

**Vanderbilt Bill Wilkerson Center for
Otolaryngology and Communication
Sciences**

**Department of Hearing & Speech
Sciences**

**Research Report
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Introduction

The Department of Hearing and Speech Sciences and the Vanderbilt Bill Wilkerson Center are dedicated to improving the lives of those with communication and associated disorders through clinical service, education, and research. In addition to recording more than 95,000 patient visits annually in our clinics, the department offers the Master of Science (MS) in speech-language pathology, the Master of Education of the Deaf (MDE), the Doctor of Audiology (AuD) and the Doctor of Philosophy (PhD) degrees.

The research program, housed primarily on the 10th floor of Medical Center East and Medical Research Building III, encompasses a wide variety of topics in the areas of hearing science, language, speech production and perception, using both animal and human models. Within each of these areas, work focuses on both applied and basic issues.

The following is our 19th research report (our first report was published in 1982), which lists our personnel, describes our facilities, and provides abstracts of our most recent scientific work. Requests for further information can be directed to the individual authors at the address given below. Email questions and comments can be directed to dhss.research@vanderbilt.edu. For additional information regarding the Vanderbilt Bill Wilkerson Center for Otolaryngology and Communication Sciences or Vanderbilt Department of Hearing and Speech Sciences, their programs, staff, and mission, please visit our home page on the World Wide Web: <http://www.vanderbilthealth.com/billwilkerson>

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Facilities and Equipment

The Department of Hearing and Speech Sciences comprises one part of the Vanderbilt Bill Wilkerson Center for Otolaryngology and Communication Sciences, which is housed within five floors of a 10-story building on the campus of the Vanderbilt University Medical Center completed in 2005. The entire 10th floor of this state-of-the-art facility is dedicated to research and houses some 20 separate laboratories that conduct both clinical and basic investigations in the areas of hearing, speech, and language science. Emphasis is on both behavioral and electrophysiological measurements associated with communication science and communication disorders. The many ongoing research projects are tied closely to our academic program (located on the 8th floor) and to the speech, language, and audiology clinics that serve the Middle Tennessee region (located on the 6th and 9th floors). Research activity is also coordinated with the Department of Otolaryngology and the Vanderbilt Voice and Balance Disorders clinics (located on the 7th floor). In addition, neuro-imaging, neurophysiologic, child development, and animal research facilities associated with communication science are located in other buildings on the Vanderbilt University Medical Center campus, Peabody College, and the Vanderbilt Kennedy Center. Following are descriptions of the various research laboratories of the Vanderbilt Bill Wilkerson Center.

The **Anechoic Chamber Laboratory (ACL)** is a stand-alone computer-controlled laboratory that allows efficient control of virtually any kind of psychoacoustic experimentation in free sound-field situations. The chamber (internal dimensions 4.6m x 6.4m x 6.7m) is covered on all six surfaces by fiberglass wedges and has a measured low-frequency cutoff of 100 Hz. This laboratory is controlled by three computer systems interfaced to Tucker-Davis System 2 and System 3 signal acquisition and processing devices. In the chamber itself, there is a full circular horizontal array of 64 loudspeakers with a radius of 2 m and spanning 360°. These loudspeakers will be employed in a variety of experiments concerned with localization, the precedence effect, and simulated motion perception.

The **Reverberation Chamber Laboratory (RCL)** is a stand-alone computer-controlled laboratory that allows efficient control and simulation of a large number of sound-field environments. This laboratory is controlled by a PC computer system interfaced to Tucker Davis Technologies (TDT) RX8 multi-I/O signal acquisition and processing device. A Crown 8-channel amplifier, GSI Audiometer, multi-channel sound card and up to 16 configurable loudspeakers are also dedicated to reverberation chamber use. The chamber itself is a random-incidence hard-walled design which is capable of producing an essentially diffuse sound field. The chamber also includes a removable blanket system which allows for systematic variation in average reverberation time from approximately 2.7 seconds to less than 0.3 seconds. The flexibility of the reverberation chamber in terms of reverberation characteristics and loudspeaker configurations have made it an ideal resource for experiments concerned with speech recognition performance, both with and without amplification, across a variety of environments of interest.

The **Dan Maddox Hearing Aid Research Laboratory (DMHARL)** is under the direction of Dr. Todd Ricketts and is devoted to the evaluation and refinement of existing amplification and cochlear implant technology; the examination of basic differences in the hearing of those with

normal and impaired thresholds; the development and refinement of fitting and counseling techniques; and, the evaluation and design of signal processing schemes for hearing aids and cochlear implants. The laboratory is equipped with a control room and two custom sound-attenuating test rooms where normal-hearing and hearing-impaired subjects are tested individually under headphones or via loudspeakers. The laboratory is controlled by four PCs and contains typical audiometric equipment such as two audiometers with high frequency testing capability, Otoscope, GSI TympStar Middle ear Analyzer, CD players, two 12-channel amplifiers, and the necessary hardware and software to program a variety of programmable hearing instruments including four different probe microphone systems. Additional hardware includes a two-channel spectrum analyzer, a System3 array processor from Tucker-Davis Technologies (TDT), two multi-channel sound cards and multiple loudspeakers allowing for a great number of sound presentation configurations. The TDT processor is linked via high-speed fiber-optics to an array of external signal processing modules providing digital recording, processing, and playback of signals.

The **Cochlear Implant Research Laboratory (CIRL)**, under the direction of Dr. René Gifford, has two fully equipped double-walled sound booths. The first sound booth is 10.0 ft x 8.0 ft, the second is 8.9 ft x 7.0 ft. The latter booth contains an 8-loudspeaker, Revitronix R-SPACE. The R-SPACE system includes eight Tannoy Di5 loudspeakers wall mounted with Ergomart fully extendable articulating arms, digital audio interface with multi-track software, iMac 3.1GHz, 1TB hard drive (required to control the R-SPACE platform), and a subject monitoring system. Both booths are equipped with Larson Davis Sound Track LXT sound level meter with measuring microphones suspending from the ceiling of the booth for soundfield calibration. Each sound booth is also equipped with a calibrated Audiometer (GSI 16 and GSI 61). In addition, the CIRL has four PC workstations equipped with cochlear implant programming software and programming control units for all commercially available cochlear implant systems. We also have a number of speech processors from all three manufacturers should a subject's own speech processor be identified as malfunctioning during a testing session. We also have access to an Audioscan Verifit system for verification of hearing aid settings prior to experimentation.

The **Psychophysiology Research Laboratory** is under the direction of Dr. Alexandra Key and focuses on EEG/ERP studies of speech/language processing and cognitive functioning in infants, children, and adults. This laboratory includes a sound-attenuated participant testing room and an adjacent control/observation room which houses equipment. The EEG equipment includes two 128-channel EEG systems (Electrical Geodesics, Inc) that also capable of functioning as a single 256-channel system (for studies focused on brain source analysis). Each system includes a Macintosh G5 computer for data collection and a Dell PC with E-prime software for experiment design and stimulus presentation (auditory and visual). EEG data are recorded with high-density geodesic sensor nets connected to super high impedance amplifiers that allow for good quality data without skin abrasion. The participant room is equipped with two video cameras for observing and recording participant behavior. Auditory stimuli can be delivered via a single ceiling-mounted speaker (mono) or two speakers (stereo) on each side of the participant. Audio-visual equipment allows to present participant with VHS, DVD, PC video/sound and to record test sessions on VHS or DVDs. The lab also includes an eye tracker system (Tobii x50 camera and a dedicated Dell PC with Tobii Studio software for data acquisition and analysis). Tobii's eye-tracking technology utilizes video images of a person's eyes and reflections in the eyes of near-infrared reference lights and

can automatically track where a person is looking at different times. The device does not require any head-mounted equipment and does not interfere with the EEG data collection.

The **Auditory Physiology Laboratory (APL)** is directed by Dr. Linda J. Hood and focuses on physiology of the auditory system at cochlear, subcortical and cortical levels. Studies encompass several perspectives including normal and disordered auditory systems and hearing loss related to genetic mutations. Recent areas of research have focused on efferent system function in normal, developing and aging human auditory systems, and neural responses from the eighth nerve through the cortex in infants, children and adults. Research related to hereditary hearing loss involves characterization of auditory function in carriers of genetic mutations associated with recessively inherited deafness in order to understand the specific phenotypic characteristics of certain genotypes. Another area of research involves auditory neuropathy/dys-synchrony where research focuses on understanding the underlying mechanisms and functional characteristics in order to improve management and communication skills of these patients. The Auditory Physiology Laboratory consists of a two-room suite with a double-walled sound-treated room and adjacent control room and a second research area for data analysis and management. Laboratory equipment includes multiple Macintosh and PC based systems that drive hardware for transient, distortion product, and stimulus frequency otoacoustic emissions studies and specialized equipment for studying characteristics of the medial olivocochlear system through suppression of otoacoustic emissions. Additional laboratory otoacoustic emissions systems are directed towards study of cochlear fine structure and separation of response components. Two state-of-the-art auditory evoked potential systems are used for recording auditory brainstem, auditory steady state, and cortical responses along with capacity for novel stimuli and recording method development. These specialized laboratory systems are supported by comprehensive signal generation, analysis and calibration systems and equipment necessary for baseline auditory testing.

The **Psychoacoustics Laboratory (PAL)** is under the direction of Dr. Wesley Grantham and is devoted to psychoacoustic experimentation, especially in areas concerned with binaural hearing. This laboratory is equipped with a control room and a double-walled sound-attenuating test room in which as many as three subjects can be tested simultaneously under headphones. The laboratory is controlled by two PC computer systems, interfaced to a wide array of signal generation and acquisition equipment from Tucker-Davis Technologies (System 2 and System 3). Other equipment includes the necessary measuring and calibrating instruments as well as a full complement of analog signal generation and control devices.

The **Auditory Development Laboratory (ADL)** is directed by Drs. Anne Marie Tharpe and Daniel Ashmead. Their work has merged Tharpe's expertise in pediatric audiology with Ashmead's background in developmental psychology, resulting in a multidisciplinary emphasis on the impact of hearing loss on infants and young children. The three-room laboratory suite is composed of two custom sound-attenuating booths (8x7 ft and 12x13 ft) with one shared control room for pediatric auditory assessments. The laboratory houses typical audiometric equipment for pediatric assessment including an audiometer with sound field and visual reinforcement capability, auditory brainstem response equipment, otoacoustic emission, and immittance equipment. In addition, probe microphone technology is available for in-situ testing of hearing technology. Two computer workstations support the lab with inferential statistical analysis software used for various studies of audition. Both sound booths are equipped with audiovisual recording units that are used for frame-by-frame data analysis of audiovideo recordings. The lab

is also equipped with a Tucker-Davis acoustics hardware/software system for control of specialized experimental protocols such as sound localization and interaural processing.

The two **Speech Science Laboratories (SSL 1 and SSL 2)** are under the direction of Dr. Ralph Ohde. SSL 1 is devoted primarily to speech perception and speech acoustics research. This laboratory consists of a control room and a double-walled sound-attenuating test room that can test up to three subjects simultaneously under headphones. SSL 1 is controlled by a pentium-based PC system and a 486 PC system, which are used in the generation and acoustic analysis of stimuli, and for the control of experimental paradigms. Acoustic analysis is performed using either KayPENTAX Multi-Speech (Model 3700) or the CSpeech software package (Milenkovic, 1996). Synthetic speech is generated using either the Klatt cascade/parallel formant synthesizer (Klatt, 1980; Klatt and Klatt, 1990) or the KayPENTAX Analysis-Synthesis Laboratory (Model 5104). SSL 1 is also equipped with an audio-video recording system for the generation of high quality tape recordings. This laboratory includes equipment necessary for measuring and calibrating instruments, for analog signal generation, and for control of devices. The emphasis of the work in SSL 2 is on the phonetic and acoustic analysis of speech sounds. This laboratory contains two workstations for the phonetic analysis of speech. Each of these stations has a phonetic transcriber used in the phonetic transcription of normal and disordered speech. In addition, SSL 2 has two workstations for the acoustic analysis of speech that is performed using KayPENTAX software for the Computerized Speech Lab (CSL - Model 4500), and pentium-based PC systems supporting CSL.

The **Developmental Stuttering Project (DSP)** laboratory, under the direction of Dr. Edward G. Conture, investigates stuttering in pre-school aged children. The DSP consists of a federally-funded research program of over 30 years standing that empirically studies linguistic and emotional contributions to childhood stuttering. These contributions are assessed by acoustic, behavioral, standardized test and psycho-physiological means. The DSP utilizes three rooms for data acquisition, one room for data analysis, and one interview room. Each of the three data acquisition rooms is equipped with two adjustable, wall-mounted high-resolution cameras and table microphones, instrumentation used for acquiring audio-video signals during standardized testing and examiner-child conversational speech samples. One of these testing rooms also houses a computer-based data collection system for the acquisition and measurement of behavioral and physiological measures. This system consists of the Biopac MP150 system for the acquisition of heart rate/variability (ECG), skin conductance (GSR), and respiratory signals as well as the Noldus Observer for the synchronization and subsequent assessment of interactions of multiple data streams. The data analysis room consists of four computer workstations used for a variety of data analyses. Each workstation includes Systematic Analysis of Language Transcripts (SALT) for transcription of conversational speech, coding of stuttering and other types of disfluency, and extraction of linguistic measures. These workstations also provide access to a statistical package for data analysis (SPSS) and behavioral coding software (Pro-Coder). Furthermore, one computer provides access to Computerized Speech Lab (CSL), a system used to for the acoustic analysis of correlates of speech, and another computer coordinates audio and video inputs among the various testing rooms for digital and analog recording.

The **Child Language and Literacy Laboratory (CLL)**, under the direction of Dr. Melanie Schuele, and the **Clinical Language Intervention Program (CLIP)**, under the direction of Dr. Stephen Camarata, are devoted to the study of typical and atypical language and literacy

acquisition and the study of the effectiveness of language and literacy interventions. The CLL and CLIP share lab space, including six research/treatment rooms and a Language Analysis Laboratory. All research/treatment rooms are outfitted with child-sized furniture providing a comfortable atmosphere for interaction between parents, children, and researchers. Three research/treatment rooms are equipped with two wall-mounted high-quality video cameras which connect to a server for video-recording with split screen recording possible. These three rooms are accessible for observation through a two-way mirror. The Language Analysis Laboratory includes five workstations, and additional workstations are available in the treatment/research rooms. These workstations allow for transcription and analysis of audio and video recordings of child speech/language, parent-child interactions, and examiner-child interactions. Workstations are equipped with Microsoft Office (Word, Excel, PowerPoint, Publisher, Excel, Access), SPSS for statistical analysis, and Systematic Analysis for Language Transcripts (SALT) and Computerized Profiling (CP). Transcription is aided by PC and MAC-based transcription software and footpedals. Video editing is completed through MAC-based software. One workstation is equipped with Computerized Speech Lab (CSL) software. The CLL lab and CLIP maintain an extensive library of norm-referenced/standardized assessment instruments as well as portable audio and video recording equipment (e.g., cameras, digital recorders, wired and wireless microphones).

The **Multisensory Research Laboratories (MRL)**, under the direction of Dr. Mark Wallace, are state-of-the-art facilities for examining the processes by which other sensory systems (e.g., vision, touch) can influence auditory behaviors and perceptions, as well as the neural mechanisms that underlie these interactions. The MRL is comprised of three laboratories for performing in vivo electrophysiological analyses, each designed to accomplish the objectives of a particular research theme. The first lab is structured to examine the development of and plasticity in cross-modal sensory representations, with emphases on how auditory-nonauditory interactions mature, and how these interactions are shaped by sensory experience. The second lab seeks to better elucidate the nature of multisensory interactions in the cerebral cortex, with the ultimate goal of understanding how visual and tactile stimuli can alter higher-order auditory perceptions, such as speech. The third lab is designed to reveal how auditory stimuli can direct certain behaviors, such as locating an object in space, and how these processes can be impacted by other sensory stimuli. Each of these labs is outfitted with a host of sophisticated equipment for recording unit activity from various regions of the brain, for the delivery a complex array of different sensory stimuli, and for the acquisition and analysis of unit data from the brain.

In addition, two research suites are dedicated to examining similar issues in human subjects. These labs are structured to examine human psychophysical performance in response to auditory and non-auditory cues. Two examples of ongoing studies are an examination of the effects of visual cues on the perceived location of an auditory target, and an examination of how the timing of auditory cues can alter the perceived time of the occurrence of visual events. Each of these labs work in conjunction with collaborations to examine the brain networks activated during the performance of these tasks, as examined using neuroimaging techniques such as event related potentials (ERPs) and functional magnetic resonance imaging (fMRI). Experiments are performed on both normal and various clinical populations (e.g., dyslexics, aged populations, hearing-impaired, visually-impaired).

The ultimate goal of the MRL research program is to further our understanding of how the brain integrates information from the different senses, and to apply this knowledge to improve the quality of life of those suffering from a variety of sensory processing deficits. Two examples of the potential application of this knowledge base lay in the realms of dyslexia and hearing-impairment. Recently, our lab has proposed that developmental dyslexia, a prevalent and costly reading disorder, may be linked to a specific dysfunction in cross-modal processing.

With this framework, we have identified a network of affected brain areas, and have proposed a remediation strategy based on this database. In the realm of hearing impairment, it has been well established that concurrent visual cues (i.e., lip-reading) can greatly improve the intelligibility of heard speech. However, little was known about the underlying neural mechanisms for such improvements, a gap that our research program is working hard to fill, and which will hopefully yield better strategies (and devices) to further improve the quality of the spoken signal.

The **Laryngeal Biology Laboratory (LBL)** is under the direction of Dr. Bernard Rousseau and is devoted to understanding the role of phonation on organization and remodeling of the vocal fold and novel methods for vocal fold tissue regeneration. Research efforts are funded by the National Institutes of Health, National Institute on Deafness and Other Communication Disorders. This laboratory includes a microsurgical dissection station, dual head operating microscope, surgical preparation, operating, and recovery areas, xenon light sources, 1.9 and 2.7 mm Karl Storz Hopkins telescopes, suspension laryngoscopes, surgical lamps, surgical instruments, xenon light sources for surgical procedures, Gould digital storage oscilloscopes, video monitoring and recording system, Windaq Data Acquisition System, on-line data entry and analysis, microelectrode manufacturing station, 5 equipment racks housing stimulators and preamplifiers, Gould digital storage oscilloscopes-DSO, Grass S88 stimulator, Teac 14 channel wideband FM tape recorder, and video monitoring and recording system with special effects generator, NuAire type A2 biological safety cabinet, NuAire autoflow air-jacketed CO₂ incubator, Micromaster inverted microscope, Leitz 2-head binocular microscope, Pixera color camera, Photo-gel doc system, Applied Biosystems StepOne Plus Fast Real-Time PCR system. Retsch mixer mill, Compaq workstation, sink area, laboratory benches, walk-in cold room, refrigeration and -80 freezer units, 6-foot fume-hood, storage cabinets for reagents, enzymes, glassware, and disposable supplies, Leica sliding microtomes and Cryostat for sectioning of frozen, paraffin, gelatin, or nitrocellulose embedded tissues, Nikon 90i Upright Microscope with Fluorescence and Dual Camera Attachment, Hamamatsu ORCA-R2 CCD high-resolution cooled digital CCD camera, DS-Fi1 5-megapixel color camera, NIS-ELEMENTS software, DELL pc workstation. The Electron Microscopy (EM) Core is used for scanning electron microscopy and transmission electron microscopy experiments, image processing, and image quantification. The laboratory is fully equipped to carry out numerous aspects of "routine" as well as specialized electron microscopy. The laboratory houses a Philips CM-12, 120 keV, with high resolution eucentric goniometer stage and Gatan cryotransfer stage, Reichert Ultracut-3 microtome, Denton DV-502 evaporators, Slam and plunge freezing equipment, a Hitachi X-650 scanning electron microscope. A computer imaging room containing additional workstations, digital imaging, processing and analysis software, 3-D reconstruction, pattern recognition, quantitation, and digital printing capabilities.

The **Auditory Neurophysiology Laboratory** is located in the Vanderbilt University Department of Psychology. This facility is equipped to conduct anatomical and neurophysiological studies of the brain in research animals. Two research rooms contain double-wall IAC sound chambers, TDT stimulus generation and Plexon multichannel recording equipment. Shared laboratory space contains microscopes for anatomical studies, a histology laboratory for tissue processing, and walk-in cold room for tissue storage.

The **Computer Laboratory** (housed on the 8th floor) is devoted to computer teaching for students and in-service training for staff and faculty members. This laboratory is equipped with

state-of-the-art computer equipment: a Local Area Network (LAN) connecting 12 computers in a classroom setting, plus a "podium" PC with direct connection to the room PC projector. All computers have hardwire internet connection. This classroom, like the other classrooms on this floor, is also equipped with a document projector and a closed-circuit camera system for FULL audio-visual capability.

The Vanderbilt Balance and Hearing Center is located on the 7th floor of the Bill Wilkerson Center. The Balance and Hearing Center, a division of the Department of Hearing and Speech Sciences, is equipped with state-of-the-art equipment for comprehensive assessment of vestibular and auditory disorders. The facility includes a sound treated room, a diagnostic audiometer, a tape recorder and compact disk player for speech audiometry, a microprocessor immittance meter, three otoacoustic emissions devices, a rotary vestibular test chair, a computerized electronystagmography system, a computerized dynamic posturography system, an evoked response system with capability for 64 channels simultaneous brain signal acquisition, a 4-channel clinical evoked potentials system, and, two computerized hearing aid analysis systems. Additionally the facility contains 6 personal computers for use by students and the four staff audiologists, and a neurologic examination room. The facility also includes student office space. Students also conduct research and acquire clinical practicum experiences at the 1000 square foot audiology facility located within The Vanderbilt Clinic on the Vanderbilt University Medical Center campus. This facility is equipped with three sound treated rooms for adult and pediatric hearing assessment, three diagnostic audiometers, two immittance meters, one evoked response system, and one electronystagmography system.

The Voice Center of the Department of Otolaryngology is adjacent to the Vanderbilt Balance and Hearing Center on the 7th floor of the Vanderbilt Bill Wilkerson Center. The Center includes four state-of-the-art laryngological examination rooms, a specially-equipped room for the treatment of Spasmodic Dysphonia and facial paralysis, a voice testing laboratory, a digital audio tape recording facility, three videostroboscopic laryngoscopy rooms, specially designed areas for patient consultation and education, and several sound-attenuated, humidity-controlled rooms with complete audio and video capabilities. The Center houses a team of physicians, speech-language pathologists, and singing voice specialists who are trained in the diagnosis and treatment of disorders of the larynx and problems affecting the voice.

Acknowledgments

Virtually all of the equipment and most of the facilities described above were nonexistent prior to 1979. We are proud of the manner in which our research program has developed over the past thirty years. Many agencies and benefactors deserve recognition for their significant contribution to the development of our facilities. We gratefully acknowledge the contributions of the following agencies, corporations, and foundations for their financial assistance.

American Speech-Language-Hearing Foundation (CCL)
Argosy Electronics, Inc.
Bernaфон AG
Cochlear Americas (ACL, RCL)
Digital Equipment Corporation (SSL 1)
Dan Maddox Foundation (Dan Maddox HARL)
Defense Advanced Research Projects Agency (DOD/DARPA)
EAR Foundation
Etymotic Research
Intelligent Hearing Systems (APL)
Life and Casualty (SSL 1, SSL 2)
Maternal Child Health Bureau (ACL, ADL)
Malcolm Fraser Foundation
MED-EL Corporation (ACL, PAL)
Medtronic, Inc. (DO)
NIH (NIDCD) (ACL, PAL, SSL 1, DO, CCL, APL, LBL, CIRL)
NIH (NINDS) (MRL)
NIH (NICHD) (MRL)
National Easter Seal Society
National Life and Trust (SSL 2)
National Organization of Hearing Research (ACL)
National Science Foundation (PAL, ACL)
Nissan Motor Corporation (SSL 1)
Northern Telecom, Inc. (SSL 1)
Office of Navy Research (DO)
Phonak, Inc. (ADL, Dan Maddox HARL)
Potter Foundation (SSL 1)
Sharplan Lasers, Inc. (DO)
Siemens Hearing Instruments
Starkey Laboratories Incorporated
Robert Wood Johnson Foundation (CLL)
South Central Bell (SSL 1)
Spencer Foundation (ACL, SSL 1, CLL)
Studer Revox America, Inc. (CLL)
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Veterans Administration-Medical and Surgical Merit Review Research
Veterans Administration-Rehabilitation Engineering (PAL)

Veterans Administration-Rehabilitation Research and Development Service
Veterans Administration-Vanderbilt Hearing Aid Study

The National Center for Childhood Deafness And Family Communication

In 2005, the Vanderbilt Bill Wilkerson Center opened the National Center for Childhood Deafness and Family Communication (NCCDFC). The NCCDFC seeks to improve outcomes for children with hearing loss and their families through a triad of exemplary service, education, and research. This influence extends beyond the walls of the NCCDFC through our commitment to public and professional education and advocacy nationwide. The specific goals of the Center are to 1) achieve excellence in service provision to infants and children with hearing loss and their families, 2) enhance knowledge and awareness of the nature and impact of auditory disorders from a multidisciplinary perspective, 3) shape the future of children with hearing loss through national and international leadership, 4) provide innovative training approaches and materials for both pre-service and post-service professionals who work with infants and children with hearing loss, and 5) promote public awareness in the prevention of hearing loss in children.

The NCCDFC Service Division strives to provide best practice and proven service delivery in the areas of early childhood oral education at the Mama Lere Hearing School, speech-language pathology, and audiologic management. Through a family-centered approach, the goal is to maximize a child's hearing potential so that he or she can communicate independently and effectively in mainstream society.

The NCCDFC Research Division brings together clinicians and scientists from a range of disciplines, and research interests – all with a focus on children with hearing loss. The research program is composed of basic science and translational research projects designed to improve understanding of normal hearing processes and various forms of childhood deafness, and to develop new and innovative methods of evaluating and managing the needs of pediatric patients and their families.

The NCCDFC Education Division initiated a Master in Education of the Deaf (MDE) degree program that accepted its first students in Fall of 2006. This one- to two-year program emphasizes the training needed to develop spoken language and auditory skills in deaf and hard-of-hearing children. This program provides a unique, interdisciplinary approach to teacher training by combining training in audiology, speech-language pathology, and deaf education. Also beginning in 2006, speech-language pathology and audiology graduate students can opt to participate in our Specialty Track in Identification and Management of Infants and Children with Hearing Loss.

The Scottish Rite Masons Research Institute For Communication Disorders

The Nashville Scottish Rite Foundation, Inc., the philanthropic arm of Scottish Rite Freemasonry in the Valley at Nashville, sponsors the Scottish Rite Masons Research Institute for Communication Disorders at the Vanderbilt Bill Wilkerson Center for Otolaryngology and Communication Sciences. The primary emphasis of the research institute is on improving the methodology for the treatment of speech, language and hearing disorders in children.

The joint project between the Wilkerson Center and the Nashville Scottish Rite Foundation has been fostered in large part by Illustrious Joseph Martin, 33^o, Deputy of the Supreme Council for Scottish Rite Freemasonry in Tennessee. Mr. Martin has also played an active role on the Bill Wilkerson board of directors; during his six-year tenure, he served on the executive committee and as chair of the board from 1993 through 1995. Active in both organizations, Mr. Martin recognized the opportunity for a cooperative effort between the Center and the Foundation. More recently, Mr. Dan Jones has become a leader in the Scottish Rite and continues the collaborative relationship between Bill Wilkerson Center and the Scottish Rite Masons Research Institute.

Since the 1950's, the various Valleys of the Supreme Council, 33^o of Scottish Rite Freemasonry have established Scottish Rite Centers nationwide for children with speech and language disorders. These Centers, which began with a pilot project in Colorado, are now found at 73 locations throughout the United States. Staffed with speech-language pathologists and other trained personnel, each Center provides diagnosis and treatment of speech and language disorders and associated learning disabilities. The project at the Wilkerson Center represents the first research effort sponsored by the Scottish Rite.

This research arm of the Scottish Rite Center is dedicated to the advancement of treatment technology for language disorders. Additionally, a service and teaching component is part of the program. Many children have the opportunity to receive therapy as a part of the applied research process. Another important function of the research program is the dissemination of information to the other Centers over the country. Continuing education courses and seminars update professional personnel on the latest research methodology.

The Nashville Scottish Rite Foundation has been a major supporter of the Wilkerson Center since 1982.

Vanderbilt University NIH NIDCD-funded Short Term Research Training Program for AuD Students (T35)

The Department of Hearing and Speech Sciences at Vanderbilt University offers short-term research traineeships each year to students in the Vanderbilt AuD program and to students from AuD programs at other universities. These traineeships are funded by the National Institute on Deafness and Other Communication Disorders (NIDCD) at the National Institutes of Health (NIH) through the Ruth L. Kirschstein National Research Service Award (NRSA) Pre-Doctoral Short-Term Research Training Grants (T35) program.

This AuD student traineeship program is part of an initiative by the NIDCD that focuses on the importance of research to the profession of audiology and the importance of exposing students to research. Students who pursue AuD degrees generally do not have opportunities to undertake directed, full-time research as a part of their AuD training program. This research traineeship program is one way that NIDCD is encouraging students with potential interest in research to explore those interests. It provides an excellent opportunity for AuD students to obtain significant exposure to research in an active laboratory conducting basic research in hearing science and/or translational research related to the auditory or vestibular systems.

Student trainees work alongside established research scientists in one of the research laboratories at Vanderbilt and are involved in a specific research project. The program is designed to give trainees an opportunity to learn about research through concentrated, focused, full-time hands-on experience. In addition to learning first hand about the process of conducting research, students have opportunities to attend seminars and lectures, participate in discussion groups, attend meetings of investigators to discuss projects, and participate in discussions related to the ethical practice of research. Traineeships also include funds that support travel to the annual meeting of the American Auditory Society where trainees present a poster related to the work they completed during their traineeship.

Traineeships are awarded each year on a competitive basis. While it is anticipated that most traineeships will be completed during the summer months of students' programs, it also may be possible to complete a traineeship at other times during the year. Students from all AuD programs in the United States who are eligible for NIH NRSA support (e.g., U.S. citizens or permanent residents) may apply for this training program. For more information and application materials, please contact Linda Hood, PhD, Principal Investigator/Program Director (email: linda.j.hood@vanderbilt.edu or phone: 615-936-4612).

T35 Traineeship Preceptors and Research Areas

Daniel Ashmead, Ph.D. – Auditory and Visual Motion Perception
Fred Bess, Ph.D. – Minimal Hearing Loss
Edward Conture Ph.D. – Developmental Stuttering
D. Wesley Grantham, Ph.D. – Binaural Hearing, Cochlear Implants
Troy Hackett Ph.D. – Auditory System Neuroanatomy
Linda Hood, Ph.D. – Auditory Physiology, Auditory Neuropathy/Dys-synchrony
Benjamin Hornsby, Ph.D. – Speech Understanding and Amplification
Gary Jacobson, Ph.D. – Vestibular System Function
Alexandra Key, Ph.D. – Cognitive Processing, Brain Activity, Event-related Potentials
Devin McCaslin, Ph.D. – Vestibular System Function
Todd Ricketts, Ph.D. – Hearing Aid Research

Anne Marie Tharpe, Ph.D. – Pediatric Audiology, Auditory Development
Mark Wallace, Ph.D. – Brain Bases of Multisensory Processing

Past T35 Trainees and Research Topics

Trainees included in the previous Research Report

- 2007: Kristy Loftin, University of Arkansas
Velocity Discrimination (Preceptor: Daniel Ashmead)
Kristen Willis, Missouri State University
Auditory Pathway Anatomy (Preceptor: Troy Hackett)
- 2008: Rita Anelli, Northeastern University
Auditory Steady-State Responses Using Simultaneous Multiple and Intensity-
Ramped Stimuli (Preceptor: Linda Hood)
Naomi Croghan, University of Colorado
Binaural Interference in the Free Field (Preceptor: Wesley Grantham)
Jonathon Whitton, University of Louisville
Generalization of Low-Level Multisensory Perceptual Training to a Speech Task
(Preceptor: Mark Wallace)
Christine Williams, Vanderbilt University
Intensity-Ramped Auditory Steady-State Responses in Infants in the NICU
(Preceptor: Linda Hood)

Trainees since the previous Research Report, abstracts included in this Research Report

- 2009: Jodi Hensel, Ohio State University
Intensity Effects on TEOAE Suppression (Preceptor: Linda Hood)
Apollonia Koleis, University of Colorado
Adult standing postural control (Preceptor: Daniel Ashmead)
Megan Pollman, Louisiana State University Health Sciences Center
Efferent effects in speech understanding (Preceptors: Benjamin Hornsby and
Linda Hood)
Lindsey Rentmeester, Vanderbilt University
Young Children's Attitudes Towards Their Peers Who Wear Hearing Aids
(Preceptor: Anne Marie Tharpe)
- 2010: Timothy Davis, Vanderbilt University
The Effect of a Speech Target's Motion on Its Detectability (Preceptor: Wesley
Grantham)
Erin Graugnard, Louisiana State University Health Sciences Center
Auditory Perception of Acceleration and Deceleration (Preceptor: Daniel
Ashmead)
Steven Marcum, Vanderbilt University
Measurement of Hearing Aid Feedback Suppression in Real Ears (Preceptor:
Todd Ricketts)
Travis Moore, Vanderbilt University
Predicting Hearing Aid Benefit from Speech Recognition Measures (Preceptor:
Benjamin Hornsby)

Current Trainees, research in progress

- 2011: Christina Do, University of Maryland
Vestibular Function (Preceptors: Gary Jacobson and Devin McCaslin)
- Kelsey Hatton, Vanderbilt University
Comparison of Otoacoustic Emission Measures of the Medial Olivocochlear
Reflex (Preceptor: Linda Hood)
- Bradley Hess, Auburn University
Interactions of Intensity, Frequency and Rate on Auditory Brainstem Responses
(Preceptor: Linda Hood)
- Elizabeth Kolberg, Vanderbilt University
Neuroanatomy and Antibodies (Preceptor: Troy Hackett)

Abstracts of Research Projects

A. Hearing and Vestibular Science - Applied

Berlin, C. I., **Hood, L. J.**, Morlet, T., Wilensky, D., Li, L., Rose Mattingly, K., Taylor-Jeanfreau, J., Keats, B.J.B., St. John, P., Montgomery, E., Shallop, J., Russell, B.A. & Frisch, S.A. 2010. Multi-site diagnosis and management of 260 patients with Auditory Neuropathy/Dys-synchrony (Auditory Neuropathy Spectrum Disorder). *International Journal of Audiology* 49:30-43.

Test results and management data are summarized for 260 patients with diagnoses of Auditory Neuropathy Spectrum Disorder (ANSD). Hearing aids were tried in 85 of these patients, and 49 patients tried cochlear implants. Approximately 15% reported some benefit from hearing aids for language learning, while improvement in speech comprehension and language acquisition was reported in 85% of patients who were implanted. Approximately 5% (13/260) of the total population developed normal speech and language without intervention. Patients were diagnosed at our laboratory (n=66) or referred from other sites (n=194), and all showed absent/grossly abnormal auditory brainstem responses (ABR), often 'ringing' cochlear microphonics, and the presence or history of otoacoustic emissions. Etiologies and co-existing conditions included genetic (n=41), peripheral neuropathies (n=20), perinatal jaundice and/or anoxia and/or prematurity (n=74). These patients comprise 10% or more of hearing impaired patients; their language acquisition trajectories are generally unpredictable from their audiograms.

Bradham, T.S. (in press). Quality 101: What every audiologists and speech-language pathology should know but was afraid to ask. *Perspectives Hearing and Hearing Disorders in Childhood Deafness*, ASHA.

The United States has the highest per capita health care costs of any industrialized nation in the world. Increasing costs are reducing access to care and constitute an ever heavier burden on employers and consumers. Yet as much as 20 to 30 percent of these costs may be unnecessary, or even counterproductive, to improved health (Wennberg, Brownless, Fisher, Skinner, & Weinstein, 2008). Addressing these unwanted costs is essential in the survival of providing quality health care. This article reviews eleven dimensions that should be considered when starting a quality improvement program as well as one commonly used quality improvement tool, the Juran model, that is commonly used in the healthcare and business settings. Implementing a quality management program is essential for survival in today's market place and is no longer an option. While it takes time to implement a quality management program, the costs are too high not too.

Bradham, T.S. & Houston, K.T. (2011). Future directions for EHDI [Programs: Recommendations from a strategic analysis. *The Volta Review*, 111(2), 281-288.

The National Center for Hearing Assessment and Management (NCHAM) at Utah State University conducted a strengths, weaknesses, opportunities, and threats (SWOT) analysis in 12 major areas within the EHDI system (Christiansen, 2002; Wehrich, 1982). The areas were (1) Infrastructure; (2) Professional Development; (3) Early Intervention; (4) Interagency Collaboration; (5) Lost to Followup; (6) Medical Home; (7) Newborn Hearing Screening; (8) Periodic Early Childhood Hearing Screening; (9) Data Management; (10) Family Support; (11) Quality Enhancement; and (12) Audiological Services. The purpose of this analysis was to provide a comprehensive, systemic review aimed at obtaining a clearer, operational picture of state EHDI programs. The primary goal of the analysis was to identify internal and external factors that contribute to the success of an EHDI program, but also to identify obstacles confronted by EHDI programs. By identifying processes that are successful, resources can be optimally allocated in ways that improve overall quality and reduce duplication of effort. Conversely, by identifying potential barriers, solutions can be formulated. The response rate ranged from 94% to 98% for each of the 12 areas surveyed. There were 3,101 total responses with 907 responses for Strengths, 788 responses for Weaknesses, 694 responses for Opportunities, and 712 responses for Threats. The EHDI coordinator, who is responsible for all 12 areas evaluated, was the ideal person to complete the survey. This article summarizes all the findings in the 12 areas of EHDI. The 12 individual article titles are listed below:

- Houston, K.T., Muñoz, K.F. & **Bradham, T.S.** (2011). Professional Development: Are We Meeting the Needs of State Early Hearing Detection and Intervention (EHDI) Programs? *The Volta Review*, 111(2), 209-224.
- Nelson, L., **Bradham, T.S.** & Houston, K.T. (2011). The EHDI and Early Intervention Connection. *The Volta Review*.
- Nelson, L., Houston, K.T., Hoffman, J. & **Bradham, T.S.** Interdisciplinary Collaboration in EHDI Programs. *The Volta Review*, 111(2), 133-150.
- Hoffman, J., Muñoz, K.F., **Bradham, T.S.** & Nelson, L. (2011). Lost to Follow-up: Issues and Recommendations. *The Volta Review*, 111(2), 165-180.
- Muñoz, K.F., Nelson, L., **Bradham, T.S.**, Hoffman, J. & Houston, K.T. (2011). Integrating the Medical Home into the EHDI Process? *The Volta Review*, 111(2). 151-164.
- Houston, K.T., **Bradham, T.S.**, Muñoz, K.F. & Guignard, G.H. (2011). Newborn Hearing Screening: An Analysis of Current Practices. *The Volta Review*, 111(2), 109-120.
- Hoffman, J., Houston, K.T., Muñoz, K.F. & **Bradham, T.S.** (2011). Periodic Early Childhood Hearing Screening: The EHDI Perspective. *The Volta Review*, 111(2), 195-208.
- Bradham, T.S.**, Hoffman, J., & Houston, K.T. (2011). Data Management in the EHDI System. *The Volta Review*, 111(2), 243-254.
- Bradham, T.S.**, Houston, K.T., Guignard, G.H. & Hoffman, J. (2011). Strategic Analysis of Family Support in EHDI Systems. *The Volta Review*, 111(2), 181-194..
- Bradham, T.S.**, Hoffman, J., Houston, K.T. & Guignard, G.H. (2011). Fostering Quality Improvement in EHDI. *The Volta Review*, 111(2), 255-266.
- Muñoz, K.F., **Bradham, T.S.** & Nelson, L. (2011). A Systematic Analysis of Audiological Services in Early Hearing Detection and Intervention (EHDI). *The Volta Review*, 111(2), 121-132.

Bradham, T.S., Snell, G., & Haynes, D. (2009). Current practices in pediatric cochlear implantation. *Perspectives Hearing and Hearing Disorders in Childhood Deafness*, ASHA.

Technological advances, specifically cochlear implants, have significantly impacted the treatment of children with severe to profound hearing loss. Many organizations, including American Speech-Language Hearing Association (ASHA), National Association of the Deaf (NAD), American Academy of Audiology (AAA), and National Institute for Health (NIH), and the William House Cochlear Implant Study Group, all have position papers or guiding documents pertaining to cochlear implants; however, there are no published “best practices” or “standard of care” guidelines for cochlear implants. NIH published a consensus document on cochlear implants in 1995 when Nucleus was the only FDA approved cochlear implant system. A technical report on cochlear implants was written in 1986 and then revised in 2003 by ASHA. AAA published algorithms on cochlear implant assessments for adults and children in 2000. With the lack of evidence based-standard of care, patients are seen as needed by the audiologists and the schools or early intervention systems are responsible for developing and implementing the aural (re)habilitation program. Cochlear implant programs typically use the Food and Drug Administration (FDA) guidelines and the cochlear implant manufacturer’s recommendations as much as possible in developing their cochlear implant program (see Table 1). In this paper, we will present a best practice model for teams to consider when implementing a pediatric cochlear implant program. We will describe the candidacy, follow-up management, practice management, and outreach/marketing issues that should be considered. This article won an award with ASHA for being one of the top five articles with the *Perspectives Hearing and Hearing Disorders in Childhood Deafness* in 2010.

Hofstetter, P.J., Kokesh, J., Ferguson, A.S. & **Hood, L.J.** 2010. The Impact of Telehealth on Wait Time for ENT Specialty Care. *Journal of Telemedicine and e-Health* 16 (5), 551-556.

Audiology in rural Alaska has changed dramatically in the past 6 years by integrating store and forward telemedicine into routine practice. The Audiology Department at the Norton Sound Health Corporation in rural Nome Alaska has used store-and-forward telemedicine since 2002. Between 2002 and 2007, over 3,000 direct audiology consultations with the Ear, Nose, and Throat (ENT) Department at the Alaska Native Medical Center in Anchorage were completed. This study is a 16-year retrospective analysis of ENT specialty clinic wait times on all new patient referrals made by the Norton Sound Health Corporation providers before (1992–2001) and after the initiation of telemedicine (2002–2007). Prior to use of telemedicine by audiology and ENT, 47% of new patient referrals would wait 5 months or longer to obtain an in-person ENT appointment; this dropped to 8% of all patients in the first 3 years with telemedicine and then less than 3% of all patients in next 3 years using telemedicine. The average wait time during the first 3 years using telemedicine was 2.9 months, a 31% drop compared with the average wait time of 4.2 months for the preceding years without telemedicine. The wait time then dropped to an average of 2.1 months during the next 3 years of telemedicine, a further drop of 28% compared with the first 3 years of telemedicine usage.

Hood, L.J. 2009. Variation among individuals with auditory neuropathy/dys-synchrony and implications for management. *Educational Audiology Review* 27:10-11,23.

Patients ranging in age from infants to adults are described with an auditory disorder variably termed auditory neuropathy (AN; Starr et al., 1996), auditory neuropathy/dys-synchrony

(AN/AD; Berlin et al., 2001) and more recently, auditory neuropathy spectrum disorder (ANSO). Clinical presentation typically, but not always, includes difficulty listening in noise, may include fluctuation in hearing ability, and, in the case of infants and children, often involves delayed development of speech and language. ANSO is identified clinically by evidence of intact outer hair cell function evidenced by present otoacoustic emissions (OAEs) and/or cochlear microphonics (CM). Poor VIIIth nerve-brainstem responses are demonstrated by absent or highly abnormal auditory brainstem responses (ABR), absent or elevated middle-ear muscle reflexes (MEMR; Berlin et al., 2005) and absent or abnormal medial olivocochlear reflexes, measured via efferent stimulation effects on OAEs (Hood et al., 2003). Despite fairly consistent findings from physiologic measures in current clinical use, there is considerable variation in characteristics and functional communication abilities across patients (e.g., Starr et al., 2000). Variation among patients underscores the need for a team approach and individualized management planning. The Vanderbilt AN Team, and other teams, involves experts from audiology, speech-language pathology, otolaryngology, neurology, early intervention, education and other specialties, as needed. This article focuses on variation among patients, particularly as this relates to communication function and management strategies. Information to support various points is drawn from a database of over 300 patients accumulated at the Kresge Hearing Research Laboratory in New Orleans (Berlin, Hood, Morlet et al., 2009).

Jacobson, G.P. 2009. Assessment of falls risk in the balance disorders laboratory. Perspectives on Hearing and Hearing Disorders: Research and Diagnostics. 13: (2), 27-59.

Falls in the elderly result in significant morbidity and mortality. They also may represent sentinel events suggesting a significant change in the health of an elderly patient. Aside from the human cost, additional costs associated with the surgical repair of hip and wrist fractures, the most common injuries resulting from falls, add expense to an already overburdened health care system. In the current report, a 10-factor falls risk assessment is described that we developed first for the Henry Ford Health System in Detroit and then for the Vanderbilt Bill Wilkerson Center in Nashville. The performance of the first 180 patients evaluated in this program also is described. Finally, a summary of the results of systematic reviews of the literature in the area of falls risk interventions is presented. In particular we were impressed by the proportion of patients with multiple sensory system impairments. While we were not surprised that 93% of these patients demonstrated somatosensory system impairments, we were surprised that 73% of these patients showed quantitative evidence of having undiagnosed peripheral and central vestibular system impairments. It is our feeling that the assessment of falls risk in the elderly falls directly within the scope of practice of audiology.

Jacobson, G.P. March 2011. The "Romberg Test of Standing on Firm and Compliant Support Surfaces" is sensitive to the presence of vestibular system impairment. Presentation at the American Balance Society, Scottsdale, AZ.

Data published by Agrawal and colleagues (2009) as part of the National Health and Nutrition Examination Survey (NHANES) suggest that as many as 35.4% of US adults aged > 40 years have "vestibular dysfunction." Since being aware of the NHANES study, we have conducted the RTSFCS in our Balance Disorders Laboratory using identical data collection protocols as those described by Agrawal et al. (2009, 2010). As such, we conducted a retrospective investigation of the relationship between vestibular system impairment (i.e. using the caloric and VEMP tests

as gold standards) and performance on the RTSFCS. Preliminary data (N = 61, mean age 55 yrs, +/- 16 yrs, 20 male) suggest that, when the caloric test is used as the “gold standard,” sensitivity and specificity of the RTSFCS to vestibular impairment are 42% and 64% respectively yielding positive and negative predictive values of 35% and 71% respectively. When either caloric and/or VEMP testing are used as “gold standards” sensitivity and specificity are 42% and 69% yielding positive and negative predictive values of 59% and 53% respectively. Accordingly, we feel that the RTSFCS is relatively insensitive to the presence of vestibular impairment.

Jacobson, G.P., McCaslin, D.L., Hatton, K., Thornton, A. (in preparation). EMG normalization does not reduce significantly variability in VEMP normative data for young controls.

This investigation was conducted to determine the optimal technique to control for EMG activity, a source of VEMP amplitude variability, when recording the cVEMP. A prospective analysis was performed on data obtained from 19 young normal subjects without conductive hearing loss or a history of vestibular dysfunction. Data was collected in 4 conditions: 1) no EMG monitoring, 2) self-monitoring of eMG using a visual target, 3) amplitude normalization using mean pre-stimulus EMG activity and 4) self-monitoring and amplitude normalization. For each condition the P 13 latency, P13-N23 peak to peak amplitude, and mean and sd of rectified EMG were collected. Asymmetry ratios were then calculated for each condition. Condition and ear stimulated served as independent variables and P13 latency, P13-N23 peak to peak amplitude, amplitude asymmetry ratios, and mean and sd of rectified EMG activity served as dependent variables. None of the conditions investigated had an effect on P13-N23 amplitudes, amplitude asymmetry ratios, or sd of the EMG activity. An ear effects was found in the amplitude normalized conditions only. The findings of this study indicate that, at least in a young normal population, if an optimal technique for activating the sternocleidomastoid muscle is used, there is no additional benefit observed for patient self-monitoring EMG or VEMP amplitude normalization.

Jacobson, G.P., McCaslin, D.L., Piker, E.G., Gruenwald, J., Grantham, S. & Tegel, L. (in press). Patterns of abnormality in cVEMP, oVEMP and caloric tests may provide topological information about vestibular impairment. *Journal of the American Academy of Audiology*.

Background: The cervical VEMP (cVEMP) is recorded from the sternocleidomastoid muscle (SCM) and represents a stimulus-evoked attenuation of electromyographic (EMG) activity following activation of the saccule and inferior vestibular nerve. In addition to the cVEMP, it is possible to record a biphasic response from the infraorbital region following stimulation that is identical to that used to record the cVEMP. This response is known as the ocular VEMP (oVEMP). The peripheral vestibular origins of the oVEMP elicited with air conduction remain controversial as some investigators argue the response originates from the saccule and others contend that the response emanates from the utricle. In this short report we review several lines of evidence and present several case studies supporting the contention that the cVEMP and oVEMP to air conduction stimulation derive their peripheral origins from different sources.

Purpose: To review the current evidence regarding the peripheral origins of the oVEMP. Further, a purpose of this report is to present case studies illustrating that the cVEMP and

oVEMP to air conduction stimulation may vary independently of one another in patients with peripheral vestibular system impairments.

Research Design: A collection of case studies illustrating three common patterns of abnormality observed in patients complaining of vertigo seen in a tertiary care referral center.

Study Sample: Illustrative case studies from three patients complaining of dizziness and/or vertigo who underwent vestibular function studies.

Results: Each case report illustrates a different pattern of abnormality of caloric, cVEMP, and oVEMP tests results from three patients with a vestibular nerve section, superior vestibular neuritis, and Meniere's disease respectively.

Conclusions: We have shown that the cVEMP and oVEMP can vary independent of one another, and in that way, provide topological information about the sites of impairment. It is our contention that, with caloric, oVEMP and cVEMP tests, it is possible to augment the diagnostic information we are able to provide regarding the location, or locations, of vestibular system impairment. These findings suggest that air conduction oVEMPs measure a part of the peripheral vestibular system different from that measured by cVEMPs, perhaps the utricle, and similar to that measured by caloric testing, the superior portion of the vestibular nerve.

Jacobson, G.P., McCaslin, D.L., Piker, E.G., Gruenwald, J., Grantham, S. & Tegel, L. (in revision). The "Romberg Test of Standing Balance on Firm and Compliant Support Surfaces" is insensitive to the presence of vestibular system impairment. *Ear and Hearing*.

Objective: The objective of the present study was to assess the sensitivity, specificity, and positive and negative predictive value of the Romberg Test of Standing Balance on Firm and Compliant Support Surfaces (RTSBFCSS) for the identification of patients with vestibular system impairments. The RTSBFCSS was developed for the National Health and Nutrition Examination Survey (NHANES) and was used recently to estimate the numbers of individuals \geq 40 years of age in the general population of the United States that have vestibular system impairments.

Design: A retrospective analysis of the medical records of 103 consecutive patients \geq 40 years (mean age 59 years, +/- 12 years, 71 female) who had undergone vestibular assessment at the Balance Disorders Clinic at the Vanderbilt University School of Medicine. Patients with complete electro- or video-nystagmography (ENG/VNG) testing, cervical vestibular evoked myogenic potential (cVEMP) testing, and the Romberg Test of Standing Balance on Firm and Compliant Support Surfaces (RTSBFCSS) screening test were included in the analysis. A series of 2x2 tables were created that represented the number of "true positives," "true negatives," "false positives," and "false negatives" of the RTSBFCSS under conditions where the caloric test was abnormal and then separately where either or both the caloric and cVEMP tests were abnormal. The data were analyzed in a manner such that sensitivity, specificity, and both positive and negative predictive value of the RTSBFCSS could be calculated.

Results: When the caloric test was used as the criterion standard and the subject selection criteria in the NHANES study were utilized (i.e. subjects who were able to maintain postural stability for trials 1 – 3 of the RTSBFCSS; n = 45), the sensitivity and specificity of the RTSBFCSS to vestibular impairment were 55% and 64% respectively yielding positive and negative predictive values of 55% and 64% respectively. When all patients \geq 40 years of age are evaluated (n = 103) the sensitivity and specificity are 61% and 58% respectively yielding positive and negative predictive values of 39% and 78% respectively. Using the cervical VEMP as the criterion standard did not improve the performance criteria of the NHANES screening measure.

Conclusions: The Romberg Test of Standing Balance on Firm and Compliant Support Surfaces should not be used as a screening measure for vestibular impairment.

McCaslin, D.L. March 2011. EMG Normalization does not reduce significantly variability in cervical VEMP normative data for young normal controls. Presentation at the American Balance Society, Scottsdale, AZ.

The purpose of this investigation was to determine whether the use of visual feedback of tonic electromyographic (EMG) activity, and/or the use of amplitude normalization techniques would reduce significantly the variability in amplitude asymmetry data in otologically and neurologically intact young adults. Subjects consisted of 25 young adult neurologically and otologically intact subjects. Neither P13 amplitudes or latencies, nor mean root mean square (RMS) of the EMG activity, nor the standard deviation of the RMS EMG activity differed significantly when subjects were and were not asked to ensure their tonic EMG activity exceeded a visual target representing > 50 uV RMS EMG. Neither use of a visual target nor amplitude normalization of the VEMP waveforms reduced significantly the variability in the amplitude asymmetry data. Activating the SCM with the patient in semi-recumbent position with head turned away from the stimulated ear and head elevated (the optimal technique) was sufficient to produce the highest amplitude VEMPs with an acceptable amount of variability in young adult subjects. For this sample, the added use of visual targets and amplitude normalization did reduce the variability in amplitude asymmetry measures; however the differences did not reach statistical significance.

McCaslin, D.L. & Jacobson, G.P. 2009. Current role of the VNG examination in the context of the multidimensional balance function test battery. *Seminars in Hearing*, 30: 242-252.

Assessment of the vestibular system once consisted of electronystagmography (ENG), and now more recently, videonystagmography (VNG). Over the last few decades this standard assessment has been expanded into a balance function assessment. The area of balance assessment now incorporates many different fields of study and possesses a strong research base. This multidisciplinary collaboration has resulted in newer tests such as vestibular evoked myogenic potential (VEMP) and off-axis rotation. However, despite its age, the ENG/VNG examination still remains the bedrock test of the balance function test battery. This article describes the role of the ENG/VNG examination in the contemporary assessment of vertigo, dizziness, and imbalance.

McCaslin, D.L., Jacobson, G.P., Burrows, H.L., Littlefield, P. & Haynes, D.S. (2010). Transforming superior canal dehiscence to chronic subjective dizziness: From SCD to CSD. *Journal of the American Academy of Audiology*, 21: 1-8.

Patients presenting with chronic dizziness and no identifiable vestibular impairments have been described as having "extravestibular" symptoms, or "psychogenic dizziness." In 2005, Staab and Ruckenstein described a syndrome they referred to as "chronic subjective dizziness" (CSD), which characterized this concept more clearly. According to Staab and Ruckenstein (2003), the primary physical symptoms of CSD are continual nonvertiginous dizziness or subjective imbalance that persists for 3 mo or longer. Patients suffering from CSD often

describe their dizziness as a rocking or swaying when sitting or standing. This case study describes a 41-yr-old female who originally presented with complaints of noise-induced vertigo. The patient's history, imaging studies, and balance function examinations led to the diagnosis of a right-sided superior canal dehiscence (SCD). After surgical repair of the dehiscence, the quantitative electrophysiological tests returned to normal. However, the patient's scores on measures of anxiety, depression, and self-perceived dizziness handicap increased significantly postoperatively. This case illustrates the transformation of a peripheral end-organ impairment (i.e., SCD) into a psychiatric condition (i.e., CSD).

McCaslin, D.L., Jacobson, G.P., Piker, E.G., Grantham, S.L., Verghese, S. (in press) The effect of unilateral saccular impairment on functional balance performance and self-report dizziness handicap. *Journal of the American Academy of Audiology*.

Background: The cervical VEMP (cVEMP) is recorded from the sternocleidomastoid muscle (SCM) and represents a stimulus-evoked attenuation of electromyographic (EMG) activity following activation of the saccule and inferior vestibular nerve. In addition to the cVEMP, it is possible to record a biphasic response from the infraorbital region following stimulation that is identical to that used to record the cVEMP. This response is known as the ocular VEMP (oVEMP). The peripheral vestibular origins of the oVEMP elicited with air conduction remain controversial as some investigators argue the response originates from the saccule and others contend that the response emanates from the utricle. In this short report we review several lines of evidence and present several case studies supporting the contention that the cVEMP and oVEMP to air conduction stimulation derive their peripheral origins from different sources.

Purpose: To review the current evidence regarding the peripheral origins of the oVEMP. Further, a purpose of this report is to present case studies illustrating that the cVEMP and oVEMP to air conduction stimulation may vary independently of one another in patients with peripheral vestibular system impairments.

Research Design: A collection of case studies illustrating three common patterns of abnormality observed in patients complaining of vertigo seen in a tertiary care referral center.

Study Sample: Illustrative case studies from three patients complaining of dizziness and/or vertigo who underwent vestibular function studies.

Results: Each case report illustrates a different pattern of abnormality of caloric, cVEMP, and oVEMP tests results from three patients with a vestibular nerve section, superior vestibular neuritis, and Meniere's disease respectively.

Conclusions: We have shown that the cVEMP and oVEMP can vary independent of one another, and in that way, provide topological information about the sites of impairment. It is our contention that, with caloric, oVEMP and cVEMP tests, it is possible to augment the diagnostic information we are able to provide regarding the location, or locations, of vestibular system impairment. These findings suggest that air conduction oVEMPs measure a part of the peripheral vestibular system different from that measured by cVEMPs, perhaps the utricle, and similar to that measured by caloric testing, the superior portion of the vestibular nerve.

Picou, E.M., Ricketts, T.A. & Mueller, H.G. (August, 2010). The effect of probe microphone system on the NAL-NL1 prescriptive gain provided to patients. Poster presented at the International Hearing Aid Conference (IHCON): Lake Tahoe, CA.

Since the 1980's, probe-microphone systems have been used to verify hearing aid fittings. Early work suggested that these systems led to valid and reliable fittings. Many changes have occurred since then, including hearing aids, verification process, and test signals. With changes in technology come increases in options and not all systems may implement NAL-NL1 similarly. With the new technologies and potential for increased variability, it became essential to re-examine the consistency and reliability of current probe-microphone systems. Thus, the purpose of this study was to investigate the consistency and reliability of the fitting provided by several popular, commercially available probe-microphone systems, specifically their implementation of NAL-NL. To evaluate consistency across probe-microphone systems, three hearing aids were each fitted to NAL-NL1 targets once based on a sloping hearing loss. Eighteen participants were tested using these hearing aid settings. Using a 65 dB input, real ear unaided gain (REUG), real ear insertion gain (REIG), and real ear aided response (REAR) were measured or calculated for each participant in each of 4 commercially available probe-microphone systems for each of the three hearing aids twice using a round-robin approach. Results demonstrated a significant difference in clinical REAR-based fittings achieved across the probe microphone systems (Figure A-1). Specifically, the clinical Fonix 7000 fitting will result in lower low-frequency, and greater high-frequency REARs than the other three systems. The similarity in the deviation patterns across systems irrespective of gain processing (linear versus compression). There were no significant differences between calculated and system targets suggesting target calculation within each system is appropriate. REAG and REUG were calculated from measured values. Surprisingly, these results were generally consistent with the deviations from REAR target suggesting that these systems measure different magnitudes of frequency specific gain, even within linear amplification. This finding supports a non-linear interaction between the test signal and data acquisition technique within at least one system.

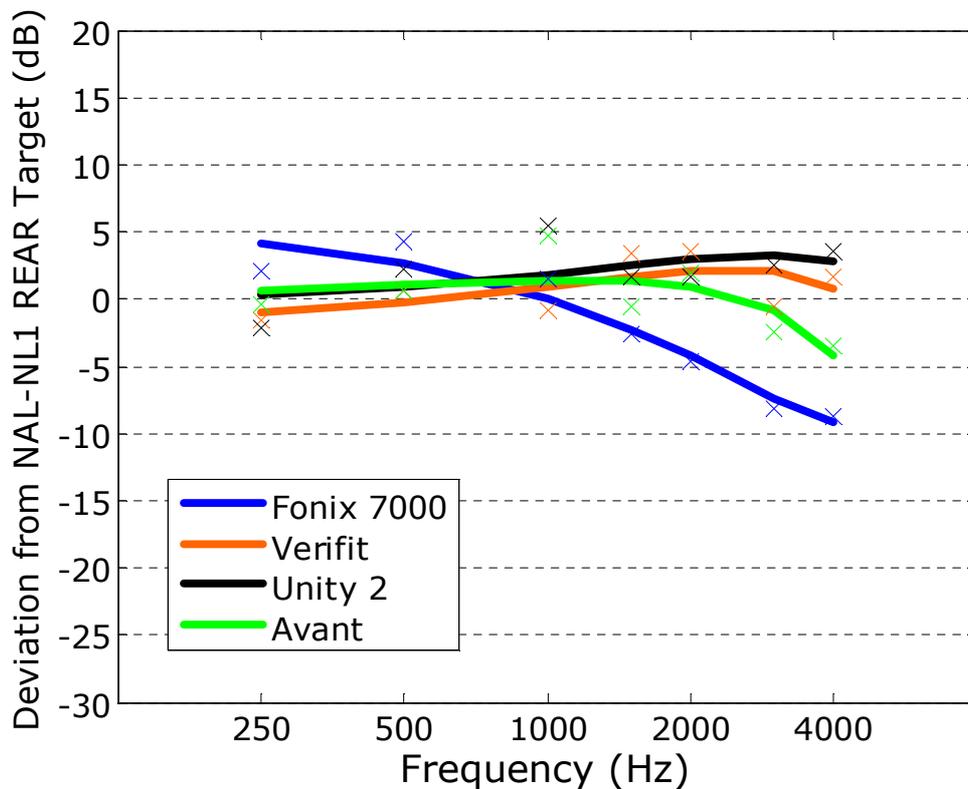


Figure A-1. Average deviation from system specific REAR target (NAL-NL1). Data points are the average deviation from target across two runs and three hearing aids. Lines are the best fit regression lines (2nd order polynomial)

Piker, E.G. & Jacobson, G.P. March 2010. Normal characteristics of the oVEMP: Latency, amplitude, threshold, age, and effect of reference electrode site. NIH Mentored Poster presentation at 2010 meeting of the American Auditory Society, Scottsdale, AZ.

The normal response characteristics of the vestibular evoked myogenic potential (VEMP) recorded from the sternocleidomastoid muscle (cVEMP) have been reported. Recent studies have demonstrated that a VEMP can be recorded from near the eyes in response to acoustical stimulation of the vestibular system. These responses are known as ocular VEMPs (oVEMP). There still remain a number of stimulus and subject-related variables for the oVEMP that have not been studied in normal ears across a wide age range. We recorded both cVEMPs and oVEMPs from 36 normal subjects across 8 different age decades to determine: 1) the normal response characteristics of the oVEMP, 2) effects of age on the response, 3) oVEMP test-retest reliability, and 4) the effects, if any, of reference contamination using the common recommended recording derivation. oVEMPs were recorded bilaterally from 94% of subjects. Means (SDs) for amplitude, latency, and threshold measures were tabulated for the group and the effects of age on these response characteristics was examined. We defined the upper limit of oVEMP amplitude asymmetry to be 32.6% (mean + 2SD) with a mean n10 latency of 12.4

msec. Test/retest reliability was acceptable. Further, using conventional recording techniques, reference contamination was present often.

Piker, E.G. & Jacobson, G.P. February 2009. Psycho-physiological factors in samples of dizzy patients. NIH Mentored Poster presentation at meeting of the American Auditory Society, Scottsdale, AZ.

Factors such as anxiety, depression, somatic awareness, autonomic symptoms and differences in coping strategies are known to impact dizziness handicap. We studied these factors in 63 consecutive “dizzy” patients. This sample was subgrouped into normals, patients with benign paroxysmal positional vertigo, compensated and uncompensated unilateral peripheral vestibular system impairment, and abnormal vestibular evoked myogenic potential as a single significant diagnostic finding. Results showed that: 1) anxiety and depression occur with greater frequency in dizzy patients than in the normal population, 2) the magnitude of anxiety, depression, somatization and autonomic symptoms does not differ significantly in subgroups of patients, 3) women demonstrated significantly greater self-report handicap and somatic/autonomic symptoms, and, 4) DHI total scores were correlated with patient’s complaints of somatic/autonomic symptoms, anxiety, depression, and coping strategies. These findings suggest that self-assessment measures represent a unique piece of information important for the management of dizzy patients.

Piker, E.G., Jacobson, G.P., McCaslin, D.L., Hood, L.J. 2011. Normal Characteristics of the ocular vestibular evoked myogenic potential. *Journal of the American Academy of Audiology*, 22, 1-9.

Background: Stimulus-evoked electromyographic changes can be recorded from the extraocular muscles. These short latency negative polarity evoked myogenic potentials are called ocular vestibular evoked myogenic potentials (oVEMPs). To date there has not yet been a large-scale study examining the effects of age on the amplitude, latency, threshold, and interaural differences of the oVEMP to air conducted stimuli. Further, before the oVEMP can become a useful clinical tool, the test-retest reliability of the response must be established. The oVEMP response, once more completely understood, may provide diagnostic information that is complementary to the cervical (i.e. SCM) vestibular evoked myogenic potential (cVEMP).

Purpose: To describe the normal characteristics of oVEMP in a cohort of age stratified subjects, to assess the test-retest reliability of the oVEMP, and to determine if reference contamination occurs using a common recommended infraorbital reference electrode derivation.

Results: Fifty otologically and neurologically normal adults and children served as subjects. Subjects ranged in age from 8 - 88 years. oVEMP responses were present bilaterally in 90% of our subjects. The upper limit of oVEMP amplitude asymmetry, defined as the mean plus two standard deviations, was 34% (mean = 14%, sd 10%) and the mean n1 latency was 12.5 (sd 1.0) msec. The amplitude of the response significantly decreased and the threshold significantly increased with increasing age, with the greatest age effects occurring in subjects 50 years and older. Test-retest reliability was acceptable (ICC for the measurement variables ranged from .53 to .87). Using conventional recommended recording techniques, evidence of reference contamination occurred for all subjects resulting in a mean amplitude reduction of 30% (range = 18-43%).

Conclusions: Age results in systematic changes in oVEMP measurement parameters. The test-retest reliability is acceptable and reference contamination averaging 30% is guaranteed using a second infraorbital electrode as the inverting input (i.e. reference electrode) for bipolar recordings. The oVEMP can be used as a complementary diagnostic tool to the cVEMP in evaluating subjects with suspected peripheral vestibular disorders

Porter, H.L., Neely, S.T. and Gorga, M.P. (2009). Using benefit-cost ratio to select universal newborn hearing screening test criteria, *Ear and Hearing*, 30(4), 447-457.

Current Universal Newborn Hearing Screening (UNHS) protocols presumably use criteria that are chosen on the basis of the hit and false-alarm rates they produce. Such an approach emphasizes test performance, but does not include societal implications of the benefit of early identification. For this reason, we examined an alternative method of evaluating test performance and selecting criteria for use in UNHS programs that is designed to include societal implications. Existing data from over 1200 ears were used to analyze benefit-cost ratio (BCR) as a function of distortion product otoacoustic emissions (DPOAE) level. Estimates of the prevalence of congenital hearing loss identified through UNHS in 37 states and U.S. territories in 2004 were used to calculate BCR. A range of estimates for the lifetime monetary benefits and yearly costs for UNHS was used based on data available in the literature. Both one-step (DPOAE alone) and two-step screening (DPOAE followed by ABR) paradigms were considered in the calculation of BCR. DPOAE level may be reduced in cases in which middle-ear effusion is present; therefore, an additional BCR analysis was performed considering this effect. The monetary benefits of a one-step newborn hearing screening (NHS) program outweighed programmatic costs for a range of proposed benefit and cost estimates. In addition, maximum BCR remained stable regardless of the somewhat "hypothetical" programmatic cost and benefit of early identification (Figure A-2). The inclusion of secondary ABR testing increased the BCR, but did not alter the DPOAE criterion level at which maximum BCR occurred (Figure A-3). The presence of middle-ear effusion reduces overall DPOAE level, subsequently lowering the DPOAE criterion level required for maximum BCR. The use of screening criteria that maximize BCR resulted in lower test sensitivity compared to other criteria. However, BCR may be used to select criteria that result in increased test sensitivity and still provide a high, though not maximal, BCR. Using BCR analysis provides a framework in which the societal implications of NHS protocols may be considered and emphasizes the value of UNHS. In addition, BCR analysis suggested that UNHS is a worthwhile investment for society, as benefits always outweigh costs, at least for the estimations included in this paper. Though some of the benefits of early identification of hearing impairment cannot be estimated through a monetary analysis, such as improved psychosocial development and quality of life, this paper provided an alternative to selecting UNHS protocols which included a consideration of the societal implications of UNHS screening criteria.

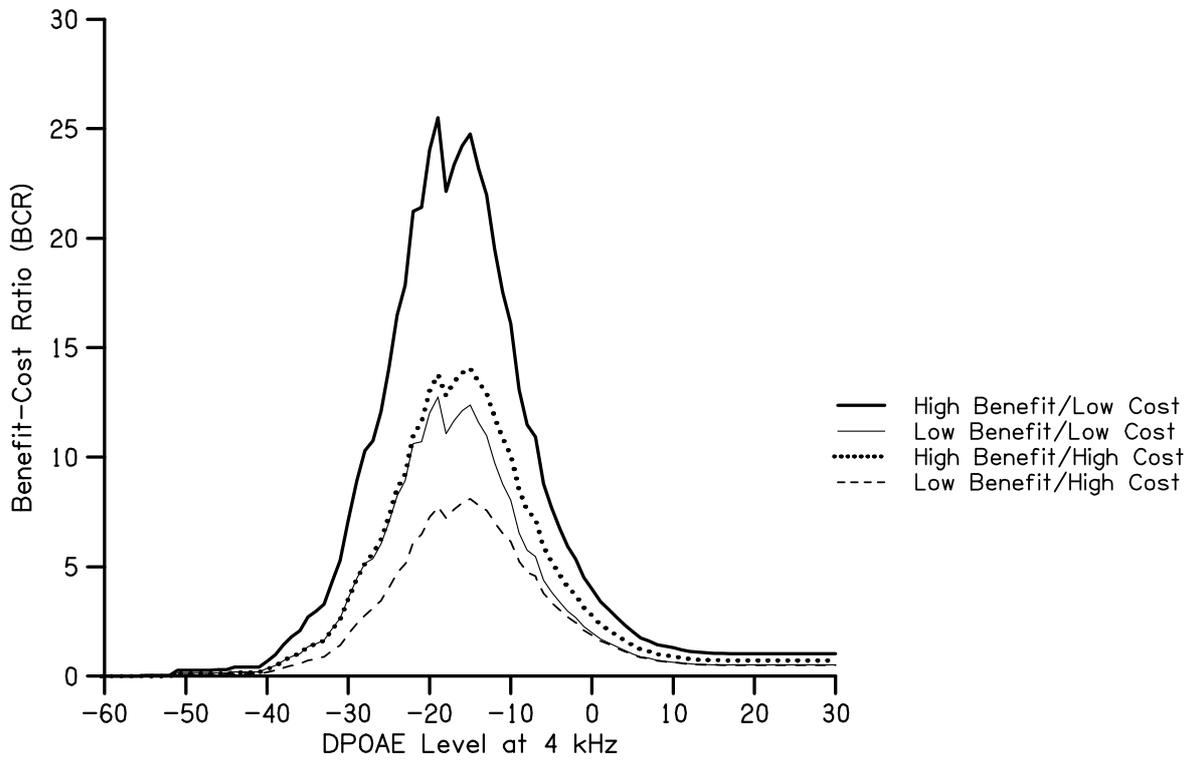


Figure A-2. BCR as a function of DPOAE level at 4 kHz. The parameter in this figure is the estimate used for benefit and for cost. These estimates of lifetime costs and monetary benefits take into account prevalence estimates for 37 states and territories in U.S. in 2004 as reported by the CDC.

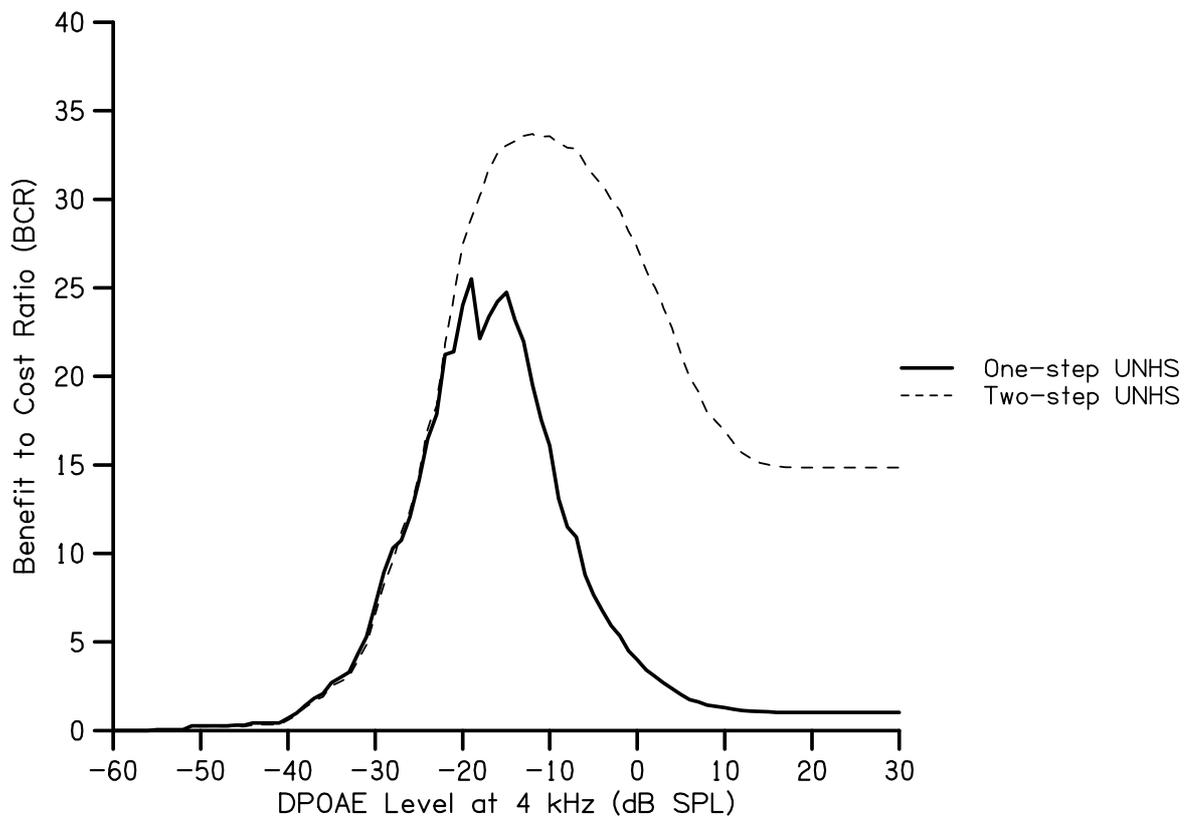


Figure A-3. BCR as a function of DPOAE level at 4 kHz for two different screening protocols. BCR for the one-step protocol is derived from the scenario in which benefit is high and cost is low (as shown in Fig. 1). BCR for a two-step protocol uses ABR as the second step and is based on estimated referral rates.

Ryan, H.A.M., Tharpe, A. M., Ashmead, D. H. & Ward, M. J. (In preparation). Attachment Q-Set criterion sort for toddlers with hearing loss.

Introduction: One of the issues debated when discussing early screening of any disease or condition is the effect a positive diagnosis, or even a false-positive test result, might have on the parent-child bond. It is no different with the implementation of newborn hearing screening and the effects of early diagnosis of hearing loss. The Attachment Q-Set (AQS; Waters & Dean, 1985; Waters, 1995) has become one of the preferred tools to evaluate attachment because of its ecological validity. When developing the AQS, Waters and Dean had experts in attachment rate the “prototypical” child, thus establishing the criterion sort against which all children are measured. Recently, the accuracy of the AQS for special populations has been explored (Clements & Barnett, 2002; Rutgers et al., 2007). For some children, the use of the AQS was found to be appropriate in determining security. However, for children with special needs (i.e., CP), the current version of the AQS is not always appropriate for accurately measuring security.

Purpose: The purpose of the current study was to establish a criterion sort for secure attachment behavior in preschoolers with hearing loss.

Participants: Ten individuals who work with children with hearing loss and their families agreed to serve as expert panel members for this study. These experts represent a range of professionals including deaf educators, speech-language pathologists, psychologists and researchers.

Materials: The Attachment Q-Set, Version 3 (Waters, 1995) was utilized to represent attachment security behavior of preschoolers as determined by our expert panel. The current version of the AQS is comprised of 90 statements that reflect different types of behavior related to attachment.

Procedure: The 90 items of the AQS were sorted by the experts based on their knowledge of secure attachment behavior. The experts completed two sorts, one for the “typical” hearing preschooler and one for the “typical” preschooler with severe-to-profound pre-lingual hearing loss. Briefly, the sorting was completed in two steps. The first step resulted in the items being sorted into 3 piles representing “least characteristic”, “neither characteristic or uncharacteristic” and “most characteristic”. In the second step, these items were further sorted into 9 piles, using a quasi-normal distribution, with the “least characteristic” pile to the far left and the “most characteristic” pile to the far right. These items were assigned a value, ranging from 1 (i.e., least characteristic) to 9 (i.e., most characteristic), based on pile placement. These assigned values were then averaged per item to create the criterion sort. Correlations were completed to compare the current study’s sorts to each other (i.e., hearing and hearing loss sorts – Figure A-4). T-tests were completed at cluster and item level as follow-up.

Conclusions: A new AQS criterion sort has been established that can be used to evaluate secure attachment behavior in preschoolers with hearing loss. Many items that were significantly different between the two sorts represented behaviors that were dependant on language and/or communication skills and auditory skills. A strong correlation between hearing and deaf sorts was present, suggesting that deaf children demonstrate similar attachment behaviors as hearing children, when communication and auditory skills (i.e., “difference items”) are taken into account. Thus, it is important that observers, using the AQS to evaluate attachment in children with hearing loss, are knowledgeable in the effects of childhood hearing loss such that they are able to rate a child based on actual attachment behavior and not on behaviors that are secondary to hearing loss and language delays.

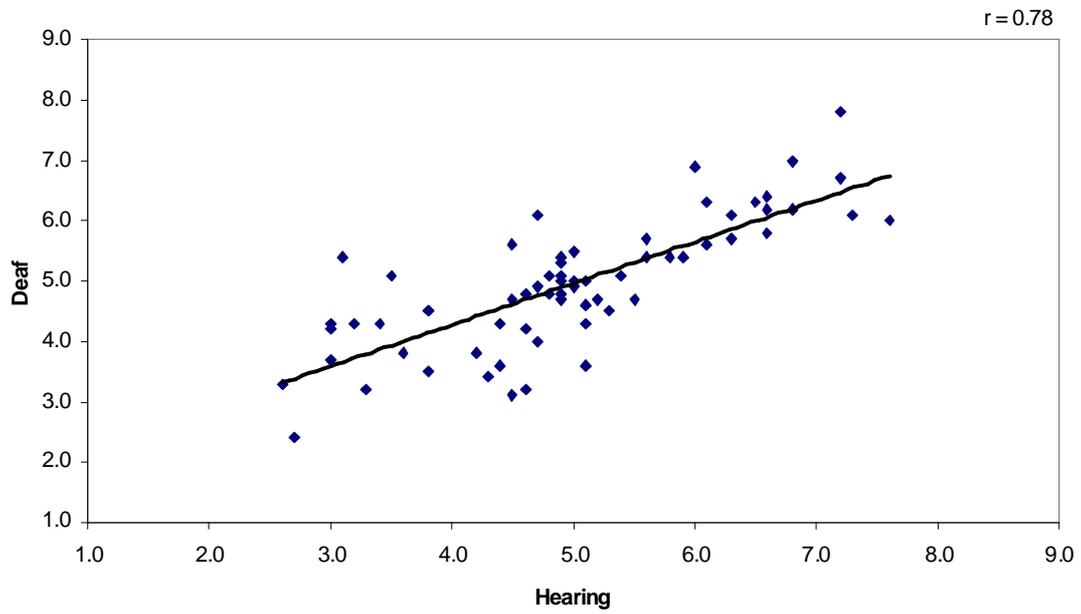


Figure A-4: Correlation between criterion sorts for hearing and deaf sorts. “Difference items” have been removed.

B. Hearing Science - Basic

Amornpongchai, A., Hornsby, B., Ricketts, T. & Ohde, R. (April, 2010). The effect of visual cues on speech recognition at high presentation levels. Poster presented at the annual American Academy of Audiology Convention, San Diego, CA.

Objects: The finding that speech recognition, in listeners with normal and impaired hearing, declines when the speech is presented at higher-than-normal levels is well established. However, to ensure adequate audibility, many individuals who wear hearing aids routinely listen to amplified speech in noise at levels known to degrade performance. The current study examined the effect of visual cues on speech recognition in noise as presentation levels increased from normal to high levels.

Research Design: Twelve participants with normal hearing participated in this experiment. Sentence recognition in noise was measured in two listening conditions (Auditory Only (AO) and Audio Visual (AV)), at three overall noise levels (70, 85, and 100 dB SPL), and at three signal-to-noise ratios (-3, -6, and -11 dB). Noise level was held constant while speech level was adjusted to achieve the indicated SNRs. The combinations of noise level and SNR were chosen to result in AO and AV performance, at the lowest level tested (70 dB SPL), of 40% and 75% correct. Equating performance at the lowest level allowed us to reduce the impact of baseline performance differences in AO and AV modes and to limit ceiling and floor effects.

Results: As expected, AV performance was higher than AO across all SNRs and levels (Figure B-1). For broadband sentence materials presented at the SNRs tested, both AO and AV speech recognition in noise begins to decrease at noise levels above 85 dB SPL (Figure 1) or at speech levels above ~74-82 dB SPL. However, when speech levels and baseline performance levels are matched, performance decrements with level increases appear similar in AO and AV modes (Figure B-2).

Conclusions: The current findings generally failed to support the hypothesis that visual cues reduce the negative effects of high presentation levels. The additional information provided by visual cues did not offset the loss of auditory information due to increases in presentation levels. This suggests that the speech information obtained from auditory cues degraded at high presentation levels may differ from the information provided by the addition of visual cues.

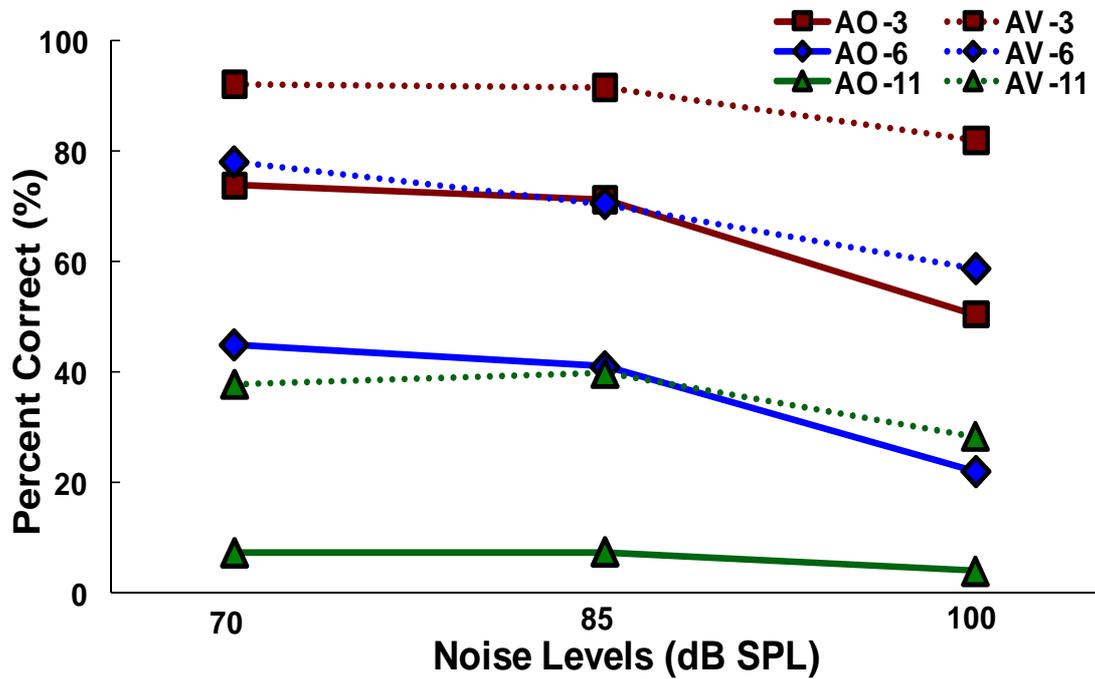


Figure B-1: Average AO and AV speech performance at different SNRs as a function of noise level.

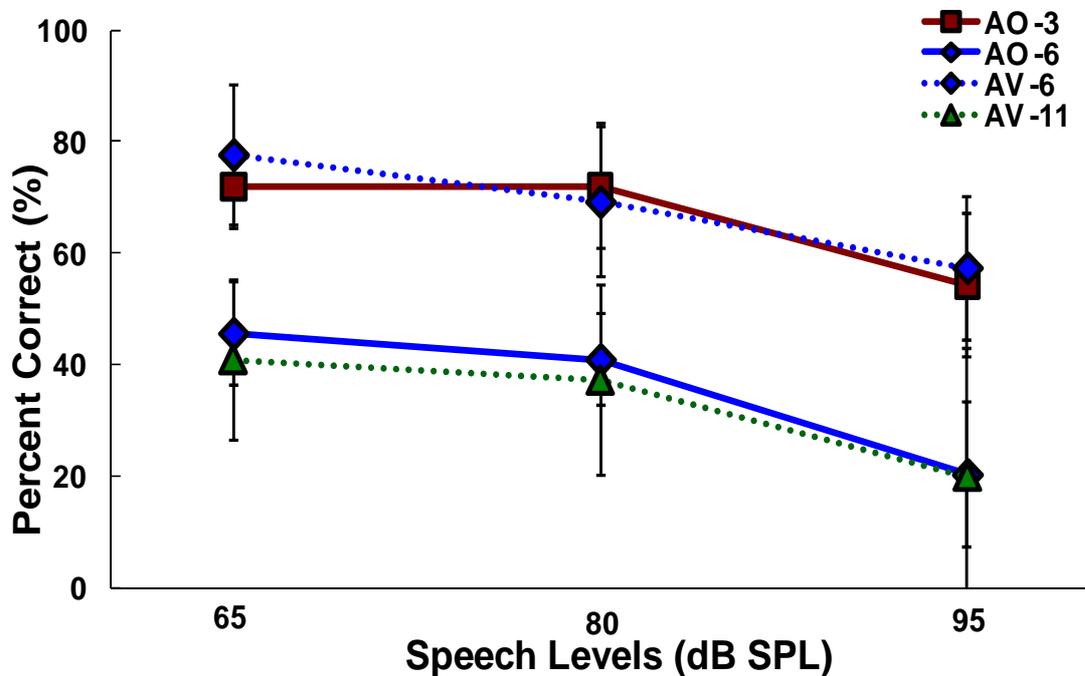


Figure B-2: Average predicted AO and AV speech performance assuming matched speech levels of 65, 80, and 95 dB SPL, using polynomial functions, as a function of speech level. Error bars = 1 standard deviation.

Ashmead, D.H., Grantham, D.W., Maloff, E.S., Hornsby, B.W.Y., Nakamura, T., Davis, T.J., Pampel, F. & Rushing, E.G. (Submitted). Auditory perception of motor vehicle paths. *Human Factors*.

Objective: These experiments address concerns that motor vehicles operating in electric engine mode are so quiet that they pose risk to pedestrians, especially those with visual impairments.

Background: The "quiet car" problem has focused on hybrid and electric vehicles, although it extends to many vehicles with internal combustion engines. Research has focused on the relative detectability of vehicles in electric vs. internal combustion engine mode, mostly in quiet settings. Pedestrians need to do more than detect vehicles, so we focused on an important ability, telling whether a vehicle is going straight or turning.

Results: In a quiet background listeners could make the straight/turn distinction soon enough in the vehicle's path to be useful for deciding whether to start crossing the street. This judgment is based largely on sound level cues, rather than on the spatial direction of the vehicle. With even moderate background traffic sound, the ability to tell straight from turn paths is severely compromised. The signal-to-noise ratio needed for the straight/turn judgment is much higher than that needed to just detect a vehicle.

Conclusion: Although a requirement for a minimum vehicle sound level might enhance detection of vehicles in quiet settings, it is unlikely that this would contribute to pedestrian awareness of vehicle movements in typical traffic settings where multiple vehicles are in the area.

Application: The findings are relevant to deliberations by government agencies and automobile manufacturers about standards for minimum automobile sounds, and more generally for solutions to pedestrians' needs for information about traffic.

Breneman, A., **Gifford, R.H.** & DeJong, M.D. (in press). Cochlear implantation in children with auditory neuropathy spectrum disorder: Long term outcomes. *J Am Acad Audiol*.

Background: Best practices concerning the audiologic management of the child diagnosed with auditory neuropathy spectrum disorder have not been definitively defined nor fully understood. One reason is that previous studies have demonstrated conflicting findings regarding the outcomes of cochlear implantation for children with ANSD. Thus the question remains whether children with ANSD are able to achieve similar outcomes following cochlear implantation as those children with sensorineural hearing loss (SNHL).

Purpose: To assess speech perception outcomes for children with cochlear implants who have a diagnosis of ANSD as well as their age-matched peers who have sensorineural hearing loss.

Research Design: Retrospective study

Study Sample: Thirty-five subject pairs (n = 70) ranging in age at implant activation from 10 to 121 months (mean 39.2 months), were included in this retrospective study. Subjects were matched on variables including age at initial implant activation and months of implant use at postoperative test point.

Data Collection and Analysis: Speech recognition scores for monosyllabic and multisyllabic stimuli were compared across the subject groups. For those not developmentally and/or linguistically ready for completion of open-set speech recognition testing with recorded stimuli, GASP word recognition and/or questionnaire data using either the LittlEARS or Meaningful Auditory Integration Scale were compared across the groups. Statistical analysis using a repeated-measures analysis of variance (ANOVA) evaluated the effects of etiology (ANSD or SNHL) on postoperative outcomes.

Results: The results of this study demonstrate that children with ANSD can clearly benefit from cochlear implantation and that their long-term outcomes are similar to matched peers with SNHL on measures of speech recognition. There were no significant differences across the ANSD and SNHL groups on any of the tested measures.

Conclusion: Cochlear implantation is a viable treatment option for children with a diagnosis of ANSD who are not making auditory progress with hearing aids verified with real-ear measures to be providing DSL v5.0 target audibility. Expected outcomes of cochlear implantation for children with ANSD, excluding children with cochlear nerve deficiency, are no different than for children with non-ANSD SNHL. These results are important for counseling families on the expected outcomes and realistic expectations following cochlear implantation for children with ANSD who demonstrate no evidence of cochlear nerve deficiency.

Camalier, C.R., **Grantham, D.W.** & Bernstein, L.R. (In preparation). Timing in binaural interference: effects of temporal fringe of interferer and interstimulus interval

McFadden and Pasanen [J. Acoust. Soc. Am. 59, 634 (1976)] demonstrated that the presence of a low-frequency band of noise may elevate the threshold interaural temporal difference (ITD) of a high-frequency band of noise, even when the two noises occupy widely disparate frequency regions (e.g., 500 Hz and 4 kHz). The degree of this "binaural interference" has been shown to depend on the temporal relation between the "target sound" and the potential "interferer" (e.g., Bernstein and Trahiotis, 1995). When the target and interferer are pulsed on and off together, considerable interference is observed. When the target is pulsed on and off but the interferer is present continuously, interference is reduced or eliminated. In the present study, the duration by which the interferer preceded or trailed the target in time was manipulated. The so-called forward and backward "fringes" were varied between 0 and 400 ms. The results showed that binaural interference decreased monotonically with fringe duration and did not depend on the type of fringe employed (forward, backward, or both – see Figure B-3). In a second experiment, binaural interference was measured (for coincidentally gated targets and interferers) as a function of the interstimulus interval (ISI = 50-700 ms) between the two observation intervals composing an experimental trial. The results showed that binaural interference decreased as ISI increased, even for ISIs greater than 300 ms.

Normalized Mean Thresholds

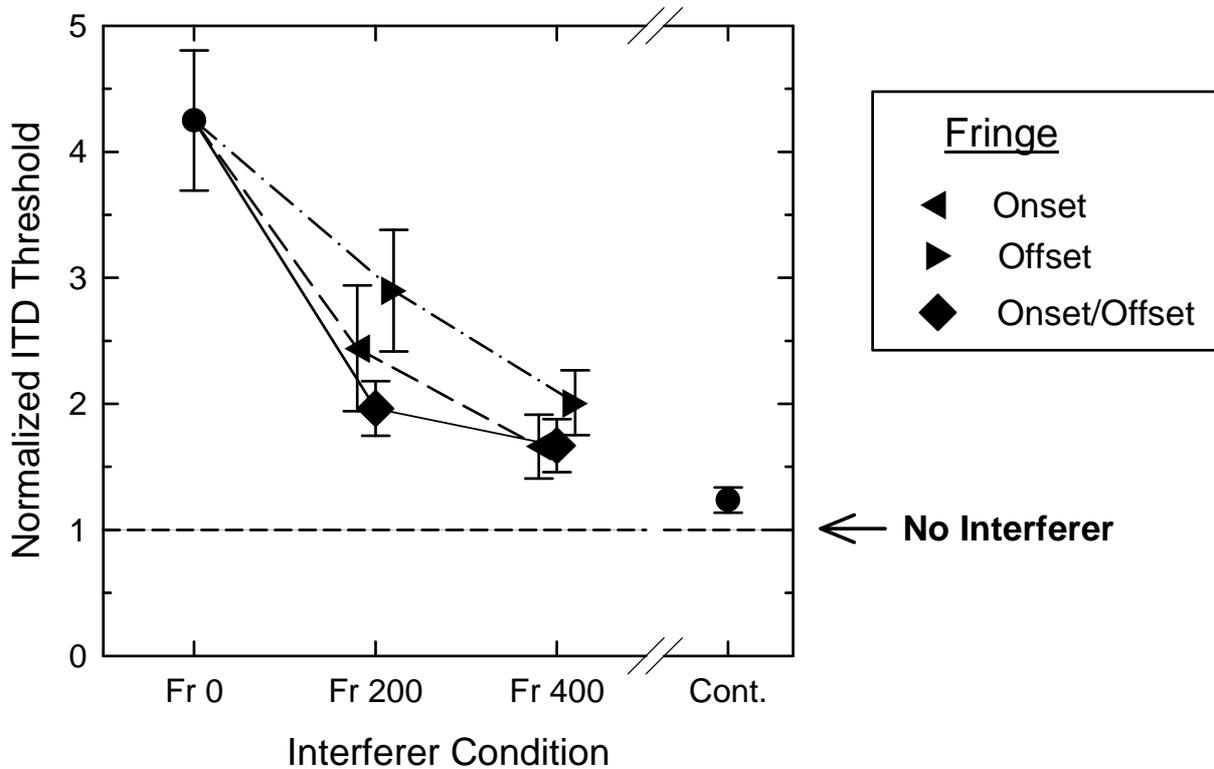


Figure B-3. Mean ITD thresholds across subjects in experiment 1 as a function of interference fringe duration. Thresholds are normalized relative to the no-interferer condition (shown as the horizontal dashed line at 1.0). Parameter is type of fringe, as shown in legend. Rightmost data point ("Cont.") shows the mean normalized threshold in the presence of a continuous interferer. Error bars show +/- 1 standard error.

Carlson, M.C., Archibald, D.J., **Gifford, R.H.** & Driscoll, C.L.W. (2011). Conversion disorder: a missed diagnosis leading to cochlear reimplantation. *Otol Neurotol*, 32: 36-38.

Objective: To report a case of a patient presenting with presumed cochlear implant (CI) device failure that underwent revision surgery and was ultimately diagnosed with conversion disorder.

Study Design: Clinical capsule report.

Setting: Tertiary academic referral center.

Patient: A pediatric patient with Waardenburg syndrome underwent unilateral CI at the age of 6 years for bilateral profound sensorineural hearing loss. During the following 2 years, the patient experienced subjective symptoms of device malfunction including abnormal sounds and intermittent loss of signal despite external component exchange. The patient subsequently underwent revision surgery only to have persistent intermittent complaints. Given the severity of the symptoms, the patient underwent a second reimplantation procedure. Extensive device testing by our institutional implant program and the manufacturer failed to reveal any causal device defects.

Interventions and Results: Given the ongoing but inconsistent subjective complaints and normal device testing, the patient was referred for psychiatric consultation to evaluate for a nonorganic underlying cause. The patient was subsequently diagnosed with conversion disorder and successfully managed with ongoing psychiatric counseling and close follow-up with our CI program.

Conclusion: This represents the first report of a patient presenting with symptoms of device failure, who underwent revision surgery and was ultimately found to have conversion disorder. Although rare, conversion disorder should be considered in the differential diagnosis of patients presenting with symptoms of device malfunction and normal integrity testing particularly among those with significant psychosocial stressors or a history of psychiatric illness. Thorough device testing and in-depth psychological evaluation is required for diagnosis, and close multidisciplinary follow-up with the CI team and psychiatrist is crucial.

Carlson, M.L., Driscoll, C.L., **Gifford, R.H.**, Service, G.J., Tombers, N.M., Hughes-Borst, B.J., Neff, B.A. & Beatty, C.W. (2011 Jun 8). Implications of minimizing trauma during conventional cochlear implantation. *Otol Neurotol.* [Epub ahead of print]

Objective: To describe the relationship between implantation-associated trauma and postoperative speech perception scores among adult and pediatric patients undergoing cochlear implantation using conventional length electrodes and minimally traumatic surgical techniques.

Study design: Retrospective chart review (2002-2010).

Setting: Tertiary academic referral center.

Patients: All subjects with significant preoperative low-frequency hearing (≤ 70 dB HL at 250 Hz) who underwent cochlear implantation with a newer generation implant electrode (Nucleus Contour Advance, Advanced Bionics HR90K [1J and Helix], and Med El Sonata standard H array) were reviewed.

Intervention(s): Preimplant and postimplant audiometric thresholds and speech recognition scores were recorded using the electronic medical record.

Main outcome measure(s): Postimplantation pure tone threshold shifts were used as a surrogate measure for extent of intracochlear injury and correlated with postoperative speech perception scores.

Results: Between 2002 and 2010, 703 cochlear implant (CI) operations were performed. Data from 126 implants were included in the analysis. The mean preoperative low-frequency pure-tone average was 55.4 dB HL. Hearing preservation was observed in 55% of patients. Patients with hearing preservation were found to have significantly higher postoperative speech perception performance in the cochlear implantation-only condition than those who lost all residual hearing.

Conclusion: Conservation of acoustic hearing after conventional length cochlear implantation is unpredictable but remains a realistic goal. The combination of improved technology and refined surgical technique may allow for conservation of some residual hearing in more than 50% of patients. Germane to the conventional length CI recipient with substantial hearing loss, minimizing trauma allows for improved speech perception in the electric condition. These findings support the use of minimally traumatic techniques in all CI recipients, even those destined for electric-only stimulation.

Croghan, N.B.H. & Grantham, D. W. (2010) Binaural interference in the free field. *Journal of the Acoustical Society of America* 127, 3085-3091.

In an anechoic chamber the minimum audible angle (MAA) was measured in seven normal-hearing adults for a narrow band of noise centered at 4000 Hz (the target). In the absence of an interfering stimulus, the average MAA was 2.1°. When a low-frequency interferer (a narrow band of noise centered at 500 Hz) was pulsed on and off with the target from directly in front of the subject, the average MAA was significantly elevated (13.4°). However, if the interferer was continuously present, or if it consisted of two independent noises presented from $\pm 90^\circ$, interference was much reduced. The interference effect was asymmetric: a high-frequency interferer did not result in elevation of MAA threshold for a low-frequency target. See Figure B-4. These results are similar to those that have been extensively reported for stimuli under headphones [e.g., Bernstein and Trahiotis, *J. Acoust. Soc. Am.* 98, 155-163 (1995)]. These data are consistent with the notion that interference from a spectrally remote low-frequency interferer occurs in the free field to the extent that the target and interferer are fused into a single perceptual object. If cues are provided that promote perceptual segregation (such as temporal onset differences or spatial location differences), the interference is reduced or eliminated. [Work supported by a T-35 training grant from NIDCD, which funded the first author's stay at Vanderbilt, summer, 2008.]

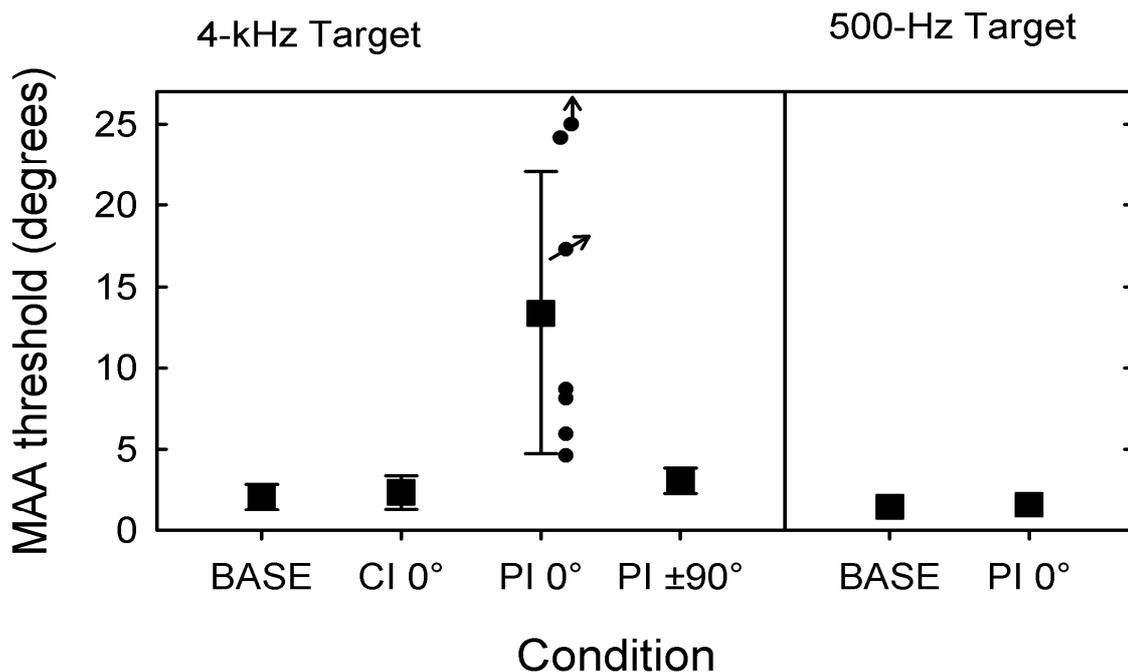


FIG. B-4. MAA thresholds for all six conditions. Means across subjects are shown as the large filled squares, and error bars indicate one standard deviation (not shown when smaller than the data symbol). Left panel: target was a band of noise centered at 4000 Hz and the interferer a band centered at 500 Hz. Right panel: target was a band of noise centered at 500 Hz and the interferer a band centered at 4000 Hz. Data for the seven individual subjects are shown as the small filled circles in the PI 0° condition, 4-kHz Target. See text for details. Conditions indicated along abscissa: BASE: baseline condition, no interferer; CI 0°: continuous interferer presented from 0° azimuth; PI 0°: pulsed interferer presented from 0° azimuth; PI ±90°: pulsed interferer presented from ±90° azimuth.

Curhan, S.G., **Eavey, R.**, Shargorodsky, J & Curhan, G.C. (2010). Analgesic use and the risk of hearing loss in men. *The American Journal of Medicine* 123(3): 231-237.

Background: Hearing loss is a common sensory disorder, yet prospective data on potentially modifiable risk factors are limited. Regularly used analgesics, the most commonly used drugs in the US, may be ototoxic and contribute to hearing loss.

Methods: We examined the independent association between self-reported professionally diagnosed hearing loss and regular use of aspirin, nonsteroidal anti-inflammatory drugs (NSAIDs), and acetaminophen in 26,917 men aged 40-74 years at baseline in 1986. Study participants completed detailed questionnaires at baseline and every 2 years thereafter. Incident cases of new-onset hearing loss were defined as those diagnosed after 1986. Cox proportional hazards multivariate regression was used to adjust for potential confounding factors.

Results: During 369,079 person-years of follow-up, 3488 incident cases of hearing loss were reported. Regular use of each analgesic was independently associated with an increased risk of hearing loss. Multivariate-adjusted hazard ratios of hearing loss in regular users (2+ times/week) compared with men who used the specified analgesic <2 times/week were 1.12 (95% confidence interval [CI], 1.04-1.20) for aspirin, 1.21 (95% CI, 1.11-1.33) for NSAIDs, and 1.22 (95% CI, 1.07-1.39) for acetaminophen. For NSAIDs and acetaminophen, the risk increased with longer duration of regular use. The magnitude of the association was substantially higher in younger men. For men younger than age 50 years, the hazard ratio for hearing loss was 1.33 for regular aspirin use, 1.61 for NSAIDs, and 1.99 for acetaminophen.

Conclusions: Regular use of aspirin, NSAIDs, or acetaminophen increases the risk of hearing loss in men, and the impact is larger on younger individuals.

Curhan, S.G., **Eavey, R.**, Shargorodsky, J & Curhan, G.C. (2011). Prospective study of alcohol use and hearing loss in men. *Ear and Hearing* 32(1): 46-52.

Objective: Hearing loss is a common and disabling sensory disorder, yet prospective data on potentially modifiable risk factors are limited. Previous studies suggest that alcohol consumption may influence the development of hearing loss, yet results have been inconsistent. The purpose of this study was to prospectively examine the relation between alcohol use and hearing loss in men.

Design: We examined prospectively the independent association between alcohol intake and self-reported professionally diagnosed hearing loss in 26,809 men aged 40 to 74 yrs at baseline in 1986. Study participants completed detailed questionnaires at baseline and every 2 yrs thereafter. Incident cases of hearing loss were defined as those professionally diagnosed after 1986. Cox proportional hazards multivariate regression was used to adjust for potential confounding factors.

Results: During 386,081 person-years of follow-up, 3447 incident cases of hearing loss were reported. Overall, there was no association between level of alcohol intake and risk of hearing loss. Compared with those who did not consume alcohol, the multivariate-adjusted hazard ratios (95% confidence interval) were 1.00 (0.89 to 1.12) for those who consumed 5.0 to 9.9 g/day, 1.08 (0.96 to 1.21) for 10.0 to 14.9 g/day, and 0.98 (0.85 to 1.13) for 30.0 to 49.9 g/day. The results did not differ by age group or folate intake. Among those with lower intake of vitamin B12, however, higher consumption of alcohol, specifically liquor, was associated with an increased risk of hearing loss.

Conclusions: Our data suggest that low or moderate alcohol consumption does not influence the risk of hearing loss in older men. A possible relation between vitamin B12 intake, alcohol consumption, and hearing loss merits further investigation.

Davis, T. J. & Grantham, D. W. (March, 2011). The effect of a target's motion on its recognition. Poster presented at the annual meeting of the American Auditory Society, Scottsdale, AZ.

It is well established that recognizing speech in a multi-talker environment can be difficult for both normal-hearing and hearing-impaired individuals. Kidd et al. (2005) investigated the effect of knowing the direction of the target talker on recognizing speech in the presence of distracter talkers coming from other directions. They found that there was a significant benefit when listeners knew where to listen. The aim of this study was to examine whether the motion of a talker can improve recognition of speech when the listener is unaware of the direction of the talker. Using the CRM corpus (Bolia et al. (2000), we conducted a 3 simultaneous talker experiment. Presenting from two locations (0 degrees and -60 degrees to the left of center), seven conditions were investigated: 3 non-moving controls, 2 moving target talker, and 2 moving distracter talkers. Results indicated that motion impaired performance in three of the four moving conditions, compared to their non-moving controls. In the fourth moving condition, change in performance varied among subjects suggesting there may be multiple listening strategies for this task. These results suggest that in general, when talker direction is unknown in advance, motion of either the target or the distracter impairs recognition compared to stationary presentation. [Supported by the NIH National Institute on Deafness and Other Communication Disorders (NIDCD) Short Term Research Traineeship (T35) awarded to the first author.]

Dorman, M.F., Yost, W.A., Wilson, B.S. & **Gifford, R.H.** (2011). Speech perception and sound localization by adults with bilateral cochlear implants. *Semin. Hear.* 32: 073-089.

Adult patients with bilateral cochlear implants report a significant gain in health-related quality of life relative to having a single cochlear implant. Gains are found in multiple domains-in this article, we focus on hearing and speech understanding. There are several factors that likely contribute to the hearing-related gain in quality of life. The provision of bilateral implants improves the probability that (1) if there are large between-ear differences in speech recognition, then the ear with the best recognition ability will be stimulated; (2) patients will benefit from the head shadow effect, which provides large gains in speech intelligibility; (3) patients will receive the relatively smaller benefits due to summation and squelch; and (4) patients will be able to better localize sound sources in the horizontal plane by using interaural-level difference cues. It is reasonable to suppose that these improvements in performance combine to reduce the stress that is associated with listening via electrical stimulation and thereby improve hearing-related quality of life.

Gifford, R.H., Olund, A.P. & DeJong, M.D. (in press). Improving speech perception in noise for children with cochlear implants. *J Am Acad Audiol.*

Background: Current cochlear implant recipients are achieving increasingly higher levels of speech recognition; however, the presence of background noise continues to significantly degrade speech understanding for even the best performers. Newer generation Nucleus cochlear implant sound processors can be programmed with SmartSound strategies that have been shown to improve speech understanding in noise for adult cochlear implant recipients. The

applicability of these strategies for use in children, however, is not fully understood nor widely accepted.

Purpose: To assess speech perception for pediatric cochlear implant recipients in the presence of a realistic restaurant simulation generated by an eight-loudspeaker (R-SPACE™) array in order to determine whether Nucleus sound processor SmartSound strategies yield improved sentence recognition in noise for children who learn language through the implant.

Research Design: Single subject, repeated measures design

Study Sample: Twenty-two experimental subjects with cochlear implants (mean age 11.1 years) and twenty-five control subjects with normal hearing (mean age 9.6 years) participated in this prospective study.

Intervention: Speech reception thresholds (SRT) in semi-diffuse restaurant noise originating from an eight-loudspeaker array were assessed with the experimental subjects' everyday program incorporating Adaptive Dynamic Range Optimization (ADRO) as well as with the addition of Autosensitivity control (ASC).

Data Collection and Analysis: Adaptive SRT's with the Hearing In Noise Test sentences were obtained for all twenty-two experimental subjects and performance—in percent correct—was assessed in a fixed +6 dB SNR for a 6-subject subset. Statistical analysis using a repeated-measures analysis of variance (ANOVA) evaluated the effects of the SmartSound setting on the SRT in noise.

Results: The primary findings mirrored those reported previously 1 with adult cochlear implant recipients in that the addition of ASC to ADRO significantly improved speech recognition in noise for pediatric cochlear implant recipients. The mean degree of improvement in the SRT with the addition of ASC to ADRO was 3.5 dB for a mean SRT of 10.9 dB SNR. Thus despite the fact that these children have acquired auditory/oral speech and language through the use of their cochlear implant(s) equipped with ADRO, the addition of ASC significantly improved their ability to recognize speech in high levels of diffuse background noise. The mean SRT for the control subjects with normal hearing was 0.0 dB SNR. Given that the mean SRT for the experimental group was 10.9 dB SNR, despite the improvements in performance observed with the addition of ASC, cochlear implants still do not completely overcome the speech perception deficit encountered in noisy environments accompanying the diagnosis of severe-to-profound hearing loss.

Conclusion: SmartSound strategies currently available in latest generation Nucleus cochlear implant sound processors are able to significantly improve speech understanding in a realistic, semi-diffuse noise for pediatric cochlear implant recipients. Despite the reluctance of pediatric audiologists to utilize SmartSound settings for regular use, the results of the current study support the addition of ASC to ADRO for everyday listening environments to improve speech perception in a child's typical everyday program.

Gopinath, B., Flood, V. M., McMahon, C. M., Burlutsky, G., **Spankovich, C., Hood, L. J. & Mitchell P.** 2010. (Submitted.) Dietary Antioxidant Intake is Associated with the Prevalence but not Incidence of Age-Related Hearing Loss.

Objectives: Diet is one of the few modifiable risk factors for age-related hearing loss. We aimed to examine the link between dietary and supplement intakes of antioxidants, and both the prevalence and 5-year incidence of measured hearing loss.

Design: Cross-sectional and 5-year longitudinal analyses. Setting: Blue Mountains, Sydney, Australia.

Participants: 2,956 Blue Mountains Hearing Study participants aged 50+ at baseline, examined during 1997-9 to 2002-4.

Measurements: Age-related hearing loss was measured and defined as the pure-tone average of frequencies 0.5, 1.0, 2.0 and 4.0 kHz >25 dB HL. Dietary data were collected in a semi-quantitative food frequency questionnaire, and intakes of α -carotene; β -carotene; β -cryptoxanthin; lutein and zeaxanthin; lycopene; vitamins A, C and E; iron and zinc were calculated.

Results: After adjusting for age, sex, smoking, education, occupational noise exposure, family history of hearing loss, history of diagnosed diabetes and stroke, each SD increase in dietary vitamin E intake was associated with a 14% reduced likelihood of prevalent hearing loss, OR 0.88 (CI 0.78-0.98). Those in the highest quintile of dietary vitamin A intake had a 47% reduced risk of having moderate or greater hearing loss (>40 dB HL) compared to those in the lowest quintile of intake, multivariable-adjusted OR 0.53 (CI 0.30-0.92), P for trend = 0.04. However, dietary antioxidant intake was not associated with the 5-year incidence of hearing loss.

Conclusions: Dietary vitamin A and vitamin E intake were significantly associated with the prevalence of hearing loss. However, dietary antioxidant intake did not increase the risk of incident hearing loss.

Grantham, D.W., Ashmead, D.H, Haynes, D.S., Hornsby, B.W.Y., Labadie, R.F. & Ricketts, T.A. (Submitted). Horizontal-plane localization in single-sided deaf adults fitted with a bone-anchored hearing aid (Baha). *Ear and Hearing*.

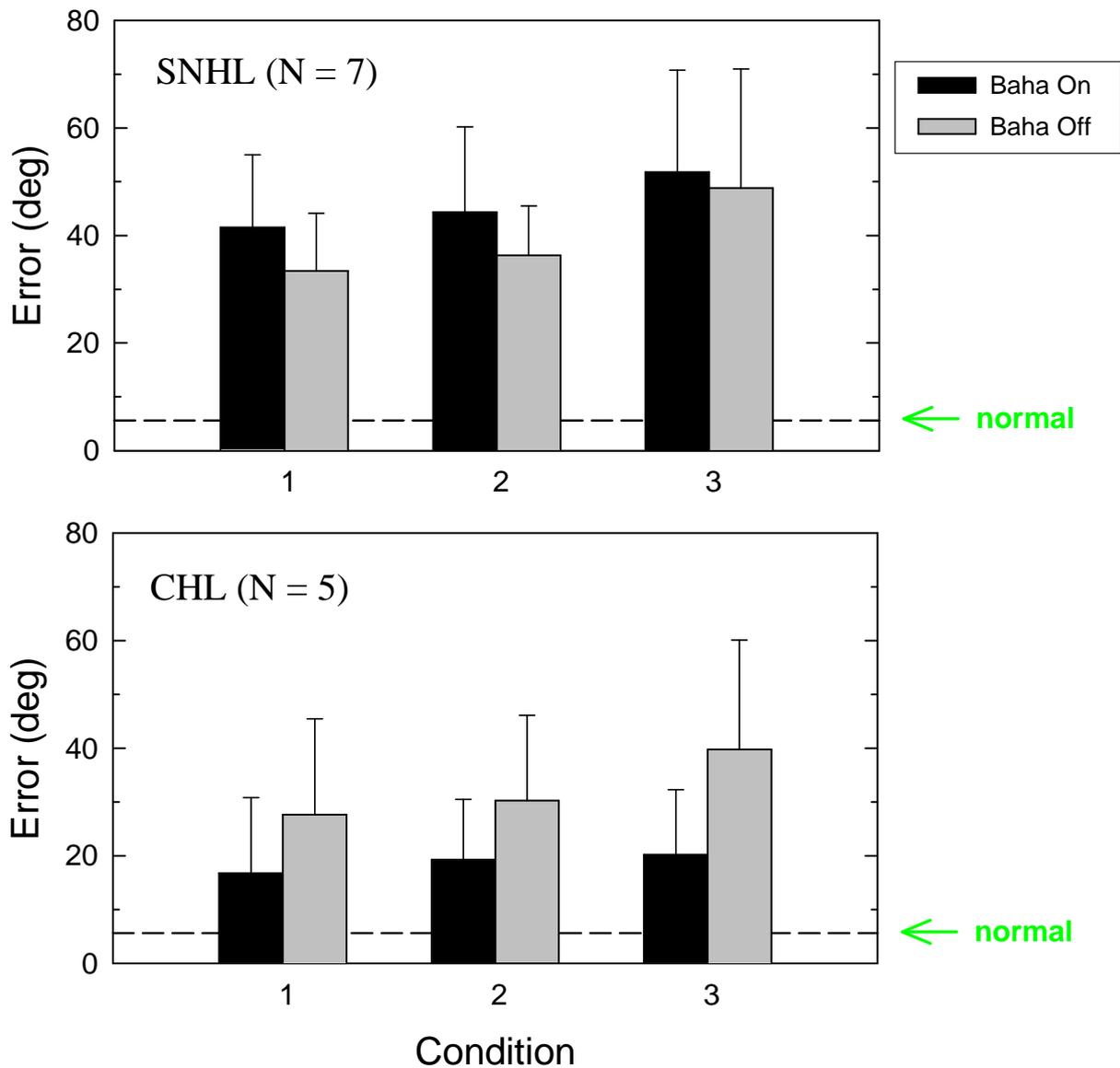
Objectives: The primary purpose of this investigation was to evaluate the effect of a unilateral bone-anchored hearing aid (Baha) on horizontal-plane localization performance in single-sided deaf adults who had either a conductive or sensori-neural hearing loss in their impaired ear. The use of a 33-loudspeaker array allowed for a finer response measure than has previously been used to investigate localization in this population. In addition, a detailed analysis of error patterns allowed an evaluation of the contribution of random error and bias error to the total rms error computed in the various conditions studied. A secondary purpose of the study was to investigate the effect of stimulus duration and head-turning on localization performance, both for Baha worn and Baha not-worn conditions.

Design. Two groups of single-sided deaf adults were tested in a localization task in which they had to identify the direction of a spoken phrase on each trial. One group had a sensori-neural (the SNHL group; N = 7), and the other group had a conductive loss (the CHL group; N = 5). In addition, a control group of 4 normal-hearing adults was tested. The spoken phrase was either 1250 ms in duration (a male saying "Where am I coming from now?") or 341 ms in duration (the same male saying "Where?"). For the longer duration phrase, subjects were tested in conditions in which they either were or were not allowed to move their heads prior to the termination of the phrase. The source came from one of 9 positions in the front horizontal plane (from -79° to +79°). However, there were 24 "dummy" loudspeakers such that the response range included 33 choices (from -90° to +90°, separated by 5.6°). Subjects were tested in all conditions, both with and without the Baha device worn. Order of testing was counterbalanced across subjects. Overall rms error was computed for each condition. Contributions of random error and bias error to the overall error were also computed.

Results. In agreement with previously reported results, the CHL group had significantly smaller overall error in all conditions when they wore the Baha than when they did not wear it. Further analysis of error patterns indicated that this improvement was based primarily on reduced response bias when the device was worn; that is, the average response azimuth was nearer to the source azimuth when the device was worn than when it was not worn. The SNHL group, on the other hand, had significantly greater overall error when wearing the Baha than when not wearing it, a result that has not previously been reported. See Figure B-5. Collapsed across

conditions and groups, localization performance was significantly better with the 1250-ms stimulus than with the 341-ms stimulus. However, for the longer-duration stimulus, there was no significant beneficial effect of head-turning. Error scores in all conditions for both groups were considerably larger than those in the normal-hearing control group.

Conclusions. Single-sided deaf adults with CHL showed improved localization ability when using the Baha, while single-sided deaf adults with SNHL showed no such benefit, and, in fact, showed a decrement in performance when wearing the device. We hypothesize that the improved performance with the Baha device in the CHL subjects is due to their having two functioning cochleae: For this group, the Baha is able to restore some binaural cues, albeit certainly impoverished relative to those available to normal-hearing individuals. According to this hypothesis, adults with SNHL, having only a single functioning cochlea, cannot benefit from binaural cues, even when wearing the Baha. The finding that the Baha can actually result in higher error rates in this group is hypothesized to be due to the possibility that it disrupts monaural spectral cues that these subjects may have learned to use to localize sounds at a better than chance level prior receiving their implant.



1. Dur = 1250 ms (Head Moving)
2. Dur = 1250 ms (Head Still)
3. Dur = 341 ms

Figure B-5. Mean performance in the indicated conditions for the SNHL group (upper panel) and the CHL group (lower panel). Error bars indicate ± 1 standard deviation around the mean. Lower dashed lines indicate performance from a normal-hearing listener in Condition 2.

Graugnard, E.M., **Grantham, D.W.**, Nakamura, T., **Maloff, E.S. & Ashmead, D.H.** (March, 2011). Auditory perception of spatial acceleration and deceleration. Poster presented at the annual meeting of the American Auditory Society, Scottsdale, AZ.

Three experiments were performed on auditory perception of spatial acceleration/deceleration of moving sound sources. This ability is used, for example, to perceive approaching motor vehicles or to gauge one's self-motion relative to stationary sound sources. Each experiment tested six adults with normal hearing. Three motion paths were used: circular (direction change only), direct approach (distance change), and tangential (direction and distance change). In Experiment 1, listeners judged whether a single motion path (lasting about 2.5 s, average velocity 2.5 or 5 meters/s) had acceleration or deceleration. The acceleration parameter varied adaptively across trials. Thresholds (absolute value of difference between initial and final velocity, divided by average velocity) averaged 1.53 overall, worse than reported for visual motion perception (0.4 to 0.8). Thresholds were better at the higher average velocity, and differed by path type (tangent best, circle worst). In Experiment 2, separate thresholds were obtained for acceleration and deceleration versus constant velocity paths. Thresholds were similar for acceleration and deceleration. Experiment 3 compared acceleration thresholds for paths with full, continuous motion versus paths with just early/middle or early/middle/late portions, showing best performance with the full path. These experiments provide an account of an important component of auditory motion perception. [Supported by the NIH National Institute on Deafness and Other Communication Disorders (NIDCD) Short Term Research Traineeship (T35) awarded to the first author.]

Hillock, A. (2010). Developmental changes in the temporal window of auditory and visual integration. Doctoral dissertation completed under the direction of **M. Wallace**, Vanderbilt University School of Medicine.

The brain is continuously processing many sources of sensory information. One of the key strategies it uses to determine what stimuli are associated with one another is the temporal delay between multisensory inputs. When stimulus onset asynchronies (SOAs) are sufficiently short, multisensory signals are highly likely to be bound. Extensive research in adults has characterized the temporal structure of audiovisual integration and the alterations in behavior and perception induced by such interactions. However, no prior work has investigated developmental changes in multisensory temporal processing in the period between infancy and adulthood. Here, we present a series of studies detailing maturational changes in the temporal window of audiovisual integration for basic stimuli and speech. Results of our early work revealed age-related differences in 10 and 11 year olds and adults on a nonspeech audiovisual simultaneity judgment task, which suggested that processing alterations persist beyond the first decade of life for basic stimuli. These findings provided the foundation for follow-up studies which sought to characterize the trajectory of multisensory temporal processing maturation from early childhood to early adulthood. To that end, the simultaneity judgment measure previously employed was administered to a group of participants ranging in age from 6 to 23 years. Comparison of responses across subjects indicated that multisensory temporal binding windows were larger in children and adolescents than adults, suggesting that the younger groups were more likely to bind asynchronous audiovisual pairings. To assay whether this developmental effect was generalizable to speech, subjects completed an audiovisual identification task wherein incongruent auditory and visual speech tokens were presented at a range of SOAs. Surprisingly, findings indicated that the temporal binding window for audiovisual speech matures earlier; window sizes were comparable in children, adolescents and adults. Overall, results

suggest that the trajectory to realization of adult-like multisensory temporal processing differs for nonspeech and speech stimuli. The role of experience in mediating faster window contraction for speech is speculated upon and the implications of delayed maturation of multisensory processing on overall development are reviewed.

Hornsby, B. & Dundas, A. (2009). Factors Affecting Prevalence Estimates of Dead Regions in Adults with Hearing. *Journal of the American Academy of Audiology* 20(4): 251-263.

Background: Recent work using the Threshold Equalizing Noise (TEN) test (Moore et al, 2000) as a gold standard, suggest that the presence of cochlear dead regions in persons with moderate-to-severe hearing loss may be quite common. In addition, results suggest that certain characteristics of hearing loss, such as severe-profound high-frequency loss or steeply-sloping configurations may be more commonly associated with positive TEN findings. However, only one study to date (Vinay and Moore, 2007b), has systematically evaluated the relationship between audiometric characteristics and TEN test findings on a large number of individuals with a wide range of hearing losses and hearing loss configurations and results of this study were limited to the frequency range of 500-4000 Hz.

Purpose: The purpose of this study was to further examine the effects of audiometric characteristics such as degree and slope of hearing loss on the rate of positive, negative and inconclusive findings on the TEN test over a wider frequency range (250-8000 Hz) than previously examined. Given that the functional impact of positive findings (i.e. findings suggestive of a dead region) may vary with the extent of potential damage, we were also interested in determining the relative occurrence of "patchy" versus contiguous positive findings on the TEN.

Research Design: Fifty-nine adults (117 ears) with a wide range of SNHL participated. To examine results over a wide frequency range (250-8000 Hz) the TEN (SPL), rather than the TEN (HL), was utilized. Thresholds, in both ears, were measured in quiet and in the TEN (SPL). Results were categorized as positive (suggestive of a dead region), negative (not suggestive of a dead region) or inconclusive.

Results: Positive test results among individuals with milder hearing losses (<60 dB HL) were common, suggesting a potential for false positive results. Consistent with past research, positive TEN (SPL) results were more common when hearing losses exceeded 60 dB HL, however, there was not a systematic increase in positive results with increases in threshold (see Figure B-6). Also consistent with past research slope of hearing loss was an inadequate predictor of TEN (SPL) results. Negative results (not suggestive of a dead region) were less common in participants with steeply sloping losses while positive test findings were unaffected by hearing loss slope (see Figure B-7). Although a large proportion of participants had positive results on the TEN (SPL), for most participants, these positive findings occurred in isolated (i.e., one or two frequencies) rather contiguous frequency regions.

Conclusions: The large number of inconclusive results and the potential for false positive results makes interpreting the functional impact of TEN (SPL) results difficult, particularly when positive results are in the high (>4000 Hz) frequencies. In addition, although a large proportion (84%) of study participants had positive findings on the TEN (SPL), the functional impact of these findings is not clear as in the majority of cases, positive findings occurred at only one or two frequencies.

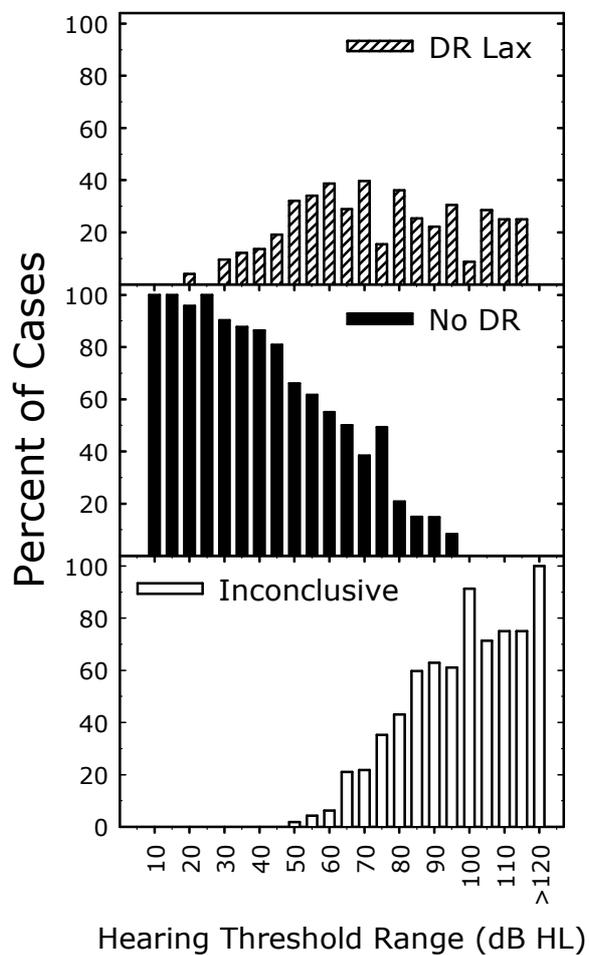


Figure B-6. Percent of cases of negative (No DR), positive and inconclusive TEN (SPL) test results as a function of range of hearing thresholds.

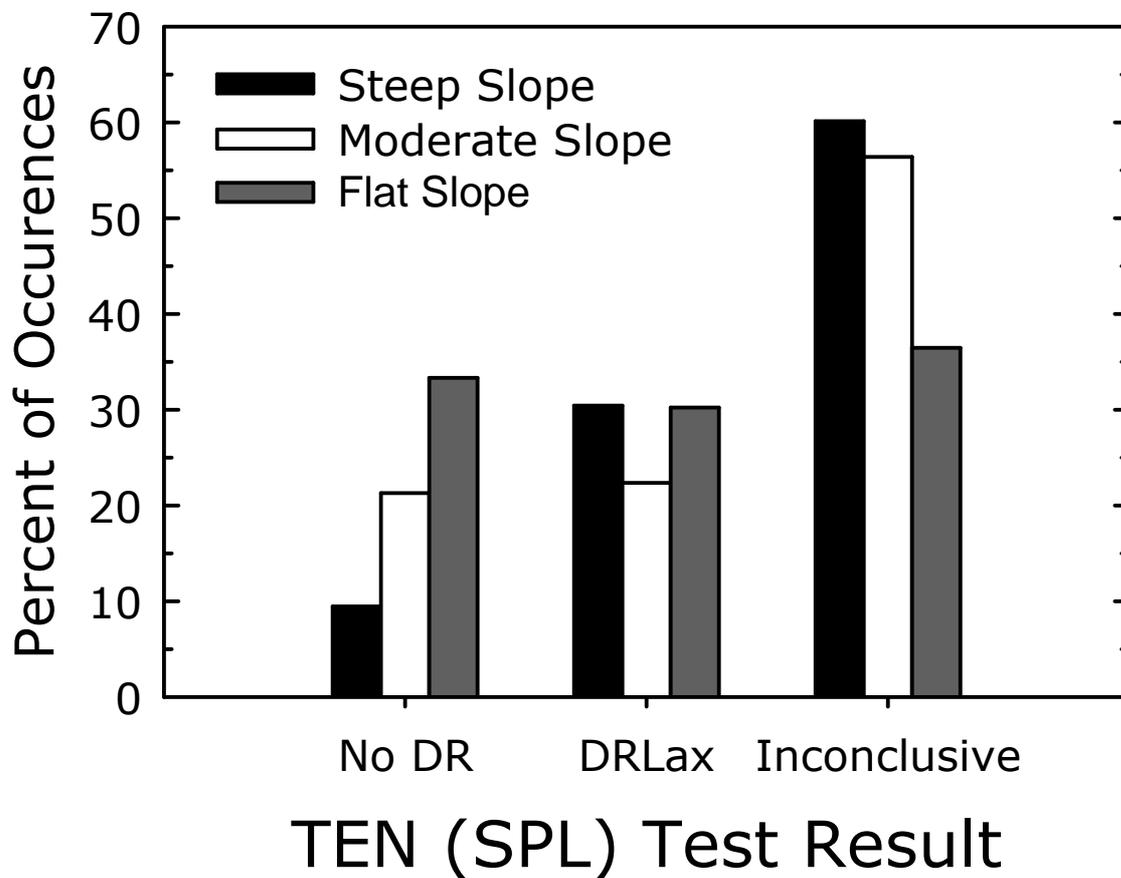


Figure B-7. Effect of hearing loss slope (Steep, moderate or flat) on negative, positive and inconclusive TEN (SPL) results in the high-frequency (3000-8000 Hz) regions.

Hornsby, B., Johnson, E. & Picou, E. (2010, in review). Effects of degree and configuration of hearing loss on the contribution of high- and low- frequency speech information to bilateral speech understanding. *Ear and Hearing*.

Objectives: The purpose of this study was to examine the effects of various factors on the use of and benefit from amplified high- and low-frequency speech in background noise. Of specific interest was the impact of degree and configuration of hearing loss on use of and benefit from amplified high-frequency speech information.

Design: Sixty-two adults with a wide range of high- and low-frequency sensorineural hearing loss (5-115+ dB HL) participated. To examine the contribution of speech information in different frequency regions, speech understanding in noise was assessed in multiple low- and high-pass filter conditions, as well as a band-pass (713-3534 Hz) condition and a wideband (143-8976 Hz) condition. To increase audibility over a wide frequency range, speech and noise were amplified based on each individual's hearing loss. A stepwise multiple linear regression approach was used to examine the contribution of several factors to 1) absolute performance in each filter

condition and 2) change in performance with the addition of both high- and low-frequency information.

Results: Degree of hearing loss in the low- or high- frequency regions was the strongest predictor of absolute performance on low- and high-pass filtered speech materials, respectively (see Figure B-8). In addition, configuration of hearing loss affected both absolute performance for severely low-pass filtered speech and benefit from access to additional high-frequency (3534-8976 Hz) speech information (see Figure B-9).

Conclusions: Consistent with previous work, study findings show that benefit from speech information in a given frequency region generally decreases as degree of hearing loss in that frequency region increases. However, configuration of hearing loss also affects the ability to utilize speech information in different frequency regions. The utility of low-frequency speech information may be greater for persons with steeply-sloping high-frequency hearing loss, than for individuals with similar low-frequency thresholds but less high-frequency loss. In contrast, the presence of a flat hearing loss may be associated with greater benefit from the addition of high-frequency speech cues (i.e., extending high-frequency bandwidth) than for individuals with a more sloping loss. Finally, except in cases with steeply sloping high-frequency losses, providing high-frequency amplification (3534-8976 Hz) had either a beneficial effect on, or did not significantly degrade, speech understanding. These findings highlight the importance of, and need for, extended high-frequency amplification for listeners with a wide range of high-frequency hearing losses, when seeking to maximize intelligibility.

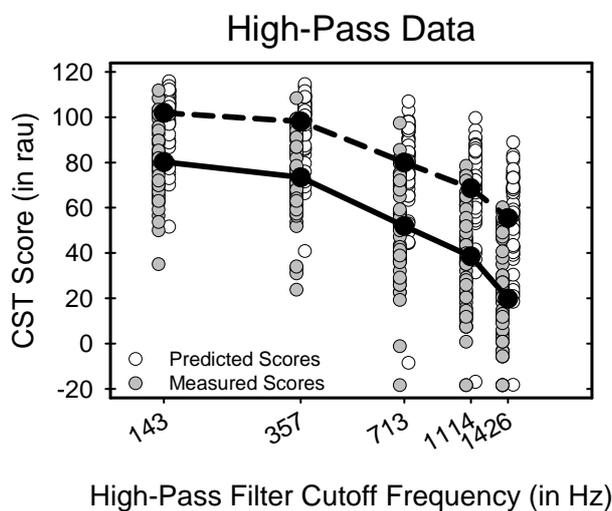
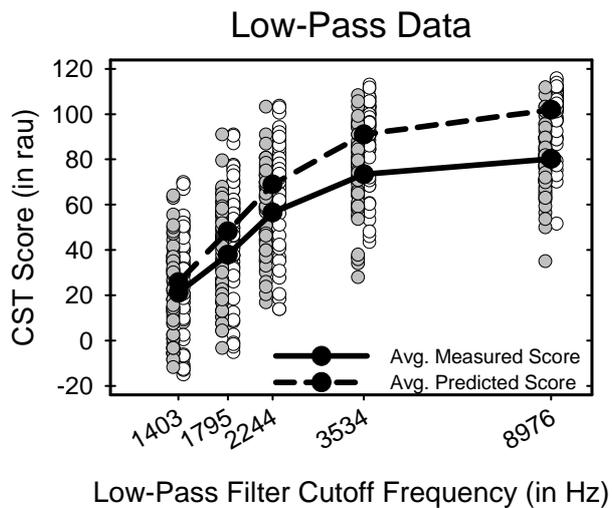


Figure B-8. Measured (grey circles) and predicted (open circles) CST scores in rau as a function of low- (upper panel) or high- (lower panel) pass filter cutoff frequency. The high-pass 143 Hz and low-pass 8976 Hz data points are the same and show performance in our wideband condition (143-8976 Hz). The solid and dashed lines show average measured and SII predicted performance. Measured and predicted data points for each filter condition are slightly offset for clarity.

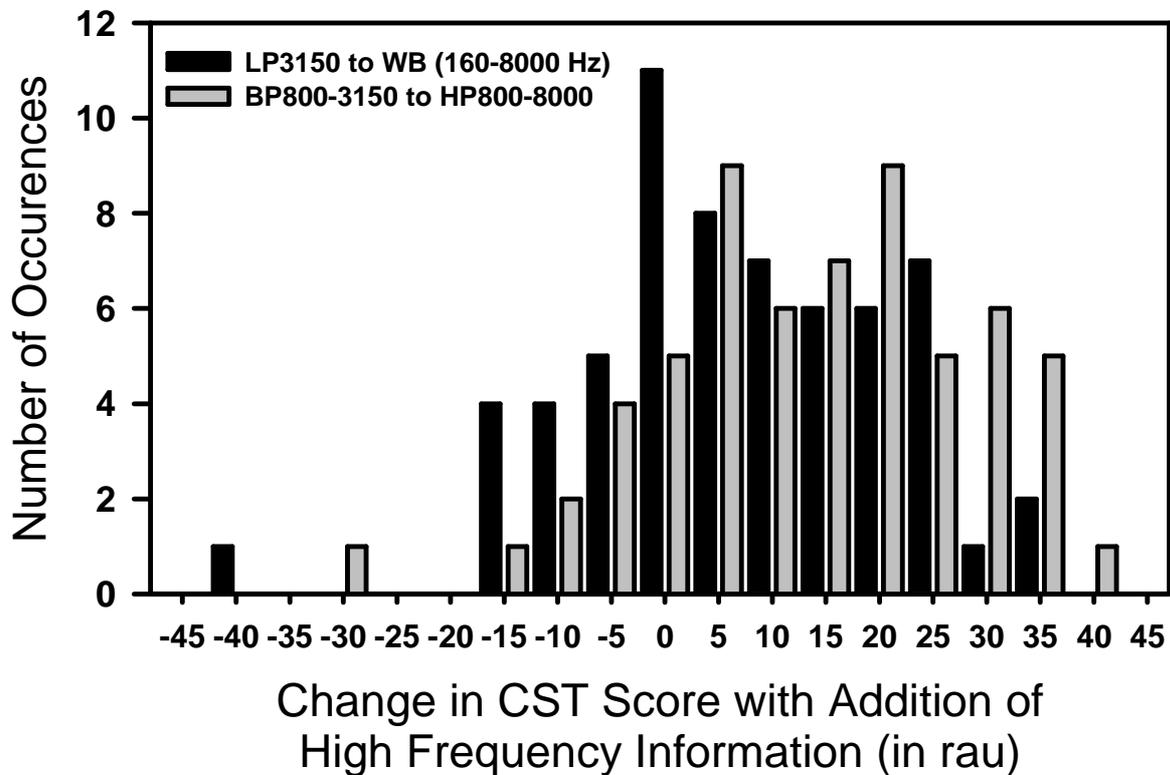


Figure B-9. Histograms of change in CST scores (in rau) with the addition of high frequency speech information (>3534 Hz). Black bars show the change in score when the filter condition changed from 143-3534 Hz to 143-8976 Hz. Grey bars show the change in score when the filter condition changed from 713-3534 Hz to 713-8976 Hz.

Hornsby, B. & Picou, E. (2009, March). Hearing loss, hearing aids and cognitive processing throughout the day. Paper presented at the American Auditory Society Annual Meeting, Scottsdale, AZ.

This study examined the effects of hearing loss and hearing aid use on cognitive processing, and indirectly, listening effort throughout the day. Cognitive processing was assessed, using the MiniCog Rapid Assessment Battery (MRAB; Shephard and Kosslyn, 2005; Shephard et al., 2006). The MRAB allows individuals to rapidly assess cognitive processing in adverse environments (e.g., space) using a handheld PDA. The MRAB consists of nine tests from the cognitive/neuroscience literature that assess various cognitive abilities (e.g., attention, working memory). Participants included 14 older adults with mild-moderate SNHL (48-75 years) and 10 younger adults with normal hearing (24-43 years). HI participants were fit with bilateral, open fit, Starkey Destiny 1600 BTE aids. For the HI participants cognitive processing was assessed 3x/day over a three week period in both unaided and aided conditions. The NH group was tested over a 1 week period. HI participants were counterbalanced into an unaided or aided condition (aids worn full time or not at all). For 1 week HI participants (aided or unaided) completed the MRAB 3x/day. During the next week participants crossed over into the opposite

condition (unaided or aided) and again completed the MRAB 3x/day for the entire week. Participants also subjectively rated recent listening effort and demands prior to taking the MRAB test. Results showed significant differences in RTs, for all nine MRAB tests, between the younger NH group and the older HI group, in both the unaided and aided conditions were observed ($p < 0.001$, in all cases). This general trend is shown in performance averaged across all tests (see Figure B-10). However, there were no significant differences, on average, between hearing impaired participants in the unaided and aided conditions. When RTs were converted to Z-scores and all test measures were included in the analysis, a small, but significant, effect of time of day was observed for the NH group ($p < 0.05$). Specifically, RTs improved in the afternoon compared to morning RTs. There was no difference in normalized RTs between morning and evening or afternoon and evening (see Figure B-11). No effect of time of day was observed in the unaided or aided hearing impaired RT data (see Figure B-12). Subjective ratings data were also obtained. Subjective results differed from our objective measures. Specifically, a significant effect of time of day was observed for the NH group for all test questions. For the NH participants ratings of concentration (question 1), effort in communication (question 2), and distractability of background sounds (question 3) all increased throughout the day. A similar, but smaller, trend was observed in response to ratings of concentration and effort (questions 1 and 2) in the unaided condition for the HI participants. No effect of time of day was seen in the aided responses. Also in contrast to our objective data, rated concentration and effort (questions 1 and 2) as significantly lower in the aided, compared to unaided condition. In contrast, participants rated aided listening as significantly more distracting than unaided (question 3; See Figure B-13). An analysis of associations between subjective effort ratings and MRAB test results (unaided and aided reaction times) were examined using the Spearman rank-order correlation coefficient. Results revealed only weak and inconsistent (some positive, some negative) correlations between effort ratings and unaided and/or aided absolute RTs.

Average Across All Tests

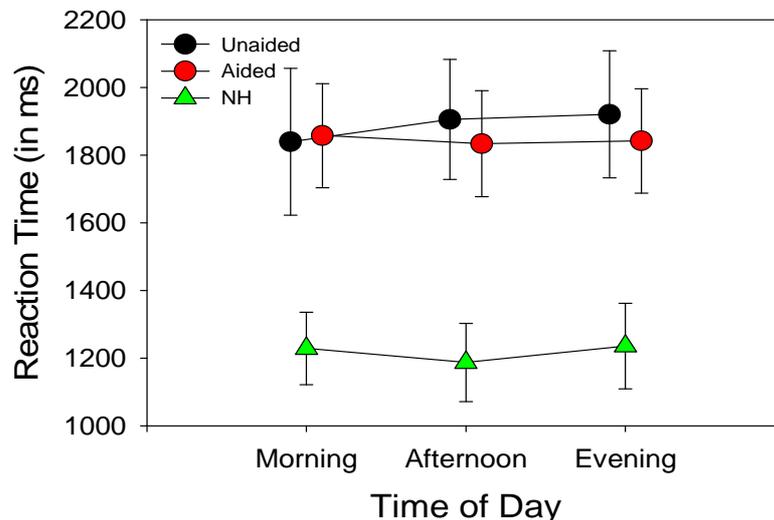


Figure B-10. Mean MRAB reaction time results (in ms) for both NH and HI (unaided and aided) groups as a function of time of day the test was taken. Results are the average across all nine MRAB tests. Error bars = 1 standard error. Results for the NH group are represented by green triangles, red and black circles represent aided and unaided HI results, respectively.

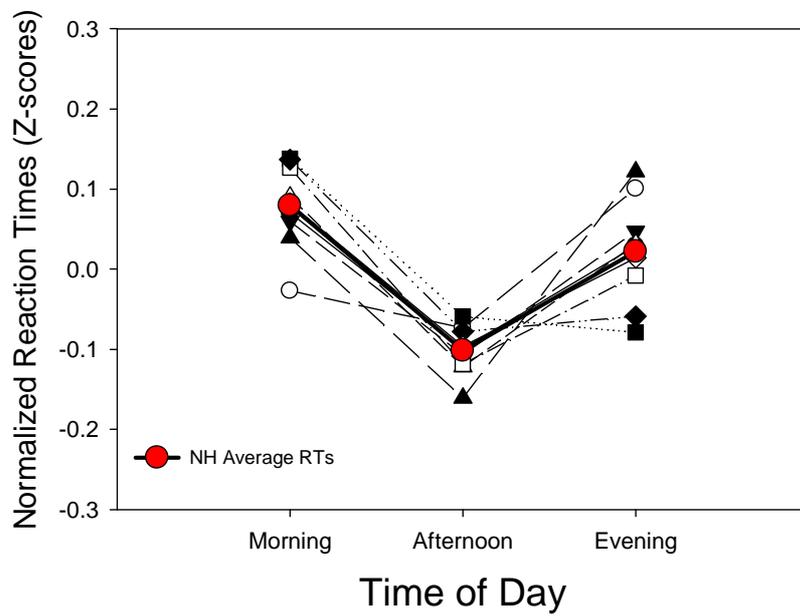


Figure B-11. Normalized RTs for the NH group as a function of time of day. Open and filled symbols represent each of the nine MRAB tests. Red circles represent normalized RT averaged across all tests.

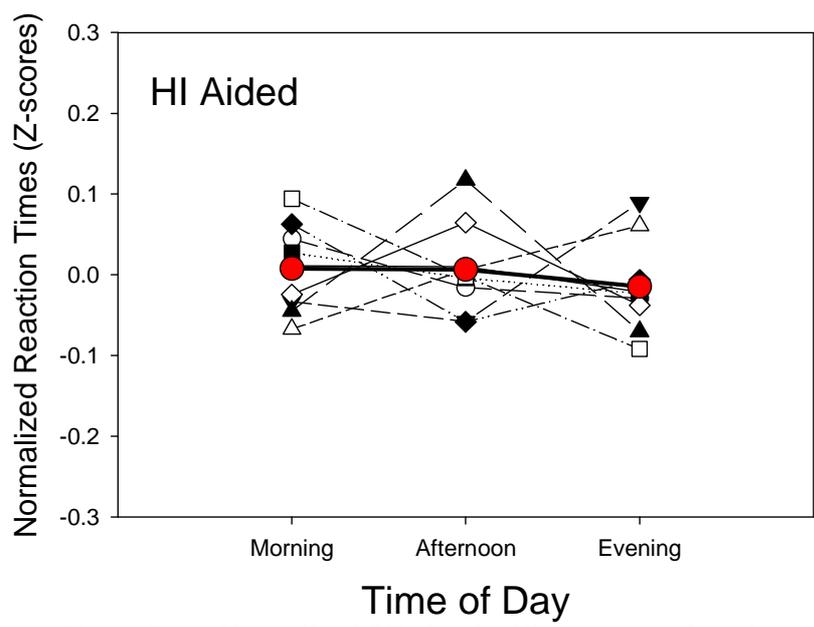
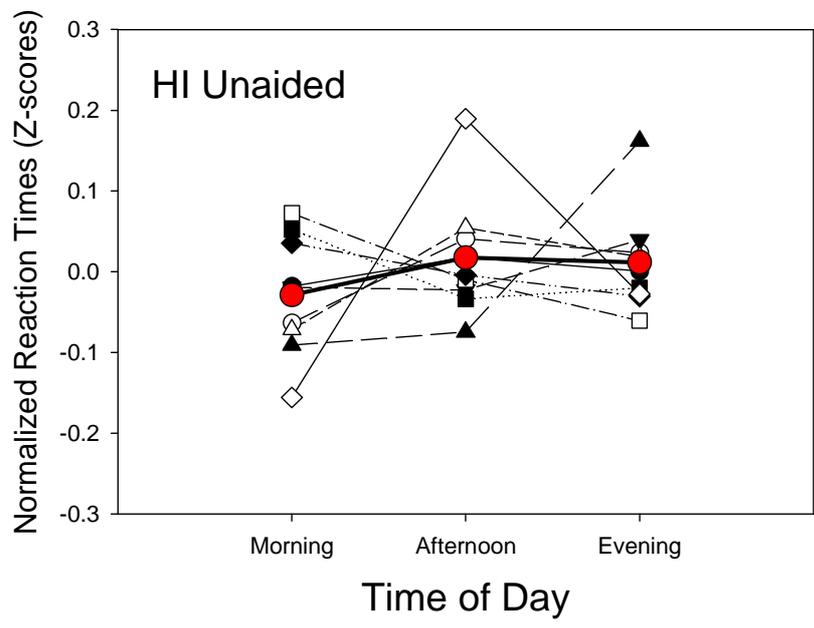


Figure B-12. Normalized RTs for the HI group as a function of time of day. Open and filled symbols represent each of the nine MRAB tests. Red circles represent average RT averaged across all tests. The upper and lower panels show unaided and aided RTs respectively.

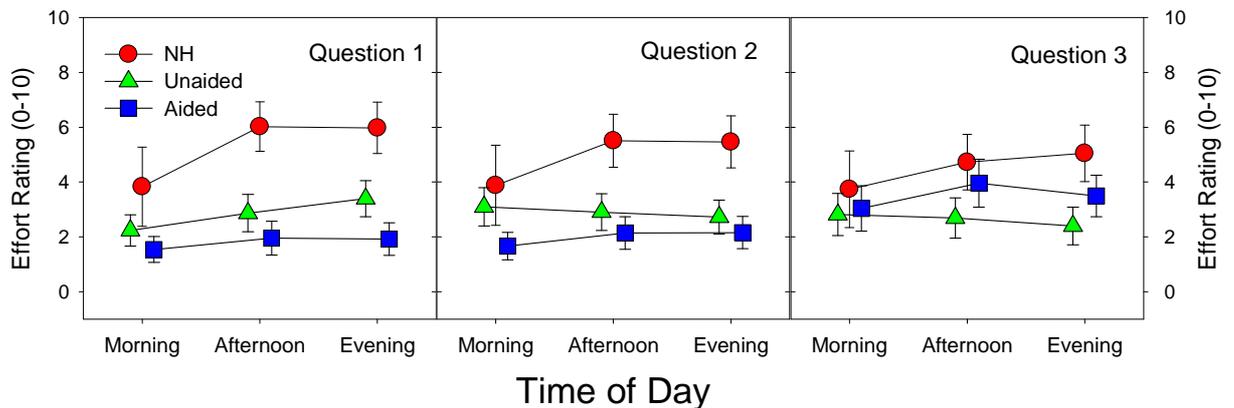


Figure B-13. Mean subjective ratings of ease of concentration (Q1), following conversation (Q2) and ignoring irrelevant sounds (Q3). NH data are shown by the red circles. Unaided and aided HI ratings are shown by the green triangles and blue squares respectively. Error bars = 1 standard error.

Kim, H., Ricketts, T.A., Hornsby, B. & Tharpe, A.M. (April, 2011). Test-retest reliability of open hearing aid fittings in children. American Academy of Audiology- Student Research Poster Awardee.

Purpose: To investigate the test-retest reliability of Real Ear Aided Response (REAR) measures in open (stored equalization) and closed (concurrent equalization) hearing aid fittings in children.

Research design: Probe microphone measurements were completed for two micro-BTE hearing aids which were coupled to the ear using open and closed eartips via thin (0.9 mm) tubing. Prior to probe microphone testing, the gain of the test hearing aids was programmed using an artificial ear simulator (IEC 711) and a Knowles Electronic Manikin for Acoustic Research (KEMAR) to match the “open” NAL-NL1 targets for a mild sloping to moderate hearing loss using an Audioscan Verifit. No further adjustments were made and the same amplifier gain was used across both eartip configurations and all participants. Probe microphone testing included Real Ear Occluded Response (REOR) and Real Ear Aided Response (REAR) measures using the Verifit’s standard speech signal (the carrot passage) presented at 65 dB sound pressure level (SPL). Two repeated probe microphone measures were made for each participant with the probe-tube and hearing aid removed and repositioned between each trial in order to assess intra-subject measurement variability. These procedures were repeated using both open and closed domes.

Study Sample: Thirty-two children, aged 4 to 14 years.

Results: The test-retest difference standard deviations for open and closed measures did not exceed 4 dB at any frequency. There was also no significant difference between the open (stored equalization) and closed (concurrent equalization) methods, particularly in the high frequencies (see Figures B-14 and B-15). These data are similar to previous reports of real ear test-retest reliability. There was also no correlation between reliability and age.

Conclusions: The findings from this study suggest that reliable open real ear measurements are obtainable on children 4 years and older. This has important implications for the accuracy of open fittings in children who are candidates for this style.

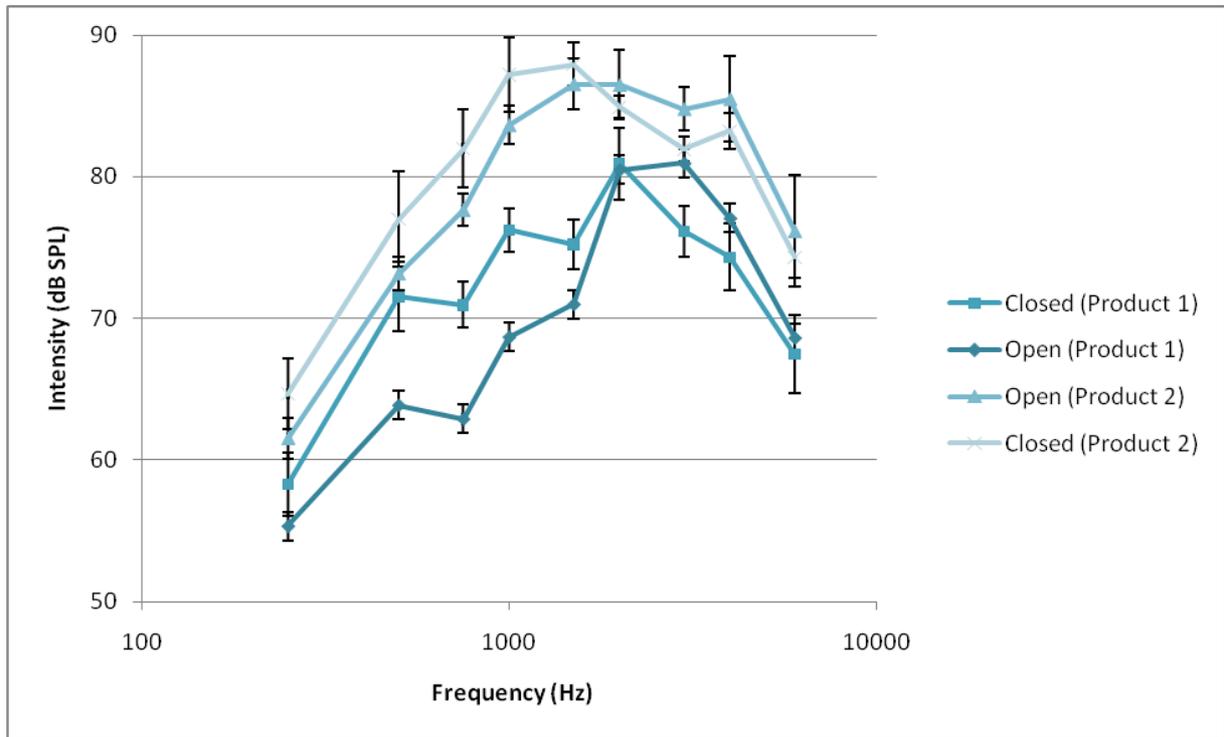


Figure B-14. Average REAR for CLOSED versus OPEN (Products 1 and 2). Test-retest standard deviations at each test frequency are indicated by error bars.

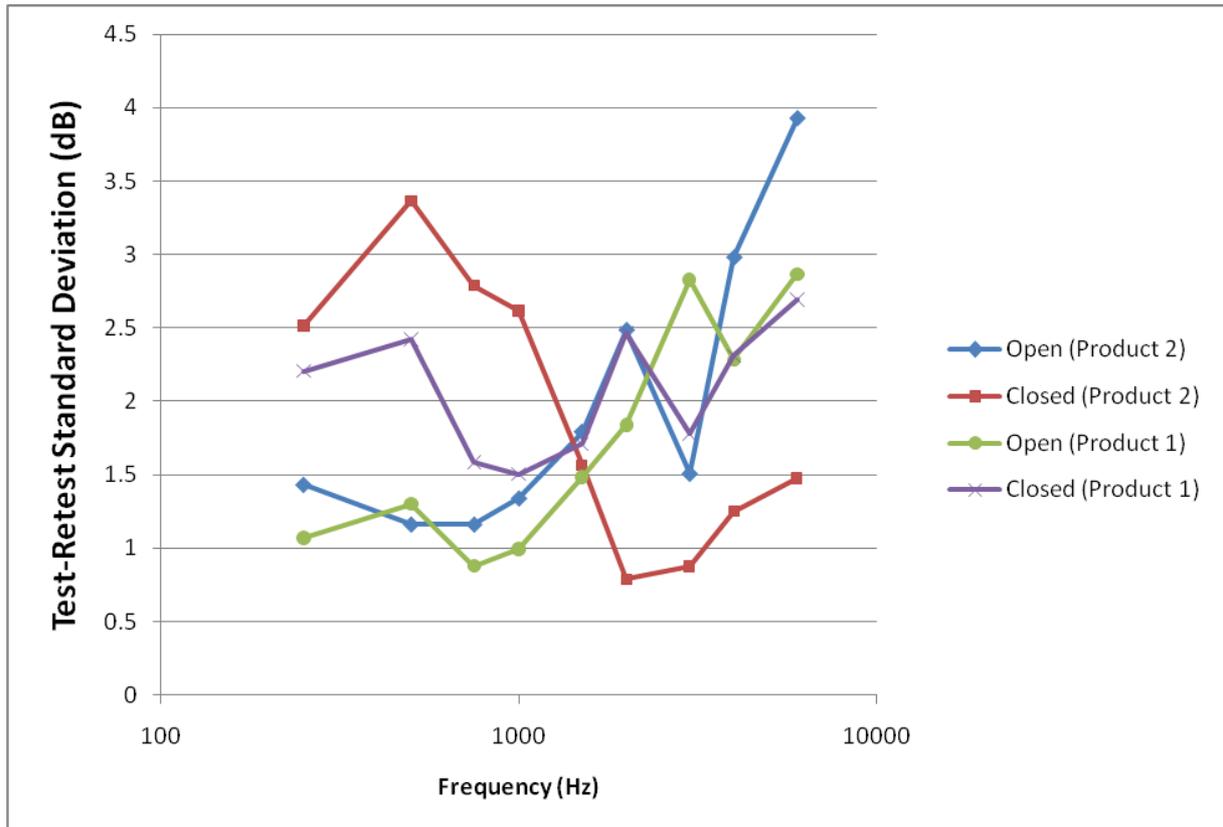


Figure B-15. Test-retest SD as a function of frequency for OPEN and CLOSED REAR (Products 1 and 2).

Koleis, A., **Maloff, E.S. & Ashmead, D.H.** (March, 2010). The role of audition in regulation of standing posture. Poster presented at the annual meeting of the American Auditory Society, Scottsdale, AZ.

Postural regulation is based primarily on vestibular, visual, and kinesthetic information. Vision plays a preemptive role in posture control, and whether audition acts likewise is important for persons with visual impairments. A role for audition has been reported, but design issues preclude a strong conclusion. Our research used a moving room to simulate visual and acoustic stimulation accompanying postural sway. Experiment 1 had 16 conditions, with various combinations of visual and auditory stimulation. The visual information consisted of seeing the room moving, and the auditory information was from loudspeakers attached to the room. Vision led to sway strongly coupled to the room, whereas audition did not do so any more than in an eyes closed, quiet condition. In Experiment 2, characteristics of the acoustic signal and room motion were varied, with similar results. Experiment 3, in progress, tests whether acoustic information is useful when the sound source is very close to the listener. The general conclusion is that, under typical circumstances, the sense of hearing is not useful for postural regulation. Supported by the NIH National Institute on Deafness and Other Communication Disorders (NIDCD) Short Term Research Traineeship (T35) awarded to the first author.]

Lim, S., Grantham, D.W., Ricketts, T. & Hornsby, B. (2010, April). The effect of asymmetric microphones on localization ability in open-fit hearing aids. Poster presented at the American Academy of Audiology Annual Convention, San Diego, CA.

The purpose of this study was to investigate the effects of asymmetrical hearing aid fittings on horizontal sound localization by studying performance under the following conditions: (1) unaided, (2) bilateral omnidirectional microphone settings, and (3) asymmetric microphone fitting with a fixed directional microphone on one ear and an omnidirectional microphone on the other ear. Six adults with symmetric sloping sensorineural hearing losses were fit bilaterally with ReSound Dot30 BTE aids with open fit dome eartips. Hearing aid gain was adjusted to match NAL-NL1 targets in both microphone conditions. Localization ability was first tested unaided and then immediately after fitting participants in either the asymmetric or symmetric omnidirectional mode. This initial aided testing provided a baseline measure of localization ability without allowing for acclimatization to the new sound processing. Participants then wore the devices full time during a two-week period of acclimatization. Localization was then reassessed in the aided condition to allow for an examination of training effects. The hearing aids were then reset to the second aided condition, and this process was repeated. Horizontal plane localization ability was assessed in an anechoic chamber using 64 loudspeakers arranged in a 360° array around the listener. Of the 64 loudspeaker choices, only 15 were used to present the target stimuli. Stimuli consisted of short ("Where", 341 ms) and long ("Where am I coming from now?" 1250 ms) duration speech. A total of 12 responses were obtained per loudspeaker for each test condition. Overall localization performance was analyzed by examining performance separately in the left-right (L/R) and front-back (F/B) dimensions. For each dimension several measures of localization ability were calculated and compared across listening conditions. Specific measures analyzed include the root mean square (RMS) error (a global measure of localization accuracy), random error (a measure of response variability), and mean signed error (a measure of response bias). In addition to examining localization error and bias in the asymmetric and symmetric conditions, the effects of listening experience with a given processing scheme were explored by comparing localization abilities immediately after the fitting to performance following a 2 week acclimatization period. The impact of stimulus duration was also explored to determine if increasing stimulus duration minimized any negative effects of a specific hearing aid fitting on localization. Results revealed that, following a 2 week acclimatization period, there were no significant difference in localization accuracy, variability or bias between unaided listening and either aided conditions (see Figure B-16). This suggests that in listeners with mild-moderate SNHL fit with open mold BTE aids, variations in microphone processing mode had only a minimal impact on horizontal plane localization ability. In addition, training effects on localization abilities were also small, although response variability did decrease over time. Finally, a significant effect of stimulus duration was observed across multiple conditions. With the longer duration stimulus localization accuracy increased while response variability and bias decreased (see Figure B-17). This finding suggests that, for listeners with mild-moderate hearing loss utilizing open mold fittings, the consequences of hearing aid microphone processing on horizontal plane localization may be minimal.

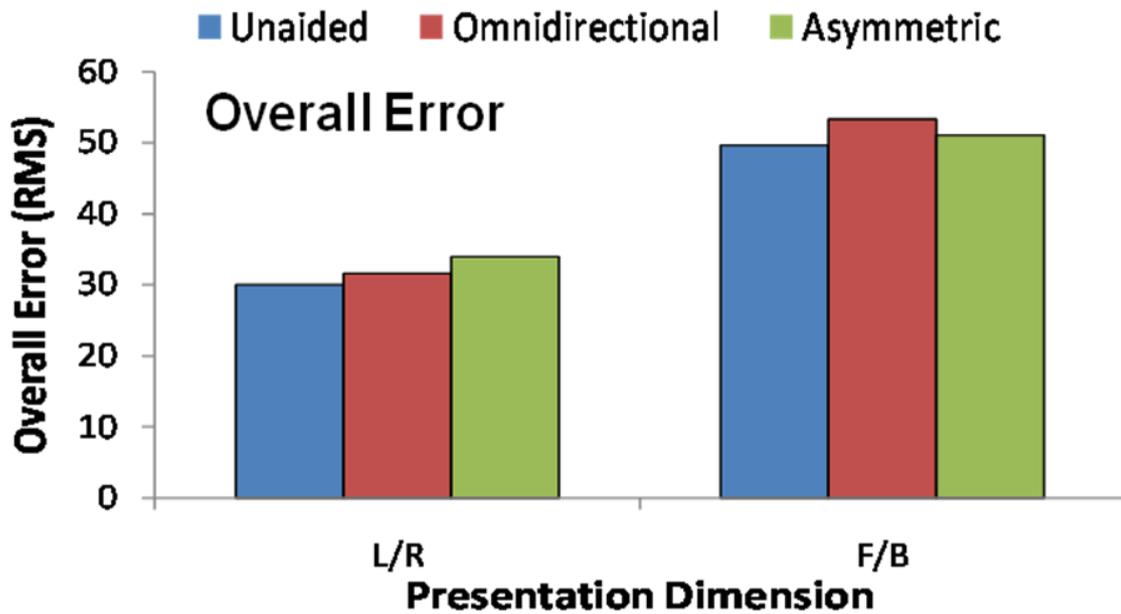


Figure B-16. Overall rms error in localization accuracy in the left-right dimension and in the front-back dimension as a function of listening condition (Unaided, Symmetric omnidirectional fitting, and Asymmetric fitting).

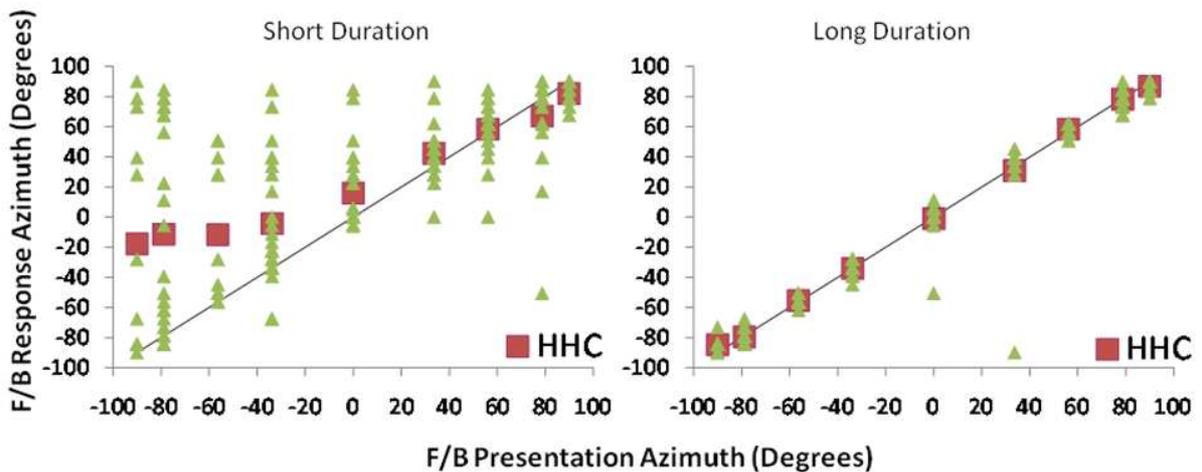


Figure B-17. Single trial and mean localization responses, for a single subject, as a function of source location for a short (341 ms; left panel) and long (1250 ms; right panel) duration stimulus. Green triangles and red squares represent single trial and mean responses, respectively.

Liu, X., Han, D., Li, J., Han, B., Ouyang, X., Cheng, J., Li, X., Jin, Z., Wang, Y., Bitner-Glindzicz, M., Kong, X., Xu, H., Kantardzhieva, A., **Eavey, R.D.**, Seidman, C.E., Seidman, J.G., Du, L.L, Chen, Z.Y., Dai, P. Teng, M., Yan, D. & Yuan, H. (2010). Loss-of-function mutations in the PRPS1 gene cause a type of nonsyndromic x-linked sensorineural deafness, DFN2. *Am. J. Hum. Genet.* 86(1): 65-71.

We report a large Chinese family with X-linked postlingual nonsyndromic hearing impairment in which the critical linkage interval spans a genetic distance of 5.41 cM and a physical distance of 15.1 Mb that overlaps the DFN2 locus. Mutation screening of the PRPS1 gene in this family and in the three previously reported DFN2 families identified four different missense mutations in PRPS1. These mutations result in a loss of phosphoribosyl pyrophosphate (PRPP) synthetase 1 activity, as was shown in silico by structural analysis and was shown in vitro by enzymatic activity assays in erythrocytes and fibroblasts from patients. By in situ hybridization, we demonstrate expression of Prps1 in murine vestibular and cochlea hair cells, with continuous expression in hair cells and postnatal expression in the spiral ganglion. Being the second identified gene associated with X-linked nonsyndromic deafness, PRPS1 will be a good candidate gene for genetic testing for X-linked nonsyndromic hearing loss.

Maloff, E.S., Ashmead, D.H. & Grantham, D.W. (In preparation). Human sensitivity to differences in the rate of auditory cue change.

Measurement of sensitivity to differences in the rate of change of auditory signal parameters is complicated by confounds among duration, extent, and velocity of the changing signal. If signal A changes faster than signal B, then A's duration is shorter when extent of change is constant, or A's extent of change is greater when duration is constant. Dooley and Moore (1988) proposed a method for measuring sensitivity to rate of change (in frequency or intensity), using a duration discrimination task. They reported improved duration discrimination when an additional cue from rate of intensity or frequency change was present. This provided a covert approach to measuring sensitivity to rate of change. The current experiments were an attempt to use this method to measure sensitivity to the rate of change in intensity and spatial position. Experiment 1 investigated whether duration discrimination was enhanced when additional cues consisting of rate of intensity change, rate of spatial position change, or both cues were provided. Experiments 2 and 3 aimed to determine whether subject listening experience or the testing environment influenced duration discrimination task performance. In contrast to the results from Dooley and Moore (1988), duration discrimination was impaired rather than enhanced by the additional velocity cues. Experiment 4 assessed whether duration discrimination could be used to measure sensitivity to rates of changes in intensity and motion if the rate differences were enhanced. Again, performance was not improved when the velocity cues were present. The findings are discussed in terms of the demands of listening to concurrent changes in multiple auditory dimensions.

NOTE: This research was a portion of the research for the doctoral dissertation completed by **E. Maloff** under the direction of **D. Ashmead**, Vanderbilt University, 2010.

Manolis, E.N., Filippou, D.K. Tsoumakas, C., Diomidous, M. Cunningham, M.J., Katostaras, T. Weber, A.L. & **Eavey, R.D.** (2009). Radiologic evaluation of the ear anatomy in pediatric cholesteatoma. *J. Craniofac. Surg.* 20(3): 807-810.

The aim of the study was to describe computed tomography (CT) findings in middle ear cholesteatoma in pediatric patients. A cohort of 32 children with cholesteatoma (3-14 years old) entered the study. From them, 30 presented acquired cholesteatoma (AC), and 2 presented congenital cholesteatoma. All of the children were investigated using CT before surgery of the middle ear and mastoid. Computed tomography was performed with 1- or 2-mm axial and coronal sections of both temporal bones. Nineteen children with AC (63.3%) revealed a diffuse soft-tissue density isodense with muscle, whereas in 6 of them, the mass mimicked inflammation. The remaining revealed localized soft-tissue mass with partially lobulated contour. In AC, ossicular erosion was detected in 23 cases (76.7%), abnormal pneumatization in 19 cases (63.3%), and erosion-blunting of spur and enlargement of middle ear or mastoid in 8 cases (26.7%). The 2 congenital cholesteatomas revealed soft-tissue mass with polypoid densities, while a semicircular canal fistula was detected in one of them. High-resolution CT facilitates early diagnosis and appropriate treatment of pediatric cholesteatoma by assessing the anatomic abnormalities and the extent of disease, which are crucial in middle ear and mastoid surgery.

Marcum, S.C. & Ricketts, T.A. (March, 2011). Assessment of modern feedback reduction systems. Poster presented at the annual meeting of the American Auditory Society, Scottsdale, AZ.

New feedback suppression techniques are routinely introduced in hearing aids; however, the amount of additional gain before feedback (AGBF) provided has been shown to vary widely across and within hearing aids (Ricketts et al., 2008). The purpose of this study was to examine the variability and reliability of AGBF and maximum REIG across six manufacturers premiere products in 20 individual listeners. A special effort was made to enhance clinical relevance by eliciting feedback in a manner consistent with patients real world experiences. Probe microphone techniques were utilized to assess REAR in six hearing aids fitted in an open configuration with feedback suppression active and inactive. These values were used to calculate AGBF and maximum REIG before feedback. AGBF values obtained from these six feedback suppression algorithms were consistent with previous research (Ricketts et al., 2008). Significant variability existed between the various manufacturers when averaging AGBF across all subjects and between subjects when compared within a given manufacturer. Significant variability was also measured with feedback suppression inactive, suggesting that maximum REIG may be more clinically meaningful than AGBF. Finally, substantial test-retest differences were identified. Caution should be exercised when selecting a feedback suppression algorithm clinically, as individual results can differ significantly from average results for a given model. [Supported by the NIH National Institute on Deafness and Other Communication Disorders (NIDCD) Short Term Research Traineeship (T35) awarded to the first author.]

Mehra, S., **Eavey, R.D.** & Keamy, D.G., Jr. (2009). The epidemiology of hearing impairment in the United States: Newborns, children, and adolescents. *Otolaryngol. Head Neck Surg.* 140(4): 461-472.

Objective: Hearing loss ranks high among disabilities in the United States. The epidemiologic parameters of hearing impairment in the United States have not been systematically studied and important historic data have not diffused to relevant stakeholders; even otolaryngologists are unfamiliar with epidemiologic data. We wished to compile known studies to establish an epidemiologic baseline beginning with pediatric data.

Data Sources: Relevant literature was retrieved from medical databases and Centers for Disease Control and Prevention reports.

Methods: Candidate articles and national data sets encompassing pediatric hearing loss were analyzed and compared. Whenever possible, group analyses were performed.

Results: The average incidence of neonatal hearing loss in the United States is 1.1 per 1000 infants, with variation among states (0.22 to 3.61 per 1000). Childhood and adolescent prevalence rates demonstrate variability. The prevalence of mild hearing impairment or worse (>20 dB) is 3.1 percent based on the average of comparable audiometric screening studies; self-reporting prevalence is 1.9 percent. Hispanic Americans demonstrate a higher prevalence of hearing impairment than other children. Low-income households demonstrate a higher prevalence of hearing loss compared to households with higher income levels. Genetic causes were attributed to 23 percent across studies.

Conclusions: Analysis of the data reveals gaps in our knowledge of the epidemiology of hearing loss and stresses the importance of consistent definitions of hearing impairment for systematic assessment of changes over time. Hearing loss in childhood deserves further epidemiologic investigation and elevated awareness among health care professionals and the public. Genetic etiologies are likely underestimated in this review.

Moore, T. & Hornsby, B.W.Y. (March, 2011). Predicting hearing aid benefit from speech recognition measures. Poster presented at the annual meeting of the American Auditory Society, Scottsdale, AZ.

A common reason cited for limited use and non-use of hearing aids is inadequate improvement in speech understanding, particularly when listening in background noise. However, objective measures of unaided and aided speech recognition obtained in the laboratory are generally poor predictors of subjective hearing aid benefit in real world settings. One reason for this disconnect may be that laboratory conditions reflect only a small subset of everyday listening conditions. We address this limitation by predicting individual unaided and aided intelligibility in a wide range of conditions. Predictions are made using the Speech Intelligibility Index (SII: ANSI S3.5, 1997). A modified version of the SII, which incorporates individual proficiency factors derived from objective measures of speech recognition obtained in the laboratory, is also used. Multiple summary measures of predicted performance were derived and compared to subjective measures of unaided and hearing difficulties using the Profile of Hearing Aid Benefit (PHAB) and the Glasgow Hearing Aid Benefit Profile (GHABP). Correlation analyses suggested that SII predictions, adjusted using individually derived estimates of speech proficiency, were more strongly correlated with subjective measures of hearing aid outcome than were predictions based on threshold information alone. [Supported by the NIH National Institute on Deafness and Other Communication Disorders (NIDCD) Short Term Research Traineeship (T35) awarded to the first author.]

Picou, E.M. & Ricketts, T.A. (in press) Comparison of Wireless and Acoustic Hearing Aid Based Telephone Listening Strategies. Ear and Hearing

Rationale: People who wear hearing aids often have difficulty understanding speech using the telephone. Recently, hearing aid manufacturers have introduced wireless routing technology and one potential application of this technology may be to improve telephone use for hearing aid wears.

Purpose: The purpose of this study was to examine speech recognition through hearing aids for seven telephone listening conditions.

Method: Speech recognition scores were measured for 20 participants in six wireless routing transmission conditions and one acoustic telephone condition. In the wireless conditions, the speech signal was delivered to both ears simultaneously (bilateral speech) or to one ear (unilateral speech). The effect of changing the noise level in the non-test ear during unilateral conditions was also examined. Participants were fitted with hearing aids using both non-occluding and fully occluding dome eartips. Participants were seated in a room with background noise present (55 or 65 dB) and speech was transmitted without additional background noise.

Results: There was no effect of changing the noise level in the non-test ear and no difference between unilateral wireless routing and acoustic telephone listening. For wireless transmission, bilateral presentation resulted in significantly better speech recognition than unilateral presentation (see Figure B-18). Bilateral wireless conditions allowed for significantly better recognition than the acoustic telephone condition for participants fitted with occluding dome eartips only.

Conclusion: Routing the signal to both hearing aids resulted in significantly better speech recognition than unilateral signal routing. Wireless signal routing was shown to be beneficial compared to acoustic telephone listening, and in some conditions resulted in the best performance of all of the listening conditions evaluated. However, this advantage was only evident when the signal was routed to both ears and when hearing aid wearers were fitted with occluding domes. It is speculated that the benefits of this new wireless streaming technology over existing telephone coupling methods will be most evident clinically in hearing aid wearers who require more limited venting than is typically used in open canal fittings.

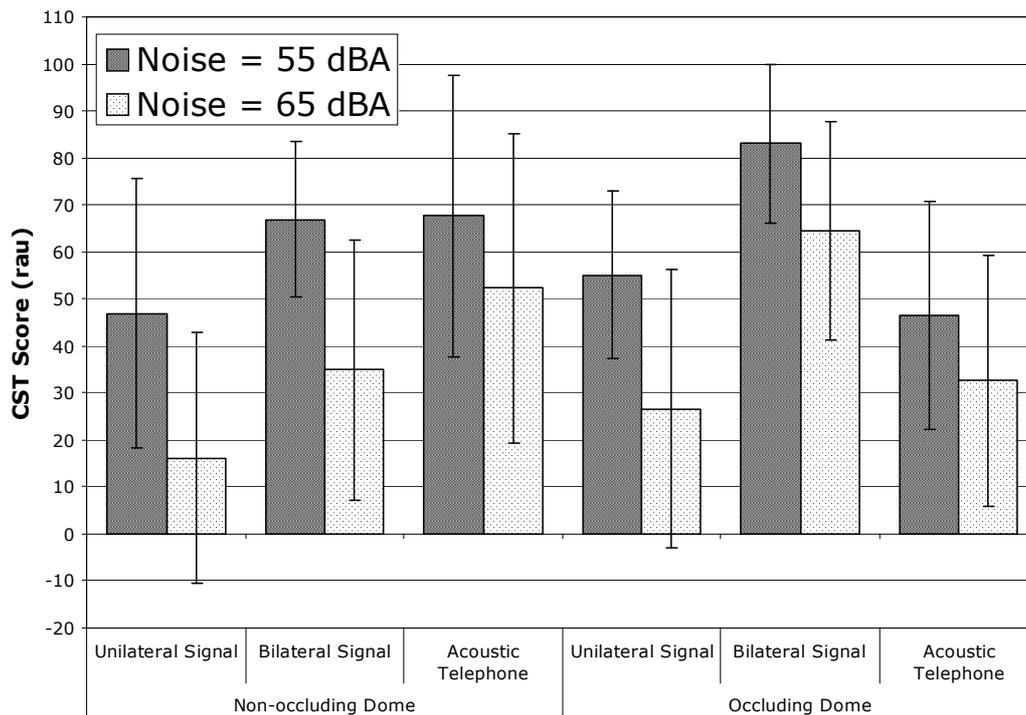


Figure B-18. Average speech recognition performance (rau) for the unilateral and bilateral wireless speech transmission conditions, in addition to the acoustic telephone condition. Error bars represent ± 1 standard deviation. Dark bars indicate conditions with background noise levels of 55 dB, while lighter bars represent conditions with 65 dB background noise.

Picou, E.M., Ricketts, T.A. & Hornsby, B.W.Y. (submitted). Visual cues and listening effort: Individual variability. *Journal of Speech, Language and Hearing Research*

Purpose: The purpose of this study was to compare the listening effort expended during auditory-only and auditory-visual tasks. An additional purpose was to investigate if predictive variables such as working memory capacity and lipreading ability affect the magnitude of listening effort.

Methods: Twenty participants with normal hearing were tested using a paired-associates recall task in two conditions (quiet, noise) and two presentation modes (audio-only/AO, audio-visual/AV). Subjective perception of listening effort was also assessed. Signal-to-noise ratios for testing were individually set such that recognition was the same in both noise conditions. In addition, two predictive variables were assessed: lipreading ability and working memory span.

Results: Results indicated that listening effort increased in the presence of noise, but on average the addition of visual cues did not significantly affect the magnitude of listening effort (Figure B-19). However, there was substantial individual variability and those who were better lipreaders (Figure B-20) or had larger working memory capacities demonstrated reduced listening effort in noise in AV conditions (Figure B-21).

Conclusions: These results support the idea that integrating auditory and visual information requires cognitive resources. However, the presence of visual cues also appears to reduce

listening effort in noise for people who are good lipreaders or have large working memory capacities.

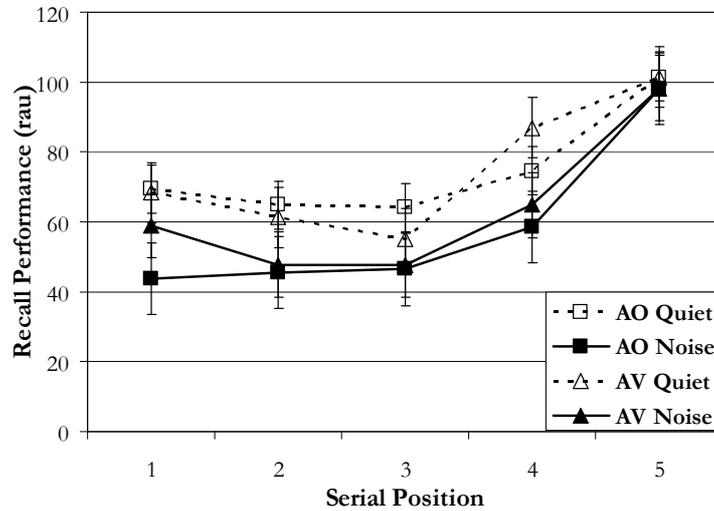


Figure B-19. Average recall performance (rau) as a function of serial position. Open symbols indicate quiet conditions while closed indicate noise conditions. Error bars represent ± 1 standard deviation.

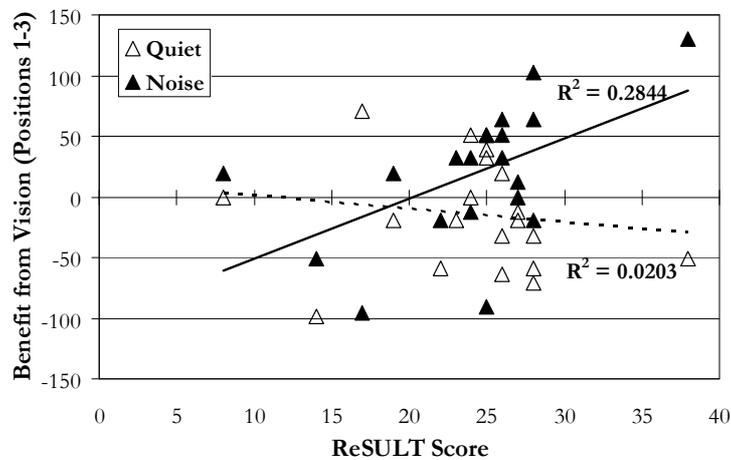


Figure B-20. Relationship between lipreading ability and benefit from visual cues in quiet and in noise. Symbols indicate the average recall benefit with visual cues in quiet and noise for open and filled symbols, respectively. Solid and dashed lines represent linear regression best fit in the noise and quiet conditions, respectively.

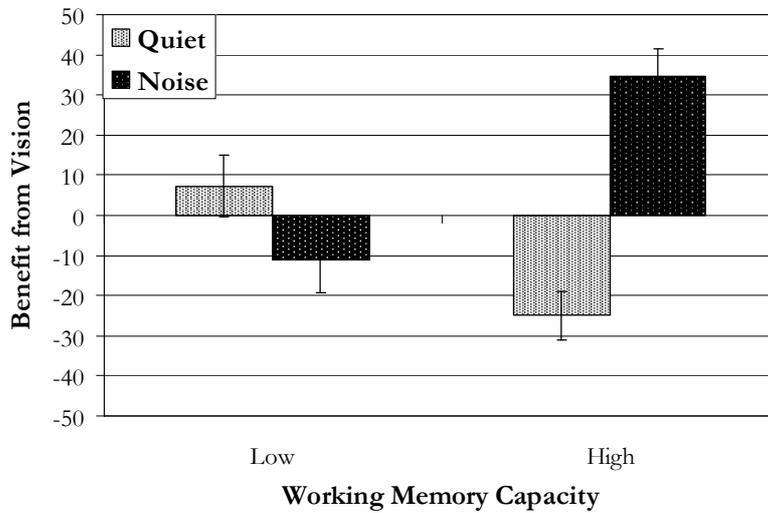


Figure B-21. Average benefit (rau) from visual cues in quiet and noise for participants in the “low” and “high” working memory capacity groups. Error bars represent ± 1 standard error.

Porter, H., Tharpe, A.M. & Sladen, D.P. (July 2011). A comparison of intervention settings for infants and toddlers with hearing loss. Presentation at the Educational Audiology Association Conference, Nashville, TN.

Early intervention efforts conducted in the home with care providers can result in significant increases in developmental skill acquisition for young children with special needs. However, the studies that have been conducted thus far looking at home-based versus center-based intervention have not included children with hearing loss. Children with hearing loss rely on optimized acoustic environments in order to develop communication and early academic skills in an oral modality. In order to achieve early speech and language skills, infants and toddlers must have acoustic accessibility to the speech and language models in their environment. Although there have been many efficacy studies conducted with children who have other disabilities, to date, no evidence exists to support the provision of early intervention services for infants and toddlers with hearing loss in one environment over another. This study was conducted to examine the speech, language, and auditory skill outcomes for children enrolled in home-based and center-based early intervention services. In addition, ambient noise levels, features of therapy sessions (e.g., family members in attendance), and family and provider satisfaction with home-based and center-based service provision were examined.

Porter, H., Sladen, D.P., Tharpe, A.M. & Ashmead, D.H. (In preparation). Theory of mind and emotion recognition in children with hearing loss.

Social behaviors, personal adjustment, emotion regulation, and emotion understanding can be adversely affected for children with hearing loss (Wake et al., 2004; Yoshinaga-Itano & deUzcategui, 2001). These delays are influenced by speech and language ability, but other factors, such as emotion recognition and Theory of Mind (ToM), might influence development of social and emotional abilities in children with hearing loss as well. Emotion recognition includes the ability to discriminate the various expressions of emotions in facial, gestural, and verbal display. It is not well defined for children with hearing loss. ToM includes the understanding that people have intentions, desires, knowledge, and beliefs, and that these mental states might be different from their own and influence one's behavior. Deaf children with hearing parents and those with cochlear implants are delayed in ToM development (Moeller, 2007; Moeller & Schick, 2006; Peterson, 2004; Peterson & Siegel, 2000; Schick et al, 2007). This study was designed to investigate two specific factors associated with psychosocial development in children with hearing loss: emotion recognition and Theory of Mind (ToM). A task examining the recognition of six facial expressions of emotion and a task examining three ToM concepts were conducted with 41 children between the ages of 4-6 years and 10-12 years with and without hearing loss. Younger children with hearing loss had poorer emotion recognition scores than younger children with normal hearing; however, older children with hearing loss and older children with normal hearing performed similarly on this task. All children demonstrated understanding of ToM concepts in the same sequence, but children with hearing loss acquired concepts at later ages than children with normal hearing. A statistically significant association was observed between categorical designations for children's performance on emotion recognition and ToM tasks. Increased exposure to emotion recognition and ToM concepts earlier in life for children with hearing loss could result in closing the performance gap seen between younger children with hearing loss and younger children with normal hearing. It might be beneficial to consider these concepts in tandem when designing interventions aimed at supplementing the psychosocial development of children with hearing loss.

Quintanilla-Dieck, M.D.L., Artunduaga, M.A. & **Eavey R. D.** (2009). Intentional exposure to loud music: the second mtv.com survey reveals an opportunity to educate. *J. Pediatr.* 155(4): 550-555.

Objectives: Music-induced hearing loss (MIHL), an unconsciously self-inflicted public health concern, could evolve into an epidemic because of the appeal of loud music. After media attention about a previous hearing-loss survey with Music Television (MTV.com), we hypothesized that a repeat survey could compare awareness and behavior trends.

Study design: We incorporated the 2002 survey into the new 73-question instrument presented to random visitors on the MTV.com website in 2007. A $P < .05$ value was used for independent t and z- tests.

Results: A total of 2500 completed surveys were analyzed. Hearing loss was considered a problem by 32% of respondents compared with other health issues such as drug/alcohol use (62%). However, nearly half of the respondents admitted experiencing symptoms such as tinnitus or hearing loss after loud music exposure. Health care providers were the least likely source of MIHL awareness despite the respondents favoring provider education for hearing protection behavior modification.

Conclusion: Most respondents still could not recall learning about prevention of potential hearing loss, although the media has become the most informative source. Most respondents

indicated that they would adopt protective ear behavior if made aware of hearing loss risk, especially if informed by health care professionals, revealing an educational opportunity.

Rentmeester, L. & Tharpe, A.M. (March 2010) Young Children's Attitudes Towards Their Peers Who Wear Hearing Aids. Poster presented at the annual meeting of the American Auditory Society, Scottsdale, AZ.

The "hearing aid effect" is a phenomenon that describes negative attitudes toward children wearing hearing aids when compared to their normal hearing peers. The "hearing aid effect" has been found in adult observers and child observers as young as 10 years of age. The purpose of this study was to determine whether the "hearing aid effect" is present in young children and if there is a difference between the attitudes of young children (aged 6-7 years) and older children (aged 9-10 years). Children with normal hearing were asked to rate photos of their peers with a hearing aid and without a hearing aid in social acceptance, and physical and cognitive competence. When forced to make a choice between a peer with a hearing aid versus a peer without a hearing aid, children were more likely to choose a peer with a hearing aid as being poorer at physical tasks and as having less acceptance from their peers. In addition to these findings, children who wore a hearing aid were considered to be not as well liked as their peers without a hearing aid. In contrast with the findings from the forced choice ratings and popularity ratings, when children rated each photo individually, there were no differences in how children with and without a hearing aid were rated. These findings suggest that when directly compared to their peers without hearing aids, children who wear hearing aids are more likely to be viewed as being less capable physically and may be less socially accepted by their peers. [Supported by the NIH National Institute on Deafness and Other Communication Disorders (NIDCD) Short Term Research Traineeship (T35) awarded to the first author.]

Shargorodsky, J., Curhan, S.G., Curhan, G.C., & **Eavey, R.** (2010). Change in prevalence of hearing loss in us adolescents. *Journal of the American Medical Association* 304(7): 772-778.

Context: Hearing loss is common and, in young persons, can compromise social development, communication skills, and educational achievement.

Objective: To examine the current prevalence of hearing loss in US adolescents and determine whether it has changed over time.

Design: Cross-sectional analyses of US representative demographic and audiometric data from the 1988 through 1994 and 2005 through 2006 time periods.

Setting: The Third National Health and Nutrition Examination Survey (NHANES III), 1988-1994, and NHANES 2005-2006.

Participants: NHANES III examined 2928 participants and NHANES 2005-2006 examined 1771 participants, aged 12 to 19 years.

Main Outcome Measures: We calculated the prevalence of hearing loss in participants aged 12 to 19 years after accounting for the complex survey design. Audiometrically determined hearing loss was categorized as either unilateral or bilateral for low frequency (0.5, 1, and 2 kHz) or high frequency (3, 4, 6, and 8 kHz), and as slight loss (>15 to <25 dB) or mild or greater loss (≥25 dB) according to hearing sensitivity in the worse ear. The prevalence of hearing loss from NHANES 2005-2006 was compared with the prevalence from NHANES III (1988-1994). We also examined the cross-sectional relations between several potential risk factors and

hearing loss. Logistic regression was used to calculate multivariate adjusted odds ratios (ORs) and 95% confidence intervals (CIs).

Results: The prevalence of any hearing loss increased significantly from 14.9% (95% CI, 13.0%-16.9%) in 1988-1994 to 19.5% (95% CI, 15.2%-23.8%) in 2005-2006 ($P = .02$). In 2005-2006, hearing loss was more commonly unilateral (prevalence, 14.0%; 95% CI, 10.4%-17.6%, vs 11.1%; 95% CI, 9.5%-12.8% in 1988-1994; $P = .005$) and involved the high frequencies (prevalence, 16.4%; 95% CI, 13.2%-19.7%, vs 12.8%; 95% CI, 11.1%-14.5% in 1988-1994; $P = .02$). Individuals from families below the federal poverty threshold (prevalence, 23.6%; 95% CI, 18.5%-28.7%) had significantly higher odds of hearing loss (multivariate adjusted OR, 1.60; 95% CI, 1.10-2.32) than those above the threshold (prevalence, 18.4%; 95% CI, 13.6%-23.2%).

Conclusion: The prevalence of hearing loss among a sample of US adolescents aged 12 to 19 years was greater in 2005-2006 compared with 1988-1994.

Shargorodsky, J., Curhan, S.G., **Eavey, R.** & Curhan, G.C. (2010). A prospective study of cardiovascular risk factors and incident hearing loss in men. *Laryngoscope* 120(9): 1887-1891

Objectives/Hypothesis: Hearing loss is the most common sensory disorder in the United States, affecting more than 36 million people. Cardiovascular risk factors have been associated with the risk of hearing loss in cross-sectional studies, but prospective data are currently lacking.

Study Design: Prospective cohort study.

Methods: We prospectively evaluated the association between diagnosis of hypertension, diabetes mellitus, hypercholesterolemia, smoking, or body mass index (BMI) and incident hearing loss. Participants were 26,917 men in the Health Professionals Follow-up Study, aged 40 to 74 years at baseline in 1986. Study participants completed questionnaires about lifestyle and medical history every 2 years. Information on self-reported professionally diagnosed hearing loss and year of diagnosis was obtained from the 2004 questionnaire, and cases were defined as hearing loss diagnosed between 1986 and 2004. Multivariable-adjusted hazard ratios (HRs) were calculated using Cox proportional hazards regression models.

Results: A total of 3,488 cases of hearing loss were identified. History of hypertension (HR 0.96; 95% confidence interval [CI], 0.88-1.03), diabetes mellitus (HR 0.92; 95% CI, 0.78-1.08), or obesity (HR 1.02; 95% CI, 0.90-1.15 for BMI ≥ 30 compared to normal range of 19-24.9) was not significantly associated with hearing-loss risk. Hypercholesterolemia (HR 1.10; 95% CI, 1.02-1.18) and past smoking history (HR 1.09; 95% CI, 1.01-1.17) were associated with a significantly increased risk of hearing loss after multivariate adjustment.

Conclusions: A history of hypertension, diabetes mellitus, or obesity is not associated with increased risk of hearing loss; a history of past smoking or hypercholesterolemia has a small but statistically significant association with increased risk of hearing loss in adult males.

Shargorodsky, J., Curhan, S.G., **Eavey, R.** & Curhan, G.C. (2010). A prospective study of vitamin intake and the risk of hearing loss in men. *Otolaryngol Head Neck Surg* 142(2): 231-236.

Objective: Hearing loss is the most common sensory disorder in the United States, afflicting more than 36 million people. Higher intakes of vitamins C, E, beta carotene, B12, and folate have been proposed to reduce the risk of hearing loss.

Study Design: We prospectively evaluated the association between intake from foods and supplements of vitamins C, E, beta carotene, B12, and folate, and the incidence of hearing loss.

Setting: Health Professionals Follow-up Study.

Subjects and Methods: A total of 26,273 men aged 40 to 74 years at baseline in 1986.

Participants completed questionnaires about lifestyle and medical history every two years and diet every four years. Information on self-reported professionally diagnosed hearing loss and year of diagnosis was obtained from the 2004 questionnaire, and cases were defined as hearing loss diagnosed between 1986 and 2004. Cox proportional hazards multivariate regression was used to adjust for potential confounders.

Results: There were 3559 cases of hearing loss identified. Overall, there was no significant association between vitamin intake and risk of hearing loss. Among men aged ≥ 60 years, total folate intake was associated with a reduced risk of hearing loss; the relative risk for men aged ≥ 60 years old in the highest quintile compared with the lowest quintile of folate intake was 0.79 (95% confidence interval 0.65-0.96).

Conclusions: Higher intake of vitamin C, E, beta carotene, or B12 does not reduce the risk of hearing loss in adult males. Men aged ≥ 60 years may benefit from higher folate intake to reduce the risk of developing hearing loss.

Spahr, A.J., Dorman, M.F., Litvak, L.M., Van Wie, S., Gifford, R.H., Loizou, P.C., Loiselle, L.M., Oakes, T. & Cook, S. (In press). Development and validation of the AzBio sentence lists. *Ear and Hearing*.

Objectives: The goal of this study was to create and validate a new set of sentence lists that could be used to evaluate the speech perception abilities of hearing-impaired listeners and cochlear implant (CI) users. Our intention was to generate a large number of sentence lists with an equivalent level of difficulty for the evaluation of performance over time and across conditions.

Design: The AzBio sentence corpus includes 1000 sentences recorded from two female and two male talkers. The mean intelligibility of each sentence was estimated by processing each sentence through a five-channel CI simulation and calculating the mean percent correct score achieved by 15 normal-hearing listeners. Sentences from each talker were sorted by percent correct score, and 165 sentences were selected from each talker and were then sequentially assigned to 33 lists, each containing 20 sentences (5 sentences from each talker). List equivalency was validated by presenting all lists, in random order, to 15 CI users.

Results: Using sentence scores from the CI simulation study produced 33 lists of sentences with a mean score of 85% correct. The results of the validation study with CI users revealed no significant differences in percent correct scores for 29 of the 33 sentence lists. However, individual listeners demonstrated considerable variability in performance on the 29 lists. The binomial distribution model was used to account for the inherent variability observed in the lists. This model was also used to generate 95% confidence intervals for one and two list comparisons. A retrospective analysis of 172 instances where research subjects had been tested on two lists within a single condition revealed that 94% of results were accurately contained within these confidence intervals.

Conclusions: The use of a five-channel CI simulation to estimate the intelligibility of individual sentences allowed for the creation of a large number of sentence lists with an equivalent level of difficulty. The results of the validation procedure with CI users found that 29 of 33 lists allowed scores that were not statistically different. However, individual listeners demonstrated considerable variability in performance across lists. This variability was accurately described by the binomial distribution model and was used to estimate the magnitude of change required to

achieve statistical significance when comparing scores from one and two lists per condition. Fifteen sentence lists have been included in the AzBio Sentence Test for use in the clinical evaluation of hearing-impaired listeners and CI users. An additional eight sentence lists have been included in the Minimum Speech Test Battery to be distributed by the CI manufacturers for the evaluation of CI candidates.

Spankovich, C., Hood, L. J., Silver, H., Flood, V. & Mitchell, P. 2009. Dietary Intake and Auditory Function in an Adult Population: The Blue Mountains Hearing Study. American Academy of Audiology – Student Research Forum Awardee.

Recent studies have investigated the influence of specific dietary factors on susceptibility to various etiologies of hearing loss. However, limited epidemiological study has been applied to examine these associations. The present study explored dietary intake variables and associations with pure-tone thresholds and otoacoustic emissions in a population of older adults. The results support the literature, reveal novel associations, and substantiate dietary intake as a relevant factor for susceptibility to and prevention of hearing loss.

C. Speech and Language Science – Applied

Abou-Khalil, R. & Schneider, S. L. TPR- A New Approach to the Treatment of Auditory Comprehension Deficit in Aphasia. Poster presented at the 2009 meeting of the American Speech-Language-Hearing Association, November, 2009, New Orleans.

We present the results of a pilot study, testing a new treatment for comprehension deficit disorder. This study relies on a method of second language learning called Total Physical Response (TPR), which is a holistic approach to language. TPR uses movement and gesture, emphasizes auditory comprehension, and presents a limited set of vocabulary at a time. For this pilot study, a single subject across subjects design was utilized to test the effectiveness of TPR in the treatment of auditory comprehension deficit in individuals with aphasia. Two participants completed a treatment plan. The results indicate that this method is effective although further research is warranted (Figures C-1 and C-2).

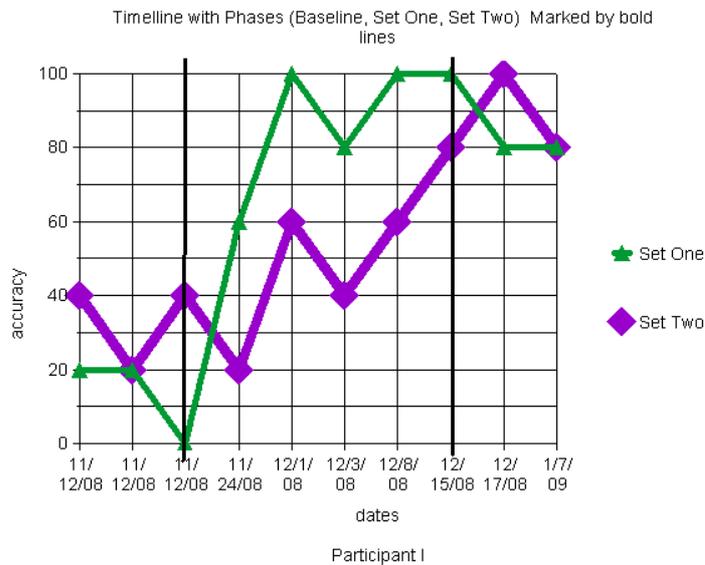


Figure C-1. Progress of Participant I as indicated by accuracy levels.

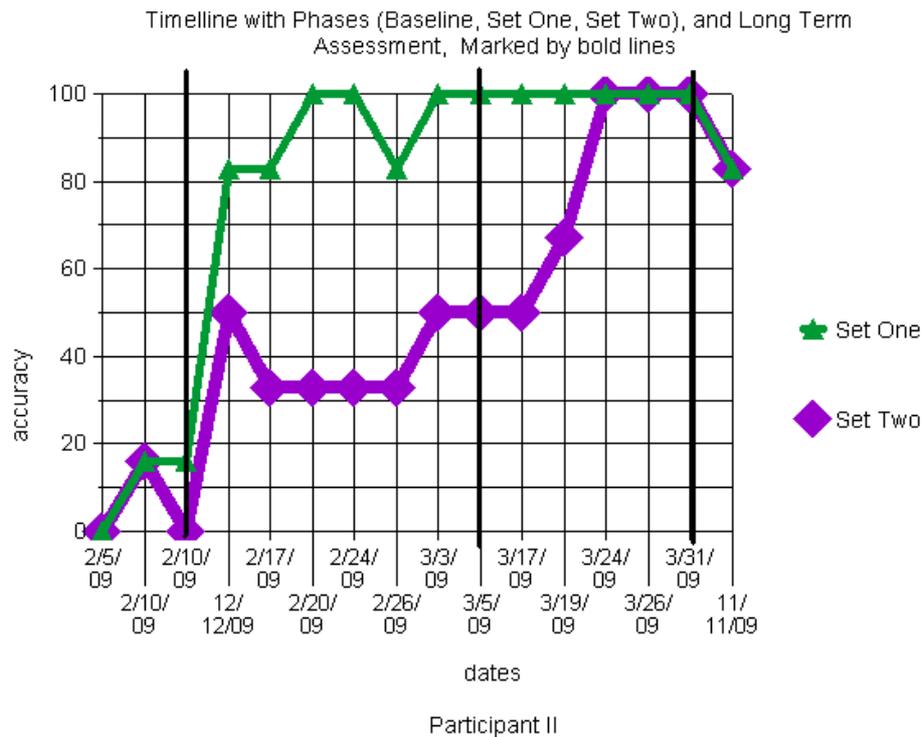


Figure C-2. Progress of Participant II as indicated by accuracy levels, including long term assessment.

Arnold, H. S., Conture, E. G., Key, A. P. & Walden, T. (2011). Emotional reactivity, regulation and childhood stuttering: A behavioral, electrophysiological study. *Journal of Communication Disorders*. 44, 276-293.

Purpose: The purpose of this study was to assess whether behavioral and psychophysiological correlates of emotional reactivity and regulation are associated with developmental stuttering.

Method: Nine preschool-age children who stutter (CWS) and nine preschool-age children who do not stutter (CWNS) listened to brief background conversations conveying happy, neutral, and angry emotions (a resolution conversation followed the angry conversation) and then produced narratives based on a text-free storybook. Electroencephalograms (EEG) were recorded during the listening part to examine cortical correlates of emotional reactivity and regulation. Speech disfluencies and observed emotion regulation were measured during the subsequent narratives.

Results: Results revealed no significant differences between CWS and CWNS in EEG measurements of emotional reactivity and regulation during background conversations designed to elicit emotions. However, behavioral findings indicated that decreased use of regulatory strategies is related to more stuttering in children who stutter (see Figure C-3).

Conclusions: Findings were taken to suggest that use of regulatory strategies may relate to the fluency of preschool-age children's speech- language output. Research supported in part by NIH/NIDCD research grant 1R01DC0006477-01AS.

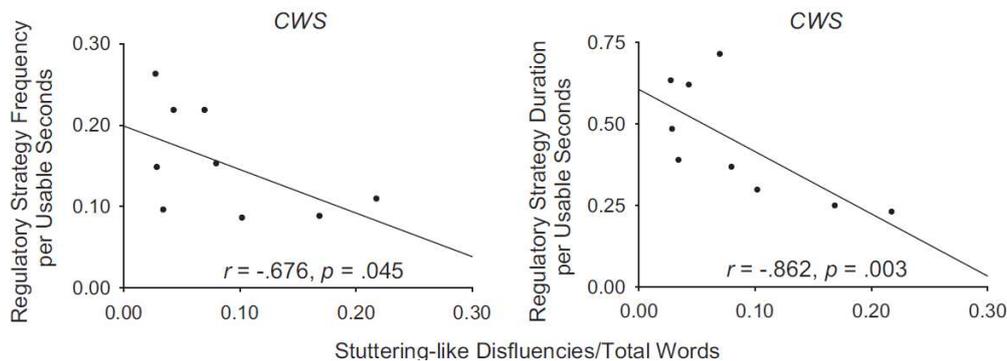


Figure C-3. The relations of stuttering-like disfluencies per total words (SLD/TW) to regulatory strategy frequency per usable seconds (left panel) and to regulatory strategy duration per usable seconds (right panel) are plotted for CWS.

Ball, A. & de Riesthal, M. (2010). Use of video technology for verbal repetition in modified ACT and CART. Poster presented at Clinical Aphasiology Conference, Isle of Palms, SC.

Three individuals with a moderate to severe aphasia and coexisting AOS post left hemisphere stroke participated in this study. A modified Anagram and Copy Treatment (ACT) and Copy and Recall Treatment (CART) with video technology for verbal home practice were implemented. The least severe participant demonstrated some benefit from verbal repetition training, whereas the others had difficulty with independent practice. In the writing condition, all participants met criteria for the trained sets, and one participant demonstrated generalization to untrained items. The results showed that the 5-point scoring system (Helm-Estabrooks, 2003) provided more detailed data on progress than traditional binary scoring.

Ball, A., de Riesthal, M., Breeding, V. & Mendoza, D. (2011). Modified ACT and CART for severe aphasia. *Aphasiology*, 25, 836-848.

Background: Anagram and Copy Treatment (ACT) and Copy and Recall Treatment (CART) have been shown to improve written communication for those with severe aphasia (Beeson, 1999; Beeson, Hirsch & Rewega, 2002; Beeson, Rising, & Volk, 2003). More recently, the addition of a spoken repetition component to the CART program has been suggested to enhance oral naming in moderate aphasia (Beeson & Egnor, 2006; Wright, Marshall, Wilson, & Page, 2008) and in cases with co-existing apraxia of speech (AOS) (de Riesthal, 2007). No studies have investigated the use of a modified ACT and CART with spoken repetition in individuals with severe aphasia and AOS. In addition, studies of ACT and CART have not examined the influence of stimulus selection on performance.

Aims: The purposes of the study were to 1) determine if a modified ACT and CART program with use of video technology for spoken repetition during home practice improved spoken and written naming performance for treated and untreated stimuli, and 2) determine if spoken and written naming performance differed between client-selected vs. clinician-selected stimuli.

Methods & Procedures: Three individuals with a moderate to severe aphasia and coexisting AOS post left middle cerebral artery strokes participated in the study. Participants were enrolled in modified ACT and CART with spoken repetition of the target word. For the CART program, a

video was created for each word in a treatment set to facilitate repetition in the home practice program.

Outcomes & Results: All participants improved in their ability to write the treatment stimuli. Generalization to untrained items was observed in Participant 1 in the written condition. A 5-point scoring system (Helm-Estabrooks & Albert, 2003) captured generalization better than the traditional binary scoring. None of the participants improved in the spoken naming condition. Comparison of stimuli selection (participant vs. clinician selected) did not reveal any difference in clinical outcome.

Conclusions: Our study supports evidence that ACT and CART may improve written naming skills in persons with severe aphasia. The inclusion of spoken repetition in the home practice CART program may not be appropriate for cases with severe aphasia with AOS. The influence of participant vs. clinician selected stimuli on naming performance requires further evaluation.

Buhr, A., Conture, E. G., Kelly, E. G. & Jones, R. M. (2011). Do preschoolers' stuttered repetitions originate as linguistic encoding errors? Manuscript submitted.

Purpose: The purpose of the present study was to investigate the nature of stuttered repetitions in preschool-age children who stutter.

Method: Thirteen preschool-age children who stuttered (CWS) and 15 preschool-age children who did not stutter (CWNS) produced narratives, which were transcribed and coded for part-word repetitions (PWR), whole-word repetitions (WWR), phrase repetitions (PR), and interjections (INT). Each repetition type was also coded for number of iterations. In addition, word class (i.e., function vs. content) was determined for all PWR and WWR.

Results: Results indicated that the tendency to produce repetitions with multiple iterations was predictive of repetition frequency. Results also showed that both CWS and CWNS tended to produce WWR on function words, and there was no significant between-group difference in the likelihood of producing PWR on content words. Finally, results showed that CWS were significantly more likely than CWNS to produce repetitions with multiple iterations, but there was no significant between-group difference in their word class (i.e., function vs. content words).

Conclusion: Findings are taken to suggest that stuttered repetitions can originate as planning delays. Research supported in part by an NICHD training grant (T32-CH18921), NICHD Grant P30HD15052, NIH Grants R01 DC000523-14 and R01 DC006477-01A2, and a Vanderbilt University Discovery Grant

Buhr, A. & Zebrowski, P. (2009). Sentence position and syntactic complexity of stuttering in early childhood: A longitudinal study. *Journal of Fluency Disorders*, 34, 155-172.

The purpose of the present investigation was to assess longitudinal word- and sentence-level measures of stuttering in young children. Participants included 12 stuttering and non-stuttering children between 36 and 71 months of age at an initial visit who exhibited a range of stuttering rates. Parent-child spontaneous speech samples were obtained over a period of two years at six-month intervals. Each speech sample was transcribed, and both stuttering-like disfluencies (SLDs) and other disfluencies (ODs) were coded. Word- and sentence-level measures of SLDs were used to assess linguistic characteristics of stuttering. Results of the word-level analysis indicated that stuttering was most likely to occur at the sentence-initial position, and that a tendency to stutter on function words was present only at the sentence-initial position. Results

of the sentence-level analyses indicated that sentences containing ODs and those containing SLDs were both significantly longer and more complex than fluent sentences, but did not differ from each other. Word- and sentence-level measures also did not change across visits. Results were taken to suggest that both SLDs and ODs originate during the same stage of sentence planning.

Choi, Da Hye. (2010). Relation of (non)stuttered disfluencies to temperamental processes in preschool-age children who stutter. Unpublished manuscript.

Purpose: The purpose of this study was to assess the relation of (non)stuttered speech disfluencies to selected aspects of temperamental processes (e.g., emotional reactivity and emotion regulation) in preschool-age children who stutter (CWS).

Method: Participants were 117 preschool-age CWS (85 boys and 32 girls; ages 3-5). Based on conversational samples, the frequencies of each participant's stuttered and non-stuttered disfluencies were assessed. Participants' temperament was assessed by a parental-report-based validated test of early childhood temperament.

Result: Findings indicated (1) no significant correlation between SLD and (parent-report-based measures of) emotional reactivity as well as emotion regulation, (2) a marginally significant positive correlation between NSLD and emotion regulation, (3) no significant correlation between SPI and (parent-report-based measures of) emotional reactivity as well as emotion regulation, and (4) a significant negative correlation between emotional reactivity and emotion regulation based on parent reports (See Figure C-4).

Conclusion: Findings indicate that CWS' SLD frequency and sound prolongation index (SPI) did not significantly relate to parent-report-based measures of emotional reactivity or emotion regulation; however, CWS' relation between emotion regulation and NSLD may suggest that CWS with greater emotion regulation may be more apt to monitor for/detect "typical" errors in their speech-language leading to increased nonstuttered disfluencies in their spoken output. Whether emotionally regulated CWS' monitoring for speech-language errors and resulting nonstuttered disfluencies help or hinder recovery from stuttering is unknown, but this possibility would seem worthy of future empirical exploration. Research supported in part by NIH Grants R01 DC000523-14 and R01 DC006477-01A2.

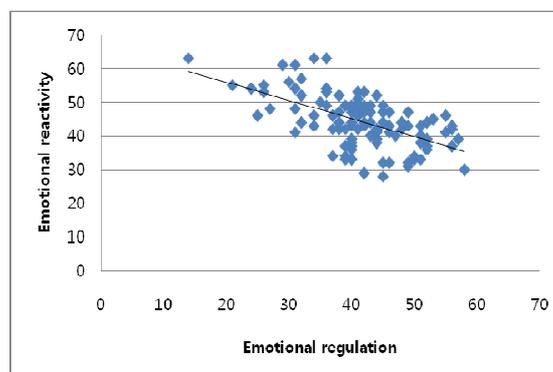


Figure C-4. The relation between emotion regulation and emotion reactivity of preschool-age children who stutter (n = 117).

Clark, C. E., Conture, E., Frankel, C. & Walden, T. (2011). Communicative and psychological dimensions of the KiddyCAT. Revised manuscript submitted for publication.

Purpose: The purpose of the present study was to investigate the underlying constructs of the Communication Attitude Test for Preschool and Kindergarten Children Who Stutter (KiddyCAT; Vanryckeghem & Brutten, 2007), especially those related to awareness of stuttering and negative speech-associated attitudes.

Method: Participants were 114 preschool-age children who stutter (CWS; $n = 52$; 15 females) and children who do not stutter (CWNS; $n = 62$; 31 females). Their scores on the KiddyCAT were assessed to determine whether they differed with respect to (1) talker group (CWS vs. CWNS), (2) age, and (3) gender. Principal components factor analysis (PCA) assessed the quantity and quality of the KiddyCAT dimensions.

Results: Findings indicated that preschool-age CWS scored significantly higher than CWNS on the KiddyCAT, regardless of age or gender. Additionally, the extraction of a single factor from the PCA indicated that one dimension—speech difficulty—appears to underlie the KiddyCAT items.

Conclusions: As reported by its test developers, the KiddyCAT differentiates between CWS and CWNS. Furthermore, one factor, which appears related to participants' awareness of and attitudes towards speech difficulty, underlies the items. Findings were taken to suggest that children's responses to the KiddyCAT are related to their perception that speech is difficult, which, for CWS, may be driven by relatively frequent experiences with their speech being hard. Research supported in part by National Institutes of Health (NIH) grants from the National Institute on Deafness and Other Communication Disorders (NIDCD) to Vanderbilt University (R01 DC000523-14; R01 DC006477-01A2), the National Center for Research Resources, a CTSA grant (1 UL1 RR024975) to Vanderbilt University, and a Vanderbilt University Discovery Grant

Conture, E. (2011, March). Emotional contributions to childhood stuttering. Invited presentation to faculty and students, Dept. Communication Sciences and Disorders, Michigan State University, E. Lansing, MI

The purpose of this presentation was to discuss emotional contributions to developmental or childhood stuttering. Based on data obtained from standardized caregiver rating scales, coded behavioral observation, and psychophysiological measures, it was shown that emotional traits and states contribute not only to childhood stuttering, the diagnostic entity, but to childhood stuttering, the behavior. These divergent perspectives (i.e., caregiver rating scales, coded behavioral observations and psychophysiology) regarding emotional processes support the notion that some aspects of emotion follow stuttering, while others precede stuttering and still others bidirectionally interact with stuttering. Findings suggest that the belief that emotions merely follow stuttering, and thus irrelevant to theory and treatment, restricts the development of a more comprehensive understanding of stuttering as involving cortical, emotional, linguistic and motoric processes.

Conture, E., Buhr, A., Jones, R., Walden, T. A., & Frankel, C. (November, 2010). Emotional contributions to developmental stuttering. Presentation at the Annual Meeting of the American Speech-Language-Hearing Association, Philadelphia, PA.

This seminar presented results and theory pertaining to emotional contributions to stuttering. Behavioral and psychophysiological measures of emotional reactivity and regulation in children who do and do not stutter and the possible role emotion plays in stuttering will be interpreted relative to the Dual Diathesis-Stress (DD-S) model of stuttering (Conture & Walden, in press).

Coulter, C., Anderson, J. & **Conture, E.** (2009). Childhood Stuttering and Dissociations Across Linguistic Domains: A Replication and Extension. *Journal of Fluency Disorders*, 34, 257-278.

The purpose of this investigation was to replicate Anderson, Pellowski, and Conture's (2005) findings that young preschool children who stutter (CWS) are more likely to exhibit dissociations in speech-language abilities than children who do not stutter (CWNS) (Study 1) and to examine the relation between these dissociations and specific characteristics of stuttering (e.g., most common disfluency type) (Study 2). Participants for Study 1 were 40 CWS and 40 CWNS between the ages of 3;0 and 5;11 matched for age, gender, and race. Participants for Study 2 were the same as for Study 1 plus the 90 used by Anderson et al (2005) for a total of 170 participants, matched for age, gender and race.. Participants were administered four standardized speech-language tests and a 300-word conversational speech sample was obtained from each participant during a play-based interaction with an adult. Standard scores, obtained from these four standardized speech-language tests, were analyzed by a correlation-based statistical procedure (Bates, Applebaum, Salcedo, Saygin & Pizzamiglio, 2003) in attempts to identify possible dissociations among the speech-language measures. Findings from the current investigation supported Anderson et al.'s (2005) findings that CWS exhibited significantly more speech-language dissociations than CWNS. Results indicated that the degree of dissociation was significantly, positively correlated with frequency of total as well as stuttering-like disfluencies. Furthermore, CWS who exhibited dissociations were significantly more likely to exhibit interjections or revisions as their most common disfluency type. Findings provide further support for the possibility that dissociations among various aspects of the speech-language system may contribute to the difficulties that some children have establishing normally fluent speech (See Figure C-5). Research supported in part by NIH/NIDCD research grant 5R01DC000523-14.

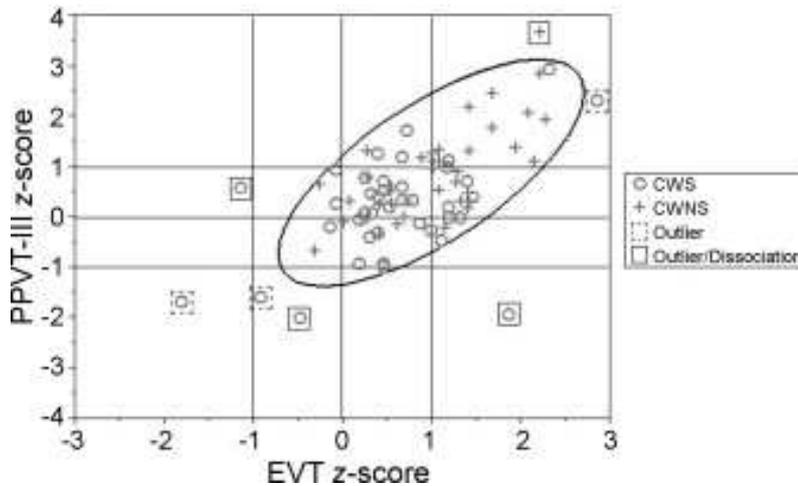


Figure C-5. Study 1. Example of a correlation between receptive (PPVT-III) and expressive (EVT) vocabulary for children between the ages of 3;0 and 5;11 (years;months) who do (CWS; $N = 40$) and do not stutter (CWNS; $N = 40$) with density ellipse (CI = 95%) shown.

de Riesthal, M. & Brookshire, C.E. (2010). Script training in a case of PPAOS with progressive aphasia. Paper presented at the 2010 International Motor Speech Conference, Savannah, GA.

Primary progressive apraxia of speech (PPAOS) is defined as the gradual onset of AOS symptoms in the absence of significant non-language cognitive deficits, resulting from a neurodegenerative disease (Duffy & McNeil, 2008). It may occur as a separate entity or in conjunction with a progressive aphasia. When the symptoms of AOS are more prominent than aphasia the appropriate label is PPAOS with aphasia (Duffy and McNeil, 2008). The purpose of this case study is to report the successful application of script training—a procedure developed for individuals with non-progressive aphasia—to an individual with PPAOS with progressive aphasia. Script training was selected because it targets functional communication interactions, requires repetitive practice of articulatory gestures in a meaningful context, and promotes automaticity of trained stimuli. Five scripts related to work place interactions and two scripts related to social interactions were developed and trained using a modified script training protocol in a multiple baseline design. The data suggest that the repetitive practice, articulatory modeling, and functional context involved in script training may improve articulation and fluency of trained stimuli and generalization to functional communication interactions.

de Riesthal, M. & Wertz, R.T. (In preparation) Predictive value of severity of aphasia and time postonset on outcome in first year of recovery with aphasia

Background: Research on prognosis for aphasia has focused on the relationship between specific biographical, medical, and behavioral variables and outcome and amount of improvement on measures of communication function. Severity of aphasia and time postonset (TPO) from aphasia have been identified as potent prognostic indicators of outcome in the first year postonset. However, no study has examined the predictive value of these variables in a

group of individuals with aphasia in whom the intensity of treatment, as well as, additional coexisting variables have been controlled.

Aims: The purpose of this investigation was to determine the relationship between selected variables and outcome and amount of improvement on the PICA and CADL after 12 weeks of treatment. Moreover, the investigation was designed to determine the contribution of the selected variables in predicting outcome and amount of improvement on the PICA and CADL.

Methods & Procedures: Ninety-two participants were evaluated with the Porch Index of Communicative Ability (PICA) and the Communicative Abilities in Daily Living (CADL) before and after twelve weeks of treatment. Pearson correlations examined the relationship between three variables—pretreatment PICA, CADL, and number of weeks postonset (WPO)—and outcome and amount of improvement on the PICA and CADL. Multiple regression analyses examined the contribution of the variables in predicting outcome and amount of improvement on the PICA and CADL.

Outcome & Results: All three variables were significantly correlated with outcome on the PICA and CADL. Pretreatment PICA performance and WPO were significantly, negatively correlated with amount of improvement on the PICA. Pretreatment CADL and PICA performance and WPO were significantly, negatively correlated with amount of improvement on the CADL. Multiple regression analyses indicated that initial PICA and CADL performance and WPO accounted for 83% of the variability in outcome and 47% of the variability in amount of improvement on the PICA. The same variables accounted for 78% of the variability in outcome and 48% of the variability in amount of improvement on the CADL.

Conclusions: Initial severity of aphasia (as measured by performance on the PICA and CADL) and time postonset are potentially powerful predictors of outcome and amount of improvement in the first year postonset. Controlling for the intensity of treatment, a variable known to influence outcome in aphasia, and specific biographical, behavioral, and medical variables permitted a more clear representation of the relationships among these variables compared to previous studies of prognosis in the first year postonset.

Ederly Clark, C., Conture, E., Frankel, C. & Walden, T. (November, 2010). Poster presented to American Speech Language and Hearing Association, Philadelphia, PA.

The purpose of the present study was to investigate the underlying constructs of the Communication Attitude Test for Preschool and Kindergarten Children Who Stutter (KiddyCAT; Vanryckeghem & Brutten, 2007). Extant KiddyCAT responses of 232 preschool-age children who do and do not stutter were subjected to a principal components factor analysis. Preliminary results indicate that two dimensions account for the KiddyCAT, one seemingly related to a social factor, and the other a speech-related factor. Findings further our understanding of how attitudes and/or awareness may contribute to developmental stuttering. Research supported in part by NIH Grants R01 DC000523-14 and R01 DC006477-01A2.

Frankel, C. B., Conture, E. & Walden, T. (2011). Differences in emotional processes between preschool-age children who do and do not stutter. Manuscript in preparation.

Purpose: The present study assessed whether preschool-age children who stutter (CWS) differed from preschool-age children who do not stutter (CWNS) in terms of expressed emotional reactions and emotion regulation.

Methods: Participants were nineteen preschool-age CWS (mean age = 46.5 mo, range 37-60 mo; 13 males) and 22 CWNS (mean age = 49.3 mo, range 37-59 mo; 9 males). Participants listened to auditory recordings of three “overheard” conversations (OC) between two adults (happy, angry and neutral), and after each OC, narrated a wordless picture book.

Results: CWS, when compared to CWNS, exhibited (a) less positive emotion during both listening and speaking, (b) less sensitivity to the manipulated context in their negative emotion and (c) less emotion regulation, particularly while speaking. See Figure C-6.

Conclusion: Results were taken to suggest that preschool-age CWS and CWNS differ in terms of both expressed emotion reactivity and emotional regulation and that such differences may contribute to the difficulties CWS have establishing normally fluent speech and language.

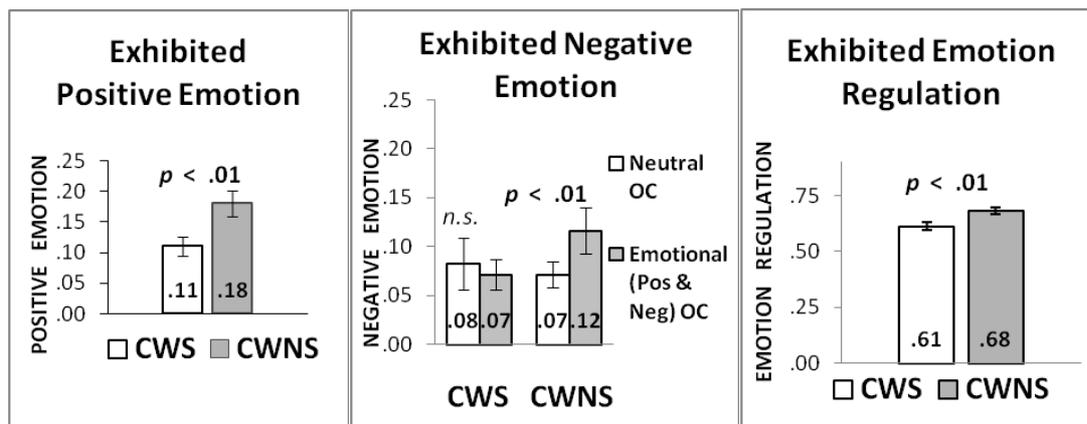


Figure C-6: Behaviorally exhibited talker-group differences in (a) positive emotion, (b) responsiveness of negative emotion, and (c) emotion regulation.

Johnson, K., Karrass, J., **Conture, E.** & Walden, T. (2009) Influence of stuttering variation on talker group classification in preschool children: Preliminary findings. *Journal of Communication Disorders*, 42, 195-210.

The purpose of this study was to investigate whether variations in disfluencies of young children who do (CWS) and do not stutter (CWNS) significantly change their talker group classification or diagnosis from stutterer to nonstutterer, and vice versa. Participants consisted of seventeen 3- to 5-year-old CWS and nine 3- to 5-year-old CWNS, with no statistically significant between-group difference in chronological age (CWS: M = 45.53 months, S.D. = 8.32; CWNS: M = 47.67 months, S.D. = 6.69). All participants had speech, language, and hearing development within normal limits, with the exception of stuttering for CWS. Both talker groups participated in a series of speaking samples that varied by: (a) conversational partner [parent and clinician], (b) location [home and clinic], and (c) context [conversation and narrative]. The primary dependent measures for this study were the number of stuttering-like disfluencies (SLD) per total number of spoken words [%SLD] and the ratio of SLD to total disfluencies (TD) [SLD/TD]. The results indicated that significant variability of stuttering did not exist as a result of conversational partner or location. Changes in context, however, did impact the CWS, who demonstrated higher SLD/TD in the conversation sample versus a narrative sample. Consistent with hypotheses, CWS and CWNS were accurately identified as stutterers and nonstutterers, respectively, regardless of changes to conversational partner, location or context for the overall participant sample. Present findings

were taken to suggest that during assessment, variations in stuttering frequency resulting from changes in conversational partner, location or context do not significantly influence the diagnosis of stuttering, especially for children not on the talker group classification borderline between CWS and CWNS. Research supported in part by NIH/NIDCD research grant 5R01DC000523-14 and a Discovery grant from Vanderbilt University.

Johnson, K., **Conture, E.** & Walden, T. (2011). Efficacy of attention regulation in preschool-age children who stutter: A preliminary study. Revised manuscript to be re-submitted for publication.

Purpose: The attentional processes of preschool-age children who do (CWS) and do not stutter (CWNS) was assessed during a traditional cueing task and an affect cueing task.

Method: Participants consisted of 12 3- to 5-year-old CWS and the same number of CWNS (all boys). Both talker groups participated in two tasks: (1) traditional cueing and (b) affect cueing. The affect cueing task was preceded by stress-heightening instructions intended to influence participants' emotionality. In both tasks participants focused on a fixation point and provided non-speech motor responses (i.e., button pressing) to computer-presented target stimuli. Targets were preceded by a visual cue (i.e., highlighted box) occurring in the same (i.e., valid trials) or opposite (i.e., invalid trials) location as the target stimuli. Reaction times (RT) were measured (in milliseconds) from the onset of the target stimuli to the onset of the non-speech motor response.

Results: Findings indicated that although there were no significant between-group differences in RT or frequency of erroneous responses, CWS and CWNS differed in type of errors exhibited during both tasks. Additionally, the validity difference of CWS and CWNS was significantly influenced by the introduction of stress-heightening instructions.

Conclusion: Findings suggest that *speed* of attentional disengaging, shifting and re-engaging does not differ between CWS and CWNS, but that the nature of CWS *errors* was influenced by the affect-stimulating condition. Research supported in part by NIH Grants R01 DC000523-14 and R01 DC006477-01A2, and a Vanderbilt University Discovery Grant

Johnson, K. N., Walden, T., **Conture, E. G.** & Karrass, J. (2010). Spontaneous regulation of emotions in preschool children who stutter: preliminary findings. *Journal of Speech, Language and Hearing Research*, 53, 1478-1495.

Purpose: Emotional regulation of preschool children who do (CWS) and do not stutter (CWNS) was assessed using a disappointing gift (DG) procedure (Cole, 1986; Saarni, 1984, 1992).

Method: Participants consisted of 16 3- to 5-year-old CWS and CWNS (11 boys and 5 girls in each talker group). After assessing each child's knowledge of display rules about socially-appropriate expression of emotions, children participated in a DG procedure and received a desirable gift preceding a free-play task and a disappointing gift preceding a second free-play task. Dependent variables consisted of participants' positive and negative expressive nonverbal behaviors exhibited *during* receipt of a desirable gift and disappointing gift, as well as conversational speech disfluencies exhibited following receipt of each gift.

Results: Findings indicated that CWS and CWNS exhibited no significant differences in amount of positive emotional expressions after receiving the desired gift; however, CWS, when compared to CWNS, exhibited more negative emotional expressions after receiving the undesirable gift (See Figure C-7). Furthermore, CWS were more disfluent after receiving the

desired gift when compared to receiving the disappointing gift. Ancillary findings also indicated that CWS and CWNS had equivalent knowledge of display rules.

Conclusion: Findings suggest that efforts to concurrently regulate emotional behaviors and (non)stutterings may be problematic for preschool-age CWS. Research supported in part by NIH Grants R01 DC000523-14 and R01 DC006477-01A2, and a Vanderbilt University Discovery Grant

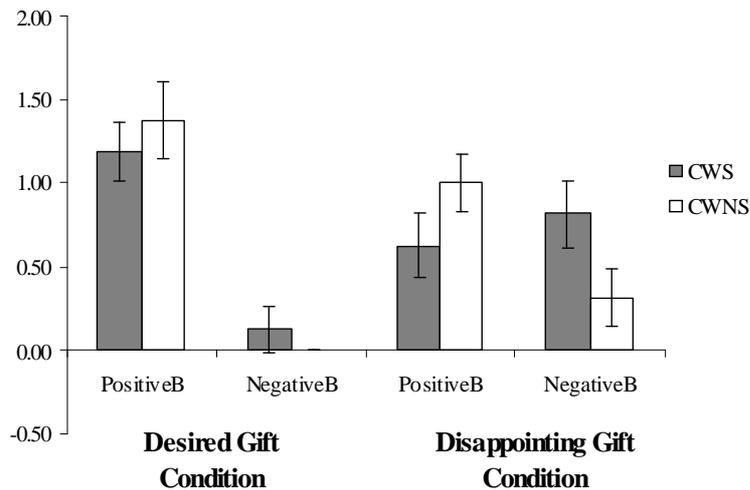


Figure C-7. Mean positive and negative expressive behaviors (\pm standard error) in both conditions (desired gift and disappointing gift) for two talker groups: preschool-age CWS (n = 16) and preschool-age CWNS (n = 16).

Jones, R., Buhr, A., Conture, E., Frankel, C. & Walden, T. (2011) Respiratory sinus arrhythmia prior and during narratives of preschool-age children who stutter. Manuscript to be submitted for publication.

Purpose: The purpose of this study was to assess whether respiratory sinus arrhythmia (RSA) of preschool-age children who do (CWS, n=16) and do not stutter (CWNS, n=15) can be reliably measured and meaningfully interpreted during talking.

Participants: Participants were 16 preschool-age CWS (13 male) and 15 preschool-age CWNS (8 male).

Methods: Participants were exposed to two emotion-inducing child video clips – angry and positive, with neutral clips used to establish pre- and post-arousal baselines, and then performed age-appropriate narrative tasks. RSA was measured while participants listen to/watch an audio-video clip presentation and perform the narrative task.

Results: Results indicated that preschool-age CWS exhibited significantly lower overall RSA and significantly greater heart period (HP) compared to their CWNS peers. In addition, CWS displayed decrease of RSA from baseline to speaking, where as CWNS displayed an increase of RSA from baseline to speaking. See Figure C-8.

Conclusions: Findings were taken to suggest that overall RSA and RSA change from baseline differ between preschool-age CWS and their CWNS peers. These apparent differences in

responsiveness to environmental challenge may contribute to difficulties these children have establishing fluent speech patterns, and they are differences that will require further empirical study during a variety of communicative and social situations. Research supported in part by an NICHD training grant (T32-CH18921), NICHD Grant P30HD15052, NIH Grants R01 DC000523-14 and R01 DC006477-01A2, and a Vanderbilt University Discovery Grant.

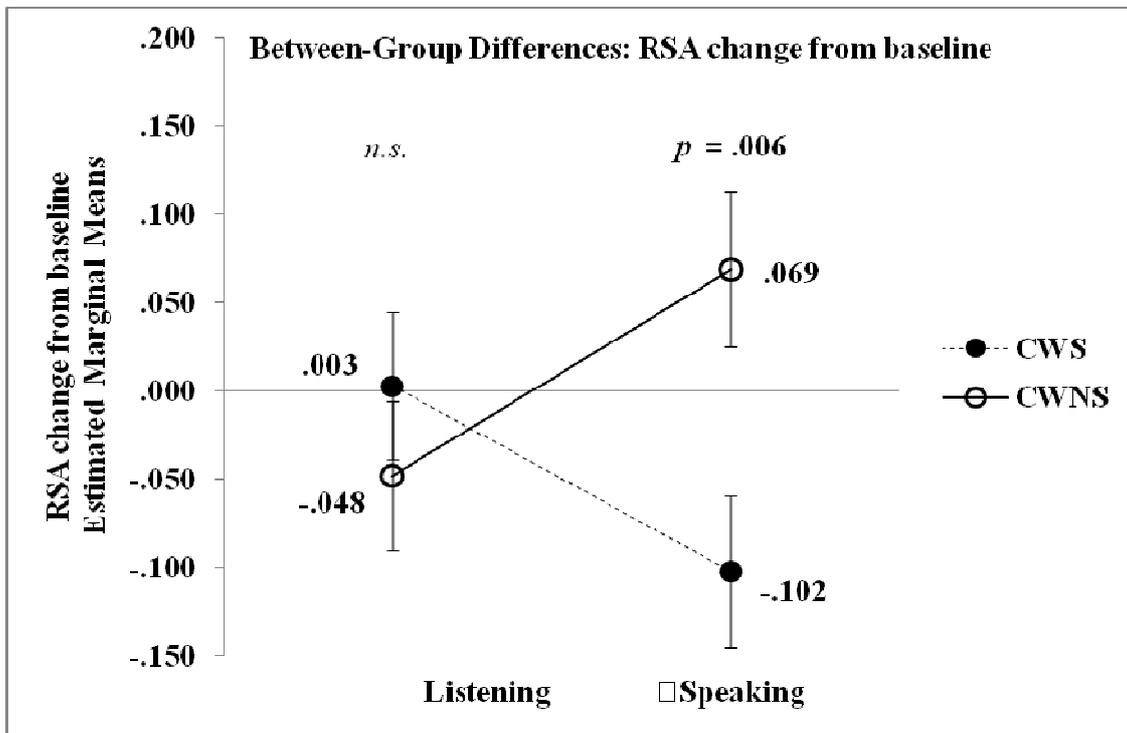


Figure C-8. Respiratory sinus arrhythmia (RSA) change from baseline: between-group interaction effect. Between-group (children who stutter, CWS, vs. children who do not stutter, CWNS) by listening versus speaking interaction effect of estimated marginal means for respiratory sinus arrhythmia (RSA) change from baseline (\pm standard error).

Jones, R., Conture, E., Frankel, C. & Walden, T. (2011). Emotional reactivity and regulation initiated prior to and during (dis)fluent utterances of preschool-age children who stutter. Manuscript submitted for publication.

Purpose: The purpose of this study was to assess the relation between emotional reactivity and regulation initiated prior to and during (dis)fluent utterances of preschool-age children who stutter (CWS).

Participants: Participants were eight preschool-age CWS and eight children who do not stutter (CWNS) aged three to five years, matched for age and gender.

Methods: Participants were exposed to three emotion-inducing overheard conversations – neutral, angry and positive, and then performed age-appropriate narrative tasks. From audio-video recordings of these narrative performances, a behavioral analysis of participants' emotional reactivity (i.e., negative affect, positive affect, and gross motor movement) and regulation (i.e., directed fidgeting) initiated prior to and during stuttered and fluent utterances was conducted.

Results: Results indicated that talker group did not significantly predict emotional reactivity or emotion regulation initiated prior to or during fluent utterances. Within-group assessment indicated that CWS' emotionally reactive behaviors were significantly more likely to initiate prior to and during their stuttered than fluent utterances. Likewise, emotion regulation was significantly more likely initiated during CWS' stuttered than fluent utterances. (See Figure C-9). **Conclusions:** Findings were taken to suggest that emotional behaviors occurring during periods of heightened speech-language planning and production may contribute to preschoolers' instances of stuttering. Research supported in part by an NICHD training grant (T32-CH18921), NICHD Grant P30HD15052, NIH Grants R01 DC000523-14 and R01 DC006477-01A2, and a Vanderbilt University Discovery Grant.

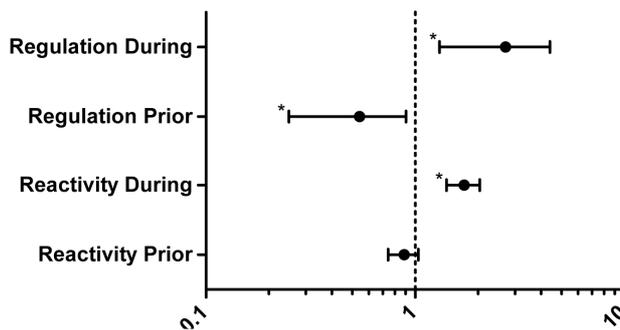


Figure C-9. Within-group (children who stutter, CWS) comparison odds ratios (\pm 95% confidence interval, CI) for stuttered versus fluent utterances across emotional reactivity and emotion regulation behaviors. Significant results are those when the 95% CI overlap with a value of one and are marked with an asterisk (*). Stuttered utterances were used as a reference category.

Ntourou, K., Conture, E. & Lipsey, M. (2011). Language abilities of children who stutter: A meta-analytical review. *American Journal of Speech-Language Pathology*, 20, 163-179.

Purpose: The purpose of this meta-analysis was to identify, integrate and summarize evidence from empirical studies of the language abilities of children who do (CWS) and do not (CWNS) stutter.

Method: Candidate studies were identified through electronic databases, the table of contents of speech-language journals, and reference lists of relevant articles and literature reviews. The 22 included studies met the following criteria: studied both children who do and do not stutter between 2;0 to 8;0 years of age and reported norm-referenced language measures and/or measures from spontaneous language samples amenable to effect size calculation. Data were extracted using a coding manual and assessed by application of general and specialized analytical software. Mean difference effect size was estimated using Hedges' g (Hedges, 1982).

Results: Findings indicated that CWS scored significantly lower than CWNS on global norm-referenced measures of language development (Hedges' $g = -0.48$), receptive (Hedges' $g = -0.52$) and expressive vocabulary (Hedges' $g = -0.41$), and mean length of utterance (MLU) (Hedges' $g = -0.23$). See Figure C-10.

Conclusions: Present findings were taken to suggest that children's language abilities are potentially influential variables associated with childhood stuttering. Research supported in part by NIH Grants (DC000523-14A1; 2R56DC000523-14A1, DC006477-01A2) and by the National Center for Research Resources, a CTSA grant (1 UL1 RR024975).

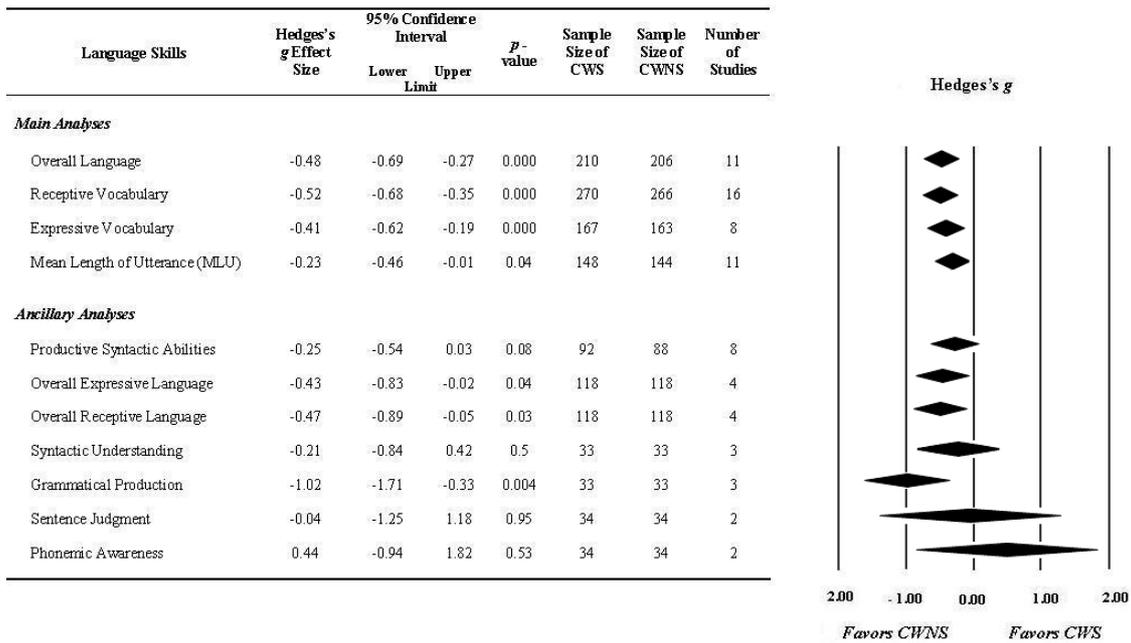


Figure C-10: Overall Mean Effect Sizes (Hedges's g) for the Language Outcome Measures. The horizontal width of the diamond represents the confidence interval and the mean effect size is at the center of the diamond.

Ntourou, K., Conture, E. G. & Walden, T. (2010). *Effects of concurrent cognitive processing on picture naming of young children who stutter.* Revised manuscript in preparation.

The purpose of this study was to assess the influence of changes in attention/monitoring on the speech reaction time (SRT) and accuracy of children who do (CWS) and do not stutter (CWNS) during a picture-naming task. In both focused (i.e., naming of pictures in presence of distractor pictures) as well as divided-attention (i.e., naming of picture while detecting the presence of another picture) tasks, a visual monitoring task was used as the secondary task, while the primary task involved picture naming. Dependent variables were the accuracy and latency (SRT) of picture naming. Results indicated that both CWS and CWNS demonstrated significantly slower SRT during the most attentionally demanding condition, the divided-attention condition; and significantly faster SRT during the control condition. However, contrary to predictions, CWS did not exhibit greater decrements in SRT when compared to their normally fluent peers. Additionally, there was no significant difference in error rate between CWS and CWNS in any of the three conditions. Finally, during the divided-attention condition, for CWNS but not CWS, there was a significant positive correlation between speed and accuracy, indicating that as SRT increased (slower naming) so did errors. Findings were taken to suggest that although preschool-age CWNS and CWS did not differ in their ability to allocate and regulate attentional resources, they did differ in their speed/accuracy relationships during attentionally-demanding tasks. Research supported in part by NIH/NIDCD research grant 1R01DC0006477-01A2.

Richels, C., **Buhr, T., Conture, E. & Ntourou, K.** (2010). Utterance complexity and stuttering on function words of preschool-age children who stutter. *Journal of Fluency Disorders*, 35(3), 314-331.

The purpose of the present investigation was to examine the relation between utterance complexity and utterance position and the tendency to stutter on function words in preschool-age children who stutter (CWS). Two separate studies involving two different groups of participants (Study 1, n = 30; Study 2 n = 30) were conducted. Participants were preschool-age CWS between the age of 3;0 and 5;11 who engaged in 15-20 minute parent-child conversational interactions. From audio-video recordings of each interaction, every child utterance of each parent-child sample was transcribed. From these transcripts, for each participant, measures of language (e.g., length and complexity) and measures of stuttering (e.g., word type and utterance position) were obtained. Results of Study 1 indicated that children stuttered more frequently on function words, but that this tendency was not greater for complex than simple utterances. Results of Study 2, involving the assessment of utterance position and MLU quartile, indicated that that stuttering was more likely to occur with increasing sentence length, and that stuttering tended to occur at the utterance-initial position, the position where function words were also more likely to occur. Findings were taken to suggest that, although word-level influences cannot be discounted, utterance-level influences contribute to the loci of stuttering in preschool-age children, and may help account for developmental changes in the loci of stuttering. Research supported in part by NIH/NIDCD research grant 5R01DC000523-14 and NIH training grant T32HD07226.

Walden, T., **Frankel, C., Buhr, A., Johnson, K., Conture, E. & Karrass, J.** (In press). Dual diathesis-stressor model of emotional and linguistic contributions to developmental stuttering. *Journal of Abnormal Child Psychology*.

This study assessed emotional and speech-language contributions to childhood stuttering. A dual diathesis-stressor framework guided this study, in which both linguistic requirements and skills, and emotion and its regulation, contribute to stuttering. The language diathesis consists of expressive and receptive language skills, and the language stressor reflects requirements of the current speaking situation. The emotion diathesis consists of proclivities to emotional reactivity and regulation of emotion, and the emotion stressor consists of experimentally manipulated emotional inductions prior to narrative speaking tasks. Preschool-age children who do and do not stutter were exposed to three emotion-producing overheard conversations—neutral, positive, and angry. Emotion and emotion-regulatory behaviors were coded while participants listened to each conversation and while telling a story after each conversation. Instances of stuttering during each story were counted. Results indicated that stuttering in preschool-age children is influenced by emotion and language diatheses, as well as coping strategies that coordinate language and emotion into children's responses to communicative/social situations. Likewise, findings indicated that stuttering was influenced by both linguistic and emotional requirements of particular speaking situations (stressors). Findings support the dual diathesis-stressor account of stuttering. Research supported in part by NIH/NIDCD research grants 1R01DC0006477-01A2, 5R01DC000523-14 and a Discovery grant from Vanderbilt University.

D. Speech and Language Science - Basic

Alaskary, H.A. & Ohde, R.N. (In preparation). The role of static and dynamic cues in the identification of voiceless stop consonants by children and adults.

The purpose of this research was to examine the role that static, dynamic and integrated cues play in the development of speech perception. Using a two-alternative forced-choice (2 AFC) paradigm, twelve adults and twelve children in each of the age groups, 3, 5, and 7 years were trained to identify place of articulation of voiceless stop consonants in CV syllables comprised of naturally produced stops [p t k] followed by the vowels [i ə u] from the full syllable and three different acoustic segments. The segments included (1) a burst only, (2) vocalic transition only, and (3) a burst + vocalic transition.

Results were interpreted and discussed based on the predictions made by the only empirically testable hypothesis that has been proposed to account for the perceptual development of sound identification in children, the developmental weighting shift hypothesis (Nittrouer & Crowther, 1998). As predicted by this hypothesis, the salience of the static cue increased as a function of listener age, with 3-year-olds being the least effective group in utilizing this cue. Contrary to predictions made by this hypothesis, the dynamic formant transition cue contributed little to the perceptual identification of place of articulation for voiceless stop consonants across all age groups. In addition to the findings regarding static and dynamic cues, the identification of integrated cues changed as a function age, with 3-year-old children utilizing the integrated cue with less accuracy than older children and adults. The phonetic informativeness of the burst and vocalic transition segments as developmental cues to place of articulation was assessed as a function of vowel context. Strong support for the development of phonetic informativeness was not obtained. However, results did support the development of perceptual consistency whereby adult-like levels of consistency were reached by age 7.

Bainbridge, N., Yoder, P., Jarzynka, M. & Tapp, J. (2010). The sequential relationship between parent attentional cues and sustained attention to objects in young children with autism. *Journal of Autism and Developmental Disorders*, 40, 200 -208. PMID: 19685286

This study examined the sequential relationship between parent attentional cues and sustained attention to objects in young children with autism during a 20 min freeplay interaction session. Twenty-five parent-child dyads with a preschool child with autism participated. Results indicated that (a) parent attentional cues that maintained the child's focus of attention were more likely to support child sustained object attention than parent attentional cues that redirected the child from his or her focus of attention or introduced a new focus of attention ($d = 4.46$), and (b) parent attentional cues that included three or more parent behaviors were more likely to support child sustained object attention than parent attentional cues that included one or two parent behaviors ($d = 1.03$).

Barako Arndt, K. & Schuele, C. M. (2009, November). *Complex syntax production in children with SLI: Longitudinal findings*. Poster session presented at the Annual Convention of the American Speech-Language-Hearing Association Convention, New Orleans, LA.

The purpose of this study was to explore the production of complex syntax in children with specific language impairment (SLI) to describe the course of complex syntax development. The study of complex syntax development in children with SLI is in its infancy. For this investigation, the spontaneous language samples of eleven children with SLI (5;2 - 7;8 at Time 1) were coded and analyzed for complex syntax. Variables included proportion of fourteen complex syntax types, frequency of complex syntax and complex syntax density within 50 and 100 utterances. Also of interest were patterns of error in production of complex syntax types. Of particular interest was inclusion of obligatory relative markers and inclusion of obligatory infinitival *to*. Growth over time was seen for a majority of the children, but complex syntax continues to be challenging for all children in this study. Growth over time was most evident with in amount and variety of compliment taking verb with an 100 utterance transcript cut. The implications of this study are both theoretical and practical in nature, with a better understanding of complex syntax development leading to the formulation of hypotheses of language development in children with SLI and guidance in relevant areas of focus in clinical intervention.

NOTE: This study was supported by NIH/NIDCD.

Barako Arndt, K. & Schuele, C. M. (In press). Production of infinitival complements by children with specific language impairment. *Clinical Linguistics and Phonetics*.

The purpose of this study was to explore the production of infinitival complements by children with SLI as compared to MLU-matched children in an effort to clarify inconsistencies in the literature. Spontaneous language samples were analyzed for infinitival complements (reduced infinitives and true infinitives). Participants included children with SLI (n = 19; 5;2 to 7;10) and children with typical language (n = 19; MLU; 3;0 to 5;9). There was no group difference in the number of infinitival complements and the number of different complement taking verbs. However, the SLI group produced more true infinitives than the MLU group. The SLI group was less accurate than the MLU group on inclusion of obligatory infinitival *to*, with 80.21% accuracy (SD = 29.42) and 99.81% accuracy (SD = 0.85), respectively. As a group children with SLI did not have problems with the clausal structure of infinitives. However, they had difficulty with the specific grammatical requirement of infinitival clauses, that is, the inclusion of the infinitival marker.

NOTE: The collection of data for this study was supported by a New Investigator Award (PI: Schuele) from the American Speech-Language-Hearing Foundation.

Carter, A. Nahmias, A. Seniz, C., Stone, W., Messinger, D. & **Yoder, P.** (2011, submitted). Initial depression moderates the effect of Hanen's More Than Words on parents' stress. *Journal of Autism and Developmental Disorders*.

This randomized controlled trial compared Hanen's "More than Words" (HMTW), a parent implemented intervention, to a "business as usual" control group. Parents of 48 toddlers who met criteria for an autism spectrum disorder (ASD) participated. Parenting stress and efficacy were measured prior to randomization (Time 1), immediately following treatment, (Time 2) and four months following treatment (Time3). Parents' level of depressive symptoms, a putative

moderator, was measured at Time 1. No main effects for HMTW were found for parenting stress or efficacy. However, treatment effects on parenting stress and efficacy changes to Time 3 were moderated by parents' Time 1 depressive symptom level. Results highlight the need to consider parents' initial mental health in evaluating the potential impact of parent-mediated interventions.

Carter, A., Stone, W., Messinger, D., Celimli, S., Nahmias, A. & Yoder, P. (2010). A randomized trial of More Than Words in toddlers with early autism symptoms. *Journal of Child Psychology and Psychiatry*.

Background: This randomized controlled trial compared Hanen's "More than Words" (HMTW), a parent-implemented intervention, to a "business as usual" control group.

Methods: Sixty-two children (51 boys and 11 girls; M age = 20 months; SD = 2.6) who met criteria for autism spectrum disorders (ASD) and their parents participated in the study. The HMTW intervention was provided over 3.5 months. There were three measurement periods: prior to randomization (Time 1) and at five- and nine-months post enrollment (Times 2 & 3). Children's communication and parent responsivity were measured at each time point. Children's object interest, a putative moderator, was measured at Time 1.

Results: There were no main effects of the HMTW intervention on either parental responsivity or children's communication. However, the effects on residualized gains in parental responsivity from Time 1 to both Times 2 and 3 yielded noteworthy effect sizes (Glass's $\Delta = .71$.50 respectively). In contrast, there were treatment effects on child communication gains to Time 3 that were moderated by children's Time 1 object interest. Children with lower levels of Time 1 object interest exhibited facilitated growth in communication; children with higher levels of object interest exhibited growth attenuation.

Conclusions: The HMTW intervention showed differential effects on child communication depending on a baseline child factor. HMTW facilitated communication in children with lower levels of Time 1 object interest. Parents of children who evidence higher object interest may require greater support to implement the HMTW strategies, or may require different strategies than those provided by the HMTW curriculum.

Dunn, M., Rodriguez, E., Miller, K., Gerhardt, C., Vannatta, K., Saylor, M., Schuele, C. M. & Compas, B. (In press). Assessment of parent-child communication in pediatric cancer: Direct observation of parental behavior, emotion, and language. *Journal of Pediatric Psychology*.

Objective: To examine the acceptability and feasibility of coding observed verbal and non-verbal behavioral and emotional components of mother-child communication among families of children with cancer.

Methods: Mother-child dyads (N=33, children ages 5-17) were asked to engage in a videotaped 15-minute conversation about the child's cancer. Coding was done using the Iowa Family Interaction Rating Scale (IFIRS).

Results: Acceptability and feasibility of direct observation in this population were partially supported: 58% consented and 81% of those (47% of all eligible dyads) completed the task; trained raters achieved 78% agreement in ratings across codes. Construct validity of the IFIRS was demonstrated by expected associations within and between positive and negative behavioral/emotional code ratings and between mothers' and children's corresponding code ratings.

Conclusions: Direct observation of mother-child communication about childhood cancer has the potential to be an acceptable and feasible method of assessing verbal and non-verbal behavior and emotion in this population.

Eisenband, L., **Schuele, C.M. & Barako Arndt, K.** (2011, June). Elicited tasks: What's important? Poster presented at the Symposium on Research in Child Language Disorders, Madison, WI.

Purpose: The purpose of this study was to explore the necessary task components of an elicited task for third-person singular tense marking. The research question addressed was: When a child produces an unmarked verb in the absence of a subject, if the child is re-prompted to provide a response that includes a subject, does the child alter the verb to be marked 3s when a subject is included?

Methods: Seventy-five preschool children participated in the study. Nearly all children were Caucasian and had a college-educated parent(s). All participants were monolingual speakers of mainstream English. Children completed the 3s probe from the Rice/Wexler Test of Early Grammatical Impairment, which includes one sample item and 10 trials. In each trial the child was shown a picture of a person engaged in an activity and the examiner provided a prompt, for example: Here is a teacher. Tell me what she does. A scorable response included a subject + verb (she teach, she teaches) or a verb marked for tense (teaches). An unscorable response was an unmarked verb without a subject (teach). Unscorable responses were prompted for the child to produced a subject along with a verb (she teach, she teaches).

Results: There were 90 trials in which children produced an unmarked verb without a subject; 86 trials were re-prompted. We were interested in the extent to which children marked the verb for tense in a re-prompted response. Re-prompted responses included 59 responses that included a subjects plus a marked 3s verb (she teaches), 7 responses that include a 3s marked verb but not subject (teachers), 5 responses included a 3s marked verb but no subject, and 15 responses were uninformative relative to the research question. To test our hypothesis, we calculated two frequencies: (a) the number of interchanges in which the child changed an unmarked verb without a subject to a subject plus a marked verb, and (b) the number of interchanges in which the child changed an unmarked verb without a subject to a subject plus an unmarked verb. We then calculated the percent of 3s marking in these total interchanges: $a / a + b$, or $59 / 66$. Children overwhelmingly included a marked verb in these contexts; 89% of re-prompted trials that included a response with a third person subject also included a main verb marked for the third person. In further analysis of the 66 trials where prompting led to the production of a response that included a third person subject, we examined whether the child (a) maintained the original verb from the unscorable response (e.g., paint) to the scorable response (e.g., she paints, she paint), or (b) altered the response to include a new verb (e.g., she colors). Children were more likely to use the same verb (54/66 or 82%). When children did alter the verb, they marked for third person singular in 100% of responses (see Table D-1).

Discussion: In elicited tasks of grammar, what are the necessary components in a child's response to ensure a valid measure of grammatical performance? Based on findings from a third-person singular probe, these data suggest that it is important to elicit the full clause containing the targeted grammatical form to ensure a valid measure of grammatical performance. In the case of the third-person singular probe, the subject was critical in eliciting the marked verb, especially for children who were prone to providing ambiguous responses when originally probed. These findings can provide guidance to other research paradigms involving elicited tasks of grammar. Clinicians may use these findings to support the use of prompting to ensure a valid measure of grammatical performance.

NOTE: The collection of this data was supported by NIH/NIDCD. This research project was completed as part of Lauren Eisenband's SPARC (Students Preparing for Academic and Research Career) Award from the American Speech-Language-Hearing Association. The conduct of this study was supported by US Department of Education, Personnel Preparation Grant (H325K090304).

**TABLE D-1
ANALYSIS OF VERB SELECTION IN REPROMPTED RESPONSES
THAT INCLUDED A SUBJECT PLUS A VERB**

	ORIGINAL VERB	NEW VERB
Marked verb	46	12
Unmarked verb	8	0

Fisher, J. & Schuele, C. M. (2009, November). Elicited infinitival complement production by preschoolers: age & socioeconomic influences. The American Speech-Language-Hearing Association Annual Convention, Technical Session, New Orleans, LA.

Purpose: The purpose of this study was to examine the production of infinitival complements by preschool children from families of lower and higher socioeconomic status (SES) background.

Methods: Eighty preschool children, ages 3;0 – 4;11, participated in an elicited story completion task adapted from Eisenberg (2005). Children were engaged in the elicited task with six verbs to elicit N-V-TO-V (1 noun) and eight N-V-N-TO-V (2 Noun) infinitival complements. Elicited productions were analyzed for the number of infinitival complements, the number of 1 noun and 2 noun infinitival complements, the percent inclusion of infinitival TO, and the number of different complement taking verbs used to produce infinitival complements. The higher SES group was primarily white and the lower SES group was primarily African American and speakers of a nonmainstream dialect.

Results: A main effect of age and SES was found for the number of infinitival complements, the number of 1 noun and 2 noun infinitival complements, and the number of different complement taking verbs used to produce infinitival complements. See Figures D-1 and D-2.

Discussion: Results are consistent with Vasilyeva and colleagues (2008), who found that children from the lower SES families used far more simple sentences in their utterances versus children from higher SES families who used more complex syntax. Vasilyeva et al. did not examine individual complex syntax types; they argued that lack of input was responsible for the decreased production of complex syntax by the children from lower SES families. Evaluation of infinitival complement production was of interest as infinitival complements are the earliest emerging form of complex syntax. The study findings indicate that children from low SES families may be less proficient in the production of complex syntax from the outset of complex syntax development. The production of infinitival complements involves a child's ability to produce a particular syntactic structure, and to do so with a variety of verbs. The limited vocabulary characteristic of children from lower SES families may play a role in course of development of complex syntax. Future studies might explore other complex syntax types across SES groups and consider the nature of complex syntax input across SES groups. NOTE: This study was supported by NIH/NIDCD and US Department of Education, PhD Leadership Grant (H325D080075).

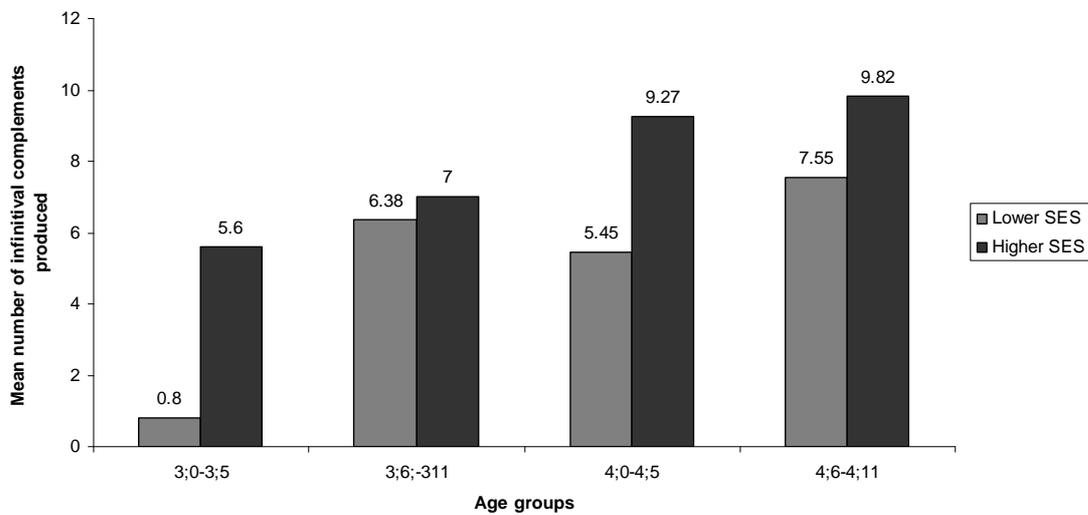


Figure D-1. Mean number of infinitival complements produced by age and SES groups.

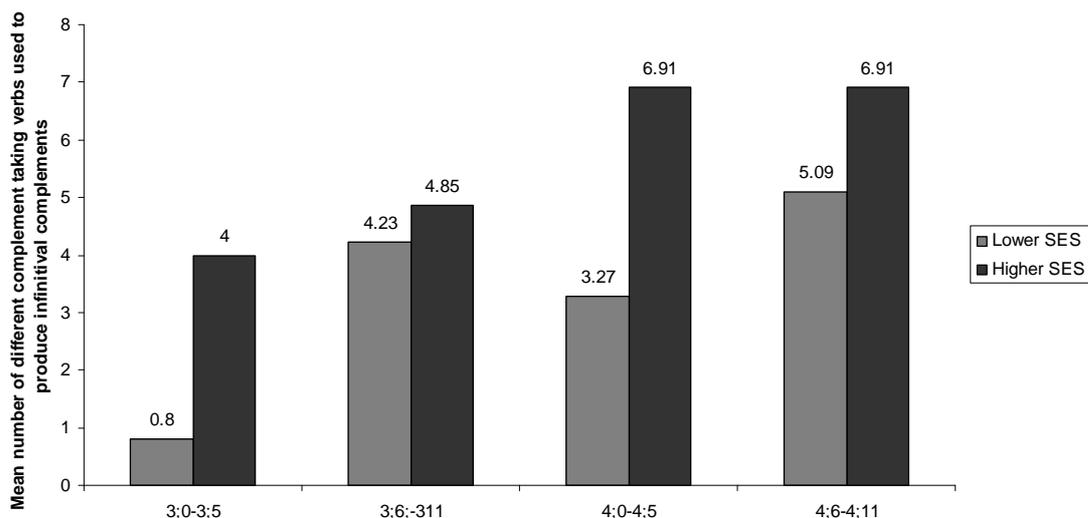


Figure D-2. Mean number of different complement taking verbs used to produce infinitival complements by age and SES groups.

Fisher, J., Schuele, C. M., Dickinson, D. & Combs, S. (2011, June). Head Start teachers' complex syntax production. Poster presentation presented at the Symposium for Research on Child Language Disorders, Madison, WI.

Purpose: The purpose of this study was to examine the production of complex syntax input Head Start teachers serving children from families of lower socioeconomic status (SES).

Introduction: Potentially, preschool classrooms offer a rich learning environment that can promote language skills necessary for literacy and academic success. Preschool teachers play a critical role in the language learning opportunities in the preschool classroom. For several

reasons, much of the language emphasis in preschool classrooms is on vocabulary. But language proficiency encompasses much more than vocabulary. Proficiency in complex syntax may also be critical for literacy and academic success.

Huttenlocher and colleagues (2002, 2008) reported that children from families of lower socioeconomic status (SES) are less proficient in complex syntax production than peers from families of higher SES. They attributed this difference to variations in parental complex syntax input. Children from low SES homes are increasingly in out-of-home care and hence, receive much of their daily language input in group care settings. Thus, we undertook a preliminary investigation of extant teacher talk data from Head Start classrooms to explore the complex syntax input children from low SES families receive in their preschool classrooms.

Methods: Fourteen Head Start teachers participated in the study. Teachers varied in years of education and experience. Each teacher was videotaped for at least 15 minutes during an art activity or a dramatic play activity. Utterances from videotaped data were transcribed into typed transcripts and coded for 11 types of complex syntax (Schuele, 2009). Archival transcripts were revised slightly to establish consistency in utterance boundaries with the conventions of Schuele (2009) transcription coding manual. Analyses of transcripts for complex syntax were conducted using the Systematic Analysis of Language Transcripts (SALT; Miller & Iglesias, 2010). The first author prepared initial transcripts data and coding for all participant transcripts, which were then checked by the second author. Disagreements were resolved by consensus. Group means and standard deviations were calculated for the dependent variables: number of complex syntax tokens across all utterances, proportion of preschool teacher complex syntax utterances, and proportion of complex syntax category (i.e., infinitive, embedding, and combining).

Results: Head Start teachers produced a mean of 149 utterances. From the mean of 149 only a mean of 24 utterances involved complex syntax; therefore, a mean proportion of .17 of Head Start teachers' utterances involved complex syntax. But there was substantial individual variation across teachers. The proportional distribution across infinitival complements, embedded clauses, and subordinate was comparable. When variables were calculated based on context, the complex syntax in art activities appeared comparable to dramatic play. This comparison was limited as there were only four teachers in the art activity context.

Discussion: Overall, these findings suggest that the majority of the language input children receive in the preschool classroom is in the form of simple sentences. We argue that Head Start teachers need to provide more diverse complex syntax input that might influence the language development of preschool children from low SES families (Vasilyeva et al., 2008). Our next step is to further explore complex syntax production by comparing preschool environments by SES.

NOTE: This study was supported by US Department of Education PhD Leadership Grant (H325D080075).

Gibson, T. & Ohde, R.N. (In preparation). Acoustic correlates of infants' concurrent babble and words: F2 Frequency and F2 Variability.

Purpose: This study examined potential speech production differences between babble and words across place of articulation for voiced stop consonants [b], [d], and [g], using spectral measurements of the second formant (F2) for early CV productions.

Method: A total of 1182 stop CV productions were collected from ten children, ages 17-22 months, who were producing concurrent babble and words. Spectral measurements of F2 yielded F2 onset (first glottal pulse) and F2 vowel (vowel target steady-state) frequencies for 500 babble and 682 word productions. F2 onset represents the anterior-posterior movement of the tongue for stop place of articulation. F2 vowel represents the front-back movement of the

tongue for vowels. Mean F2 onset and F2 vowel frequencies and their mean standard deviations (SD), SD onset and SD vowel, respectively, were statistically analyzed for babble and words across place of articulation.

Results: As shown in Table D-2, second formant measurements (F2 onset and F2 vowel) showed no speech motor differences for babble versus words. In addition, no differences were revealed in variability (SD) of speech motor movements for babble versus words. However speech production differences were noted across place of articulation. Variability parameters, SD onset and SD vowel, were significant for place of articulation. SD onset, which is indicative of the variability of tongue movement, revealed that stability of motor movement for [b], [d], and [g] was statistically different across all stop consonant comparisons. SD vowel was significantly different for alveolars when compared to bilabials and velars indicating less diverse vowel productions for alveolars. F2 onset, which provides information about anterior and posterior tongue movement, showed that [b], whose production is not constrained by tongue movement, was significantly different from [d] and [g], whose productions are shaped by constraints of opposite tongue movements. Alveolar and velar F2 onsets were marginally significant in differentiating the anterior tongue movement of [d] from the posterior tongue movement of [g]. F2 vowel revealed no statistical significance across place of articulation.

Conclusions: The results of this study support the continuity theory, which suggests that the articulatory gestures implemented in babble continue into word productions. In regard to place of articulation of stops, the toddlers differentiated motor control for consonantal occlusion of bilabials versus alveolars and velars. However, children varied in their ability to differentiate motor control for consonantal occlusions of alveolars versus velars. The importance of differences in speech motor variability was clearly observed for SD onset which showed that variability provides information about children's early speech motor movements for distinctive consonant place of articulation. [Work supported by NIH grant DC4034.]

Table D-2. Means (Hz) and standard deviations (Hz) for F2 Onset, SD Onset, F2 Vowel, SD Vowel, for babble (B) and words (W) across place of articulation.

Stop		F2 Onset		SD* Onset		F2 Vowel		SD* Vowel	
		B	W	B	W	B	W	B	W
[b]	Mean	1902	1850	403	477	2241	2320	527	673
	SD*	164	132	150	171	312	172	281	201
[d]	Mean	2762	2713	304	330	2563	2425	482	478
	SD	250	264	121	81	266	350	243	159
[g]	Mean	2496	2410	722	626	2424	2371	694	609
	SD	484	547	214	266	388	494	206	279

*SD = Standard Deviation

Guillot, K. M., Ohde, R. N. & Hedrick, M. Language Ability and Speech Perception in Children with Cochlear Implants. Poster presented at the 2010 meeting of the American Speech-Language-Hearing Association, November, 2010, Philadelphia.

This study examined the relation between language and speech perception ability in children who use cochlear implants as a function of systematic variations in place of articulation of nasal consonants. The children who use cochlear implants were divided into normal language and low language based on a norm-reference language measure. The children with normal language were more accurate on the discontinuity cue than the children with low language (Figure D-3).

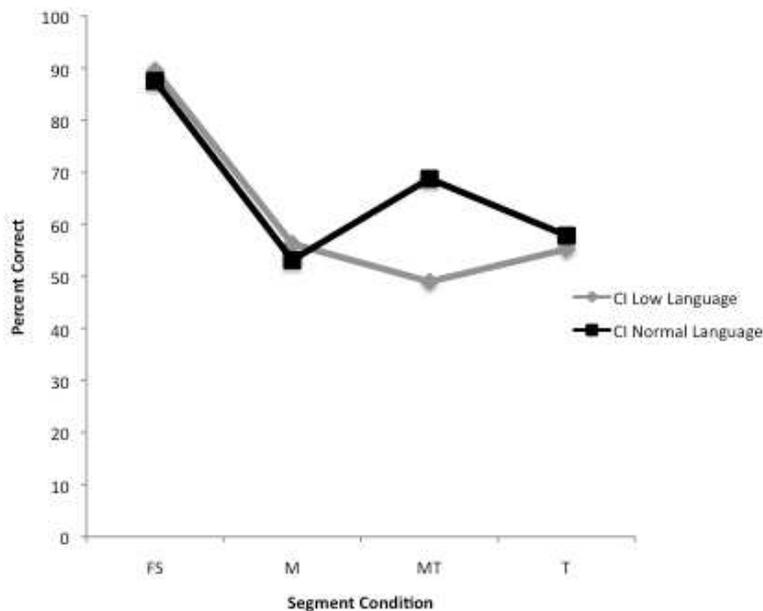


Figure D-3: Performance on the four segment conditions of the normal and low language abilities of children who use cochlear implants. FS= full syllable; M= 50 ms murmur; MT= 25 ms murmur + 25 ms transition; T= 50 ms transition.

Guillot, K.M. & Ohde, R.N. (In preparation). Development of speech perception of nasal consonants [m n] in children who use cochlear implants and in children with normal hearing.

The purpose of this study is to examine the development of speech perception in young children who use cochlear implants and in children who have normal hearing as a function of systematic variation in place of articulation of nasal consonants. The performance of the children who use cochlear implants will be compared to that of chronologically age-matched and hearing age-matched children with normal hearing, which will provide information regarding the development of speech perception in children who use cochlear implants as it relates to children with normal hearing. The participants will be presented with stimuli that were developed and used in a previous study conducted by Ohde et al. (2006). The speech stimuli will consist of nasal consonant + vowel syllables comprised of [m n] and [i æ u a]. Four stimulus segments were generated using a waveform-editing program into the following four segment types, as seen in Figure D-4. The nasal feature was selected because it provides important static (nasal murmur)

and dynamic cues (formant transitions) for perception of place of articulation. These cues also provide an important opportunity to assess developmental models of speech perception such as the sensory and acoustic discontinuity hypotheses. We predict that the children who use cochlear implants will utilize different acoustic cues than children with normal hearing in identifying nasal phonemes. In addition, it is predicted that the children who use cochlear implants in the study will rely more on the dynamic cues (formant transitions) for identifying the place of articulation rather than static cues (consonant noise). Finally, it is expected that children in particular will benefit from a combination of murmur plus vowel cues indicating the importance of spectral discontinuities in perceptual development.

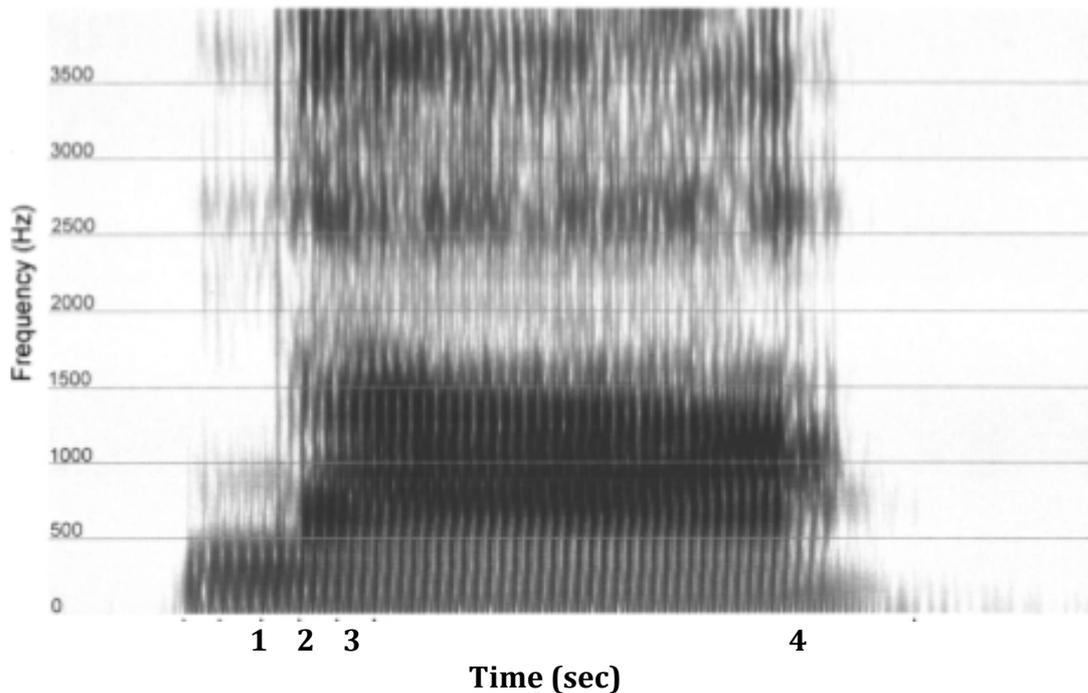


Figure D-4. (1) 50-ms murmur (50M) – the last 50 ms of the murmur; (1 to 3) 25-ms murmur + 25-ms transition (MT) – the last 25 ms of the murmur and the first 25 ms of the immediately following vowel; (2) 50-ms transition (50T) – the first 50 ms of the vowel; and (1 to 4) full syllable (FS) – the complete syllable including the full murmur and the full transition.

Lieberman, R., **Yoder, P.**, Reichow, B. & Wolery, M. (2010). Expert visual analysis of multiple-baseline across participant data showing delayed changes in the dependent variable. *School Psychology Quarterly*, 25, 28 - 44.

A within-subjects group experimental design was used to test whether three manipulated characteristics of multiple baseline across participants (MBL-P) data showing at least a month delayed change in slope affected experts' inference of a functional relation and agreement on this judgment. Thirty-six experts completed a survey composed of 16 MBL-P graphs. Graphs with steep slopes, once change began, were far more likely to be judged as showing a

functional relation. Generally, experts disagreed with each other regarding functional relation judgments. Implications for the types of dependent variables that fit the requirements of MBL-P are discussed

Lineback, A. & Schuele, C.M. (2009, November). Methods of measuring complex syntax production in preschool children. Poster session presented at the Annual Convention of the American Speech-Language-Hearing Association, New Orleans, LA.

Purpose: The purpose of this study was to provide a preliminary evaluation of several methods for exploring children's early complex syntax development.

Methods: Three three-year-old children participated in this study. Parents completed a parent report measure of complex syntax production. Children participated in an adult-child language sample interaction and elicited complex syntax tasks.

Results: The measures captured variability in children's complex syntax production.

Discussion: The measures used in this study provide promise for capturing children's early complex syntax development.

NOTE: Anna Lineback (master's SLP student) completed this project as part of her SPARC (Students Preparing for Academic and Research Careers) Award from the American Speech-Language-Hearing Association.

Malesa, E., Foss-Feig, J. Warren, Z., **Yoder, P.**, Walden, T. & Stone, W. (2011, submitted). Predicting Age 5 Language and Social Outcomes for Later-Born Siblings of Children with Autism Spectrum Disorders. *Autism*.

The relation between early joint attention and later language and social outcomes was examined in younger siblings of children with autism spectrum disorder (Sibs-ASD) and younger siblings of children with typical development (Sibs-TD). Initial levels of joint attention (at a mean age of 15 months) as well as growth of joint attention (between 15 months and 34 months) were used as potential predictors of age 5 outcomes. Results revealed that initial levels of initiating joint attention (IJA) were associated with language skills at outcome. In addition, growth of RJA was associated with social skills at outcome. Nonsignificantly different patterns of associations were found for the Sibs-TD and Sibs-ASD groups. Despite obtaining lower scores on joint attention measures at younger ages, the Sibs-ASD performed at comparable levels to the Sibs-TD on most measures at outcome.

McDuffie, A & **Yoder, P.** (2010). Types of parent verbal responsiveness that predict language in young children with autism. *Journal of Speech Language Hearing Research*, 53, 1040-1051. PMID: 20605942

Purpose: This study examined short-term predictive associations between 5 different types of parent verbal responsiveness and later spoken vocabulary for 32 young children with a confirmed diagnosis of autism spectrum disorders (ASD).

Method: Parent verbal utterances were coded from videotapes of naturalistic parent-child play sessions using interval and event-based coding. A vocabulary difference score, calculated using

the MacArthur Communicative Development Inventories, was used as the outcome measure of spoken vocabulary 6 months later.

Results: Parent follow-in comments and follow-in directives predicted spoken vocabulary after controlling for child engagement. Parent expansions of child verbal utterances predicted spoken vocabulary after controlling for child talkativeness. When entered together into a regression analysis, metrics that represented (a) the number of parent utterances following into the child's focus of attention and (b) the number of parent utterances responding to child verbal communication acts both accounted for unique variance in predicting change in spoken vocabulary from Time 1 to Time 2.

Conclusion: Parent verbal utterances that follow into the child's current focus of attention or respond to child verbal communication acts may facilitate the process of early vocabulary acquisition by mitigating the need for children with ASD to use attention-following as a word-learning strategy.

McDuffie, A., Lieberman, R. & Yoder, P. (2010, in press). Object interest in young children with autism spectrum disorders. A randomized treatment comparison. *Autism*.

A randomized control trial comparing two social-communication treatments for children with autism spectrum disorder (ASD) examined the effect of treatment on object interest. Thirty-two children, 18-60 months, were randomly assigned to the Picture Exchange Communication System (PECS) or Responsive Education and Prelinguistic Milieu Teaching (RPMT) condition. Assessment of object interest was conducted in an unstructured play session with different toys, activities, adult, and location than experienced in treatment. Results indicated children in the RPMT condition showed greater increases in object interest as compared to children in the PECS condition. Because child characteristics such as interest in objects may influence response to interventions using object-play as contexts for treatment, it is important to improve our understanding of whether intervention can affect object interest.

Oakey, M.A. & Ohde, R.N. (In preparation). The development of relative amplitude changes across acoustic discontinuities in nasal + vowel syllables.

In adult productions of nasal + vowel syllables, relative amplitude changes occur in various frequency regions across acoustic discontinuities and provide important cues as to the place of articulation of nasal consonants. The purpose of this study was to investigate the development of relative amplitude changes in children as potential acoustic correlates to place of articulation. Four age groups of 8 participants each (3, 5, 7, adults) served as speakers. Participants produced five productions each of CV syllables comprised of [m] and [n] in the context of four vowels (/a æ i u/). As shown in Figure D-5., these syllables were segmented into approximately 25 ms segments of the murmur and 25 ms segments of the vowel bordering the period of discontinuity. The relative amplitude changes in low and high frequency ranges from the murmur to the vowel were determined using summed amplitude information from fast Fourier transform (FFT) analyses. Main effects showed significance for both the factors of nasal place of articulation and vowel. The magnitude and predictability of the /m/ vs. /n/ acoustic differences were such that they support the salience of acoustic discontinuities in the perception of place of articulation. As illustrated in Figure D-6, adult /nV/ productions were significantly different from child productions, but /mV/ productions were not. This result suggests that children are

developmentally different from adults in the production of the alveolar nasal at least until the age of 7. [Work supported by NIH (DC00464 and DC00523-08) and an ASHA SPARC Award.]

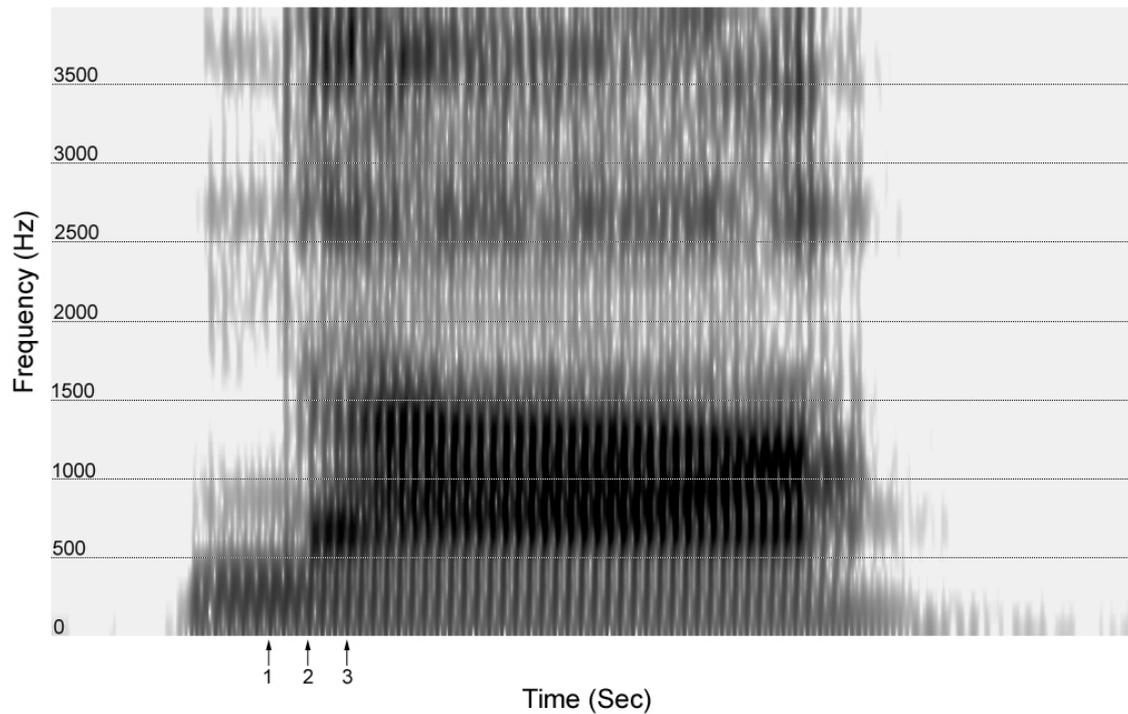


Figure D-5. A spectrographic illustration of an adult male's production of [na]. The segmentation marks (SMs) represent the following two stimulus conditions: 25-ms murmur (25M – SMs 1 to 2) and 25-ms transition (25T – SMs 2 to 3).

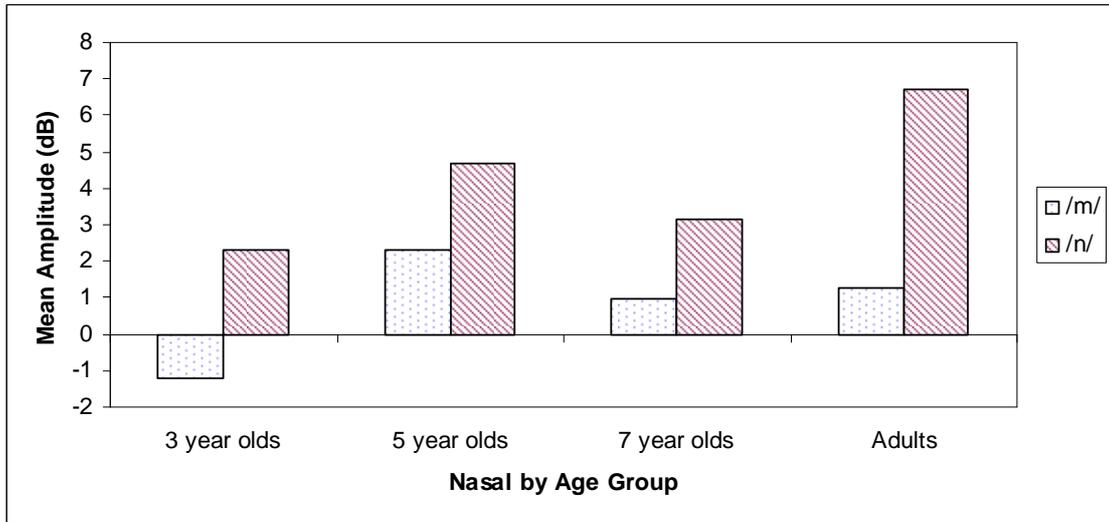


Figure D-6. Mean relative amplitude (in dB) of place of articulation of nasals across age group.

Ohde, R.N. (In preparation). Children's perception of static noise and static formant cues to stop-consonant place of articulation.

Children's processing strategies appear to favor dynamic cues such as formant transitions as compared to static cues such as F2 onsets and noise bursts. The purpose of this research was to examine children's perception of place of articulation based only on static cues. Ten children at each of five age levels (3, 4, 5, 6, and 7) and a control group of 10 adults identified synthesized stop consonants [d g] in two vowel contexts [i a]. The synthesis parameters included variations in F2 onsets and stop-consonant noise bursts. The F2 onsets were either "appropriate" or "neutral" for place of articulation. The noise bursts were short (10 ms), long (25 ms), or not present (0 ms). Preliminary data show that the F2 onset is not as salient in children's perception as in adults' perception. In addition, children more often than adults categorized neutral F2 onset stimuli as ambiguous indicating stronger category formation in the latter than former groups. The role of noise bursts was more salient in adult perception than child perception. However, as Figure D-7 illustrates, when static formant onsets were neutralized in the [a] context, all subject groups including 3-year-olds appropriately used burst cues in the perception of [g]. The findings will provide information on the role of "static" cues, on the perceptual integration of "static" noise and formant cues, and on the influence of sound category formation in perceptual development. [Work supported by NIH grant DC00464 and a Vanderbilt University Research Council Grant.]

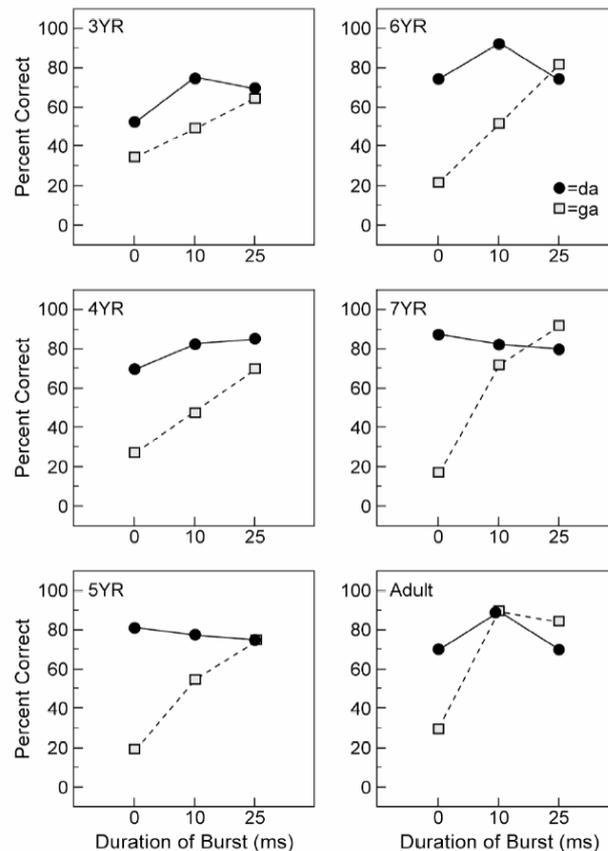


Figure D-7. Correct percent [d] and [g] responses as a function of burst duration and listener age group.

Ohde, R.N. & Camarata, S.M. (In preparation). Cue weighting of static and dynamic vowel properties by adults and children with normal language and specific language impairment.

The purpose of this study was to determine whether children with and without language impairment give more perceptual weight than do adults to dynamic spectral cues versus static cues, when identifying vowel sounds. Three experimental stimulus sets were presented, each with 30 ms stimuli. The first consisted of unchanging formant onset frequencies ranging in value from frequencies for [i] to those for [a], corresponding to a bilabial stop consonant. The second two consisted of either an [i] or [a] onset frequency with a 25 ms portion of a formant transition whose trajectory was toward one of a series of target frequencies ranging from those for [i] to those for [a]. Ten typically developing children between the ages of 3;8 and 4;1, nine children with specific language impairment (SLI) between the ages of 5;1 and 6;11, and a control group of 10 adults identified each stimulus as [bi] or [ba]. The results illustrated in Figures D-8 and D-9 showed developmental effects in that the typically developing children relied more heavily than the adults did on the static formant onset frequency cue to identify the vowels. The SLI children followed one of two perceptual profile patterns: 1) nonrandom perception of [a] onset stimuli, but random perception of [i] onset stimuli; and 2) nonrandom

perception of both [i] onset and [a] onset stimuli, but phonetic boundaries different from typically developing children and adults. The results were discussed in regard to the Developmental Perceptual Weighting Shift theory, and perceptual profile differences in SLI children.

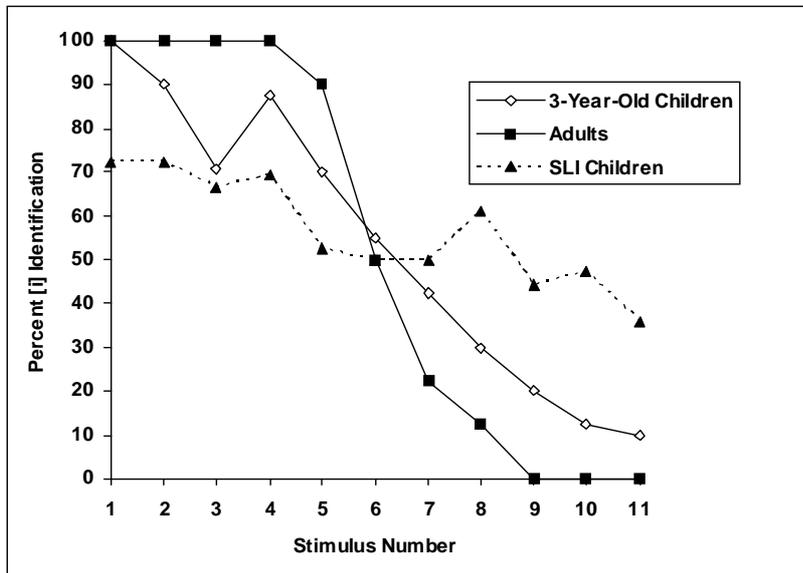


Figure D-8. Mean percent [i] identification for the F2 [i]-onset condition.

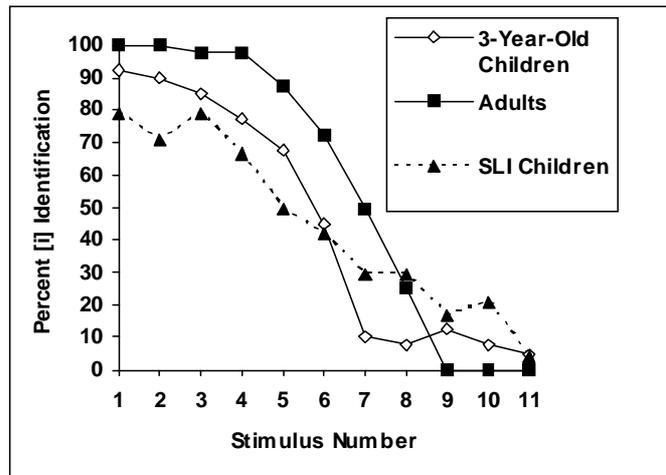


Figure D-9. Mean percent [i] identification for the F2 [a]-onset condition.

Ohde, R.N. & German, S.R. (2011). Formant onsets and formant transitions as developmental cues to vowel perception. *J. Acoust. Soc. Am.* 130, 1628-1642.

The purpose of this study was to determine whether children give more perceptual weight than do adults to dynamic spectral cues versus static cues, when identifying vowel sounds. Three experimental stimulus sets were presented, each with 30 ms stimuli. The first consisted of unchanging formant onset frequencies ranging in value from frequencies for [i] to those for [a], corresponding to a bilabial stop consonant. The second two consisted of either an [i] or [a] onset frequency with a 25 ms portion of a formant transition whose trajectory was toward one of a series of target frequencies ranging from those for [i] to those for [a]. Ten children between the ages of 3;8 and 4;1 and a control group of 10 adults identified each stimulus as [bi] or [ba]. The results showed developmental effects: the children relied more heavily than the adults did on the static formant onset frequency cue to identify the vowels, while the adults appeared to give more equal weight to both static and dynamic cues than the children did. For example, Figure D-10 illustrates that children hear fewer of the F2 [a] onset stimuli as [i] compared to adults. Thus, they appear to attend more to the [a] onset than do the adults. These findings contradict the Developmental Perceptual Weighting Shift theory and are discussed in relation to this theory and other current research on the development of vowel perception.

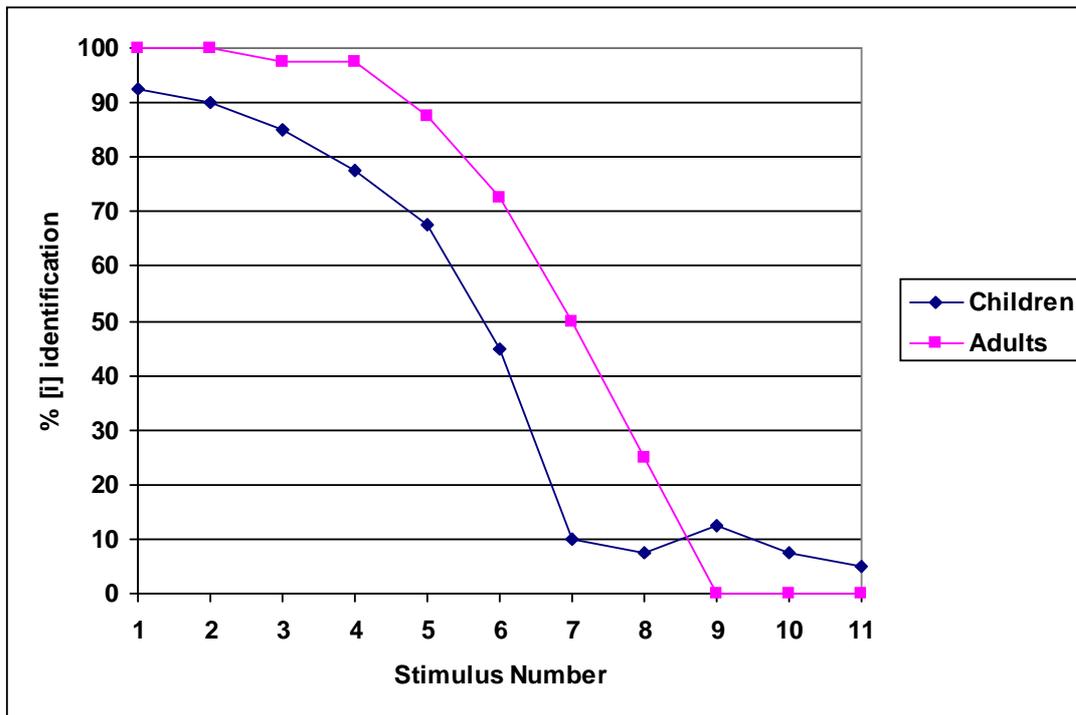


Figure D-10. Mean percent [i] responses of children and adults for the F2 [a]-onset condition.

Ohde, R. N. & Gibson, T. (In preparation). Longitudinal analysis of stop consonant-vowel productions of preterm and full term infants: A locus equation approach.

Researchers investigating prelinguistic speech have suggested that qualitative differences in consonant-vowel (CV) productions may be predictive of later speech production skills [Stoel-Gammon, *First Language* 9, 207-224 (1989)]. Qualitative differences in CV productions have been indicated in the babbling of preterm infants when compared to full term infants [Oller et al., *Journal of Child Language* 21, 33-58, (1994)]. The purpose of the current study was to investigate longitudinally the developmental trends in babbling for preterm and full term infants using locus equations to quantify the acoustic parameters. Locus equations use the F2 transition to obtain regression lines that represent relational invariant acoustic patterns for phonemic categories. The slopes and y-intercepts describe the degree of coarticulation and relational differences for place of articulation. Stop consonant-vowel productions of five full term and five preterm infants were analyzed from 8 to 17 months. The results revealed that slopes for place of articulation were significantly different, with the exception of [b] and [d]. Although preterm and full term group differences were not significant, Figure D-11 illustrates that full term infants tend to be more similar to adult coarticulation patterns than the preterm infants. Descriptive comparisons of the two groups indicated that full term infants produced more stop CV productions than preterm infants; preterm infants varied less in their coarticulation of CV syllables than full term infants; and that both groups' slope values indicate that place of articulation was less contrastive than that observed in adult or older children's slopes. In

conclusion, the results of this study support the use of the locus equation metric to describe early CV productions. [Work supported by NIH.]

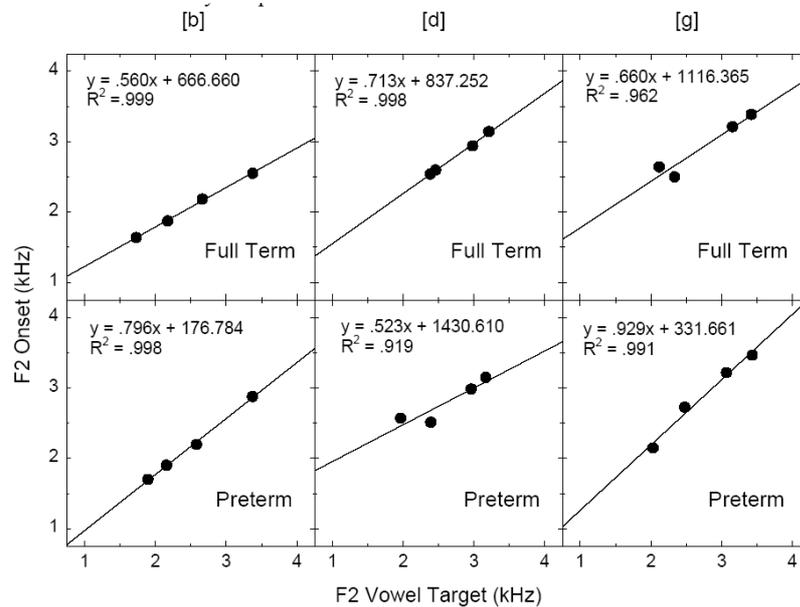


Figure D-11. Group mean locus equations for the full term infants (upper panels) and preterm infants (lower panels). Place of articulation is [b] (left panels), [d] (middle panels), and [g] (right panels). Slopes, Y-intercepts, and R² values are indicated for each regression scatterplot.

Ohde, R.N. & Hatfield, B.E. (In preparation). The development of stop consonant place of articulation in preadolescent children.

Locus equations were investigated as a metric to reflect developmental changes across a broad age range for CV syllable productions. Sixty-four subjects in eight age groups (3-, 4-, 5-, 6-, 7-, 9-, 11-year-olds and adults) produced five repetitions of isolated CV syllables in random order comprised of [b d g] and the vowels [a æ i u]. The second formant (F2) onset frequency and F2 vowel target frequency were measured for each CV syllable, and the relationships as locus equations were plotted for each stop consonant place of articulation. Locus equation statistics of slope, y-intercept, standard error of the estimate (SE), and R² were analyzed. Adult slopes were significantly different than most child group slopes (Figure D-12 illustrates the locus equations for the [g] place of articulation). Slopes for place of articulation were significantly different with the exception of [d] and [g]-palatal. Analysis of y-intercepts revealed a significant main effect for place of articulation and a significant place X age interaction. Analysis of standard error of estimate and R² showed significant main effects for age and place of articulation. In summary, the SE results indicated that children 5-years and younger were more variable in production than older children and adults. The findings for slope generally indicated a greater degree of coarticulation in children than adults. [Work supported by NIH grant DC00464.]

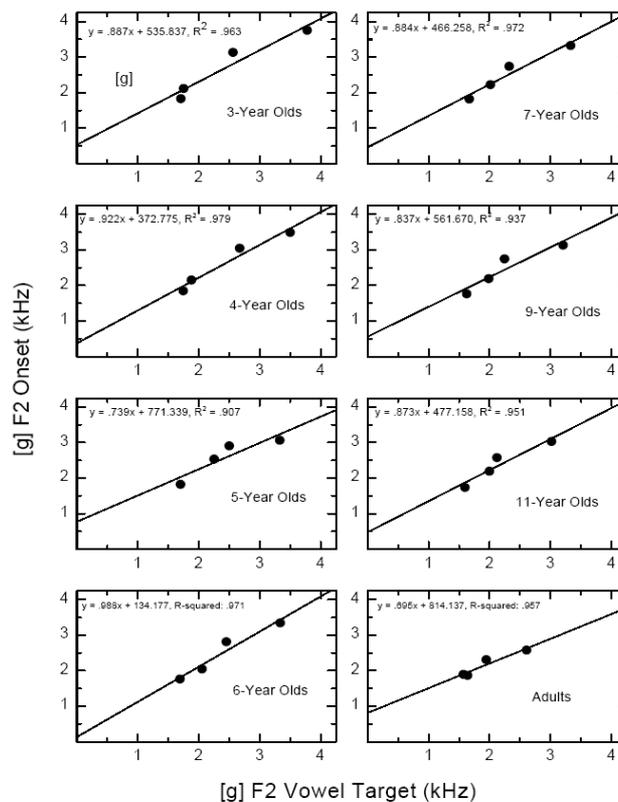


Figure D-12. Group mean locus equations for the [g] place of articulation. Slope, Y-intercept, and R-squared values are indicated for each regression scatterplot.

Ohde, R.N., Hicks, C.D., Ashmead, D. & Alaskary, H.A. (In preparation). Adult perception of the emerging vocant in toddlers.

In perceiving vowels, adults appear to use both "dynamic" formant transition cues and "static" formant target cues. The importance of these cues in perception is based on vowels produced by adults. According to theory, "dynamic" formant transition cues may be salient in adults' perception of vowels. However, the perceptual role of "dynamic" and "static" cues is unclear for vowel-like sounds (vocants) produced by vocal tracts much different from the adult vocal tract. For example, the early vocant productions by infants tend to emphasize "static" cues rather than "dynamic cues". Thus, it is unclear which cues are used by adults in the perception of infant vocants. If adults weight "dynamic" cues more than "static" cues, then poor identification of vocants would be predicted in the early infant productions. The purpose of this study is to examine adults' perceptual weighting of "dynamic" and "static" cues in the perception of infant vocants. In addition, the study will examine if an adult's ability to utilize "dynamic" versus "static" cues changes as a function of child age. The productions of three infants were recorded over a period of time from 9 months of age to 14 months of age. Vowels of the three infants judged by a panel of listeners to be of appropriate quality were edited into the following stimulus conditions: 1)

full CV stimulus, 2) vocant target, 3) vocant transition, and 4) vocant target equivalent in duration to vocant transition. Ten adults phonetically transcribe the vocant stimulus conditions of the three infants. As illustrated in Figure D-13, segment 2 for both the correct response and primary pattern response contributed most to the identification of vowels produced by infants. Segment 2 contained the static ‘target’ cues and supports the theory that the static not the dynamic information contributes to the accurate identification of vowels produced by infants.

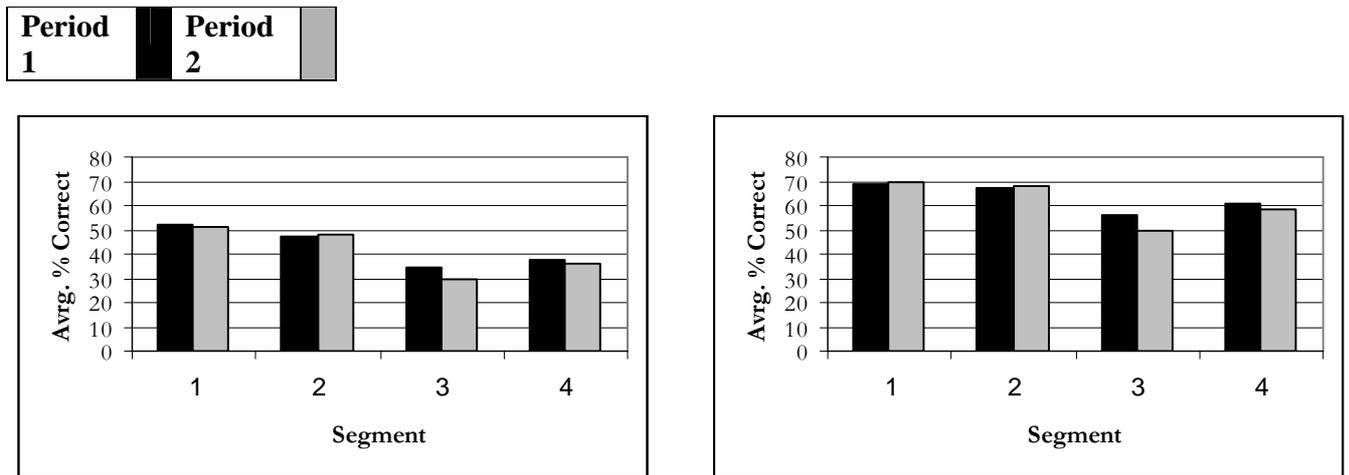


Figure D-13. All Speaker Averages for (a) Correct Responses and (b) Primary Pattern Responses for Period 1 and 2. Segment (1) represents the Full Length Syllable, (2) is the Full Vowel Portion, (3) is the Burst + Transition, and (4) is the Vowel Length that is Equivalent to Transition Length.

Ohde, R.N. & McClure, M.J. (In preparation). The development of coarticulatory and segmental properties in nasal+vowel syllables.

The vowel transitions and nasal murmurs of nasal consonant + vowel (CV) syllables were acoustically analyzed in order to identify developmental changes in coarticulatory and segmental properties of speech. Thirty-two subjects in four age groups (3-, 5-, 7-year-olds and adults) produced five repetitions of CV syllables comprised of the nasal consonants [m n] and the vowels [i æ u a]. The onset and target frequencies of the second formant (F2) of the vowel were measured for each CV syllable, and the resulting data points were plotted as locus equation regression lines to assess coarticulated properties. The second resonance peak (N2) of the nasal murmur was analyzed to assess segmental properties. The results revealed that coarticulation and variability in production decreased throughout development. As shown in Figure D-14, the N2 segmental property differentiated between [m] and [n] in children but not in adults. A measure of transition rate did not reveal extensive developmental change, but distinguished between places of articulation from a young age. These findings for nasal+vowel syllables show that both coarticulatory and segmental properties are different between children and adults. For children, there is minimum and maximum production distinction in coarticulatory and segmental properties, respectively, for place of articulation of nasals. [Work supported by NIH grant DC00464.]

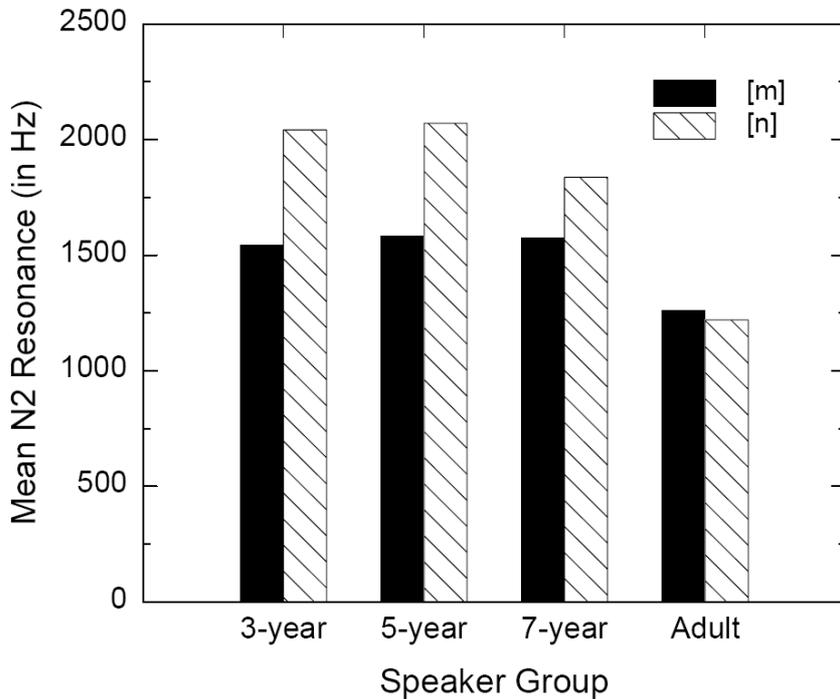


Figure D-14. Mean second nasal resonance (N2) for [m] and [n] across speaker groups.

Ohde, R.N. & Vause, N.L. (In preparation). The level of perceptual integration of place of articulation of nasal consonants from short duration segments.

Recent findings [Ohde and Perry, *J. Acoust. Soc. Am.* 96, 1303-1313 (1994); Ohde and Ochs, *J. Acoust. Soc. Am.* 100, 2486-2499 (1996)] indicate that a peripheral mechanism may be involved in processing spectral discontinuities from the nasal murmur to vowel onset. The purpose of the current study was to assess the level of perceptual integration of nasal consonants. The speech sample was comprised of CV syllables produced by a 3-year-old child and an adult female and male, and consisted of either [m] or [n] in the context of four vowels [i æ u a]. Thirteen adults identified the place of articulation of the nasal before and after the insertion of periods of silence ranging from 0 to 1000 ms between murmur and vowel transition segments of varying duration. In the experimental conditions, the murmur and the vowel were split and presented to different ears. The major findings, as illustrated in Figure D-15, were as follows: 1. Perceptual integration was significantly greater for the murmur + transition presented monaurally with a 0 ms gap duration than the comparable split channel condition; and 2. Across the split channel conditions, identification of place of articulation of the nasal was near chance level (50%). The results support the conclusion that a major component of the observed perceptual integration effect is based on a peripheral mechanism.

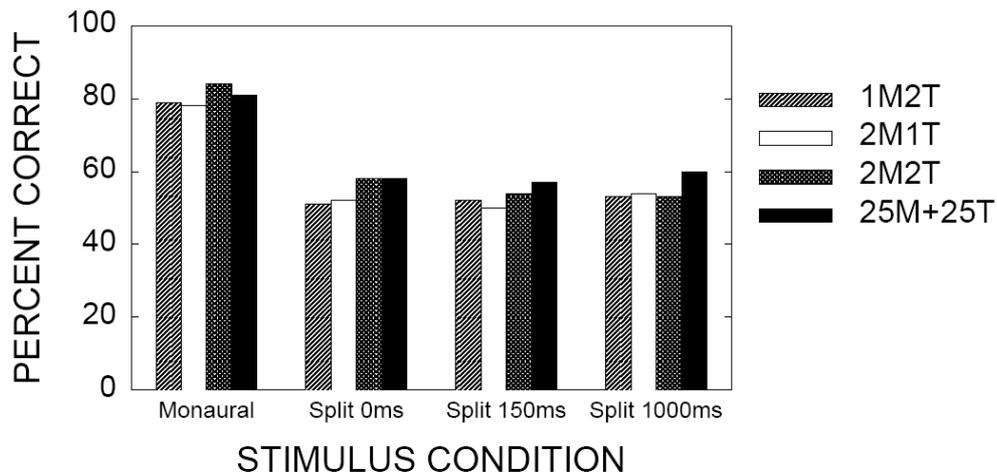


Figure D-15. Mean identification of nasal place of articulation for the adult male speaker as a function of stimulus presentation condition (Monaural: both stimuli to one ear; Split 0 ms: stimuli to different ears with 0 ms delay; Split 150 ms: stimuli to different ears with a 150 ms delay; Split 1000 ms: stimuli to different ears with a 1000 ms delay), and short duration stimuli (1M2T: one murmur + two transition periods; 2M1T: two murmur + one transition period; 2M2T: two murmur + two transition periods; 25M+25T: 25 ms murmur + 25 ms transition).

Schuele, C. M., Barako Arndt, K., Werfel, K. L., Spencer, E. J., Guillot, K. M. & Fisher, J. D. (2009, November). *Preschoolers' production of relative clauses in elicited language tasks*. Poster session presented at the Annual Convention of the American Speech-Language-Hearing Association, New Orleans, LA.

The purpose of this study was to explore the production of relative clauses using elicited language tasks with typical preschool children. Sixty-six preschool children (3;0 - 4;11) with typical language development completed elicited language tasks that targeted subject and object relative clauses. For analysis, preschool children were divided into four 6-month age groups and also into two groups based on socioeconomic status (SES). Of interest was the number of children within each age and SES group who produced the target structure and the frequency of targets produced. Additionally, analysis focused on the grammatical structure of subject relative clause responses, specifically, the inclusion of an obligatory relative marker. Four-year-old children were more proficient than three-year-old children on the production of relative clauses. Between 3;0 and 4;5, low SES children were less proficient in the production of relative clauses, but at 4;6 to 4;11, the groups performed comparably (Table D-3).

NOTE: This study was supported by NIH/NIDCD and US Department of Education, PhD Leadership Grant (H325D0800750).

Table D-3

Mean Number of Relative Clauses Produced		
	Complex Syntax Type	
	SRC	ORC
HSES		
3;0-3;5	6.7	9.3
3;6-3;11	8.5	7.0
4;0-4;5	8.2	6.0
4;6-4;11	9.2	6.7
LSES		
3;0-3;5	--	--
3;6-3;11	8.5	10.0
4;0-4;5	10.0	4.0
4;6-4;11	10.0	7.6

Simon, C.G., **Werfel, K.L. & Schuele, C.M.** (2011). Vowel representation in the spelling of kindergarten children. *Young Scientist*, 1, 13-15.

The purpose of this study was to analyze vowel representation in the spelling of monosyllabic words by kindergarten children. Fifty-seven kindergarten children from two different schools participated in the study. The children were typically developing, had no prior history of speech or language therapy, and spoke English primarily. Children who natively spoke another language were excluded for the validity of the research. The children were asked to spell seventy-four monosyllabic words with consonant blends in the second semester of their kindergarten year. Responses were analyzed for the ability to spell vowel sounds correctly and logical representation of vowels to describe differential accuracy across vowel types (front vowels, high vowels, etc.). Children demonstrated differential success, depending on the phonetic properties of vowels, including tongue height and position. These findings support an order for the way our brain learns vowels; some vowels are easier to learn than others, whether it is because there are few ways to spell or it sounds like the letter by which it is represented. Specifically, low and front vowels are the easiest for children to logically represent, whereas high and back vowels are more difficult for children to interpret.

Spencer, E. & Schuele, C.M. (2011). A preliminary examination of fast mapping part terms by preschool children from families with low socioeconomic status. Manuscript under review.

Researchers consistently find that children from low SES families have smaller vocabularies than children from higher SES families on measures of existing vocabulary knowledge. Yet few studies have examined the word learning process of children from low SES families. The present study was a preliminary examination of fast mapping by preschoolers from low SES families. The study also examined the relation between measures of existing vocabulary and performance on the fast mapping task. Forty-six

preschoolers (mean age: 4;6) from low SES families completed a part-term fast mapping task and two measures of existing vocabulary knowledge. On the fast mapping task children demonstrated use of three sources of information (familiar whole objects, possessive syntax, and whole-part juxtaposition). Measures of existing vocabulary did not correlate with performance on the fast mapping task. Findings indicate that children from low SES families make use of multiple sources information in linguistic input to learn words. NOTE: This study was completed by Elizabeth Spencer in partial fulfillment of the requirements for the Doctorate of Philosophy.

Spencer, E., Schuele, C. M., Guillot, K. & Lee, M. (In press). Phonemic awareness skill of undergraduate and graduate students relative to speech-language pathologists and other educators. *Contemporary Issues in Communication Disorders*.

Purpose: Phonemic awareness has been identified as a critical area of early literacy instruction. Evidence suggests that educators may not have sufficient phonemic awareness skill to provide effective phonemic awareness instruction. Speech-language pathologists (SLPs) demonstrate strong phonemic awareness skill relative to other educators (Spencer, Schuele, Guillot, & Lee, 2008). This study sought to identify components of speech-language pathology training that contribute to phonemic awareness skill and to examine phonemic awareness skill of students in speech-language pathology training relative to practicing SLPs and other educators.

Method: Students in speech-language pathology (n = 196) completed a paper-pencil measure of phonemic awareness. A regression analysis examined the contributions of coursework to performance on the phonemic awareness measure. Performance of students with and without phonetics was compared to speech-language pathologists (SLPs; n = 158) and other educators (kindergarten and first grade teachers, special education teachers, and reading teachers; n = 377). Patterns of performance on a phoneme segmentation task were examined.

Results: Phonetics coursework was a positive predictor of performance on the phonemic awareness measure. Students with phonetics outperformed students without phonetics and other educators but were less proficient than SLPs. Students without phonetics performed somewhat similarly to the other educators.

Implications: Phonetics coursework contributes to explicit phonemic awareness skill in students enrolled in speech-pathology coursework. But clinical practice appears to lead to more proficient performance, beyond what is acquired in graduate training. Training that develops explicit phonemic awareness skill is recommended for preservice and inservice SLPs and educators.

van Kleeck, A. & **Schuele, C. M.** (2010). Historical perspectives on literacy in early childhood. *American Journal of Speech-Language Pathology*, 19, 341-355.

Purpose: To more fully understand current trends in preliteracy research, as well as controversies that continue to surround best teaching practices, it is essential to have an understanding of the historical evolution of ideas and practices relevant to preparing young children for learning to read.

Method: Several interrelated historical movements relevant to placing current research and practices related to preliteracy development in context are reviewed. These ideas play out in the interrelated and changing ideas regarding the role of the family in children's literacy development, as well as in the appropriate curriculum for preschoolers. Both historical

reviews and original documents pertinent to the various historical trends are used to provide the current synthesis.

Conclusions: The roots of most current practices during, and controversies regarding, the preliterate period of development can be traced to a variety of different historical events, as well as to prominent philosophers and educators. Familiarity with these events, philosophers, and educators provides the perspective needed to effectively evaluate new information and approaches that come to the forefront, or that are currently being practiced by different groups or in different settings.

Werfel, K. L. & Schuele, C. M. (2009, June). A developmental exploration of kindergarten children's segmentation and representation of consonant blends. Poster presented at the Symposium on Research in Child Language Disorders, Madison, WI.

Purpose: The purpose of this study was to describe the development of kindergarten children's segmentation and representation of consonant blends and to evaluate the extent to which linguistic and phonetic features influence blend segmentation.

Method: Fifty-seven kindergarten children completed a developmental spelling measure (26 words with initial or final blends; one word per blend) three times at six-week intervals. Responses were analyzed for logical representation of speech sounds to describe developmental change and differential accuracy across blend types.

Results: Kindergarten children showed varied ability to segment and represent consonant blends and were differentially successful depending on linguistic and phonetic features of blends. Children were more likely to represent initial blends than final blends, initial l-blends than initial s- and r-blends, final nonnasal blends than final nasal blends, non-homorganic blends than homorganic blends, and initial nasal blends than final nasal blends (see Figures 1-5). The ability to segment and represent consonant blends was positively correlated with letter sound knowledge and word reading.

Conclusions: Contrary to prior evidence, the results of this study indicate that during the period of emergence, the properties of phonemes that comprise consonant blends affect children's ability to segment and represent blends. For full poster, see

<http://mc.vanderbilt.edu/language/ab>

Werfel, K.L. & Schuele, C.M. (2011, June). Error analysis of initial sound segmentation in children with hearing loss. Poster presented at the Annual Symposium on Research in Child Language Disorders, Madison, WI.

Purpose: Despite technological advances in amplification, average reading levels for children with hearing loss have not increased in the past several decades. Phonological processing deficits may contribute to poor reading outcomes. The purpose of this poster is to present the types of errors children with hearing loss made in initial sound segmentation.

Method: Two preschool children participated in individual initial sound segmentation intervention in this multiple probe design single subject study. Assessment occurred at the beginning of each session.

Results: Children's errors shifted from whole word to single sound responses during intervention. Participants exhibit different types of errors.

Conclusions: Error analysis of responses of children with hearing loss can provide insight into their ability to segment initial sounds and inform intervention targets.

Note: This study was supported by a Student Research Grant in Early Childhood Language Development awarded to the first author by the American Speech-Language-Hearing Foundation and by a Preparation of Leadership Personnel grant (H325D080075; PI: Schuele), US Department of Education.

Werfel, K. & Schuele, C. M. (2011). Segmentation and representation of consonant blends in kindergarten children's spellings. Manuscript under review.

Purpose: The purpose of this study was to describe the growth of children's segmentation and representation of consonant blends in the kindergarten year and to evaluate the extent to which linguistic features influence segmentation of consonant blends. Specifically, we were interested in the roles of word position (initial blends, final blends), class of blends, and homorganicity.

Method: Forty kindergarten children completed a developmental spelling measure (26 words with initial or final blends; one blend per word) three times at six-week intervals. Responses were analyzed for logical representation of speech sounds to describe developmental change and differential accuracy across blend types.

Results: Kindergarten children showed varied ability to segment and represent consonant blends and were differentially successful depending on linguistic and phonetic features of blends. Children were more likely to represent initial blends than final blends, initial l-blends than initial s- and r-blends, final nonnasal blends than final nasal blends, non-homorganic blends than homorganic blends, and initial nasal blends than final nasal blends. The ability to segment and represent consonant blends was positively correlated with letter sound knowledge and word reading.

Conclusions: Contrary to prior evidence, the results of this study indicate that during the period of emergence, the properties of phonemes that comprise consonant blends affect children's ability to segment and represent blends. This finding has implications for how phonological awareness and spelling instruction/intervention might proceed.

NOTE: This study was completed as part of Krystal Werfel's SPARC (Students Preparing for Academic and Research Careers) Award from the American Speech-Language-Hearing Association and was supported by the US Department of Education, PhD Leadership Grant (H325D090304).

Yoder, P. & Lieberman, R. (2010). Brief Report: Randomized Test of the Efficacy of Picture Exchange Communication System on Highly Generalized Picture Exchanges in Children with ASD. *Journal of Autism and Developmental Disorders*, 40, 629 - 632. PMID: 19904596

A randomized control trial comparing two social-communication interventions in young children with autism examined far-transfer of the use of picture exchange to communicate. Thirty-six children were randomly assigned to one of two treatment conditions, one of which was the Picture Exchange Communication System (PECS). All children had access to picture symbols during assessments. Post-treatment measurement of the number of picture exchanges in a far-transfer, assessment context favored the PECS intervention. These findings were interpreted as support for the hypothesis that the PECS curriculum can successfully teach a generalized means of showing coordinated attention to object and person without requiring eye contact to children with ASD.

Yoder, P., Molfese, D. & Gardner, E. (2010, in press). Initial MLU predicts the relative efficacy of two grammatical treatments in preschoolers with specific language impairments. *Journal of Speech, Language, Hearing, Research*. PMID pending.

Purpose: We sought to confirm predictions based on past findings that pretreatment mean length of utterance (MLU) would predict which of two grammatical treatments would best facilitate generalized and maintained grammatical development in preschoolers with specific language impairment (SLI).

Method: The participants were 57 preschoolers with SLI. A randomized group experiment was used. The 2 grammatical treatments were broad target recasts (BTR) and milieu language teaching (MLT). MLU was assessed at Time 1 in two conversational language samples. Growth rate of productive grammar was quantified using growth curve modeling on the Index of Productive Syntax (IPSyn) from two conversational language samples at each of 6 measurement periods.

Results: Predictions were confirmed for children with initially low MLU, but not for children with initially high MLUs. MLT facilitated growth of grammar better than BTR in children who were initially in Brown's stage I. Effects maintained 5 months after treatment ended.

Yoder, P., Stone, W., Walden, T., Malesa, E. (2009). Predicting social impairment in younger siblings of children with ASD. *Journal of Autism and Developmental Disorders*, 39, 1381-1391. doi: 10.1007/s10803-009-0753-0 PMID: 19449096

Later-born siblings of children with autism spectrum disorder (Sibs-ASD) are at elevated risk for social impairments. Two putative predictors of later social impairment—measures of responding to joint attention and weighted triadic communication—were examined in a sample of 43 Sibs-ASD who were followed from 15 to 34 months of age. Results revealed that initial level of responding to joint attention and growth rate of weighted triadic communication predicted the degree of social impairment at the final measurement period. Additionally, both predictors were associated with later ASD diagnosis. In contrast, unweighted triadic communication, age of entry into the study, and initial language level did not predict later social impairment. The importance of considering social outcome as a continuous variable in prospective studies of Sibs-ASD is discussed.

E. Electrophysiology and Neuroscience

Anelli, R. & Hood, L. J. 2009. Auditory steady-state responses using simultaneous multiple and intensity-ramped stimuli. American Auditory Society– T35 Mentored poster awardee.

Efficient and accurate estimation of frequency-specific hearing thresholds is essential for diagnosis and management of infants and children with hearing loss. Auditory steady-state responses (ASSR) provide objective physiologic threshold estimations and can be obtained with simultaneous presentation of multiple frequencies to both ears. The aim of this study was to compare ASSRs obtained with either two or four simultaneous stimuli and in discrete or ramped intensity paradigms. Response thresholds, noise levels and test time were assessed. Subjects were sixteen adults with normal hearing; five had participated in a previous study allowing assessment of test-retest reliability. Three stimulus conditions were compared using toneburst stimuli in an ASSR paradigm: two frequencies presented simultaneously at discrete intensities, four frequencies presented simultaneously at discrete intensities, and two simultaneous frequencies with intensity-ramping over a 40 dB range. Threshold levels for each stimulus condition were similar across frequencies, with the lowest variability and shortest test time occurring for the ramp stimulus. The results of this study show that efficiency in test time is increased while accuracy and test/re-test reliability are maintained, supporting the value of using a ramped-intensity stimuli in objective physiological testing. [Supported by NIH-NIDCD T35-DC008763]

Balaram, P., Hackett, T.A. & Kaas, J.H. (2011) VGLUT1 mRNA and protein expression in the visual system of prosimian galagos (*Otolemur garnetti*). *Eye and Brain*, in press.

The presynaptic storage and release of glutamate, an excitatory neurotransmitter, is modulated by a family of transport proteins known as vesicular glutamate transporters. Vesicular glutamate transporter 1 (VGLUT1) is widely distributed in the central nervous system of most mammalian and nonmammalian species, and regulates the uptake of glutamate into synaptic vesicles as well as the transport of filled glutamatergic vesicles to the terminal membrane during excitatory transmission. In rodents, VGLUT1 mRNA is primarily found in the neocortex, cerebellum, and hippocampus, and the VGLUT1 transport protein is involved in intercortical and corticothalamic projections that remain distinct from projections involving other VGLUT isoforms. With the exception of a few thalamic sensory nuclei, VGLUT1 mRNA is absent from subcortical areas and does not colocalize with other VGLUT mRNAs. VGLUT1 is similarly restricted to a few thalamic association nuclei and does not colocalize with other VGLUT proteins. However, recent work in primates has shown that VGLUT1 mRNA is also found in several subcortical nuclei as well as cortical areas, and that VGLUT1 may overlap with other VGLUT isoforms in glutamatergic projections. In order to expand current knowledge of VGLUT1 distributions in primates and gain insight into glutamatergic transmission in the visual system of primate species, we examined VGLUT1 mRNA and protein distributions in the lateral geniculate nucleus, pulvinar complex, superior colliculus (SC), V1, V2, and the middle temporal area (MT) of prosimian galagos. We found that, similar to other studies in primates, VGLUT1 mRNA and protein are widely distributed in both subcortical and cortical areas. However, glutamatergic projections involving VGLUT1 are largely limited to intrinsic connections within subcortical and cortical areas, as well as the expected intercortical and corticothalamic

projections. Additionally, VGLUT1 expression in galagos allowed us to identify laminar subdivisions of the SC, V1, V2, and MT.

Camalier, C.R., **de la Mothe, L. A.**, Voyles, A. C., Garcia, M. L., **Lim, S & Hackett, T. A.** (2010). Fast-spiking and regular-spiking neurons in A1 of the awake macaque: Laminar variability and response latencies. *Advances in Primate Auditory Neurophysiology Abstracts*, November 2010.

Cortical circuitry is composed of excitatory pyramidal neurons and inhibitory interneurons. Neurons in each of these categories are heterogeneous with respect to their input, outputs, neurochemistry, and neurophysiology. Units that display 'fast-spiking' waveforms have been associated with parvalbumin positive interneurons, and represent a subset of inhibitory neurons. These fast-spiking neurons have been identified in various areas of cortex including the primary auditory cortex (A1) of the cat (Atencio and Schreiner 2008). Regular-spiking units include both pyramidal neurons and interneurons. In an effort to better characterize the functional architecture of primate auditory cortex, we examine waveform shape, response latency, and depth from neurons in A1 of two awake macaques. We show that a fast-spiking subclass can be readily identified in A1. Such fast-spiking neurons generally exhibit faster response latencies than regular spiking units, consistent with what has been found in cats. Additionally, we examine differences in laminar distributions and latencies for both fast-spiking and regular-spiking units. Consistent with what has been found in other species (Sakata and Harris 2009, Wallace and Palmer 2008), average latencies in shallow layers of the primate are slower than deeper layers. Closer examination of the distributions, however, shows that the slow shallow latencies are much more variable. These results suggest timing differences both with neural class and lamina that have important implications for the understanding of auditory cortical processing.

De La Mothe, L. A., Camalier, C. R., Takahata, T. & **Hackett, T. A.** (2010). Neurochemical profile of projections from the medial geniculate to auditory cortex: expression of parvalbumin and calbindin in the macaque monkey. *Society for Neuroscience Abstracts*, November 2010.

One of the defining characteristics of auditory cortex is that the principal thalamic input is from the medial geniculate complex (MGC). The current working model divides primate auditory cortex into three regions (core, belt, and parabelt), with each region receiving a different blend of inputs from the major divisions of the MGC (Hackett, 2010). The ventral division (MGv) of the MGC is the principle source of thalamic input to the core region. Projections to the belt and parabelt regions arise largely from the dorsal division (MGd) of the MGC (comprised of anterodorsal (MGad) and posterodorsal (MGpd) subdivisions), while the magnocellular (MGm) division of the MGC projects to all areas of auditory cortex. Expression of parvalbumin (Pv) and calbindin (Cb) have been reported to be differentially distributed within the nuclei of the MGC: expression of Pv was highest in the MGv with decreased expression in the MGd, while Cb was concentrated in the MGd, with increased expression posteriorly (Molinari et al., 1995). This finding supports the proposal that two chemically defined pathways operate in the auditory system: a Pv immunoreactive lemniscal (primary) pathway, and a second Cb immunoreactive non-lemniscal pathway (Jones, 2003). Based on these results we would predict that thalamocortical projections from the MGd would preferentially express Cb and projections from the MGv would preferentially express Pv. In this study we investigate the neurochemical profiles

of these connections. An injection of Cholera Toxin Subunit-B (CTB) was made into the secondary belt region (area ML) of a macaque monkey. This injection also involved the adjacent primary core region (area A1). Consistent with known connectivity to the belt and core, retrograde labeled cells were located predominantly in the MGd but also in the MGv and MGm, which allowed the chemical characterization of thalamocortical neurons from all three nuclei. Multi-fluorescent expression of CTB, Pv, and Cb was analyzed to determine the nature of these thalamic projections. The results of this study show that most of the retrogradely labeled CTB cells express both calbindin and parvalbumin throughout the MGC, however, the levels of intensity of this expression vary. These results suggest that distribution of parvalbumin and calbindin in the MGC may not be as segregated as previously described.

Damiano, C., Catania, E., Messinger, D., Stone, W. & **Key, A.** (2010, May). Event-Related Potentials During Affective Face Processing and Social-Communicative Development in Infants at Low and High Risk for Autism Spectrum Disorders. International Meeting for Autism Research, Boston, MA.

Background: Despite the high heritability and pervasive nature of autism spectrum disorders (ASD), recent research suggests that a behaviorally-based diagnosis of ASD may not be accurate until 30 months of age (Turner & Stone, 2007). To identify individuals with ASD at younger ages, prospective studies have examined both behavioral and neural markers in infants from high-risk populations, such as infant siblings of children with ASD (sibs-ASD). In addition to being at increased risk of developing ASD, sibs-ASD often show atypical patterns of social-communicative development regardless of diagnostic outcome. The current study examines the extent to which neural correlates of affective face processing may predict later measures of social-communicative development.

Objectives: The specific aims of the current study are: 1) To determine whether 6-month-old infants are able to discriminate different degrees of positive affective expression from a neutral expression and to determine if this ability is evident in the face-specific (N290 and P400) and the non-face-specific novelty (Nc) event-related potential (ERP) components; and 2) To investigate whether individual differences in ERP amplitudes during face processing at 6 months are associated with social-communicative measures at 9 months in sibs-ASD and infant siblings of typically developing children (sibs-TD).

Methods: This study included 10 infants (1 sib-ASD and 9 sibs-TD) recruited from a larger longitudinal study of social emotional development. At 6 months of age, ERP responses were recorded during the presentation of neutral faces and faces with different degrees of positive affect (small and large smiles). At 9 months of age, parents completed the MacArthur-Bates Communicative Development Inventory (CDI) Words and Gestures form. Relations between the amplitudes of ERP components and the CDI Phrases Understood and Early Gestures subscores were examined using Pearson r correlation coefficients.

Results: Infants were able to discriminate both small and large smiles from a neutral expression, as evidenced by larger amplitudes of the P400 and Nc components in response to the positive expressions compared to the neutral. Furthermore, amplitudes of the face-specific N290 and the novelty Nc components at 6 months were related to the infant's inventory of communicative gestures at 9 months. Specifically, a larger inventory of gestures was correlated with a smaller (less negative) N290 amplitude during the neutral face condition ($r = .88, p = .02$). Greater use of gestures was also correlated with smaller (less negative) Nc amplitudes during both the big smile ($r = .95, p = .003$) and neutral conditions ($r = .85, p = .03$).

Conclusions: These findings suggest that 6-month-olds are capable of discriminating between neutral expressions and expressions of positive affect. Furthermore, neural responses during

the processing of positive affective expressions may be useful in predicting later social-communicative development. Future research will examine the potential of these ERP responses at 6 months to predict social-communicative development beyond the first year of life as well as explore the possibility that differences in these ERP responses may help to identify individuals who will later be diagnosed with ASD.

Dowell, L.E., Kadivar, H. & **Wallace, M.T.** (July, 2009). Unisensory temporal performance is predictive of the size of the temporal window of multisensory integration. Presented at the 10th Annual International Multisensory Research Forum Annual Meeting, New York, NY.

A great deal of recent research had focused on the temporal window of multisensory integration, the period of time within which multisensory stimuli are likely to be bound into a unitary construct. In contrast, few studies have attempted to relate features of unisensory temporal performance to measures of multisensory temporal processing. Studies using animal models have shown that the temporal dynamics of neuronal responses to unisensory stimuli are an important determinant of the temporal pattern of multisensory response enhancements and depressions. However, no study has demonstrated a similar relationship at the perceptual level. In the current study we attempted to accomplish this by measuring temporal thresholds on auditory and visual temporal order judgment (TOJ) tasks and relating these thresholds to the temporal window of multisensory integration as defined using two tasks - a multisensory TOJ (mTOJ) task as well as a temporally-dependent multisensory illusion (i.e., flash-beep (FB)). We found that higher visual TOJ thresholds were associated with larger temporal windows in both the multisensory TOJ ($r = .663, p < .004$) and flash-beep ($r = .418, p < .05$) tasks. In addition, higher visual TOJ thresholds were associated with increased reports of the flash-beep illusion ($r = .466, p < .02$). In contrast, auditory TOJ thresholds did not significantly correlate with window size on either multisensory task (mTOJ ($r = .397, p = .115$); FB ($r = .235, p = .292$)), or with perceptual reports on the illusory task ($r = .159, p = .447$). These results illustrate a close relationship between unisensory temporal processing and multisensory temporal processing. Future research will focus on determining the task specificity of these effects, and on better characterizing the temporal dynamics and interrelationships between unisensory and multisensory performance and perception.

Falchier A., Schroeder, C. E., **Hackett, T. A.**, Lakatos, P, Nascimento-Silva, S., Ulbert, I., Karmos, G. & Smiley, J. F. (2009) Projection from visual areas V2 and Prostriata to caudal auditory cortex in the monkey. *Cereb Cortex*, 20: 1529-38.

Studies in humans and monkeys report widespread multisensory interactions at or near primary visual and auditory areas of neocortex. The range and scale of these effects has prompted increased interest in interconnectivity between the putatively "unisensory" cortices at lower hierarchical levels. Recent anatomical tract-tracing studies have revealed direct projections from auditory cortex to primary visual area (V1) and secondary visual area (V2) that could serve as a substrate for auditory influences over low-level visual processing. To better understand the significance of these connections, we looked for reciprocal projections from visual cortex to caudal auditory cortical areas in macaque monkeys. We found direct projections from area prostriata and the peripheral visual representations of area V2 (Figure E-1). Projections were more abundant after injections of temporoparietal area and caudal parabelt than after injections of caudal medial belt and the contiguous areas near the fundus of the lateral sulcus. Only one

injection was confined to primary auditory cortex (area A1) and did not demonstrate visual connections. The projections from visual areas originated mainly from infragranular layers, suggestive of a “feedback”-type projection. The selective localization of these connections to peripheral visual areas and caudal auditory cortex suggests that they are involved in spatial localization.

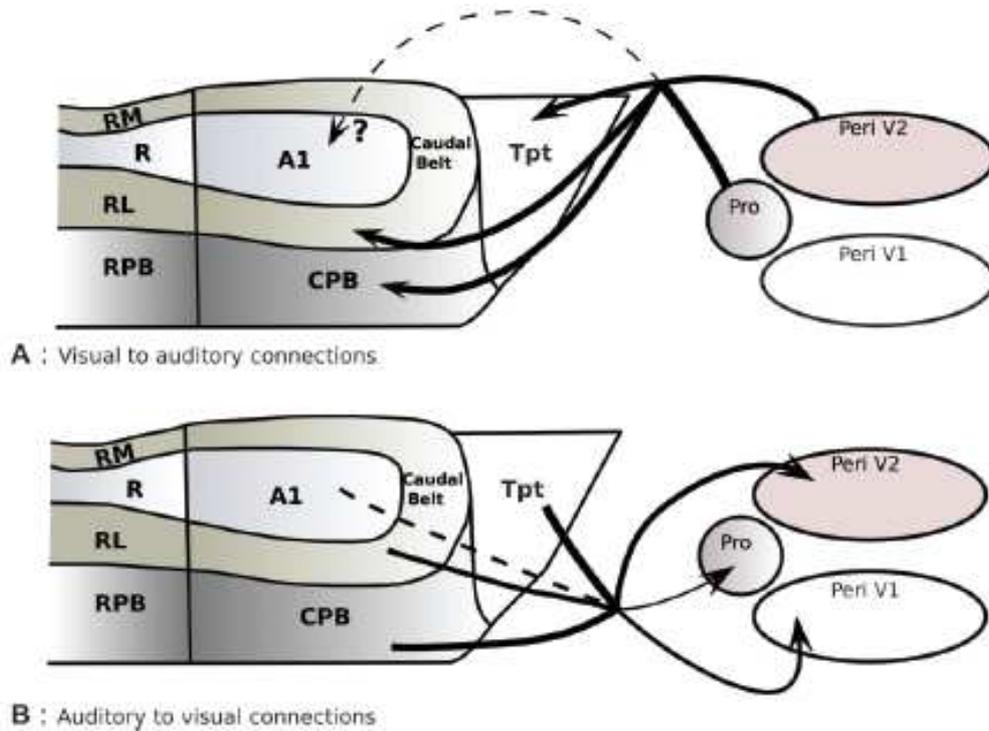


Figure E-1. Summary of cortical pathways described between caudal auditory cortex and low-level visual areas. (A) The present study demonstrated projections from the peripheral visual field representation in V2 (Peri V2) and prostriata (Pro) to caudal auditory areas. (B) The reciprocal projections from caudal auditory areas to early visual areas were previously described by Falchier et al. (2002) and Rockland and Ojima (2003). The thickness of arrows is proportional to their relative abundance. Dashed lines represent weak connections (A1 to visual) or putative pathways (visual cortex to A1, upper panel).

Foss-Feig, J.H., Kwakye, L.D., Cascio, C.J., Burnette, C.P., Kadivar, H., Stone, W.L. & **Wallace, M.T.** (2010). An extended multisensory temporal binding window in autism spectrum disorders. *Experimental Brain Research*. 203(2), 381-89.

Autism spectrum disorders (ASD) form a continuum of neurodevelopmental disorders, characterized by deficits in communication and reciprocal social interaction, as well as by repetitive behaviors and restricted interests. Sensory disturbances are also frequently reported in clinical and autobiographical accounts. However, surprisingly few empirical studies have characterized the fundamental features of sensory and multisensory processing in ASD. The current study is structured to test for potential differences in multisensory temporal function in ASD by making use of a temporally dependent, low-level multisensory illusion. In this illusion, the presentation of a single flash of light accompanied by multiple sounds often results in the

illusory perception of multiple flashes. By systematically varying the temporal structure of the audiovisual stimuli, a "temporal window" within which these stimuli are likely to be bound into a single perceptual entity can be defined. The results of this study revealed that children with ASD report the flash-beep illusion over an extended range of stimulus onset asynchronies relative to children with typical development, suggesting that children with ASD have altered multisensory temporal function (Figure E-2). These findings provide valuable new insights into our understanding of sensory processing in ASD and may hold promise for the development of more sensitive diagnostic measures and improved remediation strategies.

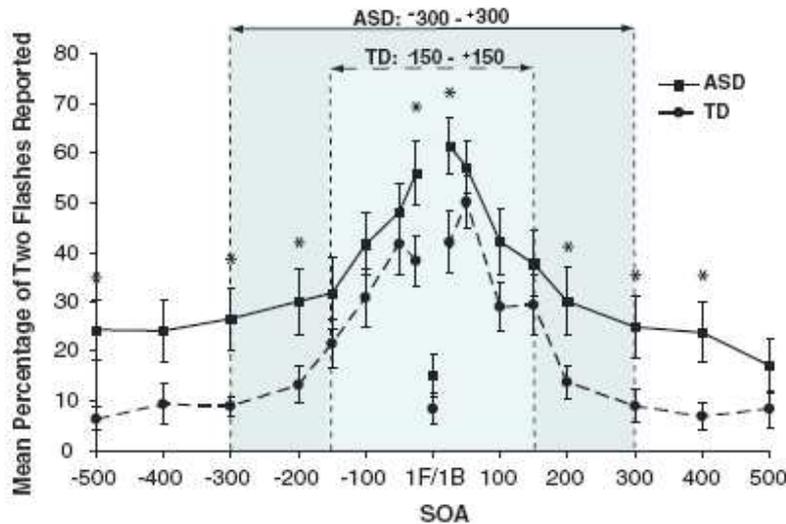


Figure E-2. Group results. The strength of the Xash-beep illusion is greater in children with ASD than in children with TD across several SOA conditions (asterisks represent $p < 0.05$; error bars represent SEM). Furthermore, the temporal window for multisensory integration is extended in ASD. Significant increases in the proportion of trials on which an illusory second flash was reported in one-flash/two-beep conditions over the proportion reported on the one-flash/one-beep control condition extend from ± 150 to ± 300 ms in children with TD, but from ± 300 to ± 300 ms in children with ASD. This difference represents a twofold increase in the temporal binding window for audiovisual stimuli in ASD.

Ghose, D., Fister, M.C. & **Wallace, M.T.** (November, 2010). The influence of spatial receptive field architecture on the temporal dynamics of multisensory interactions in the superior colliculus. Presented at the 40th Annual Society for Neuroscience, San Diego, CA.

Spatial and temporal proximity and stimulus effectiveness play a major role in shaping multisensory interactions. Emerging evidence suggests a strong interdependency between these factors such that they cannot be considered in isolation. Here we continued this analysis by focusing on how changes in stimulus location affect the temporal dynamics of both unisensory and multisensory responses in cat superior colliculus (SC) neurons. Confirming prior work, the initial analyses revealed a striking heterogeneity to the structure of the unisensory (i.e., visual and auditory) and multisensory spatial receptive fields (SRFs) of SC neurons, with dramatic differences in response magnitude being seen for stimuli positioned at different SRF locations. In addition, it was demonstrated that the SC multisensory neurons exhibited single as well as multiple excitatory regions within the

spatial receptive field architecture. This complex SRF architecture may support the role of SC in motion processing in a way that will be expanded upon. Extending this analysis further, these magnitude differences were accompanied by complex changes in temporal response dynamics, with spatially-dependent changes being seen in response latency, duration, peak firing times and rates, etc., resulting in the creation of spatiotemporal receptive field (STRF) representations. The STRF structure differed for each of the modalities and for the multisensory combination, and most importantly created a predictive framework for examining multisensory interactions in which response efficacy appeared to play a foundational role. Together, these data reveal a heterogeneity and complexity to SC STRF structure whose functional role is speculated upon.

Hackett, T.A. (2010) Information flow in the auditory cortical network. *Hearing Res.* 271: 133-146.

Auditory processing in the cerebral cortex is comprised of an interconnected network of auditory and auditory-related areas distributed throughout the forebrain. The nexus of auditory activity is located in temporal cortex among several specialized areas, or fields, that receive dense inputs from the medial geniculate complex. These areas are collectively referred to as auditory cortex. Auditory activity is extended beyond auditory cortex via connections with auditory-related areas elsewhere in the cortex. Within this network, information flows between areas to and from countless targets, but in a manner that is characterized by orderly regional, areal and laminar patterns. These patterns reflect some of the structural constraints that passively govern the flow of information at all levels of the network. In addition, the exchange of information within these circuits is dynamically regulated by intrinsic neurochemical properties of projecting neurons and their targets. This article begins with an overview of the principal circuits and how each is related to information flow along major axes of the network. The discussion then turns to a description of neurochemical gradients along these axes, highlighting recent work on glutamate transporters in the thalamocortical projections to auditory cortex. The article concludes with a brief discussion of relevant neurophysiological findings as they relate to structural gradients in the network.

Hackett, T. A. & de la Mothe, L. A. (2009) Regional and laminar distribution of the vesicular glutamate transporter, VGLUT2, in the macaque monkey auditory cortex. *J Chem Neuroanat.*, 38:106-116.

The auditory cortex of primates contains 13 areas distributed among 3 hierarchically connected regions: core, belt, and parabelt. Thalamocortical inputs arise in parallel from four divisions of the medial geniculate complex (MGC), which have regionally distinct projection patterns. These inputs terminate in layers IIIb and/or IV, and are assumed to be glutamatergic, although this has not been verified. In the present study, immunoreactivity (-ir) for the vesicular glutamate transporter, VGLUT2, was used to estimate the regional and laminar distribution of the glutamatergic thalamocortical projection in the macaque auditory cortex. Coronal sections containing auditory cortex were processed for VGLUT2 and other markers concentrated in the thalamorecipient layers: cytochrome oxidase, acetylcholinesterase, and parvalbumin. Marker expression was studied with wide field and confocal microscopy. The main findings were: (1) VGLUT2-ir was highest in the core, intermediate in the belt, and sparse in the parabelt; (2) VGLUT2-ir was concentrated in the neuropil of layers IIIb/IV in the core and layer IIIb in the belt;

(3) VGluT2-ir matched regional and laminar expression of the other chemoarchitectonic markers. The results indicate that the glutamatergic thalamic projection to auditory cortex, as indexed by VGluT2-ir, varies along the core–belt–parabelt axis in a manner that matches the gradients of other markers. See Figure E-3. These chemoarchitectonic features are likely to subserve regional differences in neuronal activity between regions of auditory cortex.

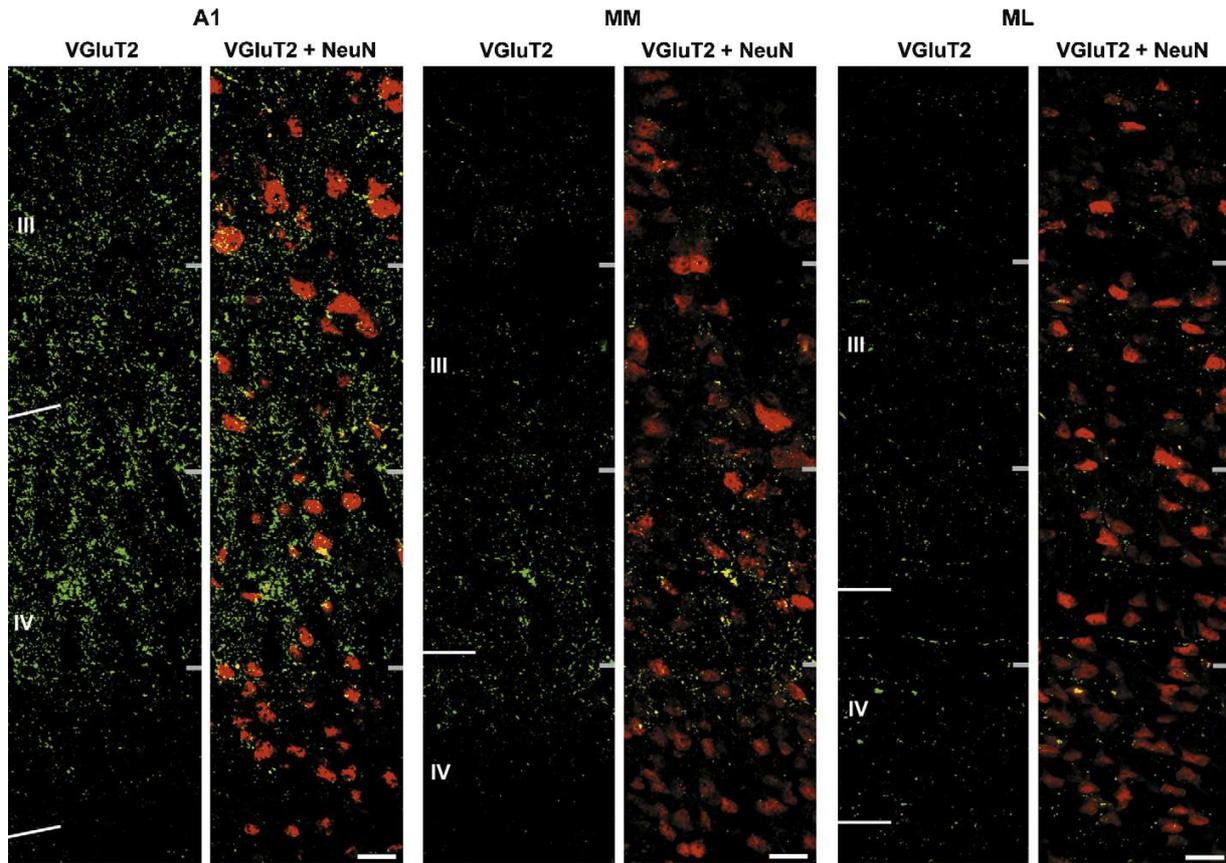


Figure E-3. Dual fluorescence confocal images of vesicular glutamate transporter 2 (VGluT2) and the neuronal marker NeuN, in auditory cortex areas A1, MM, and ML. VGluT2 expression is concentrated in layers IIIb and IV, corresponding to the location of inputs from the auditory thalamus. Each image is a four-panel confocal montage collapsed over the z-axis spanning layers III and IV. Tick marks at the right side of each image denote the bottom of each panel in the montage. Laminar boundaries are indicated by angled tick marks on the left side of each image. Scale bars, 20 μ m.

Hackett, T.A., Rinaldi Barkat, T., O'Brien, B.M., Hensch, T.K. & Polley, D.B. (2011) Linking topography to tonotopy in the mouse auditory thalamocortical circuit. *J Neurosci.*, 31(8):2983-2995.

The mouse sensory neocortex is reported to lack several hallmark features of topographic organization such as ocular dominance and orientation columns in primary visual cortex or fine-scale tonotopy in primary auditory cortex (AI). Here, we re-examined the question of auditory functional topography by aligning ultra-dense receptive field maps from the auditory cortex and thalamus of the mouse *in vivo* with the neural circuitry contained in the auditory thalamocortical slice *in vitro*. We observed precisely organized tonotopic maps of best frequency (BF) in the middle layers of AI and the anterior auditory field as well as in the ventral and medial divisions of the medial geniculate body (MGBv and MGBm, respectively). Tracer injections into distinct zones of the BF map in AI retrogradely labeled topographically organized MGBv projections and weaker, mixed projections from MGBm. Stimulating MGBv along the tonotopic axis in the slice produced an orderly shift of voltage-sensitive dye (VSD) signals along the AI tonotopic axis, demonstrating topography in the mouse thalamocortical circuit that is preserved in the slice. However, compared with BF maps of neuronal spiking activity, the topographic order of subthreshold VSD maps was reduced in layer IV and even further degraded in layer II/III. Therefore, the precision of AI topography varies according to the source and layer of the mapping signal. See Figure E-4. Our findings further bridge the gap between *in vivo* and *in vitro* approaches for the detailed cellular study of auditory thalamocortical circuit organization and plasticity in the genetically tractable mouse model.

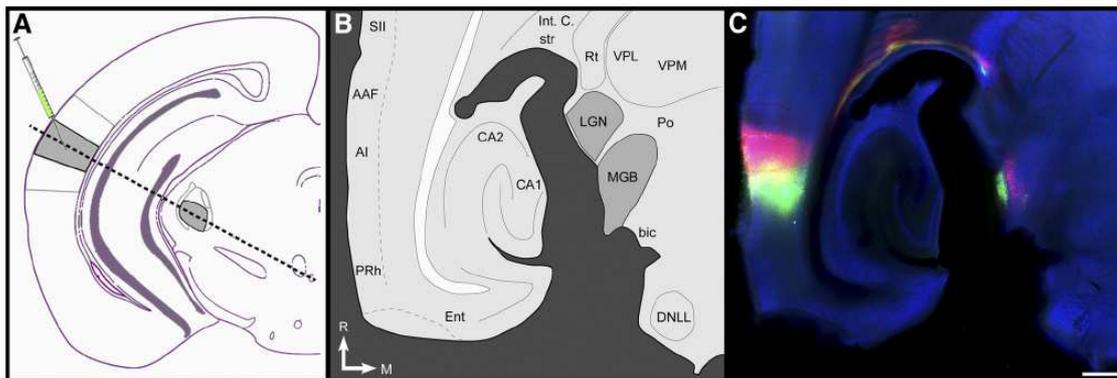


Figure E-4. Tonotopic organization of MGBv projections to AI. **A**, Schematized coronal section through the mouse brain indicating the relative locations of AI and MGBv (gray shading), the position of tracers injections, and the plane of the section used to achieve the thalamocortical slice (dashed black line). **B**, Schematic representation of major brain nuclei contained within the auditory thalamocortical brain slice. **C**, Transport of tracers from AI to MGB. CTB-green and CTB-red tracers were injected into 7 and 22.6 kHz domains in AI, respectively.

Hackett, T. A. & Schroeder, C. E. (2009). Multisensory integration in auditory and auditory-related areas of cortex, *Hearing Res*, 258:1 – 3. [Special issue, Guest editor: **T. A. Hackett**]

The articles in this issue represent a broad cross section of the efforts being brought to bear on subject of multisensory processing in and around auditory cortex. The virtual explosion of recent evidence on this theme indicates that even at its first processing stage, auditory cortex is

subject to profound non-auditory influences, and obviously, this raises more questions than it answers. Several of the papers emphasized the issue of what the auditory system has to offer (e.g., temporal resolution) and what it must borrow (e.g., spatial resolution) from vision and somatosensation. In going forward, it is worthwhile to keep this issue firmly in mind. It is likewise important to keep in mind that in both vision and somatosensation, sensory stimulation is most often “acquired” as a result of eye and hand movements, and processing is thus enslaved to a motor plan, whereas in audition this is less often the case. This contrast again underscores the importance of attention on multisensory as well as unisensory aspects of auditory processing.

Hackett, T.A., Takahata, T., Balaram, P. (2011) VGLUT1 and VGLUT2 mRNA expression in the primate auditory pathway, *Hear Res.*, 274:129-141.

The vesicular glutamate transporters (VGLUTs) regulate the storage and release of glutamate in the brain. In adult animals, the VGLUT1 and VGLUT2 isoforms are widely expressed and differentially distributed, suggesting that neural circuits exhibit distinct modes of glutamate regulation. Studies in rodents suggest that VGLUT1 and VGLUT2 mRNA expression patterns are partly complementary, with VGLUT1 expressed at higher levels in the cortex and VGLUT2 prominent subcortically, but with overlapping distributions in some nuclei. In primates, VGLUT gene expression has not been previously studied in any part of the brain. The purposes of the present study were to document the regional expression of VGLUT1 and VGLUT2 mRNA in the auditory pathway through A1 in the cortex, and to determine whether their distributions are comparable to rodents. In situ hybridization with antisense riboprobes revealed that VGLUT2 was strongly expressed by neurons in the cerebellum and most major auditory nuclei, including the dorsal and ventral cochlear nuclei, medial and lateral superior olivary nuclei, central nucleus of the inferior colliculus, sagulum, and all divisions of the medial geniculate. VGLUT1 was densely expressed in the hippocampus and ventral cochlear nuclei, and at reduced levels in other auditory nuclei. In the auditory cortex, neurons expressing VGLUT1 were widely distributed in layers II-VI of the core, belt and parabelt regions. VGLUT2 was expressed most strongly by neurons in layers IIIb and IV, weakly by neurons in layers II-IIIa, and at very low levels in layers V-VI. The findings indicate that VGLUT2 is strongly expressed by neurons at all levels of the subcortical auditory pathway, and by neurons in the middle layers of the cortex, whereas VGLUT1 is strongly expressed by most if not all glutamatergic neurons in the auditory cortex and at variable levels among auditory subcortical nuclei. These patterns imply that VGLUT2 is the main vesicular glutamate transporter in subcortical and thalamocortical (TC) circuits, whereas VGLUT1 is dominant in corticocortical (CC) and corticothalamic (CT) systems of projections. The results also suggest that VGLUT mRNA expression patterns in primates are similar to rodents, and establish a baseline for detailed studies of these transporters in selected circuits of the auditory system.

Hensel, J. & Hood, L. J. (March, 2010). Intensity effects on monaural and binaural TEOAE suppression. Poster presented at the annual meeting of the American Auditory Society, Scottsdale, AZ.

Medial olivocochlear (MOC) reflex strength, measured by suppression of transient otoacoustic emissions (TEOAE), is reduced in older adults. In addition, this reduction is greater for binaural than monaural conditions in older adults compared to younger listeners. MOC reflex strength is affected by stimulus intensity in monaural conditions; however, binaural suppressor conditions have not been evaluated. The goal of the present study was to examine intensity effects on

OAE suppression amplitude in monaural and binaural conditions in normally hearing young adults. TEOAE suppression was measured for multiple stimulus intensity levels between 45 – 65 dB peak SPL. Broadband suppressor stimuli were presented ipsilaterally, contralaterally, and binaurally. Results indicated that suppression in the binaural condition was consistently greater than monaural conditions and was constant across intensity. The lack of significant changes in suppression magnitude in the binaural condition with stimulus intensity supports a hypothesis that previously observed decreases in binaural suppression with age are related to an MOC aging effect rather than stimulus intensity differences. This further supports observed difficulties hearing in noise and loss of the ‘binaural advantage’ experienced by older listeners. [Supported by the NIH National Institute on Deafness and Other Communication Disorders (NIDCD) Short Term Research Traineeship (T35) awarded to the first author.]

Hillock, A.R. & Hood, L.J. 2010. Noise effects on the speech-evoked auditory brainstem response and syllable identification. Submitted, reviewed, now in revision.

Objective: The deleterious effects of background noise on speech understanding have been well characterized in behavioral research. However, few studies have examined the physiological effects of noise on speech syllable encoding via auditory evoked potentials in adults. The goal of the current study was to assay the systematic breakdown of brainstem responses to a speech syllable with increasing levels of background noise in the normal, adult auditory system and to explore the relationship between behavioral and physiological measures.

Design: This study examined behavioral performance on a closed-set nonsense syllable recognition task and speech-evoked brainstem responses (auditory brainstem response [ABR] and frequency following response [FFR]) in quiet and three ipsilateral pink noise conditions in 25 normal hearing adults.

Results: Findings indicated significant differences in consonant-vowel recognition scores and electrophysiological responses across conditions. Brainstem response components to speech showed differential effects on peak-to-peak amplitude, absolute peak latency and overall response morphology. No significant relationship between behavioral and physiological measures was observed.

Conclusions: Study findings confirm the deleterious effect of noise on speech understanding and demonstrate differential effects on scalp recorded speech-evoked brainstem responses. Additional research is needed to identify aspects of speech understanding that are related to the brainstem responses. Future research might involve characterization of differences in the fidelity of the speech-evoked brainstem responses of hearing impaired listeners (particularly in noise) and developmental aspects of responses with the ultimate goal of utilizing such objective approaches in infants and young children where behavioral testing is limited.

Hillock, A.R., Powers, A.R. & Wallace, M.T. (in press). Binding of sights and sounds: Age-related changes in audiovisual temporal processing. Portions of the data were presented as Poster "Maturation of audiovisual simultaneity judgment" at the 10th Annual International Multisensory Research Forum, New York, NY, July, 2009, and as Poster: "Age-related differences in audiovisual simultaneity judgment" at the American Auditory Society Scientific and Technical Meeting in Scottsdale, AZ, March, 2010.

Our world is inherently multisensory. Our ability to make assumptions about the relatedness of stimuli from the different senses is partly based on their temporal and spatial relationships.

Stimuli that are proximal in time and space are highly likely to be "bound" together by the brain and ascribed to a common external event. Hence, we can describe multisensory processes in the context of spatial and temporal filters or "windows" that compute the probability of the relatedness of multisensory stimuli and link these to their associated events. Whereas numerous studies have examined the tuning of these multisensory filters in adults, substantially less is known about the developmental sequelae leading up to the mature state. In the temporal domain, prior evidence has suggested a developmental narrowing of the multisensory window, in that infants show less capacity to detect interstimulus asynchrony; suggesting that they bind more temporally disparate stimuli when compared with adults (Lewkowicz, 1996). Despite the presence of this clear difference in multisensory temporal function between infants and adults, virtually nothing is known about how this window changes during postnatal life, and at what point it reaches its adult state. To begin to examine this issue, we compared the behavioral responses of 10 and 11 year-old children to those of adults on a simultaneity judgment task. Findings revealed significant differences between groups, in that children were more likely to report stimuli as simultaneous at moderately long stimulus onset asynchronies (150 to 350 ms) in conditions in which the auditory stimulus preceded the visual cue (Figure E-5). Consequently, these results reveal a surprisingly protracted developmental timeline for the narrowing of multisensory temporal processes, and provide the beginning of an empirical foundation for a broader study targeted toward detailing the developmental chronology of multisensory temporal function.

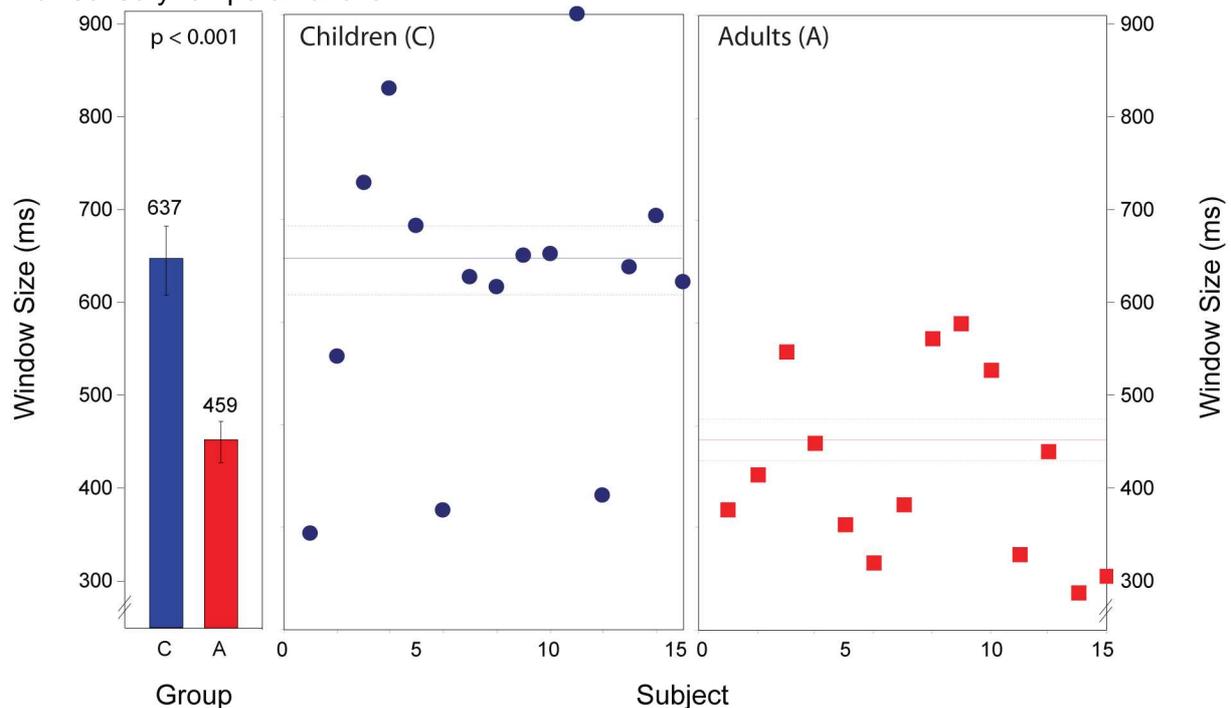


Figure E-5. Left: Bar graph displays group difference in multisensory temporal window size (i.e., distribution width at half maximum) for children (C, blue) and adults (A, red). Error bars represent +/- one standard error of the mean (SEM). Right: Scatterplots of individual window sizes for each child (blue circle) and adult (red square). Solid lines represent mean values and dotted lines denote the area encompassing +/- 1 SEM.

Kajikawa, Y., Camalier, C.R., **de la Mothe, L.A.**, D'Angelo, W.R., Sterbing-D'Angelo, S.J. & **Hackett, T.A.** (2011) Auditory cortical tuning to band-pass noise in primate A1 and CM: A comparison to pure tones. *Neurosci. Res.*, 70:401-407.

We examined multiunit responses to tones and to 1/3 and 2/3 octave band-pass noise (BPN) in the marmoset primary auditory cortex (A1) and the caudomedial belt (CM). In both areas, BPN was more effective than tones, evoking multiunit responses at lower intensity and across a wider frequency range. Typically, the best responses to BPN remained at the characteristic frequency. Additionally, in both areas responses to BPN tended to be of greater magnitude and shorter latency than responses to tones. These effects are consistent with the integration of more excitatory inputs driven by BPN than by tones. While it is generally thought that single units in A1 prefer narrow band sounds such as tones, we found that best responses for multi units in both A1 and CM were obtained with noises of narrow spectral bandwidths.

Key, A. (2009, March). Brain measures of cognitive functioning: Understanding the roles of environment and phenotype. Symposium presented at 42nd Annual Meeting of the Gatlinburg Conference on Research & Theory in Intellectual & Developmental Disabilities, New Orleans, Louisiana.

Measures of observable behavior do not always offer the most complete picture of the mechanisms underlying typical and atypical development. Noninvasive psychophysiological methods such as event-related potentials (ERPs) that reflect electrical activity of the brain provide the means to document the more subtle differences associated with the phenotype and/or environmental factors. This symposium demonstrates the value of interdisciplinary collaborations involving behavioral and brain-based measures to investigate typical and atypical functioning in children and adolescents. In particular, we demonstrate how inclusion of psychophysiological methods (ERPs) results in a more complete investigation and improved understanding of the contributions by the environmental factors (sleep restriction; prenatal cocaine exposure) and phenotypic variability within a group (autism; typical development) to observed behaviors and cognitive functioning.

Key, A., Bradham, T. & Porter, H. (2010). Auditory processing following sequential bilateral cochlear implantation: A pediatric case study using event-related potentials. *Journal of the American Academy of Audiology*, 21, 225-238.

The study examined auditory development in a child who received bilateral cochlear implants sequentially. Brain responses were recorded using two passive paradigms involving auditory perception (listening to speech syllables) and word-level processing (word-picture matching). Testing occurred prior to activation of the second cochlear implant and at 2, 4, and 6 months post-activation. The participant was a 6-year-old female child with the diagnosis of bilateral profound sensorineural hearing loss. She received the first cochlear implant in her right ear at the age of 2 years, 4 months, underwent revision surgery for lack of progress in the same ear at age 3 years, 6 months and received a second cochlear implant in the left ear at 6 years, 8 months of age. Auditory stimuli were presented at 75 dB SPL(A) through a speaker above the participant's head with the cochlear implant(s) at typical user settings. Cortical responses were recorded from 128 electrodes and demonstrated progressive improvement in processing of individual syllables and words. The results suggest that sequential bilateral cochlear

implantation contributes to improved auditory processing beyond the benefits of the single implant even in a user with extended period of deafness in the later-implanted ear.

Key, A., Damiano, C., Vinson, A., Catania, E., Henderson, H., Messinger, D. & Stone, W. (2011, March). Visual processing of facial affect in 9 month-old infants. Society for Research in Child Development, Montreal, Canada.

Later-born siblings of children with ASD (sibs-ASD) exhibit substantial variability in their social-communicative outcomes, with some manifesting behaviors consistent with an autism spectrum diagnosis, others exhibiting less severe symptoms such as language delay, and others demonstrating no detectable disorder. The purpose of this study was to investigate whether sibs-ASD process facial displays of positive affect differently from siblings of children with typical development (sibs-TD) and whether such differences are related to individual differences in language/communicative functioning and autism symptomatology.

Visual event-related potentials (ERPs) and eye tracking data were recorded in 13 9-month-old infants (6 sibs-ASD) while they viewed color photographs of unfamiliar female faces. The faces were presented using an oddball paradigm in which neutral expression served as the standard face (70% of the trials) while the same face displaying either a small smile or a big (Duchenne) smile served as the target (30%). ERPs were recorded using a 124-channel Geodesic sensor net. Eye tracking data were obtained using a table-mounted device (Tobii x50 series).

There were no group differences in the distribution, number, or duration of fixations on face stimuli. ERPs indicated that all infants distinguished neutral faces from big smiles (reflected in amplitude of the left temporoparietal N290). Detecting a change from neutral expression to small smiles resulted in shorter latencies of N290/P400 but no amplitude changes. Within-group analyses indicated that in sibs-TD, change in affective expression altered only face-sensitive temporoparietal N290/P400 responses; while in sibs-ASD, such changes also elicited the more general novelty response (frontocentral Nc).

The extent to which early differences in ERP markers of positive facial affect discrimination at 9 months can explain variability in social-communicative functioning at 12 months of age was examined using correlations between ERPs and language scores on the Mullen Scales of Early Learning and social-communicative performance on the Screening Tool for Autism in Toddlers (STAT). In sibs-TD, the more positive face-sensitive, right temporoparietal N290/P400 responses to small smiles at 9 months correlated with higher receptive language scores at 12 months. A larger Nc response to the big smile was associated with lower social-communicative score on the STAT. Alternatively, in sibs-ASD, brain-behavior associations were limited to the neutral expression. Larger left temporoparietal P400 was associated with decreased social-communicative performance, while smaller frontocentral Nc response was associated with better receptive language scores.

The results indicate that despite the absence of observable differences in face scanning behavior, 9-month-old sibs-ASD may process facial displays of positive affect using atypical brain mechanisms. In particular, greater engagement of general novelty detection processes (frontocentral Nc) were associated with poorer social-communicative functioning (Figure E-6), suggesting that infants engaging alternate mechanisms for detecting changes in facial affect may demonstrate greater social-communicative deficits at 12 months of age. Evidence of predictive associations between earlier brain responses to faces and later performance on

behavioral assessments of language/communicative functioning and autism symptomatology suggests that infants' sensitivity to differences in the degree of affective expression may serve as one of the indicators of risk for atypical developmental outcomes.

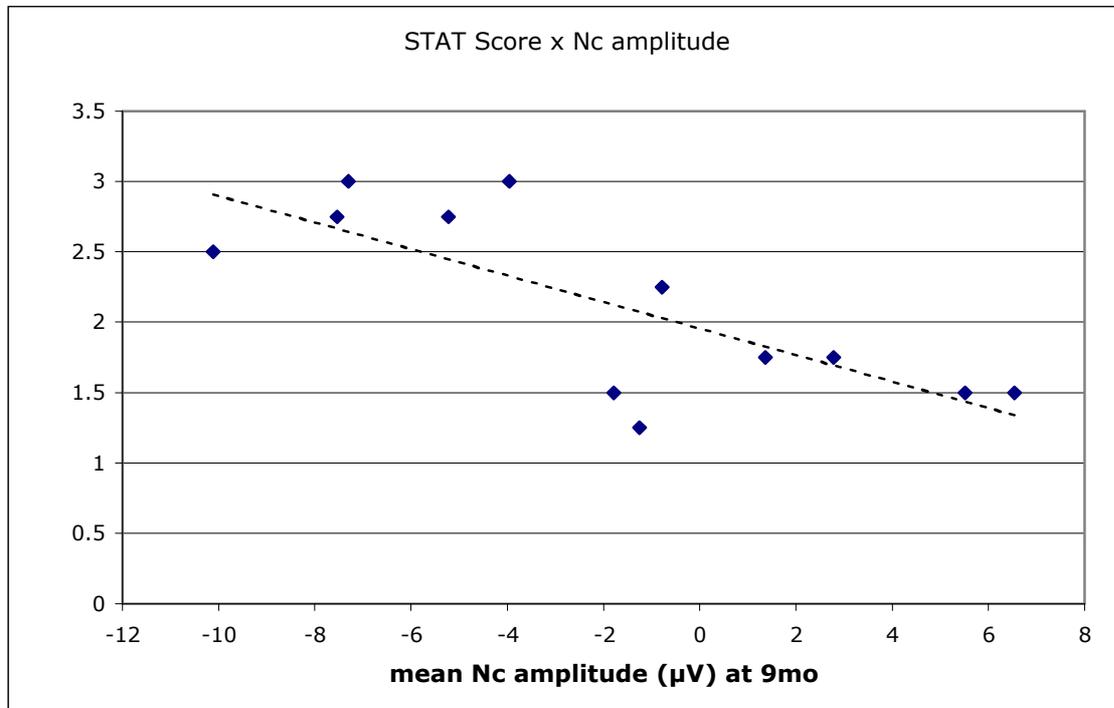


Figure E-6. Larger (more negative) Nc mean amplitude to target face in 9-month-old infants is associated with higher STAT score at 12 months.

Key, A. & Dykens, E. (2011). Electrophysiological Study of Local/Global Processing in Williams Syndrome. *Journal of Neurodevelopmental Disorders*, 3, 28-38.

Purpose: Persons with Williams syndrome (WS) demonstrate pronounced deficits in visuospatial processing. The purpose of the current study was to examine the preferred level of perceptual analysis in young adults with WS (n=21) and the role of attention in the processing of hierarchical stimuli.

Methods: Navon-like letter stimuli were presented to adults with WS and age-matched typical controls in an oddball paradigm where local and global targets could appear with equal probability. Participants received no explicit instruction to direct their attention toward a particular stimulus level. Behavioral and event-related potential (ERP) data were recorded.

Results: Behavioral data indicated a typical global precedence effect in persons with WS. However, their ERP responses revealed atypical brain mechanisms underlying attention to local information. Differences were present during the early perceptual analysis (occipital N150) as well as at the more advanced stages of cognitive processing (centro-parietal P3b, anterior P3a).

Conclusion: The results indicate that in a perceptual task, adults with WS may experience greater than typical global-to-local interference and not allocate sufficient attentional resources to local information.

Key, A., Jones, D., Williams, S. & Dykens, E. (2011, March). Brain mechanisms of food perception in children, adolescents, and adults with Prader-Willi syndrome. 44th Annual Meeting of the Gatlinburg Conference on Research & Theory in Intellectual & Developmental Disabilities, San Antonio, TX

Introduction: Prader-Willi syndrome (PWS) is a genetic disorder associated with intellectual disabilities, compulsivity, hyperphagia, and increased risks of life-threatening obesity. Atypical food-related behaviors in people with PWS are well-documented, but research has yet to focus on the developmental differences in food perception and phenotypic variability associated with the two major genetic subtypes of PWS. The current study examined differences in brain activity associated with processing of food stimuli in persons with PWS as measured by event-related potentials (ERPs).

Methods: Visual ERPs were recorded from 24 individuals with PWS, 9 children (M age = 8.71+/-1.79 years) and 15 adolescents and young adults (M age = 23.21+/-5.49 years) using 128-electrode nets. Stimuli included color photographs of foods that represent key aspects of hyperphagia in PWS, including foods that varied in composition (single food, proper combinations, unusual combinations) and availability for consumption (offered on a plate or discarded in a trash can). Stimuli were presented using a passive viewing paradigm. Participants were asked to view the pictures and consider whether they would like to eat such foods; no behavioral responses were required.

Results: While participants of all ages discriminated between offered and discarded foods at the perceptual level (within the first 200 ms after stimulus onset), age differences were present in the later affective responses (LPP). Adolescents and adults, but not children discriminated among foods of different composition, and only in the discarded condition. Perception of food also differed by genetic subtype: participants with paternal deletions analyzed food stimuli in terms of composition regardless of presentation context, while those in the UPD group focused more on presentation differences (offered vs. discarded). Additionally, compared to participants with the UPD subtype, those with the deletion subtype generated larger ERP amplitudes in the LPP range, possibly reflecting greater arousal by the food images.

Discussion: Results extend our prior finding of genetic subtype differences among adults with PWS with regard to perceptual analysis of food stimuli (Key & Dykens, 2008) by including children and adolescents with PWS, and by adding the dimension of perceived availability of food (offered vs. discarded foods). Furthermore, this is the first study to demonstrate age-related differences in responses to food stimuli in persons with PWS. There may be a developmental progression in food categorization abilities in PWS beginning with a basic discrimination of offered versus discarded foods that is present even in children, while a more detailed analysis of food composition is performed by adolescents and young adults. Differences in food perception in PWS may thus be associated with genetic subtypes and age; these findings suggest the need for more nuanced interventions that target hyperphagia and life-threatening obesity in PWS.

Key, A., Molfese, D.L., O'Brien, L. & Gozal, D. (2009). Sleep-disordered breathing affects auditory processing in 5-7 year-old children: evidence from brain recordings. *Developmental Neuropsychology*, 34(5), 1-15.

Poor sleep in children is associated with lower neurocognitive functioning and increased maladaptive behaviors. The current study examined the impact of snoring (the most common manifestation of sleep-disordered breathing) on cognitive and brain functioning in a sample of 35 asymptomatic children ages 5-7 years identified in the community as having habitual snoring

(SDB). All participants completed polysomnographic, neurocognitive (NEPSY) and psychophysiological (ERPs to speech sounds) assessments. The results indicated that sub-clinical levels of SDB may not necessarily lead to reduced performance on standardized behavioral measures of attention and memory. However, brain indices of speech perception and discrimination (N1/P2) are sensitive to individual differences in the quality of sleep. We postulate that addition of ERPs to the standard clinical measures of sleep problems could lead to early identification of children who may be more cognitively vulnerable because of chronic sleep disturbances.

Key, A. & Stone, W. (2011, May). Recognition of familiar faces in infants at low and high risk for autism. International Meeting for Autism Research, San Diego, CA.

Background: Ability to remember and recognize faces is important for successful social functioning (Schultz et al., 2005). Children and adults with ASD are often reported to have difficulty processing faces, including poor recognition of familiar faces (Boucher et al., 1998; Dawson et al., 2002; Klin et al., 1999).

Objective: The purpose of this study was to investigate whether infant siblings of children with autism process familiar and novel faces differently from typical infants and whether sensitivity to face familiarity is associated with infants' social and communicative behaviors.

Methods: Visual event-related potentials (ERPs) were recorded in 36 infants, age 9 months +/- 15 days (20 infants with no family history of autism and 16 infant siblings of children with autism, sibs-ASD). Infants repeatedly viewed photographs of their mother's smiling face and on 30% of the trials, a smiling face of an unfamiliar female (varied across participants) was presented. In addition, eye tracking data were recorded in a subset of infants (10 sibs-ASD, 14 TD infants) in response to a different stranger face (same for all infants). Mothers of infant participants completed Receptive and Expressive Communication, and Interpersonal Relationships subscales of VABS-II.

Results: The two infant groups did not differ in receptive communication or interpersonal relationships scores, but sibs-ASD had significantly lower expressive communication scores (albeit within the typical range). ERPs revealed that infants in both groups differentiated between their mothers and strangers as reflected in amplitude modulations of face-specific posterior N290/P400 as well as general novelty-sensitive frontocentral Nc and temporal PSW responses. Group differences were present only in the latency of the P400 response, where shorter latency for the mother's than stranger's face was observed in typical infants but not in sibs-ASD. When entered into a logistic regression predicting risk group membership, latency of the P400 to the stranger's face improved classification accuracy for sibs-ASD (81.3% correct) compared to the classification model based on expressive communication scores alone (68.8% correct). There was no change in classification accuracy for the TD infants (85% correct). Eye tracking data indicated no group differences in the number or duration of fixations on the stranger's face or any of its features. However, for sibs-ASD and TD infants combined, increased number of fixations on the mouth area of the stranger's face was associated with smaller amplitudes of the P400, Nc, and PSW responses to the stranger's face. Similarly, in the combined sample, shorter Nc latency to mother's face was associated with better VABS-II interpersonal relationships V-scores ($r = -.382, p = .021$).

Conclusion: Nine-month-old infants at low and high risk for autism utilize similar face scanning strategies and comparable brain mechanisms when viewing familiar faces. However, typical infants appear to be faster at detecting familiar faces than are sibs-ASD, and individual differences in the speed of detecting familiar faces are associated with stronger interpersonal skills and may therefore be an informative marker of elevated risk for autism.

Key, A., Stone, W. & Williams, S. (2009). What do infants see in faces? ERP evidence of different roles of eyes and mouth for face perception in 9-month-old infants. *Infant and Child Development*, 18, 149-162.

The study examined whether face-specific perceptual brain mechanisms in 9-month-old infants are differentially sensitive to changes in individual facial features (eyes vs. mouth) and whether sensitivity to such changes is related to infants' social and communicative skills. Infants viewed photographs of a smiling unfamiliar female face. On 30% of the trials, either the eyes or the mouth of that face were replaced by corresponding parts from a different female. Visual event-related potentials (ERPs) were recorded to examine face-sensitive brain responses. Results revealed that increased competence in expressive communication and interpersonal relationships was associated with a more mature response to faces, as reflected in a larger occipito-temporal N290 with shorter latency. Both eye and mouth changes were detected, though infants derived different information from these features. Eye changes had a greater impact on the face perception mechanisms and were not correlated with social or communication development, whereas mouth changes had a minimal impact on face processing but were associated with levels of language and communication understanding.

Key, A., Williams, S. & Dykens, E. (2009, February). Affective processing in adults with Williams syndrome: ERP evidence of social bias. 36th Annual Meeting of the International Neuropsychological Society, Atlanta, Georgia.

Objective: Williams syndrome (WS) is a genetic disorder characterized by increased anxiety and nonsocial fears in the context of high sociability. The current study examined brain activity associated with processing of social and nonsocial affective stimuli in adults with WS.

Participants and Methods: Visual ERPs were recorded from 21 adults with WS (18-52 yrs) and 16 age-matched controls during an affective priming paradigm. Participants were asked to evaluate affective valence of IAPS pictures depicting social and nonsocial scenes. The pictures appeared for 2000 ms and were preceded by a 150 ms presentation of an affectively loaded social or nonsocial prime. The prime's type and affective valence matched the following picture on 50% of the trials.

Results: Social vs. nonsocial primes resulted in shorter RT for social targets in both groups. ERP data indicated that compared to controls, persons with WS processed social primes to a greater extent as evident in the reduced occipito-temporal EPN (150-300ms) for all targets. In both groups, social primes also led to greater affective processing of following stimuli as reflected in increased centro-parietal LPP (300-500ms) for all targets, although in WS, the increase was greater for nonsocial targets.

Conclusion: The results indicate that social rather than nonsocial stimuli are more likely to not only capture attention in persons with WS but also to impact affective processing of other information presented in close temporal proximity.

Krueger, J., Fister, M.C., Lee, W.H., **Hackett, T.A. & Wallace, M.T.** (November, 2010). Anatomical connectivity patterns of the anterior ectosylvian sulcus: implications for multisensory processes. Presented at the 40th Annual Society for Neuroscience, San Diego, CA.

Processing converging sensory information from various sensory modalities is a critical feature of the central nervous system. Traditionally, multisensory processes have been studied in the cat superior colliculus (SC), a multisensory midbrain structure crucial for orientation behavior. Recent work has focused on cortical sites of multisensory integration. In the cat, the anterior ectosylvian sulcus (AES) is such a multisensory cortical structure. Prior studies established the anatomical connections from and to the cat SC but much less data is available detailing functional connectivity of the AES. Briefly, the AES contains three primary sensory domains (AEV, FAES, SIV), along with a concentration of multisensory neurons at their bordering regions. The AES is surrounded by areas that have auditory (All, AAF), somatosensory (SIV, SII), and multisensory (Ig, AS) properties. The current study sought to identify connectivity patterns between AES and its surrounding areas in the cat model. A number of tracer injections were placed into target regions guided by physiological recordings. In case 1, injections were made in All and medial to All within the AES, in a zone responsive to all three modalities. Labeled cells were found primarily in areas All, Te, 35/36, and ventral FAES. Additionally, the AES injection also labeled cells in ALLS. In case 2, injections targeted AS and Ig. Besides the areas labeled in case 1, cells were labeled throughout the AEV, SIV, and FAES. In thalamus, labeled cells in all cases were concentrated in the multisensory nuclei medial and dorsal to the MGB. These preliminary data indicate that the areas surrounding AES are highly interconnected with the three divisions of AES and with multisensory thalamic nuclei. An interesting caveat is that weights of connections may vary systematically in that they may significantly shape convergence patterns. Such specific arrangements most likely impact the construction of multisensory representations within the AES and thus may manipulate perception and behavior.

Krueger, J., Fister, M.C., Young, M.S., Barnett, Z.P., Royal, D.W., Carriere, B.N., & **Wallace, M.T.** (July, 2009). A comparison of spatial receptive field architecture of multisensory neurons in subcortex and cortex. Presented at the 10th Annual International Multisensory Research Forum, New York, NY.

Our environment is comprised of numerous dynamic sensory cues that are constantly changing in complex ways across the dimensions of both space and time. The role of the nervous system is to resolve the inherent ambiguities that result from these competing stimulus complexes in order to create veridical percepts. To accomplish this task, the brain has to correctly identify whether multiple sensory energies belong to a single event or several discrete events. Specific brain structures, including the midbrain superior colliculus (SC) and the cortex of the anterior ectosylvian sulcus (AES), have evolved to integrate multiple unisensory signals in order to resolve these uncertainties (i.e., multisensory integration). Prior work has established that the spatial location of stimuli is an important determinant of multisensory interactions. More recently, spatial receptive field (SRF) analyses of multisensory AES neurons has revealed strikingly heterogeneous receptive field architectures under both unisensory and multisensory conditions. The current study sought to extend this line of investigation to the superior colliculus (SC), and compare SRF architecture in these two multisensory structures. Multisensory SC neurons were isolated via standard extracellular single unit recording methods. Unisensory and multisensory SRFs were derived and compared to one another, to several predictive models, and between brain structures. In general, the unisensory and multisensory SRFs for individual SC neurons had a similar spatial organization (although gains could be dramatically different). In contrast, AES SRFs are frequently markedly different between both the unisensory and multisensory conditions. In addition, whereas cortical (i.e., AES) multisensory neurons are typically characterized by a single area of maximal response (i.e., hot spot), SC multisensory neurons ranged from having a similar singular architecture to having multiple hot spots. Despite

these differences in SRF organization, the spatial heterogeneity of SRFs in both AES and SC dictated the final product of the resultant multisensory interactions, in that response efficacy was inversely related to multisensory interactive magnitude. These results suggest a universal multisensory coding concept in which receptive field architecture is a key factor, and which highlights the dynamic interplay between space and effectiveness in shaping the final neural product.

Krueger, J., Royal, D.W., Fister, M.C. & **Wallace, M.T.** (2009). Spatial receptive field organization of multisensory neurons and its impact on multisensory interactions. *Hearing Research*, 258, 47-54.

Previous work has established that the spatial receptive fields (SRFs) of multisensory neurons in the cerebral cortex are strikingly heterogeneous, and that SRF architecture plays an important deterministic role in sensory responsiveness and multisensory integrative capacities. The initial part of this contribution serves to review these findings detailing the key features of SRF organization in cortical multisensory populations by highlighting work from the cat anterior ectosylvian sulcus (AES). In addition, we have recently conducted parallel studies designed to examine SRF architecture in the classic model for multisensory studies, the cat superior colliculus (SC), and we present some of the preliminary observations from the SC here. An examination of individual SC neurons revealed marked similarities between their unisensory (i.e., visual and auditory) SRFs, as well as between these unisensory SRFs and the multisensory SRF. Despite these similarities within individual neurons, different SC neurons had SRFs that ranged from a single area of greatest activation (hot spot) to multiple and spatially discrete hot spots. Similar to cortical multisensory neurons, the interactive profile of SC neurons was correlated strongly to SRF architecture, closely following the principle of inverse effectiveness. Thus, large and often superadditive multisensory response enhancements were typically seen at SRF locations where visual and auditory stimuli were weakly effective. Conversely, subadditive interactions were seen at SRF locations where stimuli were highly effective (Figure E-7). Despite the unique functions characteristic of cortical and subcortical multisensory circuits, our results suggest a strong mechanistic interrelationship between SRF microarchitecture and integrative capacity.

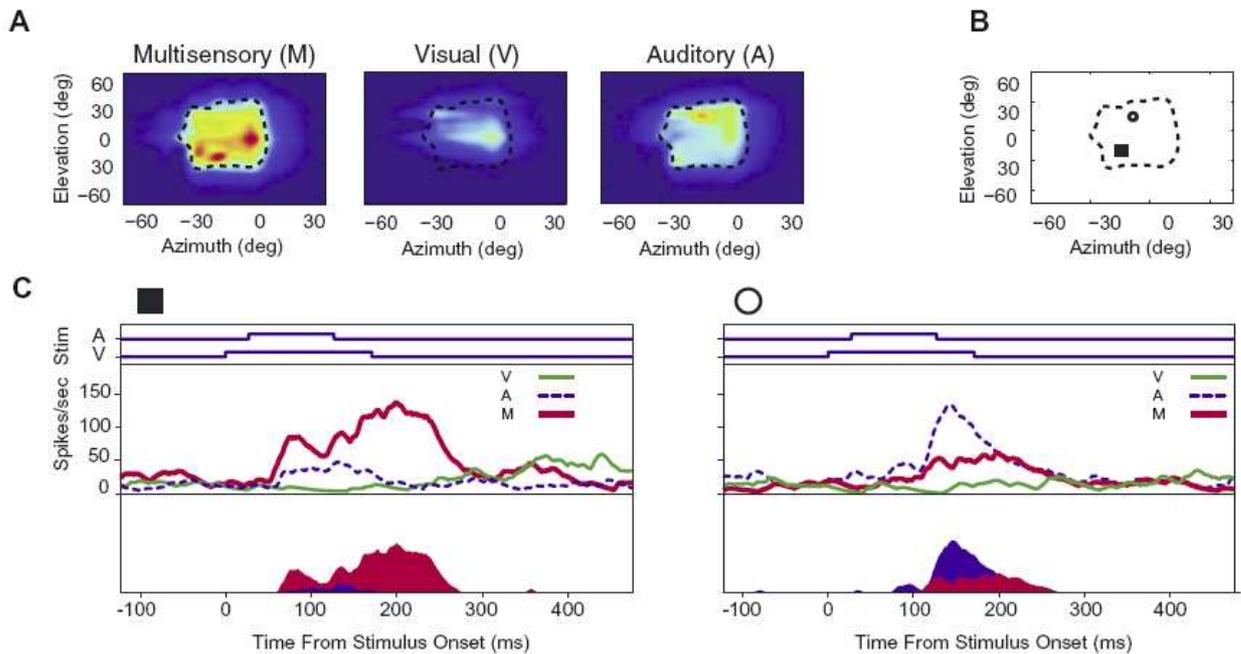


Figure E-7. An example of a SRF analysis in an SC neuron illustrating the relationship between stimulus effectiveness and multisensory integration as a function of space. (A) Spatial receptive fields (SRF) for this visual–auditory neuron. Warmer colors indicate higher evoked firing rates. The borders of the multisensory SRF are outlined with dotted black line in all three panels. (B) Stimulus locations for two spatially-coincident multisensory pairings (circle and square) within the SRF. (C) Evoked responses for these two locations for the visual, auditory and multisensory conditions. Note that whereas the pairing at a weakly effective location (square) results in a large superadditive multisensory interaction, the pairing at a location in which a vigorous auditory response could be evoked (circle) results in a clear subadditive interaction.

Kwakye, L.D. & Wallace, M.T. (June, 2010). Temporal multisensory processing of low-level audiovisual stimuli: an event-related potential analysis. Presented at the 11th Annual International Multisensory Research Forum Annual Meeting, Liverpool, England.

We receive information from all our senses that allows us to respond quickly and accurately to external events. The benefit of multisensory stimuli is crucially dependent on the temporal structure of the component unisensory stimuli. The neural networks that underlie this temporal dependence have not been fully elucidated. Previous research has shown that participants respond faster to simultaneous audiovisual stimuli than would be predicted by the race model. The event-related potential (ERP) waveform produced in response to audiovisual stimuli differs from the summed unisensory waveforms at several time points and scalp locations. By introducing temporal disparities of varying durations we can observe how the well-characterized behavioral and electrophysiological effects are altered by the temporal structure of the audiovisual stimuli. Preliminary findings suggest that the multisensory ERP waveform resulting from short SOAs (100 ms) show similar deviations from the summed unisensory waveform. Longer SOAs (200 and 400 ms) resulted in a different pattern of deviations from the summed unisensory waveform (particularly a marked sub-additivity around 300 ms) indicating a change

in the multisensory network that underlies this behavioral benefit. Future analyses will focus on characterizing these key changes to further increase of understanding of the networks that subserve temporal multisensory processing.

Lemons, C.J., **Key, A.P.F.**, Fuchs, D., Yoder, P.J., Fuchs, L.S., Compton, D.L., Williams, S.M. & Bouton, B. (2010). Predicting reading growth with event-related potentials: Thinking differently about indexing “responsiveness.” *Learning and Individual Differences*, 20(3), 158-166.

The purpose of this study was to determine if event-related potential (ERP) data collected during three reading-related tasks (Letter Sound Matching, Nonword Rhyming, and Nonword Reading) could be used to predict short-term reading growth on a curriculum-based measure of word identification fluency over 19 weeks in a sample of 29 first-grade children. Results indicate that ERP responses to the Letter Sound Matching task were predictive of reading change and remained so after controlling for two previously validated behavioral predictors of reading, Rapid Letter Naming and Segmenting. ERP data for the other tasks were not correlated with reading change. The potential for cognitive neuroscience to enhance current methods of indexing responsiveness in a response-to-intervention (RTI) model is discussed.

Maitre, N., Aschner, J., Slaughter, C. & **Key, A.** (2011, May). Neural functioning in preterm infants correlates with postnatal experience and gestational age and is associated with neurodevelopmental outcomes. *Pediatric Academic Societies & Asian Society for Pediatric Research Joint Meeting*, Denver, CO.

Background: Neurodevelopmental delays in preterm infants are common but difficult to predict. Event-related potentials (ERP), or time-locked EEG, can quantify neural functioning. We hypothesized that efficiency of neonatal information processing would be related to not only with gestational maturity but also with post-natal experience in the intensive care unit and would be associated with neurodevelopment in infancy.

Methods: In a prospective study, ERP responses to speech sounds were recorded in 57 infants prior to discharge from the Vanderbilt NICU (post-conceptual age 32-40 weeks).

Neurodevelopmental outcomes were measured at 6 months of age using the Developmental Assessment of Young Children. Regression analysis and general estimating equations described associations between population characteristics, ERPs, and outcomes.

Results: In the subsample of 50 normal infants, mean ERP amplitudes increased as gestational age (GA) at birth increased ($p < 0.001$). This effect was modified by post-natal experience approximated by length of stay (LOS) in the NICU: as LOS increased, the effect of GA at birth on brain function increased ($p < 0.001$). Hemisphere differences in ERP amplitudes at the temporal sites were associated with development of communication and motor milestones and at frontal locations with cognitive scores (all $p < 0.01$). Normative equations predicting mean ERP amplitudes while accounting for GA and LOS were defined for frontal and temporal locations in the left and right hemisphere (all $p < 0.001$). Accordingly, ERPs of seven infants with brain abnormalities differed from the equation-predicted values, but were nonetheless predictive of neurodevelopmental outcomes at 6 months.

Conclusions: This is the first study to establish a systematic relationship between infants' gestational age, post-natal experience and efficiency of brain functioning. It also supports the power of ERP to predict the neurodevelopment of preterm infants.

Maitre, N., Simmons, A., Henderson, G., Gogliotti, S., Vinson, A., Jones, D. & **Key, A.** (2011, May). Constraint-induced movement therapy improves neural processing and neurobehavioral function in children with cerebral palsy. Pediatric Academic Societies & Asian Society for Pediatric Research Joint Meeting, Denver, CO.

Background: Cerebral palsy (CP) is a non-progressive disorder of movement resulting from insults to the developing brain, for which there are few evidence-based approaches. The current study used a combination of neurobehavioral, electrophysiological and neuroimaging assessments to quantify the effect of an intensive one-week camp model of constraint-induced movement therapy (CIMT) on functional measures of neural and behavioral processing.

Methods: Prospective study of pre- and post-CIMT effect in 10 children ages 5-12 years with a diagnosis of hemiparetic CP associated with neonatal brain lesions. Standardized neurobehavioral assessments of upper extremity function and developmental disregard were correlated with the latency and amplitude of event-related potentials (ERPs) in response to 2 established paradigms targeting speed and efficiency of brain processing.

Results: There was a strong positive effect of CIMT on neurobehavioral and electrophysiologic function and the two measures were often correlated (Table). ERP measures also indicated more pronounced changes in processing function in children with left-sided brain lesions with shorter latencies on the side contralateral to the lesions after CIMT ($F = 26.8, p = 0.001$).

Conclusions: A combination of standard neurobehavioral assessments can be successfully combined with ERP to quantify significant improvements in neural function after rehabilitative therapy for CP. To assess persistence of the positive effects, neurobehavioral and ERP testing will be repeated 6-months following CIMT and correlated with neuroimaging findings. CIMT holds promise as a rehabilitative therapy for improvement in sensory and motor function in children with CP.

Maloff, E., Grantham, D. W., Key, A. & Ashmead, D. H. (2009, March). Auditory motion perception in humans: an event-related potential study. American Auditory Society Annual Meeting, Scottsdale, Arizona.

The neural mechanisms responsible for auditory motion perception at the cortical level are not fully understood. Previous studies using event-related potentials (ERPs) and functional magnetic resonance imaging have attempted to identify the underlying brain regions involved in auditory motion perception, but the results among these are incongruent. The purpose of this study was to investigate the ERP correlates of stationary and moving stimuli in normal hearing adult participants ($n = 12$). Principal component analysis (PCA) was used to determine the spatial and temporal characteristics associated with these data. This analysis revealed coordinated electrical activity among electrodes surrounding and posterior to vertex. In addition, PCA illustrated strongly coordinated electrical activity in longer latency periods of approximately 350-850 ms. Statistical results revealed a significant difference between the stationary and moving conditions in a time window of approximately 500-800 ms within spatial regions posterior to vertex. The results of this ERP study indicate that auditory motion perception occurs in several brain regions and in a time window of several hundred milliseconds. The outcomes suggest that auditory motion perception may have a prolonged time course and involve cognitive processing to some extent. The purpose of this study was to evaluate event-related potential responses to auditory signals that corresponded to stationary and moving sound sources. The auditory stimuli were carefully designed to have auditory cues where

humans have the best spatial acuity (Grantham, 1995). The major finding was that the response differences between the stationary and motion stimuli occurred in latency regions of approximately 350-800 ms, and at electrode locations surrounding and just posterior to vertex. Previous ERP studies have reported auditory motion responses but the results are varied due to differences between study designs (Ducommun et al., 2002; Jerger and Estes, 2002; Krumbholz et al., 2007). A common thread in this literature, including the present experiment, is the lack of control conditions to assess whether “motion responses” might be attributable to other factors, such as a more general response to stimulus change. Although we observed a robust difference between the motion and stationary conditions, ongoing experimental work is needed to distinguish between “change” and “motion” components of the ERP response.

Maloff, E. & Hood, L.J. (In revision.) Auditory brainstem responses elicited by chirp stimuli in adults with normal hearing and sensorineural hearing loss.

Objectives: To compare the human auditory brainstem response elicited by clicks and chirps to overall behavioral auditory hearing thresholds. We hypothesized that ABRs to chirps are more robust and these thresholds are more similar to overall behavioral hearing thresholds compared to ABRs to clicks in normal hearing and sensory hearing loss populations.

Design; Twenty-five adults with normal hearing and twenty-five adults with sensory hearing loss were recruited from the Vanderbilt community and surrounding Nashville, TN area. Subjects were without middle ear or neurological pathologies at the time of testing. Behavioral hearing thresholds were obtained at nine octave and interoctave frequencies ranging from 250-8000 Hz; an average of these nine frequencies was calculated for each participant. Evoked potential thresholds were measured using ABRs to click and chirp stimuli. Analyses included Wave V latencies and Wave V peak-to-peak (Wave V peak to the following negative trough, Wave V') amplitudes. ABRs to clicks and chirps were compared as well as their relationship to overall behavioral hearing thresholds (PTAo) in both groups.

Results: ABR thresholds to chirp stimuli were significantly better than ABR thresholds to click stimuli in both populations. Wave V peak-to-peak amplitude comparisons showed more robust responses for chirps than clicks at various intensities, particularly at lower intensities, for both groups. ABR thresholds to chirps were closer to behavioral (PTAo) thresholds than clicks in both groups. Moreover, ABR thresholds to chirps did not differ significantly from behavioral thresholds in the sensory hearing loss group.

Conclusions: ABRs to chirps are an efficient method for estimating hearing thresholds in individuals with normal hearing and sensory hearing loss where broadband signals are selected for testing. ABRs to chirps display higher peak-to-peak amplitudes than those obtained with clicks and may provide responses closer to threshold. This information could result in improved accuracy in identifying hearing loss and estimating hearing sensitivity for broad band signals in infants, children, and more difficult to test older populations.

O'Brien, B., **Hackett, T. A.**, Khatri, V., Kleeman, K., Young, M. & Polley, D. (2010). Organization and experience-dependent modification of the mouse auditory thalamocortical circuit: structure, function and behavior. Association for Research in Otolaryngology Abstracts, February, 2010.

Experience plays an important role in the formation and dynamic maintenance of receptive field (RF) organization in the primary auditory cortex (AI) and auditory thalamus. Further study in transgenic mice will permit a deeper understanding of the molecular mechanisms that translate auditory experience into long-lasting plasticity of these circuits. As a first step, we have characterized the tonal RF organization and plasticity in AI and the ventral division of the medial geniculate body (MGBv) in wild type C57BL6 mice using high-density mapping, neuroanatomical tracer injections, developmental sound exposure and prepulse inhibition (PPI) behavioral testing. The straightforward best frequency (BF) organization of AI was juxtaposed against a more complicated tonotopic organization in MGBv that was eventually resolved through reconstruction of electrophysiologically guided tracer injections and lesions. Critical period regulation of tonotopic map plasticity was assessed by exposing mice to pulsed 7 kHz tones either at the onset of hearing (P11-15) or from P16-20. A significant overrepresentation of BFs near the exposure frequency was observed in mice exposed from P11-15, but not P16-20. Interestingly, commensurate changes in BF distributions were not observed in MGBv or inferior colliculus. Experience-dependent modification of PPI behavior closely paralleled the developmental regulation of AI tonotopic map plasticity. However, tone-evoked PPI was reduced in P11-15 mice, rather than enhanced, and this effect generalized to frequencies other than 7 kHz. By describing the basic RF organization of the thalamocortical circuit, its developmental and hierarchical regulation and the impact of cortical reorganization on a simple auditory behavior, these data provide an effective backdrop for future studies in transgenic models.

Pergolizzi, D., **Hackett, T.A.**, Rosoklija, G., Dwork, A. J. & Smiley, J.F. (2009) Areal differences of GABA neuron subtypes in human auditory cortex. Abstract Viewer/Itinerary Planner. Washington, DC: Society for Neuroscience, online.

Subclasses of GABAergic interneurons immunoreactive for the calcium binding proteins calbindin (CB), calretinin (CR), and parvalbumin (PV) reveal distinct patterns of staining in different cortical areas, suggesting that they have specific roles in regulating cortical circuitry. To provide a better understanding of their distribution across cortical regions, we compared the primary auditory cortex (area TC of von Economo, 1929) and lateral surface of the superior temporal gyrus (area TA).

Pollman, M., **Hornsby, B.W.Y. & Hood, L.J.** (March, 2010). Efferent effects and speech understanding. Poster presented at the annual meeting of the American Auditory Society, Scottsdale, AZ.

Although the functional role of the efferent auditory system is not fully understood, previous work suggests that efferent processing may aid in detection of signals in noise. This study examined relationships between measures of efferent reflex strength (TEOAE suppression and speech anti-masking) and between measures of efferent strength and perceptual tolerance to background noise. Thirteen adults with normal hearing and present TEOAEs participated.

Monaural speech understanding was assessed at 3 signal to- noise ratios, without and with a 60 dBA uncorrelated contralateral noise, to measure release from masking (speech anti-masking). Tolerance of background noise was quantified using the Acceptable Noise Level (ANL) test. TEOAE suppression was obtained using ipsilateral, contralateral and bilateral broad-band suppressors. Results revealed the presence of speech anti-masking at all signal-to-noise ratios. No correlation between release from masking and TEOAE suppression or between ANLs, efferent suppression or speech anti-masking was observed. The lack of relationship between efferent function and speech perception may be due to limited sensitivity in our test measures, or that the measures of efferent strength have different underlying mechanisms, or cortical influences may differ among measures. [Supported by the NIH National Institute on Deafness and Other Communication Disorders (NIDCD) Short Term Research Traineeship (T35)]

Powers, A.R., Hevey, M.A. & **Wallace M.T.** (June, 2010). Neural Correlates of Multisensory Perceptual Learning. Presented at the Organization for Human Brain Mapping in Barcelona, Spain and 11th Annual International Multisensory Research Forum in Liverpool, England.

The brain's ability to bind incoming auditory and visual stimuli depends critically on the temporal structure of this information. Specifically, there exists a temporal window of audiovisual integration within which stimuli are highly likely to be perceived as part of the same environmental event. Several studies have described the temporal bounds of this window, but few have investigated its malleability. Recently, our laboratory has demonstrated that a perceptual training paradigm is capable of eliciting a 40% narrowing in the width of this window that is stable over at least one week. In the current study we sought to reveal the neural substrates of these changes. Eleven subjects completed a two-day, two-interval forced choice audiovisual simultaneity judgment training paradigm, immediately before and after which they performed the same task during an event-related 3T fMRI session. The posterior superior temporal sulcus (pSTS) and areas of auditory and visual cortex exhibited robust BOLD decreases following training, and resting state and effective connectivity analyses revealed significant increases in coupling between these cortices after training. These results represent the first evidence of the neural correlates underlying plastic change in adult multisensory networks that likely represent the substrate for a multisensory temporal binding window.

Powers, A.R., **Hillock, A.R.** & **Wallace, M.T.** (July, 2009). Multiple modes of perceptual training induce a narrowing in the multisensory temporal binding window. Poster presented at the 10th Annual International Multisensory Research Forum, New York, NY.

The brain's ability to bind incoming auditory and visual stimuli depends critically on the temporal structure of this information. Specifically, there exists a temporal window of audiovisual integration within which stimuli are highly likely to be bound together and perceived as part of the same environmental event. Several studies have described the size and malleability of this window in adults, and we have shown in recent work that the size of the multisensory temporal binding window can be narrowed with the use of a perceptual training paradigm. However, the specific mechanisms underlying these changes were not clear, and to rule out the possibility that they could be the result of cognitive biases, a new, two-interval forced choice (2IFC) paradigm was undertaken during which participants were instructed to identify a simultaneously-presented audiovisual pair presented within one of two intervals, and in which the stimulus onset asynchrony between the visual and auditory stimuli in the other interval was variable.

While the new training paradigm also resulted in a window narrowing and generalization pattern similar to that seen using the two alternative approach, the 2IFC paradigm resulted in a larger overall decline in window size that took place over a slower time course (Figure E-7). These findings indicate that these different methods of multisensory perceptual training both result in substantial alterations in the circuits underlying the perception of audiovisual simultaneity, a hypothesis supported by preliminary imaging data showing blood-oxygen-level dependent (BOLD) changes in canonical multisensory cortical regions after perceptual training. Taken together, these results suggest a high degree of flexibility in multisensory temporal processing and have important implications for interventional strategies that may be used to ameliorate clinical conditions (e.g., autism, dyslexia) in which multisensory temporal function may be impaired.

Powers, A.R., **Hillock, A.R. & Wallace, M.T.** (2009). Perceptual training induced narrowing of the multisensory temporal binding window. *Journal of Neuroscience*, 29(39),12265-12274.

The brain's ability to bind incoming auditory and visual stimuli depends critically on the temporal structure of this information. Specifically, there exists a temporal window of audiovisual integration within which stimuli are highly likely to be bound together and perceived as part of the same environmental event. Several studies have described the temporal bounds of this window, but few have investigated its malleability. Here, the plasticity in the size of this temporal window was investigated using a perceptual learning paradigm in which participants were given feedback during a two-alternative forced choice (2-AFC) audiovisual simultaneity judgment task. Training resulted in a marked (i.e., 40%) narrowing in the size of the window. To rule out the possibility that this narrowing was the result of changes in cognitive biases, a second experiment using a two-interval forced choice (2-IFC) paradigm was undertaken during which participants were instructed to identify a simultaneously presented audiovisual pair presented within one of two intervals. The 2-IFC paradigm resulted in a narrowing that was similar in both degree and dynamics to that using the 2-AFC approach (Figure E-8). Together, these results illustrate that different methods of multisensory perceptual training can result in substantial alterations in the circuits underlying the perception of audiovisual simultaneity. These findings suggest a high degree of flexibility in multisensory temporal processing and have important implications for interventional strategies that may be used to ameliorate clinical conditions (e.g., autism, dyslexia) in which multisensory temporal function may be impaired.

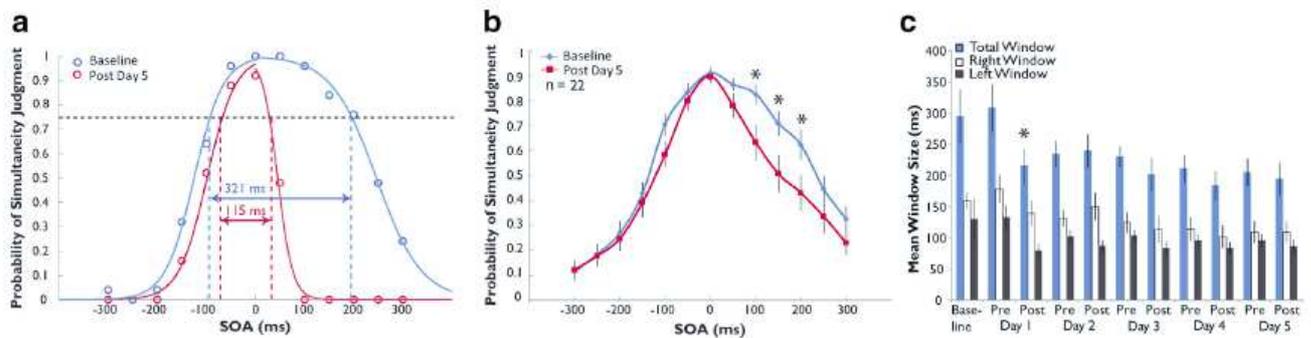


Figure E-8. Training on a 2-AFC simultaneity judgment task narrows the temporal window of multisensory integration. a, Two sigmoid curves were fit to each individual's single-assessment data to derive an estimation of the temporal binding window (criterion, 75% of maximum). In this individual, the size of the window narrows from 321 to 115 ms after 5 h of feedback training. b, After training on the 2-AFC paradigm, a group of 22 participants showed significant decreases in their probability of judging nonsimultaneous audiovisual pairs as simultaneous. c, Average window sizes (total, left, and right) across the 5 d of training. Note that window size dropped significantly after the first hour of training, after which it remained stable. Error bars indicate 1 SEM, * $p < 0.05$.

Royal, D.W., Krueger, J., Fister, M.C. & **Wallace, M.T.** (2009). Adult plasticity of spatiotemporal receptive fields of multisensory superior colliculus neurons following early visual deprivation. *Restorative Neurology and Neuroscience*, 28, 259-270.

Previous work has established that the integrative capacity of multisensory neurons in the superior colliculus (SC) matures over a protracted period of postnatal life (Wallace and Stein, 1997), and that the development of normal patterns of multisensory integration depends critically on early sensory experience (Wallace et al., 2004). Although these studies demonstrated the importance of early sensory experience in the creation of mature multisensory circuits, it remains unknown whether the reestablishment of sensory experience in adulthood can reverse these effects and restore integrative capacity. **Methods:** The current study tested this hypothesis in cats that were reared in absolute darkness until adulthood and then returned to a normal housing environment for an equivalent period of time. Single unit extracellular recordings targeted multisensory neurons in the deep layers of the SC, and analyses were focused on both conventional measures of multisensory integration and on more recently developed methods designed to characterize spatiotemporal receptive fields (STRF). **Results:** Analysis of the STRF structure and integrative capacity of multisensory SC neurons revealed significant modifications in the temporal response dynamics of multisensory responses (e.g., discharge durations, peak firing rates, and mean firing rates), as well as significant changes in rates of spontaneous activation and degrees of multisensory integration. **Conclusions:** These results emphasize the importance of early sensory experience in the establishment of normal multisensory processing architecture and highlight the limited plastic potential of adult multisensory circuits.

Spankovich, C., Hood, L. J., Liberman, M. C. & Kujawa, S. K. 2009. Consequences of noise induced neural degeneration on peripheral auditory processing. American Auditory Society – NIH Mentored poster awardee.

Noise induced hearing loss is a serious problem, and understanding the long-term consequences is critical to public health. Previous work has shown that overexposures causing moderate, but reversible, threshold elevation leave cochlear sensory cells intact, but cause delayed degeneration of up to 60% of the cochlear afferents contacting inner hair cells. Since the affected type-I neurons constitute 95% of the cochlear nerve, dysfunction in this neural population must have important consequences for hearing, even if threshold sensitivity recovers. This subtotal loss of neural elements may reflect differential vulnerability of neurons with low- vs. high-spontaneous rates (SR). Single unit studies have suggested preferential loss of low-SR fibers with aging. These high-threshold fibers recover slowly from prior stimulation, whereas low-threshold, high-SR units recover more rapidly. These response properties may be reflected in CAP forward masking functions; for example, abnormally rapid CAP recovery from forward masking may reflect such losses. We begin to explore this hypothesis here, in previously-noise exposed, aging ears, to gain further insight into the functional consequences of this noise-induced, primary neural degeneration. Our results suggest that threshold-based metrics of function dramatically underestimate the impact of noise insult and raise important concerns for delayed consequences of noise exposure on age-related hearing loss and processing of suprathreshold signals.

Spankovich, C., Hood, L.J., Silver, H.J., Lambert, W., Flood, V.M. & Mitchell P. 2010. Associations between Diet and Both High and Low Pure Tone Averages and Transient Evoked Otoacoustic Emissions in an Older Adult Population-based Study. Journal of the American Academy of Audiology. In press.

Background: Evidence from animal models suggests that redox homeostasis (the balance between oxidative stressors and antioxidants) and vascular health are important in the pathogenesis of sensorineural hearing loss (SNHL) and that dietary nutrients that have roles in these processes could influence the susceptibility to SNHL.

Purpose: To examine associations between total nutrient intakes and auditory function outcomes in an older human population.

Research Design: Descriptive characteristics and dietary data from food frequency questionnaires were collected in a cross-sectional study design and analyzed for associations with auditory function outcomes (i.e., otoacoustic emissions and pure tone audiometry measured in a sound-treated room by an audiologist).

Study Sample: 2111 adults, 49-99 years of age

Results: Higher carbohydrate, vitamin C, vitamin E, riboflavin, magnesium and lycopene intakes were all significantly associated with larger TEOAE amplitude and better pure tone thresholds. Higher cholesterol, fat and retinol intakes were significantly associated with lower TEOAE amplitude and worse pure tone thresholds.

Conclusions: These data suggest that nutrients with known roles in redox homeostasis and vascular health are associated with auditory function measures in a human population. Further investigation is warranted to determine direct and indirect influences of dietary intake on measures of auditory function and to explore which nutrients/nutrient combinations are predictive of SNHL.

Stein B.E., Burr D., Constantinidis C., Laurienti P.J., Meredith A.M., Perrault T.J., Jr., Ramachandran R., Roder B., Rowland B.A., Sathian K., Schroeder C.E., Shams L., Stanford T.R., **Wallace M.T.**, Yu L., and Lewkowicz D.J. (2010). Semantic confusion regarding the development of multisensory integration: a practical solution. *Eur J Neurosci*, 31: 1713-1720.

There is now a good deal of data from neurophysiological studies in animals and behavioral studies in human infants regarding the development of multisensory processing capabilities. Although the conclusions drawn from these different datasets sometimes appear to conflict, many of the differences are due to the use of different terms to mean the same thing and, more problematic, the use of similar terms to mean different things. Semantic issues are pervasive in the field and complicate communication among groups using different methods to study similar issues. Achieving clarity of communication among different investigative groups is essential for each to make full use of the findings of others, and an important step in this direction is to identify areas of semantic confusion. In this way investigators can be encouraged to use terms whose meaning and underlying assumptions are unambiguous because they are commonly accepted. Although this issue is of obvious importance to the large and very rapidly growing number of researchers working on multisensory processes, it is perhaps even more important to the non-cognoscenti. Those who wish to benefit from the scholarship in this field but are unfamiliar with the issues identified here are most likely to be confused by semantic inconsistencies. The current discussion attempts to document some of the more problematic of these, begin a discussion about the nature of the confusion and suggest some possible solutions.

Wallace, M.T. (2009). Dyslexia: Bridging the gap between hearing and reading. *Current Biology*, 19 (6), R260-R262.

Recent work with dyslexic subjects provides the first empirical evidence linking changes in the brain networks subserving phonological processing to deficits in the matching of speech sounds to their appropriate visual representations.

Williams, C. & **Hood, L. J.** 2009. Intensity-ramped ASSRs in infants in the NICU. *American Auditory Society* – T35 Mentored poster awardee.

The advent of universal newborn hearing screening programs has resulted in a reduction in the age of identification of hearing loss in children. This achievement underscores the need for time-efficient methods in estimating frequency-specific thresholds in infants and young children. This project investigated the use of an intensity-ramped stimulus in an auditory steady-state response (ASSR) paradigm to estimate frequency-specific thresholds in infants hospitalized in the neonatal intensive care unit (NICU) at Vanderbilt University Hospital. Thirteen full term and eleven preterm infants underwent testing before hospital discharge. Testing consisted of: 1) baseline screening auditory brainstem response with 35 dB nHL clicks, 2) intensity-ramped ASSR with tonebursts, and 3) discrete-intensity ASSR. The results of this study showed that it is possible to estimate frequency-specific thresholds in a time-efficient manner for both full and preterm infants using the intensity-ramped ASSR paradigm. Comparison of these data with previous studies showed that infant response thresholds tended to be similar to those of older children and higher than those measured for adults. Response amplitudes tended to be larger in

fullterm than preterm infants and even larger in older children. Noise levels were higher for infants tested in incubators than cribs. [Supported by NIH/NIDCD T35-DC008763.]

Yoder, P., Molfese, D., Murray, M. & **Key, Alexandra P. F.** (submitted). Normative topographic ERP analyses of speech processing speed predict grammatical treatment efficacy and remaining grammatical impairment. Invited article for *Journal of Developmental Neuropsychology*.

Event related potentials (ERPs) can be used to measure speed of speech processing with excellent temporal resolution and are not confounded by motivation, cognitive, language, and motor differences. Topographic ERP analyses (TEA) allow momentary quantification of the brain's response to stimuli over the entire scalp and afford a normative approach to quantifying individual differences in speed of speech processing. Fifty-nine typically developing (TD) preschoolers and forty-seven age-matched preschoolers with specific language impairment (SLI) participated. ERPs to four monosyllabic speech sounds were measured in both groups prior to treatment. The children with SLI were randomly assigned to one of two grammatical treatments: Milieu Language Teaching (MLT) or Broad Target Recasting (BTR). ERPs were assessed again after the 6-month treatment phase in the SLI group. Before treatment, the TD group processed speech sounds faster than the SLI group. After the treatment, the SLI group had increased the speed of their processing such that the diagnostic groups were no longer statistically different. After treatment, speed of speech processing was associated with later degree of impairment in comprehension of phrase elaboration in the SLI group. Finally, change in speed of speech processing was positively related to growth rate of grammar during the treatment phase. The potential value of norm-referenced applications of TEA is discussed.

F. Voice Science

Ge, P., French, L.C., Ohno, T., Zeale, D.L. & Rousseau, B. (2009). Model of evoked rabbit phonation. *Annals of Otology, Rhinology, and Laryngology*. 118:51-5

Objectives: To describe a methodology for eliciting phonation in an in-vivo rabbit preparation using low frequency, bipolar, pulsed stimulation of the cricothyroid muscles with airflow delivered to the glottis.

Methods: Ten New Zealand White breeder rabbits weighing 3-5 kg were involved in this study. The cricothyroid muscles were isolated bilaterally, and separate pairs of anode-cathode hook wire electrodes were inserted into each muscle. A Grass S-88 stimulator and two constant current PSIU6 isolation units were used to deliver bipolar square wave pulses to each cricothyroid muscle, with airflow delivered to the glottis through a cuffed endotracheal tube.

Results: Phonation was evoked using a 50 Hz, 4mA stimulus train of 1ms pulses delivered to each cricothyroid muscle. The pulse trains were on for 2 seconds and repeated every 5 seconds over a period of 180 minutes. Airflow was delivered at 143 cm³/sec, producing phonation measuring 71 to 85 dB SPL.

Conclusions: Evoked phonation is feasible in rabbits using bipolar stimulation of the cricothyroid muscles with airflow delivered to the glottis. The in-vivo rabbit preparation described may provide a useful small animal option for studies of evoked phonation. Based on the level and consistency of adduction observed, we hypothesized that current spreading to the underlying adductor muscles and nerves resulted in neural pathway involvement beyond discrete cricothyroid muscle activation, providing sufficient approximation of the vocal folds for phonation.

Ohno, T., Hirano, S. & Rousseau, B. (2009). Gene expression of transforming growth factor- β 1 and hepatocyte growth factor during wound healing of injured rat vocal fold. *Laryngoscope*. 119(4): 806-810.

Objectives: To investigate the expression of genes coding transforming growth factor (TGF)- β 1, hepatocyte growth factor (HGF), and the membrane-spanning tyrosine kinase (c-Met) during the inflammatory, proliferative, and remodeling phases of rat vocal fold after injury.

Study Design: prospective animal study.

Methods: Thirty five rats were involved in this study. Bilateral vocal fold wounds were created in 30 rats. Injured vocal fold specimens were harvested on post-injury day 1, 3, 7, 14, 28, and 56. Real-time polymerase chain reaction (PCR) was used to quantify messenger RNA (mRNA) expression of TGF- β 1, HGF and c-Met. Five uninjured rats were used to establish PCR control.

Results: Results of ANOVA revealed a significant main effect for TGF- β 1 ($p = .000$), HGF ($p = .000$), and c-Met ($p = .000$) expression across time points. Post-hoc testing revealed that expression of TGF- β 1 was significantly increased on post-injury day 7 ($p = .001$) compared to control. HGF was significantly decreased on post-injury day 1 ($p = .001$), and significantly increased on post-injury day 14 ($p = .000$). c-Met expression was significantly decreased on post-injury day 1 ($p = .000$), 3 ($p = .000$), and 56 ($p = .000$), and significantly increased on post-injury day 28 ($p = .000$).

Conclusions: Results revealed time-dependent TGF- β 1, HGF and c-Met mRNA changes in the vocal fold after injury. Findings provide better understanding for the process of vocal fold scarring.

Ohno, T., Hirano, S. & **Rousseau, B.** (2009). Extracellular matrix gene expression during wound healing of the injured rat vocal fold. *Otolaryngology-Head and Neck Surgery*. 140(5): 757-761.

Objectives: To measure the expression of procollagen -I and III, decorin, hyaluronan synthase (HAS)-1, -2, and -3 during the inflammatory, proliferative, and remodeling phases of rat vocal fold injury.

Study-Design: Prospective, animal model.

Subjects and Methods: Vocal folds were injured in 30 rats. Injured specimens were harvested on post-injury day 1, 3, 7, 14, 28, and 56. Five uninjured rats were used for polymerase chain reaction (PCR) control. Real-time PCR was used to measure the expression of procollagen -I and III, decorin, HAS -1, -2, and -3.

Results: Compared to control, expression of procollagen -I and III were significantly decreased on post-injury day 1 and 56; decorin expression was significantly decreased on post-injury day 1, 3, 7 and 56; HAS-1 expression was significantly decreased on post-injury day 3, 7, 14, 28, and 56; HAS-2 expression was significantly decreased on post-injury day 28 and 56; HAS-3 expression was significantly decreased on post-injury day 56.

Conclusions: Results revealed time-dependent alterations in the expression of genes coding procollagen -I and III, decorin, HAS-1, -2, and -3. Knowledge of the temporal regulation of these genes and underlying histology will be used in future studies to investigate molecular approaches for manipulation of vocal fold injury.

Ohno, T., Hirano, S. & **Rousseau, B.** (2009). Age-associated changes in the expression and deposition of collagen and hyaluronan in rat vocal folds. *Annals of Otology, Rhinology, and Laryngology*. 118(10): 735-741. NIHMS 155710

Objectives: To investigate age-associated changes in the expression and deposition of collagen and hyaluronan (HA) in aged vocal folds.

Methods: Thirty, Sprague-Dawley rats were involved in this study. For gene expression analyses, fifteen animals were divided into three age groups of young (2 month), adult (9 month), and elderly (18 month) rats. Real-time PCR was used to quantify messenger RNA expression of procollagen type I, -III, matrix metalloproteinase (MMP) -2, -9, and hyaluronan synthase (HAS)-1, -2, -3. The remaining fifteen animals were divided into the same three groups and underwent histological analyses to investigate age-associated changes in the deposition of collagen and HA.

Results: Results revealed downregulated expression of procollagen type I, -III, MMP-2, -9, and HAS-1, -2, -3 in adult and elderly vocal folds, compared to young vocal folds. Histologically, staining of collagen was dense and HA was less dense in the vocal folds of adult and elderly rats, compared to young rats.

Conclusions: A slowdown in the expression of procollagens and MMPs was associated with dense collagen in aged vocal folds, as observed in elderly humans. A similar decrease in the expression of genes coding HAS was consistent with low density of extracellular matrix HA in the vocal folds of elderly rats.

Ohno, T., Yoo, M., Swanson, E.R., Hirano, S., Ossoff, R.H. & **Rousseau, B.** (2009).
Regeneration of Aged Rat Vocal Folds using Hepatocyte Growth Factor Therapy.
Laryngoscope. 119(7): 1424-1430. Recipient of the Young Faculty/Practitioner Award.

Objectives/Hypothesis: We investigated acute changes in extracellular matrix gene expression and histologic changes in the deposition of collagen and hyaluronan (HA) from hepatocyte growth factor (HGF) treatment of the aged rat vocal fold. We hypothesized that: 1) HGF induces matrix metalloproteinase gene expression, which may contribute to the downregulation of collagen; and 2) HGF induces hyaluronan synthase (HAS) gene expression, which may play a role in the upregulation of ECM HA.

Study Design: prospective animal study.

Methods: Fifteen, 18-month old, Sprague-Dawley rats were involved in this study. For gene expression analyses, ten rats were divided into two groups and received serial injections of sham (saline) or HGF (2ng/□L) and sacrificed 2 weeks after the initial injection to investigate acute changes in extracellular matrix gene expression. A separate group of five animals received the above treatment and were sacrificed 4 weeks after the initial injection to investigate histologic changes in the deposition of collagen and HA.

Results: Real-time polymerase chain reaction revealed significantly upregulated MMP-2, -9, and HAS-3 messenger RNA (mRNA) expression and significantly downregulated procollagen type I mRNA expression in the HGF-treatment group, compared to the sham-treatment group. Histologic staining revealed significantly reduced collagen deposition and increased deposition of HA in the HGF-treated vocal fold, compared to the sham-treated vocal fold.

Conclusions: HGF induced the upregulation of MMP-2, -9, and HAS-3, and downregulated the expression of procollagen type I. Histologically, aged vocal folds treated with HGF revealed decreased collagen deposition, and increased deposition of HA, compared to sham-treated vocal folds.

Ohno, T., Yoo, M., Swanson, E.R., Hirano, S., Ossoff, R.H. & **Rousseau, B.** (2009).
Regenerative effects of basic fibroblast growth factor on extracellular matrix production in aged rat vocal folds. *Annals of Otology, Rhinology, and Laryngology*. 118(8): 559-64.
NIHMS 155739

Objectives: To investigate acute changes in extracellular matrix (ECM) gene expression and histologic changes in the deposition of collagen and hyaluronan (HA) from basic fibroblast growth factor (bFGF) treatment of the aged rat vocal fold.

Methods: For the polymerase chain reaction (PCR) experiments, ten 18 month old, Sprague-Dawley rats were divided into two groups and received serial injections of sham (saline) or bFGF (2ng/□L) and euthanized 2 weeks after the initial injection to investigate acute changes in ECM gene expression. A separate group of five animals received treatment and were sacrificed 4 weeks after the initial injection to investigate histologic changes in the deposition of collagen and HA.

Results: Real-time PCR revealed significantly upregulated hyaluronan synthase (HAS) -2, -3, matrix metalloproteinase (MMP) -2, and procollagen type I gene expression in the bFGF-treatment group, compared to the sham-treatment group. Histologic staining revealed significantly increased deposition of HA in the bFGF-treated vocal fold, compared to the sham-treated vocal fold. No differences in ECM collagen were observed between treatment sides.

Conclusions: Basic fibroblast growth factor induced the upregulation of HAS -2, -3, MMP -2, and procollagen type I. Histologically, aged vocal folds treated with bFGF revealed increased deposition of HA, compared to sham treated vocal folds.

Rousseau B., Cohen, S.M., Zeller, A.S., Scarce, L., Tritter, A.G. & Garrett, C.G. (2011). Compliance and quality of life in patients on prescribed voice rest. *Otolaryngology-Head and Neck Surgery*. 144(1): 104-107.

Objectives: To determine patient compliance with voice rest and the impact of voice rest on quality-of-life (QOL).

Study Design: Prospective. **Setting:** University-hospital.

Subjects and Methods: Demographics, self-reported compliance, QOL impact on a 100 mm visual-analog-scale (VAS), and communication methods were collected from 84 participants from two academic voice centers.

Results: Of 84 participants, 36.9% were male, 63.1% were female, and 64.3% were singers. The mean age of participants was 47.2. The mean duration of voice rest was 8.8 (range 3-28) and median was 7 days. Overall compliance was 34.5%. Post-operative voice rest patients were more compliant than non-post-operative patients (42.4% versus 16.0%, $p = 0.04$, Chi-square). Voice rest had an impact on QOL (mean 68.5 ± 27.7 SD). Voice rest had a greater impact on singers than non-singers (mean VAS 77.2 versus 63.6, $p = 0.03$, t-test), and on those < 60 years than ≥ 60 years (mean VAS 74.4 versus 46.7, $p < 0.001$, t-test). More talkative patients and those with longer periods of voice rest had worse QOL scores (Spearman correlation = 0.35, $p = 0.001$ and 0.24, $p = 0.03$, respectively). Restrictions in personal and social life were noted in 36.9% of patients, 46.4% were unable to work, 44.0% felt frustrated, and 38.1% reported feeling handicapped while on voice rest.

Conclusions: Given poor patient compliance and the significant impact of voice rest on QOL, further studies are warranted to examine the efficacy of voice rest and factors that may contribute to patient non-compliance with treatment.

Rousseau B., Suehiro, A., Echemendia, N. & Sivasankar, M. (2011). Raised intensity phonation compromises vocal fold epithelial barrier integrity. *Laryngoscope*. 121:346-351.

Objectives/Hypothesis: We investigated the hypothesis that 30 minutes of raised intensity phonation alters transcript levels of vocal fold intercellular tight junction proteins and disrupts the vocal fold epithelial barrier.

Study Design: Prospective animal study.

Methods: Eighteen New Zealand white breeder rabbits were randomly assigned to receive 30 minutes of raised intensity phonation or approximation of the vocal folds without phonation. Quantitative polymerase chain reaction (qPCR) was used to investigate transcript levels of the epithelial intercellular tight junction proteins, occludin and zonula occludin-1 (ZO-1), and the adherens junction proteins β -catenin and E-cadherin. Structural alterations to the vocal fold epithelium were further examined by scanning electron microscopy (SEM) and transmission electron microscopy (TEM).

Results: Mann Whitney U revealed significantly decreased occludin ($P = .016$) and β -catenin ($P = .016$) gene expression from rabbits undergoing raised intensity phonation, compared to control. There were no significant differences in ZO-1 and E-Cadherin gene expression between groups ($P > .025$). SEM revealed significant obliteration, desquamation, and evidence of microhole formation in rabbit vocal folds exposed to raised intensity phonation, compared to control, while TEM revealed dilated intercellular morphology between groups.

Conclusions: Results provide support for the hypothesis that a transient episode of raised intensity phonation alters transcript levels of vocal fold intercellular tight junction proteins and disrupts integrity of the epithelial barrier. The loss of barrier integrity may have significant

consequences on epithelial defenses and compromise protection of the underlying mucosa from damage secondary to prolonged vibration exposure.

Singh, V., Cohen, S.M., **Rousseau, B.**, Noordzij, J.P., Garrett, C.G. & Ossoff, R.H. (2010). Acute dysphonia secondary to vocal fold hemorrhage after vardenafil use. *Ear, Nose, & Throat Journal*. 89(6): E21-2.

Owing to their vasodilatory effects, the phosphodiesterase-5 inhibitors have become widely used for the treatment of erectile dysfunction. Among the reported adverse events of these agents are epistaxis, variceal bleeding, intracranial hemorrhage, and hemorrhoidal bleeding. We report a case of vocal fold hemorrhage that occurred after vardenafil use in a 31-year-old man who was a professional singer.

Suehiro, A., Hirano, S., Kishimoto, Y., Tateya, T., **Rousseau, B.** & Ito, J. (2010). The effects of basic fibroblast growth factor on rat vocal fold fibroblasts. *Annals of Otolaryngology, Rhinology, and Laryngology*. 119(10): 690-6.

Objectives: The overarching goal of this line of research is to translate basic fibroblast growth factor (bFGF) treatment for vocal fold scarring into practical clinical use. In a previous canine investigation, we demonstrated that bFGF improves phonation threshold pressure, mucosal wave amplitude, and histologic measures in treated vocal folds after injury to the vocal fold. In the present study, we studied the effects of bFGF on gene expression of the extracellular matrix and growth factors in rat vocal fold fibroblasts.

Methods: Fibroblasts harvested from the vocal folds of five rats were treated with three concentrations of bFGF (0, 10, 100ng/ml). Fibroblasts were collected at 24 hours and 72 hours following bFGF administration. Quantitative polymerase chain reaction was then used to investigate gene expression of the investigated growth factors and extracellular matrices.

Results: Results revealed significantly down-regulated expression of procollagen I and significantly up-regulated expression of hyaluronic acid synthase (HAS) - 2 and fibronectin in fibroblasts treated with bFGF. Basic fibroblast growth factor administration also resulted in the upregulation of bFGF and hepatocyte growth factor (HGF). No changes in the expression of HAS-1, tropoelastin or procollagen III were observed between treatment and control conditions.

Conclusions: Basic fibroblast growth factor treatment induces the down-regulation of procollagen I and up-regulation of HAS-2 from vocal fold fibroblast cell cultures. These gene expression alterations to key mediators of the wound healing process may translate into potential benefits in the remediation of vocal fold injury. The up-regulation of HGF, an anti-fibrotic effector molecule, may demonstrate additional benefits by optimizing the wound healing environment, and accelerating the wound repair cascade. These findings may provide fuel for additional discoveries into the development of growth factor therapy for the treatment of vocal fold scar.

Suehiro, A., Hirano, S., Kishimoto, Y., **Rousseau, B.**, Nakamura, T. & Ito, J. (2010). Treatment of acute vocal fold scar with local injection of basic fibroblast growth factor: A canine study. *Acta Oto-Laryngologica*. 130(7):844-50.

Objectives: We investigated the effects of local injection of basic fibroblast growth factor (bFGF) for treatment of acute vocal fold injury in a canine model.

Study Design: Prospective animal study.

Methods: Vocal folds of eight beagles were unilaterally injured by removal of the mucosa under direct laryngoscopy. Four beagles received local injections of bFGF delivered to the scarred vocal fold at one month after injury. The remaining four beagles received local injections of saline to the scarred vocal fold and served as a sham-treatment group. Larynges were harvested five months after treatment and excised larynx experiments were performed to measure phonation threshold pressure (PTP), normalized mucosal wave amplitude (NMWA), and normalized glottal gap (NGG). Histologic staining was performed to evaluate structural changes of the extracellular matrix, and measurements of thickness of the lamina propria were made between bFGF-treated and sham-treated vocal folds.

Results: Excised larynx measurements revealed significantly lower PTP and increased NMWA in bFGF-treated, compared to sham-treated larynges. Elastica-Van-Gieson staining revealed less contraction of the bFGF-treated vocal fold, compared to the sham-treated vocal fold. Histologic measurements revealed that thickness of the lamina propria was significantly greater in the bFGF-treated vocal fold. Alcian-Blue staining revealed improved restoration of hyaluronic acid in the bFGF-treated vocal fold, compared to the sham-treated.

Conclusions: Results of the current study revealed improved PTP, NMWA, and less contraction of the lamina propria in injured larynges treated with bFGF, compared to sham-treated larynges.

Suehiro, A., Wright, H.V. & **Rousseau, B.** (2011). Optimal concentration of hepatocyte growth factor for treatment of the aged rat vocal fold. *Laryngoscope* 121(8): 1726-1734.

Objectives/Hypothesis: Hepatocyte Growth Factor (HGF) demonstrates beneficial properties in the treatment of aged vocal folds. However, the optimal concentration of HGF remains unknown. The purpose of the present study was to investigate the effects of HGF concentration on treatment of the aged rat vocal fold.

Study Design: Prospective animal study.

Methods: Seventy-five rats were studied. The rats were divided into five groups and received serial injections of HGF in 10µl of phosphate-buffered saline (PBS) at the following concentrations: 10 ng/10 µl, 50 ng/10 µl, 100 ng/10 µl, 200 ng/10 µl, or control (PBS only). Alcian blue staining was performed to investigate hyaluronan (HA), and immunohistochemistry (IHC) was performed to investigate collagen type I and III. Gene expression of hyaluronic acid synthase (HAS) -1, -2 matrix metalloproteinases (MMP) -2, -9, and procollagen I, and III were also investigated using reverse transcriptase polymerase chain reaction (RT-PCR).

Results: Histological analyses revealed increased HA and decreased collagen type I in rats receiving injections of HGF at 100 ng/10 µl. Results were supported by RT-PCR revealing upregulated expression of HAS-2, decreased expression of procollagen I, and a significant increase of MMP-9 mRNA in rats receiving HGF at 100 ng/10 µl.

Conclusions: We report the first in vivo concentration study of HGF for treatment of the aged vocal fold. Results revealed desirable biochemical effects of HGF at 100 ng/10 µl. These data will be used to provide immediate direction to programmatic efforts aimed at examining future applications of HGF for treatment of the aged vocal fold.

Swanson, E.R., Abdollahian, D., Ohno, T., Ge, P., Zelear, D.L. & **Rousseau, B.** (2009). Characterization of raised phonation in an evoked rabbit phonation model. *Laryngoscope*. 119(7): 1439-1443

Objectives/Hypothesis: Our laboratory has developed an in-vivo rabbit model to investigate the effects of phonation on expression and turnover of the vocal fold extracellular matrix. As a logical outgrowth of this research to include phonotrauma, in the present study, we investigated the hypothesis that an increase in airflow rate delivered to the glottis produces a change in glottal configuration and an increase in mean phonation intensity.

Study Design: prospective, animal study.

Methods: Six New Zealand White breeder rabbits weighing 3 to 5 kg were used in this study. A rigid endoscope and camera were used to document glottal configuration. Acoustic signals of modal and raised phonation were recorded and digitized. Two separate one-way repeated measures analysis of variance (ANOVA) tests were used to investigate within subject differences in phonation intensity and fundamental frequency between modal and raised phonation.

Results: Phonation intensity was 54.19 dB SPL (6.21 SD) during modal phonation and 60.31 dB SPL (5.68 SD) during raised phonation. Endoscopic images revealed a convergent glottis, with greater separation of the vocal folds during raised phonation. Results of ANOVA revealed a significant within subjects effect for phonation intensity ($p = 0.011$). Pairwise comparisons revealed that phonation intensity increased significantly during raised phonation, compared to modal phonation ($p = 0.008$). No differences in mean fundamental frequency were observed between phonation conditions.

Conclusions: Improved understanding of factors that control phonation output in the in-vivo rabbit model will result in improved capabilities to match phonation dose across animals and provide immediate direction to future biochemical studies.

Swanson, E.R., Ohno, T., Abdollahian, D., Garrett, C.G. & **Rousseau, B.** (2010). Effects of raised intensity phonation on inflammatory mediator gene expression in normal rabbit vocal fold. *Otolaryngology-Head and Neck Surgery*. 143(4): 567-72. NIHMS 20025135.

Objectives: To investigate the hypothesis that a transient episode of raised intensity phonation causes a significant increase in vocal fold inflammatory messenger RNA (mRNA) expression in-vivo.

Study Design: Prospective animal study. **Setting:** Laboratory.

Subjects and Methods: Ten New Zealand white breeder rabbits received 30 minutes of experimentally induced modal or raised intensity phonation, followed by a 30 minute recovery period. A separate group of five rabbits served as sham controls. Real-time PCR was performed to investigate the mRNA expression of Interleukin-1beta (IL-1 β), Transforming Growth Factor beta-1 (TGF β -1), and Cyclooxygenase-2 (COX-2). Separate one-way analysis of variance (ANOVA) tests were used to investigate differences in gene expression across groups, with an appropriate alpha correction of .016 to control for type I error. Significant main effects were further examined using Fisher's Least Significant Difference.

Results: ANOVA revealed that there were differences for IL-1 β , TGF- β 1, and COX-2 between sham-control, modal phonation, and raised intensity phonation ($p < .0001$). Pairwise comparisons revealed that the expression of IL-1 β , COX-2, and TGF- β 1 increased significantly during raised intensity phonation, compared to modal phonation and sham-control ($p < .0001$).

Conclusions: Results provided support for the hypothesis that a transient episode of raised intensity phonation causes a significant increase in vocal fold inflammatory mRNA expression.

Future studies will investigate the signal transduction pathways and mechanisms regulating the vocal fold inflammatory response. The long-term goal of these studies is to advance understanding of the molecular and cellular events underlying phonation-related tissue alterations.

Watts, C.R., Marler, J. & **Rousseau, B.** (2011). Qualitative characterization of elastic fiber distribution in the mouse vocal fold: Further Development of an Animal Model. *Journal of Voice*, 25(1): e1-6.

The purpose of this study was to identify the presence and characteristics of the distribution patterns of elastic fibers in the 15 week old C57BL/6J mouse vocal fold, to confirm the presence and distribution of collagen fibers, and to describe potential gender differences in staining patterns, with the aim of further developing the mouse model for use in translational research of vocal fold physiological mechanisms. The vocal folds from 12 mice, divided equally into gender categories, were stained for elastic fibers and collagen fibers using conventional staining methods. Qualitative visual analyses were performed by identifying the staining density of elastic and collagen fibers in the superficial half and deep half of the vocal fold lamina propria. Analyses revealed the presence of elastic fibers in both male and female vocal folds, although patterns of staining density were greatest in the deep half of the lamina propria, a location which is deeper than the greatest concentrations of elastic fibers in human vocal folds. Collagen fibers were also present in locations similar to those within human vocal folds, consistent with previously published data. . The results of this study support the use of the mouse model in translational and basic science research, and this model may be especially useful for research aimed at furthering our knowledge of genetic influences on vocal fold structural development and function.

Books, Monographs, and Chapters

Berlin, C.I. & Hood, L.J. 2009. Current physiologic bases of audiologic interpretation and management. In Katz, J., Burkard, R., Hood, L.J. & Medwetsky, L., Eds. Handbook of Clinical Audiology, Sixth Edition. Baltimore MD: Lippincott, Williams & Wilkins.

The premises of this chapter depend on the reader being aware of the following research-based principles:

1. Audiologists are capable of separating outer from inner hair cell function.
2. This differentiation is essential because the hair cells have vastly different functions that are NOT always reflected in the audiogram. Outer hair cells are nature's wide dynamic amplifier (Ruggero, 1992 cited in Berlin et al., 1996), and when they are present, hearing aids are usually, but not always, contraindicated.
3. Thus someone can appear to be severely impaired by behavioral audiogram, have no auditory brainstem response (ABR), and appear to be deaf physiologically but have normal otoacoustic emissions, creating a conflict that we will discuss in great length in the body of the chapter. See also Berlin et al. (2002).
4. Outer hair cell function is measured with two tests: otoacoustic emissions and cochlear microphonics (CM). (See body of chapter for measurements of CM.) When we see normal emissions, we also acquire indirect data on the mechanical status of the middle ear because if the middle ear is obstructed, the emissions will be attenuated or blocked. However, normal emissions do not guarantee normal or near-normal audiograms despite conventional wisdom to the contrary (Bonfils and Uziel, 1989).
5. CM come from any hair cell and reflect the electrical fields around the hair cells. They can be measured during ABR by reversing click polarity and observing the reversal of the waves that will only occur if the waves come from hair cells rather than nerve fibers (Berlin et al., 1998).
6. Inner hair cells, which are the primary driving force of the eighth nerve (Spoendlin, 1979), can be measured with five different tests, one of which includes middle ear muscle reflexes. The reflexes are not normal and not present in auditory neuropathy/auditory dyssynchrony (AN/AD) (Berlin et al., 2005). Thus, normal emissions and absent reflexes are a hallmark of AN/AD and can also be used to rule out central auditory processing disorder (CAPD) in the presence of normal audiograms. The audiogram alone, no matter how mild or severe, cannot be relied on to reveal the underlying physiologic state of the inner ear and brainstem. For example, we found that more than 10% of children in a school for the deaf had unexpectedly normal emissions (Cheng et al., 2005).
7. In this chapter, we are advising our colleagues to pretest the physiology with tympanometry, reflexes, and emissions before accepting the audiogram at face value, not only for the differential diagnosis of AN/AD but also for uncovering measurement errors (misplaced earphones, collapsed canals, functional hearing loss, out of calibration systems, etc.). More rationale is found in Berlin et al. (2002).

Bradham, T.S. (In preparation). In **Golper, L.** & Frattali, C. Eds. Outcomes in speech-language pathology, 2nd Ed. New York: Thieme Medical Publishers Inc.

The United States has the highest per capita health care costs of any industrialized nation, many other developed countries are also experiencing the same cost increases (Kowdley & Ashbaker, 2010). Increasing costs are reducing access to care and constitute an ever heavier burden on employers and consumers. Yet as much as 20 to 30 percent of these costs may be unnecessary, or even counterproductive, to improved health (Wennberg, Brownless, Fisher, Skinner, & Weinstein, 2008). Addressing these unwanted costs are essential in the survival of providing quality clinical services. One avenue to reduce unwanted costs while maintaining quality of services has been termed quality management. Some argue that implementing quality management programs is costly. Others would argue that poor quality is even more costly. The Centers for Medicare and Medicaid services defines quality as “how well the health plan keeps its members healthy or treats them when they are sick. Good quality health care means *doing the right thing at the right time, in the right way, for the right person*—and getting the best possible results” (CMS, 2008). To improve our organizational effectiveness and efficiencies, both leaders and service providers in all settings need to make changes in current practices. Hence, our chapter will begin with introducing change to our employees, developing teams, and setting goals. We will also discuss ideas on evaluating our programs to select items to change and suggest models and tools used for improvement to obtain the best outcomes.

Brown, K. & **Golper, L.** (in press) Evidence-Based Practice. In R. Lubinski and M. Hudson (Eds.), Professional Issues in Speech-Language Pathology and Audiology, 4th Edition. San Diego: Delmar (in press).

Conture, E. & Walden, T. (in press). Dual Diathesis-Stressor Model of Stuttering. Chapter to appear in Beliakova, L., & Filatova, Y. (Eds.) Theoretical Issues of Fluency Disorders. Moscow: Vldos

For the approximately 1% of children who continue to stutter after 6 years of age, the negative impact of stuttering can be significant in terms of academic, emotional, social, vocational achievement, development and potential. Thus, there is a need to determine which variables may initiate/cause, exacerbate or perpetuate stuttering to eventually develop more efficient, effective data-motivated approaches to diagnosis and treatment. Trying to address that need, the presenter has pursued a program of empirical study of speech-language planning and production as well as dispositional and situational aspects of emotions in attempts to determine whether these variables may be causal contributors to developmental stuttering. Based on a relatively large data-base (n = 300) involving preschool children who do and do not stutter, findings from select descriptive as well as experimental investigations will be presented. These findings will be used to support a dual diathesis-stressor model of developmental stuttering (See Figure G-1). Specifically, subtle, probably developmental, inefficiencies in speech-language planning production (vulnerability or diathesis 1) and/or lowered threshold of reactivity to change, difference or novelty (diathesis 2) are thought to be present for at least some children who stutter. These diatheses are believed to be exacerbated by the degree to which speech-language is generated spontaneously or on-the-fly (stressor 1) and/or the degree to which change, difference or novelty occurs in the environment (stressor2). Because the nature and number of interactions between these causal contributors is probably unevenly distributed

across the population of children who stutter, it seems reasonable to suggest that no one size (explanation) will fit all children who stutter. Research supported in part by NIH/NIDCD research grants 5R01DC000523-14 and 1R01DC006477-01A2.

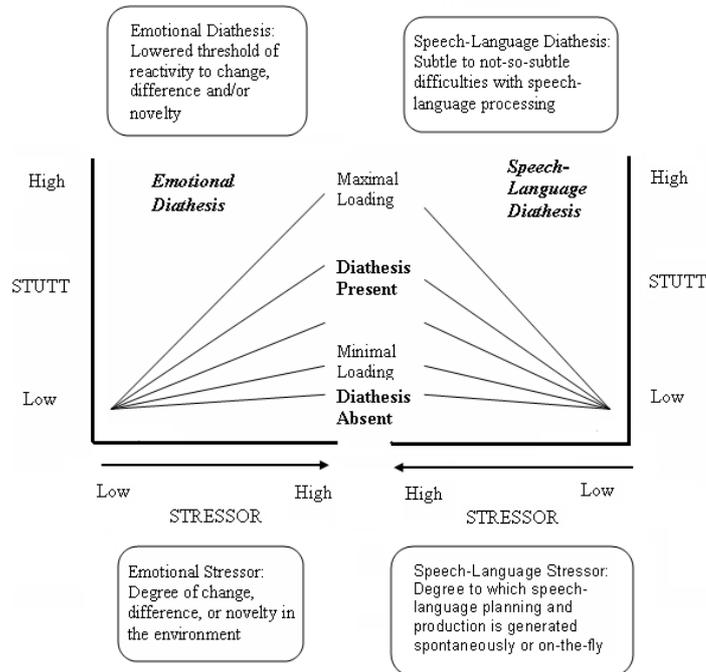


Figure G-1. Dual Diathesis-Stressor Model of Developmental Stuttering.

Golper, L. (2009). Leadership: Finding Your Inner Throgmartin. Perspectives on Administration and Supervision. 19: 39 – 44.

This monograph discusses the internal traits and external influences that engender leadership. The article considers the various forces that cause some individuals gravitate toward and assume leadership positions (finding their “inner Throgmartin”) while others do not. The monograph argues for the importance of emotional intelligence and work-life balance as central to good leadership and describes the differences between management and leadership, the variations in leadership styles, what sources of power available to leaders, and methods for practicing and developing leadership skills in the workplace and in professional service activities.

Golper, L. (2010). Medical speech-language pathology: A desk reference (3rd ed). Clifton Park, NY: Cengage.

This third edition text (retitled from the Sourcebook of Medical Speech Pathology, 1st and 2nd eds) provides a comprehensive desk reference for practicing clinicians and students working in medically-allied settings. The text provides a basic understanding of the vernacular of health care settings, with medical terminology, abbreviations, and procedure descriptions: anatomic

structures and physiology pertinent to speech, language, and swallowing; and the fundamental principles of medical and surgical management of disorders most frequently encountered in medical speech-language pathology practices. The 14 chapters and Appendices include: Speech-Language Pathology in Medical Settings; Communicating Information and Recording-Keeping; Vital Signs and the Physical Examination; mental Status and the Neurologic Examination; Nutrition, Hydration, and Swallowing; Medical Genetics; Imaging Studies and Radiologic Oncology; Infectious Diseases and Infection Control; Cardiac, Pulmonary, and Hematologic Functions; Neurologic and Psychiatric Disorders; Acute and Critical Illness; Oncology; Surgeries and Other Procedures; Rehabilitation Medicine and Geriatrics; Normal Laboratory Values and selected Anatomic Figures.

Golper, L. & Frattali, C. Eds. (in preparation). *Outcomes in speech-language pathology*, 2nd Ed. New York: Thieme Medical Publishers Inc.

This textbook brings together 25 contributing authors across 17 chapters, collectively addressing the broad topic and importance of data-driven decision making in clinical practices across settings and in higher education. The public policy mandates and the resulting forms and methods for outcomes reporting currently in use across the profession are described. Chapter topics are organized within the following schema: Section I. Outcomes measurement: History and Contemporary Issues; Section II: Outcomes in Clinical Services; Section III: Outcomes in Organizational Performance; Section IV: Outcomes Research; and Section V: Outcomes in Graduate Education.

Golper, L. (in preparation). Contemporary issues and current practices in outcomes measurement: An overview. In **L. Golper** and C. Frattali, (Eds) (in preparation). *Outcomes in Speech-Language Pathology*. New York, NY: Thieme Medical Publishers Inc.

This introductory chapter to a textbook on *Outcomes in Speech-Language Pathology* provides an overview and context for the subsequent chapter topics within a textbook that examines broadly the topic of outcomes measurement across various practice settings and for various purposes in the profession.

Golper, L. (in preparation). Outcomes assessment in medical speech-language pathology. In A. Johnson and **B. Jacobson** (Eds). *Medical speech pathology: A practitioner's guide*, 2nd Ed. New York, NY: Thieme Medical Publishers, Inc.

Outcomes assessment specific to speech-language pathology services in healthcare practice settings is reviewed. Issues related to the current emphasis on functional and patient reported outcomes are discussed, and the clinical practitioners' reluctance to avail themselves to systematic reviews and evidence-maps despite increased accessibility of systematic reviews and evidence maps is examined.

Guth, D.A., Rieser, J.J. & **Ashmead, D.H.** (2010). Perceiving to move and moving to perceive: Control of locomotion by students with vision loss. In Blasch, B., Welsh, R.L., & Wiener, W.R. (Eds.). *Foundations of orientation and mobility*. Third edition. Volume 1. New York: American Foundation for the Blind.

This chapter describes three fundamental aspects of the challenge of establishing and maintaining orientation. The first is access to perceptual information that guides spatial decision making. The second concerns the ability of individuals who are visually impaired to acquire information from their mental maps of places and to make strategic use of this information to guide their travel. The third is the selection of strategies for gathering information and for orientation-related decision making. The chapter reviews relevant research and provides practical suggestions for orientation and mobility instruction.

Grantham, D. W., Croghan, N. B. H., Camalier, C. R. & Bernstein, L. R. (2010). Binaural interference: The effects of listening environment and stimulus timing. In: Suzuki, Y., Brungart, D., Kato, H., Iida, K., Cabrera, D., & Iwaya, Y. (Eds.) *International Workshop on the Principles and Applications of Spatial Hearing 2009*. World Scientific Publishing Company.

Interaural time difference (ITD) thresholds for a high-frequency stimulus are elevated in the presence of a low-frequency interferer [McFadden and Pasanen, *J. Acoust. Soc. Am.* 59, 634 (1976)]. This phenomenon, known as “binaural interference,” was further explored in the present series of experiments. In experiment 1 binaural interference was measured in the free field. The minimum audible angle for a high-frequency target was considerably elevated when a low-frequency interferer was pulsed on and off with the target from a position directly in front of the subject. However, if the low-frequency interferer was presented continuously, or if its spatial position was different from that of the target, the interference was practically eliminated. Experiment 2 showed that the degree of binaural interference in an ITD task decreased monotonically with the duration of interferer fringe that came before, after, or both before and after the target. These results are consistent with the notion that interference from a spectrally remote low-frequency interferer may be influenced by the extent to which the target and interferer are fused into a single perceptual object. Experiment 3 showed that binaural interference increased as the interstimulus interval between the two target presentations decreased (see Figure G-2). This unexpected finding indicates that the weights assigned to target and interferer in an interference paradigm are governed by temporal windows that may be even longer than those associated with binaural sluggishness.

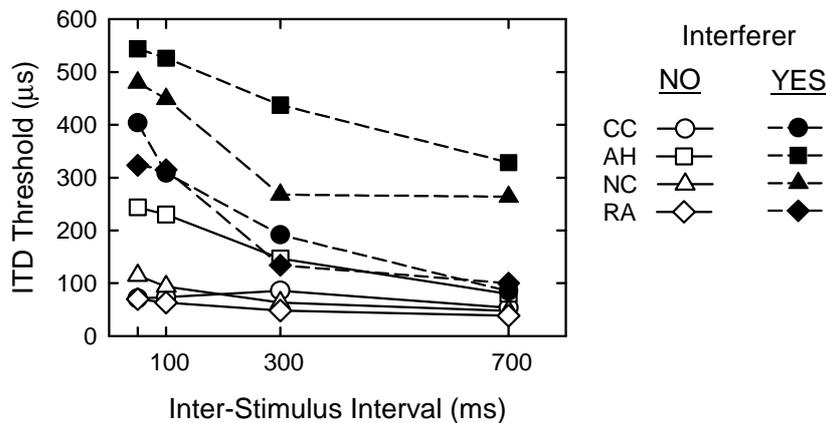


Figure G-2. ITD thresholds for the high-frequency target for four subjects obtained with (filled symbols) and without (open symbols) the low-frequency interferer, plotted as a function of interstimulus interval.

Hackett, T. A. (2009) Organization of the central auditory pathways in nonhuman primates and humans. In *Current Controversies in Central Auditory Processing Disorders (CAPD)*, AT Cacace and DJ McFarland (Eds.), San Diego: Plural Publishing, 15-46.

Hackett, T. A. & Kaas, J. H. (2009). Audition. In *Handbook of Neuroscience for the Behavioral Sciences*. GG Berntson and JT Cacioppo (Eds.), John Wiley and Sons, 251-266.

Hale, S.T. & Bess, F. H. (2011). Professional Associations. In R. Lubinski and M. Hudson (Eds.), *Professional Issues in Speech-Language Pathology and Audiology*, 4th Edition. San Diego: Delmar (in press).

A variety of options for affiliating with other professionals are available for students. The chapter addresses the nature of professional associations including bylaws, governance, and ethical standards for members. Student organizations, the American Speech-Language-Hearing Association, the American Academy of Audiology, and other related professional organizations are described including the benefits of affiliation.

Hale, S.T. & Ivy, L.J. (2011). Outcome Measurement in Graduate Clinical Education and Supervision. In L. Golper and C. Frattali (Eds.), *Outcomes in Speech-Language Pathology*, Thieme Publishers. NYC (in press).

Student clinical achievement and supervisory competence are interdependent and highly influential on the accurate measurement of students' knowledge and skills. Delineation of expected outcomes for students' clinical performance and decreasing dependence on

supervisory support lead to the development of clinical competence and readiness for independent practice.

Hale, S.T. (2011). Professional Issues in Speech-Language Pathology. In A. Johnson and G. Lof (Eds.), *Speech and Language Pathology Exam Study Guide, Therapy Ed.* Evanston, IL (in preparation).

Professional issues including ethical conduct, professional affiliations, credentialing, and standards of care and workplace behavior are discussed in a format which assists the student in studying for the examination for state and national credentialing.

Hood, L. J. & Keats, B. J. B. 2010. Genetics of Childhood Hearing Loss. In Seewald, R., Gravel, J. S. & **Tharpe, A. M.**, Eds. *Handbook of Pediatric Audiology.* San Diego: Plural Publishing, in press.

Epidemiologic and Demographic Aspects of Genetic Hearing Loss. Congenital hearing loss occurs in approximately one to two of 1,000 births, and genetic factors account for at least 60% of childhood hearing loss. Genetic hearing loss is usually classified according to the presence (syndromic) or absence (nonsyndromic) of other clinical anomalies and the pattern of inheritance (autosomal, X-linked, dominant, recessive, mitochondrial). Over the past 10 to 15 years more than 80 hearing loss genes have been described, and the causal mutations in patients can often be identified through genetic testing. Most cases (> 70%) of childhood hearing loss are nonsyndromic with an autosomal recessive pattern of inheritance. Mutations in the gene (GJB2) encoding the protein known as connexin 26 explain as many as 50% of these cases in some populations. A genetic etiology should be considered for every patient with a hearing problem. Even if a possible environmental cause is reported, a genetic cause cannot be ruled out. Conversely, if no obvious environmental insult or other cause can be determined, then the cause is most likely genetic. Also, it is important to realize that a family history of hearing loss is not necessary for the cause of a hearing loss to be related to a genetic defect. For example, a child with autosomal recessive hearing loss is often the only affected person in the family (see below). Not all inherited hearing loss is present at birth; hereditary loss can also have later onset. This is further discussed in the context of identification of hearing loss.

Hood, L. J. & Morlet T. 2010. Auditory neuropathy spectrum disorder. In Burkard, R. & Tremblay, K. L., Eds. *Translational Perspectives in Hearing Science.* In press.

Patients ranging in age from infants to adults are described with an auditory disorder variably termed auditory neuropathy (AN; Starr et al., 1996), auditory neuropathy/dys-synchrony (AN/AD; Berlin et al., 2001) and more recently, auditory neuropathy spectrum disorder (ANSD; Gravel, 2008). For purposes of the discussion that follows and with the caveats and knowledge of the inherent problems discussed later, we shall use the term ANSD.

ANSD is characterized by evidence of intact outer hair cell function as shown by otoacoustic emissions (OAEs) and/or cochlear microphonics that is accompanied by poor VIIIth nerve-brainstem responses demonstrated by absent or highly abnormal auditory brainstem responses (Berlin et al., 1998). Further evidence of effects on neural function are demonstrated by

generally absent or sometimes elevated middle-ear muscle reflexes (Berlin et al., 2005) and abnormal medial olivocochlear reflexes, measured via efferent stimulation effects on OAEs (Hood et al., 2003). Most ANSD patients show bilateral symptoms, though function may be asymmetric between ears, and cases of unilateral ANSD have been documented.

Despite fairly similar findings from physiologic measures in current clinical use, there is considerable variation in characteristics and functional communication abilities across patients (e.g., Starr et al., 2000; Berlin et al., 2010). Clinical presentation typically, but not always, includes difficulty listening in noise, may include fluctuation in hearing ability, and, in the case of infants and children, most often involves delayed or impaired development of speech and language. ANSD may or may not be accompanied by neural problems in other systems. Patients with ANSD typically demonstrate timing problems (Zeng et al., 1999), which suggest a disturbance in neural synchrony. This variation impacts both evaluation and management of ANSD.

Key, A., Charboneau, E. & Cowan, R. (in press). Food perception in adults: Neuroimaging findings. To appear in *International Handbook of Behavior, Diet and Nutrition* (Preedy, V.R., Martin C., & Watson R.R., Eds.)

This chapter presents an overview of the neuroimaging studies of food perception in adults. A brief introduction to EEG/ERP, PET and fMRI methods is provided, followed by a review of current literature using these techniques in typical healthy participants to investigate brain structures and processes involved in visual, olfactory and tactile perception of food-related stimuli. The role of higher-order cognitive processes (e.g., attention, self-control) is also examined. A separate section examines brain mechanisms of food perception in adults with Prader-Willi syndrome, a genetic disorder associated with insatiable appetite, chronic overeating and obesity. Evidence across studies reveals that food stimuli are processed mainly by the same brain structures as other attention-grabbing non-food stimuli, but the specific patterns of brain activity differ across satiated vs. hungry states. Furthermore, perception of food stimuli can be affected by self-imposed eating restrictions and beliefs, even at the early, pre-attentive stages of information processing. Finally, examination of brain responses to food stimuli in a clinical group (Prader-Willi syndrome) reveals that differences in behavioral phenotypes are associated with altered brain functioning during perceptual categorization and affective evaluation of food stimuli, suggesting that brain-based measures can yield valuable information for improved understanding of typical and atypical eating behaviors.

Key, A. & Thornton-Wells, T (in press) Brain-based methods in the study of developmental disabilities. To appear in Burack, J.A., Hodapp, R.M., & Zigler, E. (Eds), *Handbook of Developmental Approaches to Intellectual Disabilities* (2nd Ed.). Oxford, UK: Oxford University Press.

Over the past twenty years, research in the area of developmental disabilities, particularly those with a known genetic basis, has expanded from reliance almost entirely on behavioral assessments to inclusion of brain-based measures. Brain-based research methods provide information about which areas of the brain are involved in performing particular types of tasks or behaviors (e.g., recognizing letters or listening to music) and how these brain structures differ between individuals with typical development (TD) and those with a particular developmental disability (DD). It is also possible to assess how efficiently various brain regions function and

how well they communicate with other parts of the brain. Such detailed information can provide crucial insights into whether a particular behavioral pattern or cognitive difficulty is related to anatomical or functional brain characteristics. Brain-based measures can also help disambiguate the contributions of sensory processes, attention, motivation, emotion regulation, response selection and execution, or higher cognitive functions to the cognitive and behavioral profiles of persons with DD. In this chapter, we will focus on two of brain imaging technologies—ERP and MRI—which are increasingly being used in research on developmental disabilities. We will briefly discuss how each methodology works and what kinds of research questions each is well-suited to answer. We will also illustrate how these methods have been used in four specific genetic disorders: Down syndrome, Prader-Willi syndrome, Williams syndrome and Fragile X syndrome. Finally, we will discuss gaps in current research, issues of experimental design, and suggest directions for future studies.

McCaslin, D.L., Jacobson, G.P. (in press). Anatomy and physiology of the vestibular system. In: Anatomy and physiology of the auditory system. Musiek F. Ed., Plural.

The anatomy and physiology of the peripheral and central vestibular systems are described.

McCaslin, D.L., Jacobson, G.P., Gruenwald, J.M. 2011. The Predominant Forms of Vertigo in Children and their Associated Findings on Balance Function Testing. In Kesser B.W. & Gleason, A. T., Eds. Otolaryngologic Clinics of North America: Dizziness and Vertigo across the Lifespan. Volume 44, Number 2, 291 – 307.

There are many disorders that can cause dizziness in the pediatric population. In 1999, Russell and Abu-Arafeh published an epidemiologic study showing that 15% of school-age children had experienced at least one episode of vertigo in the previous year. Numerous investigators have also reported the most common disorders causing vertigo and imbalance in children in their clinics. Even though these reports originate from different clinics and regions of the world, there is surprisingly good agreement regarding the primary causes of dizziness in the pediatric population. Regardless of this fact, children suffering from vertigo and imbalance have received less attention in the literature than their adult counterparts, most likely due to the difficulty that young children have in describing their symptoms, coupled with the challenges that exist for clinicians who work through the differential diagnostic process with children. Despite these limitations, it is now known that the most common disorders that cause dizziness in children may manifest themselves as abnormalities on quantitative balance function testing (i.e. rotational testing, electronystagmography [ENG], and vestibular evoked myogenic potential testing). The purpose of this brief report is to describe techniques for determining which children may benefit from quantitative balance function testing and what the reported findings are for the 5 most common disorders accounting for vertigo and imbalance in children.

Malmierca, M. M. & **Hackett, T. A.** (2010) Structural and functional organization of the auditory brain. In OUP Handbook of Auditory Science, Volume 2, The Auditory Brain, AR Palmer and A Rees (Eds.), Oxford: Elsevier, 9 – 42.

Porter, H.L. & Bess, F.H. (2010). Children with unilateral hearing loss. In R. Seewald & **A.M. Tharpe** (Eds.) *Comprehensive Handbook of Pediatric Audiology* (pp. 175-191). San Diego: Plural Publishing, Inc.

This chapter reviewed historic and current research regarding unilateral hearing loss in children. Topics included etiology, prevalence, auditory performance, real-world outcomes, audiological considerations, and future research directions. It is generally believed that UHL in children does not produce handicapping conditions. An evidence-supported case was made that children with UHL experience a variety of auditory, linguistic, and cognitive problems that appear to be compromising, in some unknown way, educational progress. The major conclusion from this chapter, was that a growing body of scientific-based research exists to support the premise that unilateral hearing loss can indeed compromise social and emotional behaviors, success in school, and ultimately, life learning. Clearly a need exists to develop a better understanding of unilateral hearing loss in children in such areas as identification, diagnosis, prevalence, etiology, educational and social risk factors, and management strategies.

Porter, H.L. & Tharpe, A.M. (2010). Hearing loss among persons with Down syndrome. In R. Urbano (Ed.) *International Review of Research in Mental Retardation: Health Issues in Down Syndrome* (195-220). Elsevier, Inc.

Communicative interactions provide the foundation for cognitive and social development early in life and continue to impact our behaviors, social patterns, and thoughts throughout our lives. Expressive and receptive exchanges are essential to communication, and hearing is an essential part of all spoken communicative attempts. For individuals who use spoken communication, maximizing auditory ability is imperative. This is especially true for those with Down syndrome as they are susceptible to expressive and receptive communicative difficulties and vulnerable to auditory disorders. Hearing loss can interfere with a child's ability to develop spoken language and influence subsequent academic and psychosocial development. Even children with mild hearing loss can experience greater academic difficulty than their peers with normal hearing. The early effects of hearing loss on academic and social development can remain throughout adulthood. Though individuals with Down syndrome are prone to hearing loss, the effects can be lessened with accurate and early identification when accompanied by appropriate ongoing medical and audiology management. It is important for all those involved in the lives of children and adults with Down syndrome to recognize the auditory barriers that are likely to exist and to remain diligent in their efforts to seek ongoing otologic and audiology care. This review discusses typical development of the human auditory system and what is known about the structure and function of the auditory systems of individuals with Down syndrome. In addition, we describe behavioral and physiologic assessments of auditory sensitivity and conclude with a discussion of hearing technology options for individuals with Down syndrome and hearing loss.

Richels, C. & **Conture, E.** (2009). Indirect treatment of childhood stuttering: Diagnostic predictors of treatment outcome. Chapter in Guitar, B. & McCauley, R. (Eds). *Treatment of Stuttering: Emerging and established approaches* (pp. 18-55). Baltimore, MD: Lippincott, Williams & Wilkins.

The purpose of this chapter was to discuss the role of assessment as a means of diagnosing childhood stuttering as well as informing clinicians about the course and outcome of treatment. The chapter focused on the assessment of preschool (ages 2.5- to 5-year-olds) and young school-age (ages 5- to 6-years 11-months-old) children who stutter (hereafter referred to as child or children). This age-range was selected because it brackets the time period during which the onset of stuttering is most likely to occur (e.g., Maansson, 2007; Yairi & Ambrose, 2005; Yaruss, 1999; Yaruss, LaSalle & Conture, 1998) and when the differential diagnosis of children with incipient stuttering versus transient disfluency is most challenging (Curlee, 1993, Finn, Ingham, Ambrose, & Yairi, 1997). The authors begin by discussing the theoretical underpinnings that guide their assessment procedures as well as the empirical support for our means of assessing children known or thought to be stuttering.

Following this discussion, the chapter presents the rationale, strategies, and outcome data regarding the present authors' approach to assessment as it relates to successfully implementing treatment for children who stutter. The chapter concludes with a summary of what the authors believe to be the essential aspects of assessing children as well as areas in need of future exploration and modification. It is hoped that the reader of this chapter will better understand the importance of the initial assessment of children and families in the treatment of young children who stutter. Additionally, we believe that clinicians should then be able to appropriately modify our approach to best fit various service delivery settings as well as the individual needs of their young clients and their families. Research supported in part by an NIH Grants R01 DC000523-14 and R01 DC006477-01A2, and a Vanderbilt University Discovery Grant.

Seewald, R.C. & **Tharpe, A.M.** (2010). *Comprehensive handbook of pediatric audiology*. San Diego CA: Plural Publishing.

This comprehensive text covers knowledge areas requisite to the provision of the full range of quality, comprehensive pediatric audiologic services to children from the neonatal period through school-age. This text is intended for use in doctoral-level education programs in audiology or hearing science, as well as to serve as an in-depth reference source for practicing audiologists and other professionals, educators, scientists, and policy makers seeking current and definitive information on evidence-based pediatric audiology practice.

Shapiro, W. & **Bradham, T.S.** (in press). Cochlear Implant Programming. In: T. Roland and **D. Haynes** (Eds.). *Otolaryngologic Clinics of North America*. Philadelphia PA: Elsevier.

This chapter focuses on cochlear implant programming. Cochlear implants have become a viable treatment for individuals who present with severe to profound hearing loss. This technology allows them to access sound in their environment and communicate more effectively with their peers. This chapter focuses on general (traditional) device programming, programming techniques specific to children, objective programming techniques, a brief overview of the programming parameters of the currently commercially available multichannel systems available in the United States- Harmony device (Advanced Bionics Corporation, Valencia, CA), Med El combi 40+ (Innsbruck, Austria), and the Nucleus Freedom and N5 device (Cochlear Corporation, Sydney Australia), as well as managing patient programming complaints, device failures, and finally what we believe the future may hold for new programming techniques.

Soman, U.G., Kan, D. & Tharpe, A.M. (in press). Rehabilitation and educational considerations for children with cochlear implants. In: T. Roland and D. Haynes (Eds.). *Otolaryngologic Clinics of North America*. Philadelphia PA: Elsevier.

This chapter focuses on rehabilitation and educational considerations for children with cochlear implants. Although distinctly different, the goals of rehabilitation and education overlap considerably in good practice. The term rehabilitation is typically used to refer to an individualized model of therapy, such as one-on-one training with a speech-language pathologist or auditory-verbal therapist; education typically refers to learning facilitated by a teacher in a school-based environment. Children with cochlear implants benefit from the intentional collaboration of these two practices. For example, teachers should integrate speech and language goals into academic lessons and speech-language pathologists should integrate academic content into speech and language activities. Throughout this chapter, we use the terms interchangeably as a reminder of their ideal interconnectedness.

Tharpe, A.M. & Dickinson, W.W. (2010). Audiologic management of unilateral and minimal to mild bilateral hearing loss in children. In: R.C. Seewald and A.M. Tharpe (Eds.). *Comprehensive Handbook of Pediatric Audiology*. San Diego CA: Plural Publishing.

Most audiologists agree that the audiological management of children with unilateral (UHL) or minimal to mild bilateral hearing loss (MBHL) must be made on a case-by-case basis. Although approximately 30-40% of children with UHL and MBHL appear to be at high risk for academic difficulty, it is unclear exactly which of these children will require some form of intervention and which children will not. Therefore, at this point in time, all children with permanent UHL or MBHL must be considered at risk for psychoeducational difficulties and monitored accordingly. This chapter addresses the components of a comprehensive monitoring plan for these children, including:

- counseling and education
- etiologic evaluation
- daycare and school environments
- hearing aids and assistive technologies
- audiologic monitoring
- functional assessments

Tharpe, A.M. & Ryan, H.M. (2010). Hearing instrument orientation for children and their families. In: R.C. Seewald and A.M. Tharpe (Eds.). *Comprehensive Handbook of Pediatric Audiology*. San Diego CA: Plural Publishing.

The purpose of early identification of hearing loss in infants and children is the implementation of early intervention. And, the foundation of early intervention for children with hearing loss is the accurate and timely fitting of amplification. However, the fitting of amplification is only the first step. If families do not understand the importance of hearing aids or are not confident placing the devices on their children, our best efforts will be thwarted. Only when families are

comfortable with and understand the importance of hearing aids will they be carefully cared for and worn consistently. Therefore, effective hearing aid orientation is fundamental to the long-term goals of consistent hearing aid use and care, and the development of auditory and speech-language skills. This chapter describes the family support and education needed from audiologists throughout the hearing aid orientation process. Hearing aid orientation is referred to as a process because it does not occur only at the time when the child is fit with his or her first hearing aids. Rather, audiologists continue to educate families and children about hearing technology after the first fitting as technology options change and as the child's hearing needs change over time. This education extends to the child's other caregivers via interactions with daycare workers, educational audiologists, teachers, and other qualified interventionists. Furthermore, although in many instances adults are the intended targets of the orientation information, as a child gets older and is able to participate in the care of and decisions about hearing technology, children also become direct recipients of this information.

Wallace, M.T., Ghose, D., Fister, M.C. & Krueger, J. (In press). Development of Multisensory Integration in Subcortical and Cortical Brain Networks. *Multisensory Development*. Oxford Press.

Recent neurophysiological studies have highlighted the dramatic integrative capacity of multisensory neurons and networks in response to stimulus combinations. This work has revealed that multisensory processes are surprisingly ubiquitous, follow a seemingly universal set of principles based on the spatial and temporal relationships of the stimuli and their relative effectiveness, and play important roles in modulating behavior and shaping perception. In comparison to this rapidly expanding wealth of data on adult multisensory circuits, substantially less has been known about how multisensory neurons and their associated networks develop during early life. However, this situation is quickly changing as the developmental chronology of multisensory processes is mapped in both subcortical and cortical brain structures. These studies have revealed that multisensory neurons appear rather late in development, and initially lack the striking integrative characteristics that define their adult counterparts. As postnatal life progresses, the incidence of multisensory neurons rapidly increases and their non-linear integrative capabilities appear. Sensory experience appears to play a major role in shaping these developmental events, in that animals raised in environments devoid of multisensory associations or with altered associations develop abnormal integrative features. Future work will seek to better relate these developmental processes at the neural level to their behavioral and perceptual correlates, and will strive to provide a better mechanistic framework for understanding the key cellular and molecular events in multisensory development.

Wallace, M.T., Krueger, J. & Royal, D.W. (2010). Neural Development and Plasticity of Multisensory Representations. *Multisensory Object Perception in the Primate Brain*. Springer.

Although we live within a rich multisensory world, it is only relatively recently that we have gained some understanding of the brain mechanisms that serve to bind together information from the different senses. Despite this, our understanding of the developmental progression of events leading up to the mature multisensory state has lagged behind. Recent work carried out in both the primate and cat model has enriched our understanding of the neural bases of multisensory development. This work has shown that there is a gradual growth in the size of the

multisensory neuronal pools in both subcortical and cortical structures during early postnatal life, and that these neurons transition from an early non-integrative mode to a later mode in which they actively synthesize their multisensory inputs. The postnatal window within which these processes mature suggest that early sensory experience is a critical determinant in multisensory development. To assess the role of sensory experience, visual-nonvisual experiences have been eliminated (via dark-rearing) or altered (via spatial- or temporal-disparity rearing). In the absence of early postnatal visual experiences, a mature multisensory circuit fails to develop. In contrast, altering the statistics of early multisensory experiences results in the development of a circuit that reflects these experiences. New work is focused on characterizing the spatial receptive field (SRF) and spatiotemporal receptive field (STRF) architecture of subcortical and cortical multisensory neurons, and has shown receptive field microstructure to be a key determinant in the evoked multisensory response. Although focused on the development of multisensory spatial representations, these studies provide important insights for studies examining the maturation of multisensory object representations.

Sources of funding (Department of Hearing & Speech Sciences)

Currently active support

- Source & number:** MCHB MCJ000217-55 -- Anne Marie Tharpe, Principal Investigator
Title: Communication Disorders in Children
Project period: 7/01/08 - 6/30/13
Description: To train students in speech-language pathology and audiology from Vanderbilt University School of Medicine and Tennessee State University.
- Source & number:** IES/R324A110266--Fred H. Bess, Principal Investigator
Title: Listening Effort and Fatigue in School-Age Children with Hearing Loss
Project period: 7/1/11-6/30/2015
Description: The purpose of this exploratory study (Goal 1) is to examine whether school-age children with mild to moderate hearing loss (CHL) expend greater listening effort and subsequently experience more fatigue under noisy conditions (similar to a classroom) than a group of normal hearing children (CNHL). We also propose to evaluate the impact of hearing-related fatigue on basic skills essential for learning in school.
- Source & number:** 3R01DC008640-03 – Stephen Camarata, Principal Investigator
Title: Treatment of Speech Disorders in Children with Down Syndrome
Project period: 9/1/07-8/31/11
Description: This project is designed to develop more effective treatments for speech disorders in children with Down Syndrome.
- Source & number:** 3R01DC008640-02S1 – Stephen Camarata, Principal Investigator
Title: Treatment of Speech Disorders in Children with Down Syndrome/Research Supplement
Project period: 9/1/08-8/31/11
Description: This project is designed to provide a postdoctoral student with an opportunity to gain research experience as a postdoctoral fellow on an ongoing research project in accordance with stated goals of “broadening research experience” and in accordance with the objectives of the program announcement.
- Source & number:** R324A080143 – Stephen Camarata, Principal Investigator
Title: TOP9 and G2 Related Services Intervention for Expressive and Receptive Language Skills in ASD and in CI
Project period: 7/1/08-6/30/12
Description: This purpose of the proposed project is to systematically develop, using single subject design, whether an intervention for improving receptive language (as well as expressive language) in preschool children with mild-moderate cognitive impairments and to develop this intervention program for preschool children with ASD.

Source & number: NIH-NEY/2R01EY012894-09 – Subcontract with Western Michigan University – Daniel H. Ashmead, Principal Investigator

Title: Blind Pedestrians' Access to Complex Intersections
Project period: 7/1/08-6/31/13
Description: The central aims of this program are to use the strengths of a multi-disciplinary team to understand the perceptual and cognitive requirements of negotiating complex intersections without vision and with low vision; to design and test engineering and training solutions to problems of information access that are currently known and that are identified in the course of this partnership and to produce materials about the problems and solutions that are useful to transportation engineers, individuals with visual impairments, and rehabilitation personnel.

Source & number: NIH-NIDCD/2R01DC000523-14A1 – Edward G. Conture, Principal Investigator

Title: Emotional and Linguistic Contributions to Developmental Stuttering
Project period: 8/1/10-7/31/15
Description: The proposed project builds on our preliminary findings and theoretical model, **longitudinally**, to relate emotional and speech-language to developmental stuttering, using **multiple methods** (i.e., observational, standardized testing, parent-report, and psychophysiology) that assess our major constructs of emotion and speech-language.

Source & number: Malcolm Fraser Foundation – Edward G. Conture, Principal Investigator

Title: Parent-Child Stuttering Group
Project period: 7/1/98-8/31/12
Description: To permit the DHSS to refine and expand upon the quality and quantity of our speech-language pathology services for people who stutter and their families in the Middle Tennessee and surrounding regions.

Source & number: NIH-NIDCD/5R01DC04318-09 – Troy Hackett, Principal Investigator

Title: Functional Organization of the Auditory Cortex
Project period: 5/1/08-4/31/13
Description: The primary goal is to obtain a comprehensive map of the human auditory cortex. Anatomical and physiological analyses are combined to identify the number of regions and areas involved, their connections, neuron response properties, and neurochemical profiles.

- Source & number:** NIH-NIMH/9R01DC011490-11 –Troy Hackett, Co-principal Investigator
Title: Neurophysiology and Anatomy of Multisensory Processing
Project period: 12/01/10-11/30/15
Description: Our broad goal is to investigate multisensory interaction across levels of the auditory system as a general model for integrative operations in the brain. We combine anatomical analyses with electrophysiological methods indexing laminar profiles of synaptic activity and concomitant action potentials to differentiate “driving” inputs from the cochlea and non-auditory “modulatory” inputs arising from various cortical and subcortical sources, and to determine how these input types interact physiologically during attentive discrimination.
- Source & number:** Association of University Centers on Disabilities –Anne Marie Tharpe
Principal Investigator
Title: Tennessee-Vanderbilt MCH-LEND Pediatric Audiology Training
Project period: 1/15/09-1/14/12
Description: The primary purpose of this project is to expand and enhance our pediatric audiology training within the LEND/MIND program. We plan to focus our efforts on preparation of highly competent professionals at Vanderbilt University and at the other selected LEND programs to meet the underserved needs of infants, young children, and adolescents with hearing loss.
- Source & number:** Private Foundation, Anne Marie Tharpe, Principal Investigator
Title: Proposal for Master’s Degree Program in Education of the Deaf and a Concurrent Specialty Track for Audiology and Speech-Language Pathology Students
Project period: 7/1/10-6/30/12
Description: The specific aims of this program will emphasize the development of spoken language, effective audiologic management, counseling, and family-centered service provision.
- Source & number:** H325D080075– C. Melanie Schuele, Principal Investigator
Title: Preparation of Teacher/Scholars in Language and Literacy
Project period: 8/1/08-7/31/12
Description: The purpose of this project is to provide specialized training in language and literacy at the doctoral level to Ph.D. student.
- Source & number:** N/A VA IPA—Todd A. Ricketts, Principal Investigator
Title: Evaluation of Open-Canal and Traditional Custom Fit Hearing Aids
Project period: 10/15/08-10/14/11
Description: The goal of this work is to develop an evidence-based hearing aid selection model based on hearing aid style factors. A total of 13 hearing-aid fitting and style-related factors are measured in a large (n = 288), randomized-controlled, three-site clinical trial, utilizing a three-period (two months each), cross-over design which compares traditional and open canal fittings.
- Source & number:** Department of Education/H325K090304 – Melanie Schuele Principal Investigator

- Title:** Enhancing the Preparation of Speech-Language Pathologists to Collaboratively Address the Language and Literacy Needs of Children with Disabilities
- Project period:** 7/1/09-6/30/13
- Description:** This purpose of this Personnel Preparation Project is to provide specialized training in language and literacy to at least 20 graduate student trainees in speech-language pathology at Vanderbilt University.
- Source & number:** Starkey Laboratories – Benjamin Hornsby, Principal Investigator
- Title:** Hearing Loss, Hearing Aids, and Mental Fatigue
- Project period:** 10/25/10-10/24/11
- Description:** The purpose of this proposal is to 1) explore modifications of variables to enhance the sensitivity of a test of auditory fatigue and 2) to use this modified test to examine the benefits of hearing aid use and the use of advanced signal processing (directional processing and DNR) to reduce auditory fatigue in older adults with hearing loss.
- Source & number:** Vanderbilt Bill Wilkerson Center 2011 In-House Grant – D. Wesley Grantham, Principal Investigator
- Title:** Evaluation of Cochlear Implant Temporal Fine Structure Coding: Spatial Hearing
- Project period:** 2/1/11-1/31/12
- Description:** This project evaluates how temporal fine structure processing for cochlear implants (CIs) enhances access to spatial features of the listener's surroundings. Four experimental tasks are proposed to investigate the effects of temporal fine structure processing on spatial hearing in 18 bilaterally implanted subjects and 6 subjects with normal hearing. The tasks measure participants' ability to localize sounds in space and to discriminate differences in interaural time and interaural level of sounds presented over headphones. In addition, we will measure CI users' orientation to sound sources that are in motion, both in laboratory and real-world settings. Accurate perception of moving sounds is critical for maintaining a sense of "connectedness" to the environment, yet it has not previously been studied in CI users.
- Source & number:** 1R43DC011432-01 – Rafael Delgado, Principal Investigator; Linda Hood, Co-Principal Investigator
- Title:** Bone Conduction Testing for Newborn Hearing Screening
- Project period:** 9/24/10-9/23/11
- Description:** This study aims to develop improved neonatal hearing screening procedures that incorporate novel testing procedures.
- Source & number:** 5T35DC008763-05– Linda Hood, Principal Investigator
- Title:** Developing Research Careers in the Hearing Sciences
- Project period:** 4/1/07-3/31/12
- Description:** This project is to provide experience in hearing research to pre-doctoral students who are enrolled in a clinically based degree (AuD) programs to develop interest in pursuing a career in hearing research.

- Source & number:** 5R01MH063861-09– Mark T. Wallace, Principal Investigator
Title: Development of Multisensory Cortex: Role of Experience
Project period: 8/5/08-5/31/13
Description: This research posits that early postnatal experience plays a critical role in determining the nature of multisensory processes and their consequent impact on perception and behavior.
- Source & number:** 3R01MH063861-08S1– Mark T. Wallace, Principal Investigator
Title: ARRA - Development of Multisensory Cortex: Role of Experience
Project period: 7/5/09-6/30/11
Description: The proposed administrative supplement is structured to accelerate the pace of discovery for one of the key aims of the parent R01 – specifically to describe the timeline for the appearance and maturation of cortical multisensory circuits.
- Source & number:** NARSAD Research Grants Program – Mark T. Wallace, Principal Investigator
Title: Multisensory processing Alterations in Schizophrenia
Project period: 9/15/08-9/14/11
Description: The purpose of the research is to designed to provide new insights into the neural underpinnings of this debilitating disease, and to use this knowledge (and the conceptual framework it is based upon) for the development of more effective clinical strategies and interventions.
- Source & number:** Vanderbilt Bill Wilkerson Center 2011 In-House Grant – Mark T. Wallace, Principal Investigator
Title: Testing and Engaging Perceptual Function and Plasticity in Cochlear Implant Patients
Project period: 2/1/11-1/31/12
Description: The proposed study seeks to investigate this issue in more detail by characterizing visual temporal function in a group of CI patients before and after implantation as well as in a matched control population. The hypothesis with this first aim is that patients with the poorest visual temporal scores will receive less benefit from implantation when tested using standard measures of CI efficacy. In aim 2 we then seek to train subjects to improve visual temporal function using classic perceptual plasticity-based approaches, with the goal of improving implant outcomes via such training.
- Source & number:** 5R34DC0109927-02 – Mark T. Wallace/Stephen M. Camarata, Principal Investigators
Title: Evaluation of Sensory Integration Treatment in ASD
Project period: 9/17/09-8/31/12
Description: The purpose of this R34 proposal will be to complete developmental analyses in preparation for a relatively large randomized comparison trial examining the effects of commonly implemented sensory integration treatment techniques on communication development in ASD.

Source & number: 5R01DC009404-02– René Gifford, Principal Investigator
Title: Cochlear Implants: Combined Electric and Binaural Acoustic Stimulation
Project period: 12/1/09-11/30/14
Description: The goals of this project are to assess the value of preserving acoustic hearing in the implanted ear for cochlear implant recipients with binaural low-frequency hearing and to determine the benefit afforded by preserved acoustic hearing for speech recognition and auditory function in complex listening environments.

Source & number: 1R01DC010821-02– René Gifford, Principal Investigator
Title: Cochlear Implant Performance in Realistic Listening Environments
Project period: 7/1/10-6/30/15
Description: The goal of this project is to develop a tool for clinical decision making relative to determination of bimodal hearing (one cochlear implant plus a contralateral hearing aid) versus bilateral cochlear implantation. Clinical decision making will depend critically on the nature of the tests and environments used to assess the benefit of having two ears participate in speech understanding in realistic listening environments.

Source & number: 1F32DC011993-01 – Ryan Stevenson, Principal Investigator
Title: Multisensory Integration and Temporal Processing in Autism
Project period: 12/01/11-11/30/14
Description: This research proposal proposes a line of translational research focused on the influence that the temporal relationship between different sensory inputs has on perceptual processing.

Pending

Source & number: N/A R24 Subcontract with Children’s Hospital of Philadelphia– Linda Hood, Principal Investigator
Title: Audiological and Genetic Resource for Pediatric Hearing Research
Project period: 7/1/12-6/30/17
Description: The overall goal of this project is to develop a national biomedical computing infrastructure to gather clinical data on pediatric patients with hearing loss.

Source & number: 2T35DC008763-05– Linda Hood, Principal Investigator
Title: Developing Research Careers in the Hearing Sciences
Project period: 4/1/12-3/31/17
Description: This project is to provide experience in hearing research to pre-doctoral students who are enrolled in a clinically based degree (AuD) programs to develop interest in pursuing a career in hearing research.

Source & number: N/A R43/44 SBIR Phase I Subcontract with Intelligent Hearing Systems Corporation - Linda Hood, Principal Investigator
Title: Optimized Otoacoustic Emissions Efferent Feedback Test Module
Project period: 4/1/12-3/31/13

- Description:** The objective is to optimize clinical assessment of auditory medial olivocochlear reflex strength.
- Source & number:** N/A R43/44 SBIR Phase I Subcontract with Intelligent Hearing Systems Corporation - Linda Hood, Principal Investigator
- Title:** Acquisition of Auditory Transient and Steady State Evoked Potentials
- Project period:** 4/1/12-3/31/13
- Description:** This project addresses acquisition of transient and steady state auditory evoked potentials using efficient and advanced processing techniques.
- Source & number:** 1K99NS075138-041– Diana Sarko, Principal Investigator
- Title:** Neural Substrates and Population Dynamics Underlying Multisensory Processing
- Project period:** 4/1/12-3/31/17
- Description:** This research proposal aims to examine audiovisual interactions in the neocortex of a awake, behaving animal – specifically the cat, which has proven to be an excellent mammalian model for examining multisensory processing.
- Source & number:** N/A DOE/NIDRR – Stephen M. Camarata, Principal Investigator
- Title:** Developing an Auditory Comprehension Intervention Protocol in Adolescents with Autism Spectrum Disorders
- Project period:** 7/1/11-6/30/13
- Description:** The purpose of the proposed project is to systematically develop, using single subject design, an intervention for improving receptive language (as well as expressive language) in adolescents with mild-moderate cognitive impairments with ASD.
- Source & number:** N/A NIH Subcontract with Florida State University– Stephen Camarata, Principal Investigator
- Title:** An Efficacy Trail of Early Social Language Intervention in Toddlers and Preschoolers with Autism Spectrum Disorders (ASD)
- Project period:** 7/1/12-6/30/16
- Description:** The intervention being evaluated will focus on establishing prelinguistic and early linguistic abilities as well as targeting generalized social skills using a combination of parent training and direct services.
- Source & number:** 1K18DC012328-01 NIH – Stephen Camarata, Principal Investigator
- Title:** Research Career Enhancement in fMRI, DTI and Functional Connectivity
- Project period:** 7/1/12-12/31/13
- Description:** The purpose of the research training proposed herein is to supplement and augment this ongoing behavioral research with fMRI neuroimaging, and functional connectivity and diffusion tensor imaging.
- Source & number:** N/A DOE– Stephen M. Camarata, Principal Investigator
- Title:** Development and Testing of a Standard Sensory Processing Intervention Approach to Social and Behavioral Outcomes
- Project period:** 7/1/12-6/30/15

- Description:** The purpose of the Goal II project is to develop a standard procedure set, manualize these procedures and conduct pilot testing for the key components of the intervention in preparation for conducting a goal III efficacy trial. In addition, an independent measure of multisensory integration will be employed to determine to what extent the intervention techniques are associated with improved integration of multisensory (visual and auditory) inputs. Behavioral and neurological measures (ERP) will be included.
- Source & number:** 1R03MH092253-01– Mark Wallace, Principal Investigator
Title: Development of Multisensory Temporal perception in Typical & Autistic Individuals
Project period: 12/1/11-11/30/16
Description: The proposed research seeks to better characterize the maturation of multisensory temporal processes during typical development and in autism spectrum disorders (ASD).
- Source & number:** N/A Wallace Research Foundation– Mark Wallace, Principal Investigator
Title: Studies of Sensory and Multisensory Function in Children with Sensory Processing Disorder
Project period: 1/1/12-12/31/14
Description: The goal of this pilot work is to begin to provide an empirical framework upon which to better understand the constellation of sensory deficits seen in SPD and their neural bases. Such a framework will undoubtedly be of great utility in the development of better diagnostic tools and remediation approaches directed toward improving the quality of life of those living with SPD.
- Source & number:** N/A Federal Highway Administration Subcontract with NCSU– Daniel H. Ashmead, Principal Investigator
Title: Technology Solutions for Way-Finding and Navigation Guidance for People with Vision Impairment and Other Disabilities
Project period: 4/1/12-3/31/15
Description: This proposed project would integrate information sources to provide phone-based way finding guidance for route planning and execution. It would draw on the following technological sources: geographic information system, global positioning system, route algorithms, vehicle-to-vehicle communication, and road infrastructure wireless markings.
- Source & number:** N/A IES– Melanie Schuele, Principal Investigator
Title: Prevention of Speech-Language Impairment: An Exploration of Outcomes for Preschoolers At-Risk for Speech-Language Impairment
Project period: 7/1/12-6/30/16
Description: The purpose of this project is determine the extent to which there is underidentification of speech-language impairment among **at-risk preschoolers**, that is, preschoolers who receive a Local Education Agency (LEA) Full and Individual Initial Evaluation due to speech-language concerns but for whom the IEP team determines the child is not eligible as a child with a disability (speech-language impairment).

Source & number: 2R03MH093931-01A1 NIH– Alexandra Key, Principal Investigator
Title: Face Processing and Social-Communicative Skills in Infants at Risk for ASD
Project period: 4/1/12-3/31/14
Description: Findings from this study will increase understanding of the relationship between face scanning preferences and social-communicative phenotype of infants at high risk for ASD and contribute to the development of novel infant-specific diagnostic tools for identifying risks for atypical social-communicative development.

Source & number: N/A Subcontract with Compreval, Inc.– Todd Ricketts, Principal Investigator
Title: Use of Speech Recognition Technology for Functional Hearing Assessment
Project period: 4/1/12-3/31/14
Description: This project aims to further develop and refine a tool which for use in functional assessment of job critical hearing skills.

Source & number: N/A NIH– Troy A. Hackett, Principal Investigator
Title: Gene Expression During Postnatal Development of the Central Auditory Pathway
Project period: 7/1/12-6/30/14
Description: The scientific aims of this proposal address this need in a novel study designed to document changes in gene and protein expression in the mouse at key stages of postnatal development to maturity.

Sources of funding (Department of Otolaryngology)

Currently active support

- Source & number:** 5K08 DE017953-03(Goudy)
Title: The Role of IRF6 during Craniofacial Development
Project Period: 8/1/08 – 7/31/13
Description: Isolated cleft lip and palate is a common congenital problem with a complex etiology. The objective of this research is to identify the function of genes critical to palatal formation. Genetic variation in Interferon Regulatory Factor 6 (IRF6) causes Van der Woude syndrome (VWS) and contributes 12% risk of isolated cleft lip and palate.
- Source & number:** AAO-HNSF Research Grant (Hall)
Title: Modulation of Inflammatory Signaling in Acute Phonotrauma
Project Period: 07/01/10 - 06/30/11
Description: This proposal will investigate the effectiveness of pharmacological therapies directed at the inhibition of TGF- β 1, IL-1 β , and COX-2 in the context of acute phonotraumatic injury.
- Source & number:** 5R01DC008408–04 (Labadie)
Title: Clinical Validation and Testing of Percutaneous Cochlear Implantation
Project Period: 4/5/07 – 3/31/12
Description: The major goal of this study is to validate a new technique for cochlear implantation. This technique utilized image–guided surgery to reduce a wide–field, time intensive procedure to a minimally–invasive procedure. The proposal consists of two sequential studies. The first is to validate the accuracy of a currently FDA–cleared technique (for deep–brain stimulators for Parkinson’s patients) as applied to cochlear implantation. The second is to apply the technique. The study is PI–initiated and multi–center with University of North Carolina at Chapel Hill, University of Texas at Southwestern and Case Western Reserve as participating sites.
- Source & number:** 5R01DC010184–02 (Labadie)
Project Period: 9/19/09 – 8/31/13
Title: Pediatric Percutaneous Cochlear Implantation Clinical Validation and Implementation
Description: The major goal of this study is to validate a new technique for cochlear implantation. This technique utilized image–guided surgery to reduce a wide–field, time intensive procedure to a minimally–invasive procedure. The proposal consists of two sequential studies. The first is to validate the accuracy of a currently FDA–cleared technique (for deep–brain stimulators for Parkinson’s patients) as applied to cochlear implantation. The second is to apply the technique. The study is PI–initiated and multi–center with Boys Town (Omaha, NE) and Medical Hospital of Hannover (Hannover, Germany) as participating sites.

Source & number: 1K25 (Parekh)
Title: The Role of Basement Membrane Biomechanics in Cancer Cell Invasion
Project Period: 9/1/2010 – 8/31/2015
Description: Cancer cells that originate in the breast and invade other parts of the body continue to be a challenging clinical problem that severely affects the long-term survival rates of patients. Mechanical factors are now thought to play a crucial role in driving cancer cells to leave the primary tumor site, invade neighboring tissue, and eventually spread throughout the body. In order to develop new medical therapies to prevent cancer cell invasion and significantly impact patient outcomes, the mechanism by which mechanical factors regulate cancer cell invasion must first be elucidated.

Source & number: VBWC Collaborative Grant (Rousseau)
Title: *Randomized controlled trial of text-to-speech communication versus standard care in patients on prescribed voice rest*
Project Period: 02/01/2011-01/31/2012
Description: Completion of the proposed aims will provide immediate direction into issues regarding compliance and quality of life in patients with voice disorders. If the overarching hypothesis is supported, these findings will provide the pilot data necessary to substantiate further investigation of a novel approach of providing patients with an AAC strategy at the time of intervention to improve compliance, quality of life, and communicative effectiveness. These data address an area of high impact as outlined in the NIDCD Strategic Plan.

Source & number: 1R01 DC011338-01 (Rousseau)
Title: *Molecular Pathophysiology of Acute Phonotrauma*
Project Period: 12/01/2010-11/30/2015
Description: The goal of this grant is to define the molecular and cellular mechanisms by which acute phonotrauma compromises vocal fold function.

Source & number: 2R56 DE013173-10 (Yarbrough)
Title: Tumor suppressor qualities and mechanisms of LZAP activity
Project Period: 09/01/10 to 08/31/11
Description: Identify molecular differences in HNSCC related to HPV status

Source & number: 1RC1 DE020332-01 (Yarbrough)
Title: Development and Profiling of Human-in-Mouse Models of Salivary Carcinomas
Project Period: 09/22/09 – 08/31/11
Description: Develop human-in-mouse models of and profile salivary cancers.

Source & number: 5RC1 CA145010-02 (Yarbrough)
Title: Human in Mouse Modeling of HNSCC to Predict Response to Therapy
Project Period: 09/01/10 – 08/31/11
Description: Use a xenograft model of HNSCC to test targeted therapy and to validate results by comparison of molecular characteristics of the parental tumors.

Source & number: 5R01 DC008429-05 (Zealear)
Title: *Electrical Stimulation of the Bilaterally Paralyzed Larynx Paced with Respiration*
Project Period: 08/15/06 – 07/31/11
Description: The overall goal of this five-year research program is to conceive an implantable laryngeal pacemaker for patients with bilateral vocal fold paralysis. Sensor and muscle stimulation technology will be developed to reestablish bilateral glottal opening in synchrony with inspiration. Such a device could restore normal ventilation through the mouth without alteration of voice or swallowing. Studies will be performed initially in the canine, and then translated into the human through a clinical trial.

Pending

Source & number: 5R01DC010184-02 (Labadie)
Project Period: 12/1/2011 – 11/30/2016
Title: A Robotic Mastoidectomy
Description: Mastoid bone drilling can be accomplished more accurately, rapidly, and safely, by combining image-guided surgical techniques and miniature bone-mounted parallel robots. This represents a paradigm shift away from the current imprecise manual procedures which fundamentally rely on hand-eye coordination and memory to machines that precisely use preoperative image information.

Source & number: 1R21 NS075590-01 (Yarbrough)
Project Period: 07/1/2011 – 03/30/2012
Title: Development of a HTS Screen for Inhibitors to the Human Oncogene Wip1
Description: Advances in therapy of many cancers are directly attributable to discovery of molecular therapeutics targeting oncogenic kinases. The Wip1 phosphatase is a recently identified oncogenic phosphatase that has many targets in critical cancer pathways including: 1) p53 tumor suppressor and 2) DNA damage response. Given the role of Wip1 in tumor initiation and maintenance, small molecule inhibitors of Wip1 discovered using assays developed through this proposal, will be useful for treatment of human cancers that display aberrant Wip1 activity.

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