, and 7 patients had BPPV of the posterior semicircular canal (on the same CI side in 6 patients, and on the opposite side in 1), which were detected and presented during the last examination. In 5 patients, the onset of symptoms varied from 7 to 130 days after implant activation; in 2 patients, the onset occurred before activation. Conclusion: Three different mechanisms are proposed for the occurrence of BPPV in patients with CI. The first focuses on the fall of bone dust particles into the cochlea during cochleostomy. In the second, the vibration caused by drilling the cochlea would be sufficient to dislodge otoconia into the labyrinth. The third hypothesis suggests dislodging of an otolith because of the electric stimulation. In our patients, conservative approaches have been used with a minimal invasive cochleostomy and without perilymph suction. Thus, the vibratory trauma affecting the cochlea during cochleostomy seems to play a fundamental role in the development of paroxysmal vertigo in patients with implant.

118. **"Spatial selectivity to intracochlear electrical stimulation in the Inferior colliculus is degraded following long-term deafness in cats".** Vollmer, M.; Beitel, R. E.; Snyder, R. L.; Leake, P. A.; (2007); Journal of Neurophysiology

In an animal model of electrical hearing in prelingually deaf adults this study examined the effects of deafness duration on response thresholds and spatial selectivity (i.e., cochleotopic organization, spatial tuning and dynamic range) in the central auditory system to intracochlear electrical stimulation. Electrically evoked auditory brainstem response (EABR) thresholds and neural response thresholds in the external (ICX) and central (ICC) nuclei of the inferior colliculus were estimated in cats after varying durations of neonatally induced deafness: 1) in animals deafened <1.5 yr (short-deafened unstimulated, SDU cats) with a mean spiral ganglion cell (SGC) density of ~45% of normal and 2) in animals deafened >2.5 yr (long-deafened, LD cats) with severe cochlear pathology (mean SGC density <7% of normal). LD animals were subdivided into unstimulated cats and those that received chronic intracochlear electrical stimulation via a feline cochlear implant. Acutely deafened, implanted adult cats served as controls. Independent of their stimulation history, LD animals had significantly higher EABR and ICC thresholds than SDU and control animals. Moreover, the spread of electrical excitation was significantly broader and the dynamic range significantly reduced in LD animals. Despite the prolonged durations of deafness the fundamental cochleotopic organization was maintained in both the ICX and the ICC of LD animals. There was no difference between SDU and control cats in any of the response properties tested. These findings suggest that long-term auditory deprivation results in a

significant and possibly irreversible degradation of response thresholds and spatial selectivity to intracochlear electrical stimulation in the auditory midbrain.

119. **"Cochlear implantation: one or two?".** Wei, B. P.; Wei, B.; O'Leary, S. J.; O'Leary, S.; Dowell, R.; (2007); Lancet. 370(9589):719-720

Abstract unavailable.

120. **"Cochlear implants: The young people's perspective".** Wheeler, A.; Archbold, S.; Gregory, S.; Skipp, A.; (2007); The Journal of Deaf Studies and Deaf Education. 12(3):303-316

Cochlear implantation is a relatively new procedure, which has already had significant impact on the lives of many profoundly deaf children and adults, in providing useful hearing to those unable to benefit significantly from hearing aids. After 16 years of cochlear implantation in the United Kingdom, there is now a body of evidence covering a range of outcomes, much of which covers perceptual and linguistic outcomes. This study looks at the impact of cochlear implantation on a group of 29 young people aged 13-16 years, using a semistructured questionnaire. It examines issues from the perspective of the young people themselves, including their understanding of and degree of satisfaction with the way their implant works for them, their social and communication abilities and choices, their educational challenges, and their identity. It concludes that the young people in this group feel positive toward their cochlear implants and the decisions made on their behalf by parents. Many have a flexible attitude to communication modes and an identity which is not fixed in terms of conventional descriptors.

121. **"[Legal aspects of cochlear-implantation].** Wienke, A. & Janke, K.; (2007); Laryngorhinootologie. 86(9):664-665

Abstract unavailable.

122. **"1-year postactivation results for sequentially implanted bilateral cochlear implant users".** Wolfe, J.; Baker, S.; Caraway, T.; Kasulis, H.; Mears, A.; Smith, J.; Swim, L.; Wood, M.; (2007); Otol Neurotol. 28(5):589-596

Objective: Evaluate speech recognition in quiet and in noise for a group of 12 children, all of whom underwent sequential bilateral cochlear implantation at various ages (range, 1 yr, 8 mo to 9 yr, 6 mo at time of second implant). Study Design: Retrospective. Setting: Outpatient cochlear implant clinic. Patients: Children who underwent sequential bilateral cochlear implantation. Intervention: Rehabilitative. Main Outcome Measures: Speech recognition in quiet was evaluated for each ear separately using single-word speech recognition assessments (Multisyllabic Lexical Neighborhood Test and Early Speech

Perception Test) via recorded presentation. Speech recognition in noise was assessed for each ear separately and in the bilateral condition by obtaining a spondee recognition threshold in the presence of speech-weighted noise presented at 45 dB hearing level. The primary outcome measure for speech recognition in noise assessment was the signal-to-noise ratio for 50% performance, which was calculated by determining the difference between the presentation level of the noise and the presentation level at which the speech recognition threshold was obtained. The results of these assessments were contrasted between children receiving their second cochlear implant before 4 years of age and children receiving their second cochlear implant after 4 years of age. Results: A statistically significant difference for speech recognition scores in quiet was obtained between the early-implanted ear and the late-implanted ears for children receiving their second cochlear implant after 4 years of age. There was not a statistically significant difference in speech recognition scores in quiet between the early-implanted and late-implanted ears of children receiving their second cochlear before 4 years of age. Both groups of children possessed better speech recognition scores in noise (statistically significant at an alpha = 0.05) in the bilateral condition relative to either unilateral condition. However, there was not a statistically significant relationship between speech recognition performance in noise and the duration of deafness of the later implanted ear. Conclusion: Bilateral cochlear implantation allowed for better speech recognition in noise relative to unilateral performance for a group of 12 children who underwent sequential bilateral cochlear implantation at various ages. There was not a statistically significant relationship between speech recognition in noise benefit, which was defined as the difference in performance between the first implanted ear and the bilateral condition and the age at which the second implant was received. Children receiving bilateral cochlear implants younger than 4 years of age achieved better speech recognition in quiet performance for the later implanted ear as compared with children receiving their second cochlear implant after 4 year of age.

123. **"Spectral-ripple resolution correlates with speech reception in noise in cochlear implant users".** Won, J. H.; Drennan, W. R.; Rubinstein, J. T.; (2007); J Assoc Res Otolaryngol. 8(3):384-392

Speech perception ability in noise is one of the most practical measures of success with a cochlear implant; however, with experience, this ability can change dramatically over time, making it a less than ideal tool for comparing performance among different processing strategies. This study examined performance on a spectral discrimination task and compared it to speech perception in noise. An adaptive procedure was used to determine the spectral-ripple density that subjects could discriminate. A closed-set, forced-choice adaptive procedure was used to determine speech reception thresholds for words in two-talker babble and in speech-shaped, steady-state noise. Spectral-ripple thresholds (ripples/octave) were significantly correlated with speech reception thresholds (dB SNR) in noise for 29 cochlear implant users ($r = -0.55$, $p = 0.002$ in two-talker babble; $r = -0.62$, $p = 0.0004$ in steady-state noise), demonstrating that better spectral resolution was

associated with better speech perception in noise. A significant correlation was also found between the spectral-ripple discrimination ability and word recognition in quiet ($r = 0.50$, $p = 0.009$). In addition, test-retest reliability for spectral-ripple discrimination was good, and no learning was observed. The present study demonstrates that the spectral-ripple discrimination test, which is time efficient and nonlinguistic, would be a useful tool to evaluate cochlear implant performance with different signal processing strategies.

124. **"Changes in speech production in an early deafened adult with a cochlear implant".** Wong, P. C.; (2007); Int J Lang Commun Disord. 42(4):387-405

Background and Aims: The current study is a first investigation reporting the speech production characteristics of an early deafened adult cochlear implant user after a course of speech-language treatment. Methods and Procedures: The participant is culturally deaf and received the cochlear implant when she was 43 years old. A 24-week ABCABC single-subject treatment programme was conducted addressing articulation, the oral production of printed words, and voice production, with two 4-week segments for each area. Outcomes and Results: Treatment-specific progress, revealed by untrained stimuli, was made in areas of articulation and oral production of printed words, but not voice production. Formal measures also confirmed the patient's progress. Conclusions: These results were discussed in relation to how long-term reduction of general auditory input and under-use of the speech production mechanisms can be remediated by technological and behavioural treatment.

125. **"Spectral and temporal cues for phoneme recognition in noise".** Xu, L. & Zheng, Y.; (2007); J Acoust Soc Am. 122(3):1758

Cochlear implant users receive limited spectral and temporal information. Their speech recognition deteriorates dramatically in noise. The aim of the present study was to determine the relative contributions of spectral and temporal cues to speech recognition in noise. Spectral information was manipulated by varying the number of channels from 2 to 32 in a noise-excited vocoder. Temporal information was manipulated by varying the low-pass cutoff frequency of the envelope extractor from 1 to 512 Hz. Ten normal-hearing, native speakers of English participated in tests of phoneme recognition using vocoder processed consonants and vowels under three conditions (quiet, and +6 and 0 dB signal-to-noise ratios). The number of channels required for vowel-recognition performance to plateau increased from 12 in quiet to 16-24 in the two noise conditions. However, for consonant recognition, no further improvement in performance was evident when the number of channels was >/=12 in any of the three conditions. The contribution of temporal cues for phoneme recognition showed a similar pattern in both quiet and noise conditions. Similar to the quiet conditions, there was a trade-off between temporal and spectral cues for phoneme recognition in noise.

126. **"Predictions of psychophysical measurements for sinusoidal amplitude modulated (SAM) pulse-train stimuli from a stochastic model".** Xu, Y. & Collins, L. M.; (2007); IEEE Trans Biomed Eng. 54(8):1389-1398

Two approaches have been proposed to reduce the synchrony of the neural response to electrical stimuli in cochlear implants. One approach involves adding noise to the pulse-train stimulus, and the other is based on using a high-rate pulse-train carrier. Hypotheses regarding the efficacy of the two approaches can be tested using computational models of neural responsiveness prior to time-intensive psychophysical studies. In our previous work, we have used such models to examine the effects of noise on several psychophysical measures important to speech recognition. However, to date there has been no parallel analytic solution investigating the neural response to the high-rate pulse-train stimuli and their effect on psychophysical measures. This work investigates the properties of the neural response to high-rate pulse-train stimuli with amplitude modulated envelopes using a stochastic auditory nerve model. The statistics governing the neural response to each pulse are derived using a recursive method. The agreement between the theoretical predictions and model simulations is demonstrated for sinusoidal amplitude modulated (SAM) high rate pulse-train stimuli. With our approach, predicting the neural response in modern implant devices becomes tractable. Psychophysical measurements are also predicted using the stochastic auditory nerve model for SAM high-rate pulse-train stimuli. Changes in dynamic range (DR) and intensity discrimination are compared with that observed for noise-modulated pulse-train stimuli. Modulation frequency discrimination is also studied as a function of stimulus level and pulse rate. Results suggest that high rate carriers may positively impact such psychophysical measures.

127. **"Is psychological status a determinant of speech perception outcomes in highly selected good adolescent cochlear implant users?".** Yucel, E. & Sennaroglu, G.; (2007); Int J Pediatr Otorhinolaryngol. 71(9):1415-1422

Objective: The main purpose of this study was to assess the relationship between the speech perception skills and state-trait anxiety in cochlear implant user adolescents who were highly selected good candidates. The impact of preoperative speech perception ability on postoperative speech perception and state-trait anxiety status were also examined. Subjects and Methods: The subjects for this study were 25 consecutively chosen congenitally profoundly deaf adolescents (12 boys, 13 girls) who received nucleus multi channel cochlear implants and were followed for at least a year at Hacettepe University. Daily Sentences in Turkish and State-Trait Anxiety Inventories (STAI) were administered to subjects after 12-72 months (mean: 35.28+/-18.27) of implant use. Results: The trait and state anxiety scores were matched with the relative rank of normal hearing subjects' trait-state anxiety scores and the analysis of post-implant state-trait anxiety findings shows that both state and trait anxiety scores were widespread but still in normal range. The correlation between trait, state anxiety

scores and speech perception ability was not statistically significant in adolescent cochlear implant users. However, their preoperative speech perception scores were significantly correlated with their postoperative speech perception abilities. Conclusion: The majority of adolescents, in this study, achieved varying degrees of open-set speech recognition and made greater gains than their previous auditory experience with hearing aids. Also, the indirect positive effects of early identification-amplification, communication therapy and counseling programs on their personal well-being is clearly observed from the outcomes of their state and trait anxiety scores. As a result of correlating the trait and state anxiety levels with pre- and post-implant speech perception skills, a significant negative correlation was expected. However, no statistical correlation was found between speech perception skills and the psychological outcomes. This result may be the indicator of the positive effect of the early habilitation-parental support and cochlear implant on the quality of life as the adolescents involved in this study were developmentally and audiologically ready for implantation. The present study provides understanding of the audiological and social-emotional influences of early identification and habilitation programs on adolescents with cochlear implants.

128. **"Changes across time in spike rate and spike amplitude of auditory nerve fibers stimulated by electric pulse trains".** Zhang, F.; Miller, C. A.; Robinson, B. K.; Abbas, P. J.; Hu, N.; (2007); J Assoc Res Otolaryngol. 8(3):356-372

We undertook a systematic evaluation of spike rates and spike amplitudes of auditory nerve fiber (ANF) responses to trains of electric current pulses. Measures were obtained from acutely deafened cats to examine time-related changes free from the effects of hair-cell and synaptic adaptation. Such data relate to adaptation that likely occurs in ANFs of cochlear-implant users. A major goal was to determine and compare rate adaptation observed at different pulse rates (primarily 250, 1000, and 5000 pulse/s) and describe them using decaying exponential models similar to those used in acoustic studies. Rate-vs.-time functions were best described by two-exponent models and produced time constants similar to (although slightly greater than) the "rapid" and "short-term" components described in acoustic studies. There was little dependence of these time constants on onset spike rate, but pulse-rate effects were noted. Spike amplitude changes followed a time course different from that of rate adaptation consistent with a process related to ANF interspike intervals. The fact that two time constants governed rate adaptation in electrically stimulated and deafened fibers suggests that future computational models of adaptation should not only include hair cell and synapse components, but also components determined by fiber membrane characteristics.