Session 3pAAa

Architectural Acoustics: Absorption Testing and Characterization

Ron Sauro, Chair
NWAA Laboratories Inc., 25132 Rye Canyon Loop, Santa Clarita, CA 91355

Contributed Papers

1:00

3pAAa1. Impedance tube absorption testing of poly blend materials presently used in the carpet industry. Ruth Anne Mazur (Columbia College Chicago, 237 E. Wildflower Ln., Round Lake Beach, IL 60073, ruthie.mazur@sbcglobal.net)

Cyril M. Harris authored a paper in 1955 titled "Acoustical Properties of Carpet" in which absorption coefficients for carpet were examined according to specific parameters, including fiber content. Since then, new fibers and blends have been introduced into the carpet industry. This study aims to compare absorption coefficients found from testing of these newer fibers. New blends that are now commonly used and sold in the carpet industry include polyester, polypropylene, and polyurethane. Using a Bruel & Kjaer Two Microphone Impedance Measurement Tube and Bruel & Kjaer PULSE LabShop, normal incidence absorption coefficients are gathered in order to compare the coefficient curves for these materials. Testing is performed in accordance with the ASTM E 1050-98 standard. Preliminary testing on carpet with these fibers shows lower values from 3.5 to 6.5 kHz in the curves for polypropylene carpet with padding compared to other fibers with padding. Several parameters of the preliminary samples were not constant and may have affected the results. Ongoing analysis and testing of newer fibers will enable comparison with previous studies. Absorption coefficients and parameters for carpet available in acoustical modeling programs will also be assessed in relation to the results. [Work supported by Columbia College Chicago.]

1:15

3pAAa2. Felt panels for an art space. Jessamyn A. Newcomb (Dept. of Architecture, Virginia Polytechnic and State Univ., 201 Cowgill Hall (0205), Blacksburg, VA 24061)

The art building on Virginia Tech's campus is an adaptive reuse project. Despite its current function, the transformation of the space has left it acoustically ill suited for class instruction. This research focuses on absorption of specific frequencies through the use of felt panels to reduce noise and increase speech intelligibility for class instruction. Microperforated panels are proposed as a solution due to their simple structures and predictable wideband absorption characteristics. Benefits will be quantified by measuring pink noise decay in the building pre- and postpanel installation.

1:30

3pAAa3. Absorption coefficients part 1: Is square area enough? Ron Sauro, Michael Vargas (NWAA Labs., Inc., 25132 Rye Canyon Loop, Santa Clarita, CA 91355, audio_ron@msn.com), and Gary Mange (Western Electroacoustics Labs., Santa Clarita, CA 91355)

Attempting to correlate the measurements of absorption coefficients in ASTM-C423, ISO-354, and ISO-17497-1, it was observed that the results were varying to a large degree. An experiment was set up with 1 in., 6 lb density fiberglass panels having different shapes, sizes, and parameters. The shapes, sizes, and parameters of the panels are described in this paper. The types of experiments are also described along with the process that was used based on input from many of the members of the industry. The end results and conclusions are described in a paper titled "Absorption coefficients part 2: Is "edge effect" more important than expected?"

1:45

3pAAa4. Absorption coefficients part 2: Is "edge effect" more important than expected? Ron Sauro, Michael Vargas (NWAA Labs., Inc., 25132 Rye Canyon Loop, Santa Clarita, CA 91355, audio_ron@msn.com), and Gary Mange (Western Electro-Acoust. Labs., Santa Clarita, CA 91355)

Attempting to correlate the measurements of absorption coefficients in ASTM-C423, ISO-354, and ISO-17497-1, it was observed that the results were varying to a large degree. An experiment was set up as described in a paper titled "Absorption coefficients part I: Is square area enough?" It was observed that the edges of the sample had a significant effect on the absorption coefficient. The results of these experiments are presented in numerical and graphic form in this paper along with conclusions and suggested corrections to the "absorption coefficient" as used in all calculations in acoustics.

Session 3pAAb

Architectural Acoustics: American Institute of Architects Short Course

K. Anthony Hoover, Chair
McKay Conant Hoover, Inc, 5655 Lindero Canyon Rd., Suite 325, Westlake Village, CA 91362

Chair's Introduction—1:00

Invited Papers

1:05

3pAAb1. Introduction to workshop goals. K. Anthony Hoover (McKay Conant Hoover, Inc., 5655 Lindero Canyon Rd., Westlake Village, CA 91362) and Bennett M. Brooks (Brooks Acoust. Corp., Vernon, CT 06066)

Many states require that architects obtain continuing education unit (CEU) credits annually, in order to maintain their registration or licensure. The American Institute of Architects (AIA) Continuing Education System (CES) offers continuing education courses, which may be given by third party providers. The Technical Committee on Architectural Acoustics (TCAA) is an AIA/CES Registered Provider. The goal of this workshop is to prepare members of the TCAA so that they may be authorized to present a short course which can earn attendees CEU credit. In order for TCAA members to qualify to meet the AIA requirements, they must attend this workshop, which is given in two parts. The first part will be devoted to the short course presentation material, which is in a standardized format. The second part of the workshop will focus on the AIA CEU Program registration and reporting requirements. Of course, anyone is free to register with the AIA to provide their own CEU program. However, the advantages of participating in this program are that the TCAA short course is already prepared, is preapproved by the AIA, and the registration fees are paid by the Acoustical Society of America.

1:25

3pAAb2. Architectural acoustics: Short course presentation material. K. Anthony Hoover (McKay Conant Hoover, Inc., 5655 Lindero Canyon Rd., Westlake Village, CA 91362)

The Technical Committee on Architectural Acoustics (TCAA) is a Registered Provider in the American Institute of Architects (AIA) Continuing Education System (CES). The TCAA has developed a standardized introductory short course for architects, called "Architectural Acoustics." An architect can earn one continuing education unit (CEU) by attending this short course, if it is presented by a qualified member of TCAA. The course covers topics in sound isolation, mechanical system noise control, and finish treatments. This paper will cover the course material in order to prepare and qualify potential presenters. There will be time at the end of the paper for questions and answers on the course material. In order to qualify as an authorized presenter for this AIA/CES short course, attendance at this workshop and membership in TCAA are required.

2:25

3pAAb3. Provider registration and reporting requirements. Bennett Brooks (Brooks Acoust. Corp., 30 Lafayette Sq., Ste. 103, Vernon, CT 06066)

The Technical Committee on Architectural Acoustics (TCAA) is a Registered Provider in the American Institute of Architects (AIA) Continuing Education System (CES). The TCAA has developed a standardized introductory short course for architects. The TCAA short course is called "Architectural Acoustics" and attendance at this 1-hour-long course can earn an architect one continuing education unit (CEU). This paper will cover the administrative requirements of the AIA/CES, to prepare potential presenters. These requirements include the proper handling of paperwork, so that AIA members may receive credit for the course. Also, the manner in which the course is given is dictated by AIA requirements. TCAA membership and attendance at this workshop are required to qualify as an authorized presenter for this AIA/CES short course.

Session 3pAB

Animal Bioacoustics and Acoustical Oceanography: Autonomous Remote Monitoring Systems for Marine Animals IV

Catherine L. Berchok, Chair
National Marine Mammal Lab., Alaska Fisheries Science Ctr./NOAA, Seattle, WA 98115-6349

Invited Paper

1:00

3pAB1. Call localization of marine mammals using directional autonomous recorders. Susanna B. Blackwell, Charles R. Greene, Jr. (Greeneridge Sci., Inc., 1411 Firestone Rd., Goleta, CA 93117, susanna@greeneridge.com), Christopher S. Nations, Trent L. McDonald (WEST, Inc., Cheyenne, WY 82001), Aaron Thode (Univ. of California, San Diego, La Jolla, CA 92037), and A. Michael Macrander (Shell Exploration and Production Co., Anchorage, AK 99503)

Directional sensors of low-frequency acoustic waves have been used by navies in sonobuoys for submarine detection and localization for decades. Composed of an omnidirectional pressure sensor and two horizontal directional elements sensitive to particle motion, they provide information for determining the relative bearing to a sound source without ambiguity. They were adapted for bowhead whale monitoring in the mid-1980s and have been used in autonomous seafloor acoustic recorders since 2000. Applied to the coastal Beaufort Sea north of Alaska, fall bowhead migration was observed in detail during 2007 and 2008, providing a wealth of information on variability in the migration paths of calling whales and the influence of industrial sounds on the locations of calling whales. For example, many calls were detected within about 30 km of seismic survey activities, where received sound pressure levels from airgun pulses were often greater than 140 dB per 1 μPa. Also, seismic activities were correlated with statistically significant shifts in the whales' distance from shore, either offshore or inshore. However, interpretation of the results was challenged by the difficulty in distinguishing between a whale that ceases calling and a whale that deflects away from the study area. [Work supported by Shell Oil Co.]

Contributed Papers

1:20

3pAB2. Killer whale habitat use and prey fields from remote hydrophones and echosounders. Scott Veirs (Beam Reach Marine Sci. and Sustainability School, 7044 17th Ave NE, Seattle, WA 98115, scott@beamreach.org), Val Veirs (Colorado College, Colorado Springs, CO 80903), Jason Wood (The Whale Museum, Friday Harbor, WA 98250), Brian Moore, Bob McClure (BioSonics, Inc., Seattle, WA 98107), and Bob Otis (Ripon College, Ripon, WI 54971)

The Salish Sea Hydrophone Network has been providing live audio streams to listeners around the globe for the past three years. Five hydrophones around the core summer habitat of the endangered southern resident killer whales allow detection of killer whale presence and inference of pod identity based on call associations. Detection of calls, whistles, and clicks is accomplished automatically by spectral and time domain analysis and manually by a global network of trained human listeners. The hydrophone network is more effective than a sighting network for detecting killer whales during inclement weather and at night, and for generating real-time notifications to alert researchers and managers. Additionally, the live streams and archived recordings have enriched educational activities of local museums and aquariums. In 2008, the hydrophone at Lime Kiln State Park was supplemented by hydroacoustic surveys conducted using a Biosonics echosounder (200 kHz). From August through December the echosounder was deployed at 15 m depth to conduct a continuous, fixed, horizontal survey. Remote display technology was used to monitor the echosounder in real time while also listening to the live audio stream. The resultant time series of fish density and acoustic behavior of killer whales is presented.

1:35

3pAB3. Detecting humpback whale sounds in the Bering Sea: Confounding sounds in a cacophony of noise. Sara L. Heimlich, David K. Mellinger, Sharon L. Nieukirk, Holger Klinck (Cooperative Inst. for Marine Resour. Stud., Hatfield Marine Sci. Ctr., Oregon State Univ., 2030 S. Marine Sci. Dr., Newport, OR 97365), Kate Stafford, Sue E. Moore, and Phyllis J. Stabeno (Univ. of Washington, Seattle, WA 98105)

Humpback whales (*Megaptera novaeangliae*) are top predators of large zooplankton and forage fish, and one of the most common large whales in the Bering Sea. While present on feeding grounds, humpback whales produce nonsong sounds probably associated with feeding or social contacts. However, little is known about these highly variable sounds, and their detection is challenging. Recordings were collected during 2006–2007 at the long-term oceanographic moorings M2, M4, and M5 in the eastern Bering Sea. Passive acoustic detection of humpback whale calls in these recordings was confounded by a variety of other sounds, which fall within the same parameters as nonsong humpback vocalizations. An automatic algorithm that detects tonal sounds in the 300–950 Hz frequency band was used to find humpback calls. Raw detections were visually examined to verify the accuracy of the detections. This algorithm resulted in a significant number of wrong detections (false positives), especially sounds of bearded seals (*Erignathus barbatus*) and bowhead whales (*Balaena mysticetus*). An error rate was calculated to correct the high number of false detections, and further refinements were made to the automatic detection algorithm. The problems and possible solutions to detecting humpback whale sounds in complex acoustic recordings will be presented.

1:50

3pAB4. Monitoring cetaceans on seamounts in the Azores using passive acoustic techniques. Irma Cascão (Inst. of Marine Res., Dept. of Oceanogr. and Fisheries, Univ. of the Azores, Horta, Portugal, irmacascao@uac.pt), Marc O. Lammers (Univ. of Hawaii, Kailua, HI 96734), Monica A. Silva, Pedro Afonso, Rui Prieto, and Ricardo S. Santos (Univ. of the Azores, Horta, Portugal)

Seamounts are hotspots of marine life in the Azores, acting as feeding stations for diverse top predators, including cetaceans. Long-term monitoring of remote marine ecosystems is logistically difficult and expensive, involving high costs in terms of ship time and human resources, as well as being reliant on sea conditions. Passive acoustic methods are a highly efficient monitoring technique to study the distribution or abundance of

vocalizing cetacean species. In 2007, we began to deploy Ecological Acoustic Recorders (EARs)—two shallow (35 m) and two deep (190 m) units—around seamounts to explore and monitor the occurrence of cetaceans, their temporal patterns, and changing levels of activity. A wide variety of time series acoustic signals were collected, revealing the presence of different species of cetaceans and specific associations between species, based on their vocalization characteristics. Detections of vessels are being used to determine levels of activity at one of the study sites, Formigas bank marine reserve, making the EAR a useful tool to monitor protected areas. The EARs are an effective ecological instrument for monitoring cetaceans year-round and will provide a better understanding of the influence of seamounts on cetaceans' behavior.

WEDNESDAY AFTERNOON, 20 MAY 2009 PAVILION WEST, 2:15 TO 3:15 P.M.

Session 3pAO

Acoustical Oceanography: Acoustical Oceanography Prize Lecture

Jeffrey A. Nystuen, Chair
Applied Physics Lab., Univ. of Washington, Seattle, WA 98105-6698

Chair's Introduction—2:15

Invited Paper

2:20

3pAO1. Seabed characterization and model based processing: Past, present, and future. Martin Siderius (Dept. of Elect. and Comput. Eng., Portland State Univ., 1900 SW 4th Ave., Portland, OR 97201, siderius@pdx.edu)

One of the most active areas of research in acoustical oceanography has been the study of seabed acoustics. This has been partly motivated by the need for accurate sonar performance prediction, which often depends on knowledge of the seabed properties. There has also been significant research on environmentally adaptive and model based signal processing such as matched field processing. One of the obstacles to model based processing has been the required knowledge about seabed properties, which is needed as input. This dependency, in part, led to the innovation of matched field inversion methods to obtain seabed properties. In recent years, new algorithms have been introduced that use ambient noise (e.g., from breaking waves) as a surrogate sound source to probe the seabed and estimate geoacoustic properties. These noise methods have received much attention since measurements and processing are simple and the results are surprisingly good. In fact, current developments in noise processing may be the key to enabling model based methods that, in the past, were not considered practical. In this presentation a review of seabed inversion methods will be given with discussion about current developments in noise processing and the potential for renewed interest in model based processing.

Session 3pBB

Biomedical Ultrasound/Bioresponse to Vibration and Physical Acoustics: Shock Wave Therapy II

Michael R. Bailey, Cochair
Applied Physics Lab., Univ. of Washington, Seattle, WA 98105

Thomas J. Matula, Cochair
Applied Physics Lab., Univ. of Washington, Seattle, WA 98105

Contributed Paper

12:45

3pBB1. Interaction of single biological cell with tandem microbubbles in microfluidics. Georgy Sankin, Fang Yuan, and Pei Zhong (Dept. of Mech. Eng. Mat. Sci., Duke Univ., 144 Hudson Hall, Durham, NC 27708, gns @duke.edu)

Coupled oscillation of two laser generated microbubbles (maximum radius = 28 μm) and associated shear stresses are investigated experimentally. Bubble-bubble interaction in a microchannel of 25 μm height is observed using high-speed video cameras and μPIV technique. Two liquid microjets moving in opposite directions can be generated when the second bubble is produced at the maximum size of the first one. The interaction of these tandem microbubbles with single cell leads to controllable poration of adjacent cell membrane and dye uptake. μPIV data are compared with cell viability at various bubble-cell distances and azimuthal orientations. This method provides a new approach for highly selective cell treatment in situ, applicable to targeted microinjection of macromolecules and gene vectors in microfluidics devices. [Work supported in part by NIH.]

Invited Papers

1:00

3pBB2. Treating heterotopic ossification with shockwaves. Michael W. Chang (12340 NE 8th St., Ste. 101, Bellevue, WA 98005), Thanaphum Osathanon, and Cecilia Giachelli (Univ. of Washington, Seattle, WA 98195)

Heterotopic ossification (HO) is formation of lamellar bone in soft tissue, commonly seen among patients with burns, orthopedic fractures/procedures, brain/spinal cord injuries, muscle contusions, and rare hereditary disorders. Patients with HO experience pain and joint limitations, which further exacerbate their disability. Reduction of HO preventatively and/or for treatment has been attempted using medications, radiation, and surgery with limited success. Recent encouraging clinical HO outcomes using shockwave therapy have been discussed but treatment mechanisms were unclear. Mechanisms such as spallation, cavitation, squeezing, superfocusing, fatigue, and layer separation have been proposed for lithotripsy. Mineralized calcium phosphate macroporous nanofibrous fibrin scaffolds were used as a HO model to study treatment mechanisms. The HO was treated with electrohydraulic shockwave devices. The scaffold calcium contents decreased from 45.4(3.6) (untreated) to 20.9(18.1) (OssaTron, 0.71 mJ/mm2) and 27.5(23.5) ugCa/mg dry weight (EvoTron, 0.46 mJ/mm2) with 200 shocks (1 Hz). Scanning EM of the shockwave-treated HO supports separation of the calcium phosphate from the fibrin matrix probably contributed by shear and cavitation. Biological responses to shockwaves, such as inflammation, neovascularization, angiogenesis may also play important roles in clinical HO treatment. A unique clinical HO case is discussed to illustrate risks, benefits, and challenges from shockwave therapy.

1:15

3pBB3. Histotrispy: Urologic applications. William W. Roberts, Timothy L. Hall, Christopher R. Hempel (Dept. of Urology, Univ. of Michigan, TC 3879, 1500 East Med. Ctr. Dr., Ann Arbor, MI 48109-5330, willrobe@umich.edu), Zhen Xu, J. Brian Fowlkes, and Charles A. Cain (Univ. of Michigan, Ann Arbor, MI. 48109)

Histotripsy is an extracorporeal ablative technology that utilizes microsecond pulses of intense ultrasound to produce nonthermal, mechanical fractionation of targeted tissue. We have previously demonstrated the feasibility of histotripsy ablation in *in vivo* renal and prostate models. We sought to assess the chronic tissue response, tolerability, and safety of prostate histotripsy in a chronic *in vivo* canine model. Five acute and thirteen chronic canine subjects were anesthetized and treated with histotripsy targeting the prostate. Pulses consisting of three cycle bursts of 750-kHz ultrasound at a repetition rate of 300 Hz were delivered from a highly focused 15-cm aperture array. Prostates were harvested at 0, 7, 28, or 56 days after treatment. Transrectal ultrasound imaging provided accurate targeting and real-time monitoring of histotripsy treatment. Consistent mechanical tissue fractionation and debulking of prostate tissue was seen acutely and at delayed time points without collateral injury. Canine subjects tolerated histotripsy with minimal hematuria or discomfort. Only mild transient lab abnormalities were noted. Histotripsy is a promising noninvasive therapy for prostate tissue fractionation and debulking that appears safe and well tolerated without systemic side effects in the canine model.

1:30

3pBB4. Improving efficiency of ultrasound histotripsy sources by transmitting at the second harmonic frequency. Timothy A. Bigelow (Dept. of Elec. and Comput. Eng., Dept. of Mech. Eng., Iowa State Univ., 2113 Coover Hall, Ames, IA 50011, bigelow@iastate.edu)

Therapeutic ultrasound has shown potential for improving many aspects of medical care in recent years. Therapeutic ultrasound often involves high pressures or intensities, but pressures and intensities in tissue are limited by nonlinear propagation. The impact of nonlinear propagation is most severe for therapies involving cavitation where the peak rarefactional pressure plays the dominate role. As a result, in applications such as histotripsy, the size and power of the ultrasound source must be significantly increased in order to obtain the pressures needed *in vivo*. In this study, a new ultrasound source design was developed that will help mitigate the effects of nonlinear propagation. Specifically, sound was transmitted at both the fundamental and the second harmonic with the amplitude and phase of the second harmonic designed to counter nonlinear propagation effects for varying source powers from 10 to 500 W. The simulations demonstrated a 30% increase in the peak rarefactional pressure relative to a source where only the fundamental was transmitted when the appropriate phase was used for the second harmonic.

1:45

3pBB5. Skull flexure from blast waves: A mechanism for brain injury with implications for helmet design. William C. Moss, Michael J. King (Lawrence Livermore Natl. Lab., 7000 East Ave., Livermore, CA 94551, wmoss@llnl.gov), and Eric G. Blackman (Univ. of Rochester, Rochester, NY 14627)

Traumatic brain injury [TBI] has become a signature injury of current military conflicts. The debilitating effects of TBI are long-lasting and costly. Although the mechanisms by which impacts cause TBI have been well researched, the mechanisms by which blasts cause TBI are not understood. Various possibilities have been investigated, but blast-induced deformation of the skull has been neglected. From numerical hydrodynamic simulations, we have discovered that nonlethal blasts can induce sufficient flexure of the skull to generate potentially damaging loads in the brain, even if no impact occurs. The possibility that this mechanism may contribute to TBI has implications for the diagnosis of soldiers and the design of protective equipment such as helmets. [This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344].

2:00

3pBB6. Cavitation bubble activity during treatment of cortical bones by shock waves. Dorothée Bossis (CNRS LIP UMR 7623, 15 rue de l'Ecole de Medecine, 75006 Paris, France), Frederic Padilla, and Robin O. Cleveland (Boston Univ., Boston, MA 02114.)

Shock wave (SW) induced cavitation might be a physical effect by which bioeffects on bones are mediated, especially for SW treatment of bone nonunion. To assess the presence of cavitation and to study bubbles activity at the surface of cortical bones, we treated rat femurs with SWs using a clinical SW therapy device (Ossatron). Sequences of 14 images were acquired using a high speed camera capable of recording up to 100 million frames per second (Imacon). The sequences showed that for all voltage settings of the Ossatron a cloud of cavitation bubbles was induced at the surface of the bone. The bubbles near the surface of the bone appeared to form and act as a single larger bubble, which collapsed violently against the surface of the bone. For a voltage setting of 28 kV the collapse time was measured to be 720 micro-seconds after a single SW and reduced to 620 micro-seconds after 10 SWs at 1 Hz. In the case of a bone with an artificially fractured surface cavitation events were found to occur preferentially within the fracture gap. Cavitation might therefore be an important mechanisms in the SW treatment of bone defects.

2:15

3pBB7. Shock waves micro-damage induction in cortical bones: Comparison between experimental and simulations results. Frederic Padilla (Dept. of Mech Eng., Boston Univ., 110 Cummington St., Boston, MA 02115; CNRS LIP UMR 7623, 75006 Paris, France) and Robin O. Cleveland (Boston Univ., Boston, MA 02115)

Shock waves (SW) are considered a promising method to treat bone non unions. One potential mechanisms of action is the initiation of local microfractures, which may in turn trigger the start of bone healing. In this study, a set of eight intact rat femurs have been subjected to SWs (peak positive pressure of 40 MPa and peak negative pressure of -8 MPa, PRF of 2 Hz). The number of SW was varied from 50 to 1500. Micro-CT images of the specimens were acquired before and after treatment (16 microns resolution). In parallel, numerical simulations were used to quantify the stresses induced by SWs in cortical bone tissue. We used a 3-D FDTD code to solve the linear lossless equations that describe wave propagation in solids and fluids. A 3-D model of a fractured rat femur was obtained from micro-CT data. Results demonstrate that damages were induced in the bone tissues from 150 SWs. Comparison of the location of the induced damages on micro-CT images with predictions of maximum stresses by numerical simulations show that damages principally appeared in regions of highest stresses, suggesting that SW-induced tremendous stresses in bone tissue might be an important mechanisms implied in SW bone therapy.

2:30

3pBB8. Empirical angle-dependent tortuosity functions and sound transmission through cancellous bone. Keith Attenborough (Dept. of Eng., The Univ. of Hull, Cottingham Rd., Hull HU6 7RX, UK, k.attenborough@hull.ac.uk) and Haydar Aygun (Univ. of Hull, Hull HU6 7RX, UK)

Recent literature concerning the angle dependence of sound transmission through cancellous bone has suggested that it might be due either to elastic anisotropy or to microgeometrical anisotropy in the pore structure; e.g., an angle-dependent tortuosity. The elastic anisotropy approach has been found able to explain the observed variation in fast wave speed with angle better than the angle-dependent tortuosity at the cost of underpredicting slow wave speeds. In reality, it is likely that both influences are present in cancellous bone. Nevertheless the angle-dependent tortuosity approach has been revisited on the basis of orthotropic data for sound transmission through air-filled stereo-lithographical bone replicas [Attenborough *et al.*, JASA 118, 2779 (2005)]. [Work supported by Leverhulme Grant F/00181/N.]

2:45

3pBB9. Numerical simulation of propagation of acoustic and elastic waves in human head with fast integral equation solver. Elizabeth Bleszynski, Marek Bleszynski, and Thomas Jaroszewicz (Monopole Res., 739 Calle sequoia, Thousand Oaks, CA 91360)

An approach to numerical simulations of acousto-elastic waves in the human head is described, and simulation examples are presented. The primary goal of our work is to construct an efficient and high fidelity numerical simulation tool for investigating such effects as, e.g., acoustic energy transfer to the inner ear via non-airborne pathways. The solver employs a modified form of the volumetric Lippmann–Schwinger integral equation, adapted to high material-contrast problems, and an FFT based stiffness matrix compression implemented for distributed-memory systems enabling large scale (several million unknowns) simulations for realistic geometries. Some of the new aspects of the technique and its applications include (a) extension of the technique for problems involving large density contrasts,in situations involving elastic media; (b)improved, more economical, and more accurate Galerkin discretization scheme involving linear tetrahedral elements; (c) verification of the solver by comparison of its predictions with an exact analytical solution for a sphere composed with layers supporting both compressional and shear waves; (d) applications in representative numerical simulations of mechanisms of energy transfer to the inner human ear and

comparative analysis of the pressure distributions in a human head with and without the presence of noise protective devices, carried out with realistic geometry models. [Work supported by AFOSR].

3:00

3pBB10. Guided waves analysis using multiemitter and multireceiver arrays. Jean-Gabriel Minonzio, Marilyne Talmant, and Pascal Laugier (Universite Pierre et Marie Curie—Paris 6, Laboratoire d'Imagerie Paramétrique, CNRS LIP UMR7623, 75006 Paris, France)

Structural and material properties of elastic waveguides can be characterized by fitting measured to theoretical guided wave phase velocities. Here emitters and receivers are placed in contact on the same side of the waveguide (i.e., axial transmission geometry). Multireceiver arrays allow the determination of phase velocities using two-dimensional spatial-temporal Fourier transform, which requires a large distance probed by the receivers. Practical constraints, as in clinical inspection of cortical bones, may reduce the inspected spatial length and therefore the efficiency of this technique. We propose a technique which takes benefit of using both multiple emitters and multiple receivers. This approach derived from the DORT method adapted to the transmission problem. The singular values decomposition at different frequencies of the transmission matrix between the arrays give the invariants of transmission, which are linked with the guided modes. First, experiments carried out on different metallic plates are shown. Experimental velocities are in good agreement with Lamb waves theoretical values. In particular, zero group velocity resonance and negative phase velocities are shown. These results allows a good evaluation of the thickness and the transverse and longitudinal bulk waves velocities. Further applications concerning evaluation of elastic properties of cortical bone are finally mentioned.

WEDNESDAY AFTERNOON, 20 MAY 2009 EXECUTIVE SALON II/III, 1:00 TO 2:00 P.M.

Session 3pID

Interdisciplinary: Hot Topics in Acoustics

Paul E. Barbone, Chair
Dept. of Aerospace and Mechanical Engineering, Boston Univ., Boston, MA 02215

Invited Papers

1:00

3pID1. Hot topics in youth education outreach. Grace Klonoski (Optical Society of America, 2010 Massachusetts Ave., N.W., Washington, DC 20036-1012)

This presentation will focus on ways in which professional societies and their volunteers can make a lasting, positive difference in supporting the science and math learning of young students. The introduction will provide a brief overview of trends in student achievement in math and science and will discuss the availability of qualified teachers in the United States. Four features of effective learning environments will be described. The remainder of the presentation will be devoted to examples of how scientific communities can become directly involved in reaching out to students on a local and global scale. A variety of youth programs hosted by the Optical Society of America (OSA) and the OSA Foundation will be highlighted with an emphasis on the scope, goals, and quantitative results of each initiative. From a multilingual Web site that provides students, teachers, and parents with basic science information, lesson plans, and hands-on activities, to the production and worldwide distribution of "optics suitcases" that give students the opportunity to participate in hands-on demonstrations, OSA's recent efforts have benefited thousands of individuals in more than 20 countries. The planned collaboration between ASA and OSA to develop acoustics-focused classroom materials, a Web site, and demonstration kit will be described.

1:20

3pID2. Auditory attention and the active listener. Barbara Shinn-Cunningham (Cognit. and Neural Systems, 677 Beacon St., Boston, MA 02215)

Traditionally, psychoacousticians and auditory physiologists have focused on how stimulus properties affect perceptual abilities, measuring just-detectable differences in different acoustic attributes or thresholds for audibility of different sounds. However, in everyday settings with more than one audible sound source, these low-level abilities are often not the factors limiting understanding of an important sound source. Instead, the way the brain organizes sound and focuses attention has an enormous impact on what we actually hear and analyze out of an auditory scene. Recent studies in both perceptual and physiological acoustics are working to uncover how the intentions and goals of the listener influence processing of sound in the brain. This talk will review some recent advances in auditory neuroscience that demonstrate the importance of top-down attention on neural processing and perception of sound.

1:40

3pID3. Hot topics of signal processing in acoustics. Ning Xiang (Graduate program in Archit. Acoust., Rensselaer Polytech. Inst., Troy, NY, 12180) and David Chambers (Lawrence Livermore Natl. Lab., Livermore, CA 94551)

Signal processing is used to some extent in all areas of acoustics, such as extracting relevant information from acoustic measurements made either in the laboratory or in the field, processing signals and/or synthesizing data to cope with demanding tasks raised in acoustics. Techniques range from simple classical approaches based on Fourier transforms and Gaussian noise, to sophisticated model-based techniques that incorporate physical/parametric models of the acoustical system. In this paper we highlight new approaches to

signal processing that could be applied to a broad variety of acoustical problems. These include coded signals for architectural-acoustics, acoustical communications, and medium characterization, Bayesian methods for room acoustics, physical acoustics, and underwater acoustics including highly nonlinear problems with non-Gaussian noise, and extensions to the familiar Kalman filtering to nonlinear models. Examples of each approach will be shown that illustrate the advantages and disadvantages of each technique. Additional topics may be discussed as time allows.

WEDNESDAY AFTERNOON, 20 MAY 2009 PARLOR B/C, 1:00 TO 2:30 P.M.

Session 3pMUa

Musical Acoustics: Acoustics of Bagpipes

D. Murray Campbell, Chair
School of Physics and Astronomy, Univ. of Edinburgh, Edinburgh EH9 3JZ, U.K.

Chair's Introduction—1:00

Invited Papers

1:05

3pMUa1. An introduction to bagpipes of the world. Paul A. Wheeler (Dept. of Elec. & Comput. Eng., Utah Stat Univ., 4120 Old Main Hill, Logan, UT 84322-4120)

When one hears the term "bagpipe," the Great Highland bagpipe from Scotland comes to mind. There are actually several types of bagpipes played across Europe and the Middle East, each with its unique characteristics. This paper classifies bagpipes from around the world based on their construction and acoustic properties. These include: method of filling the bag (bellows versus mouth pipe), bag properties and materials, reeds (single or double), pipes used for chanters and drones (cylindrical or conical), and general characteristics of the instrument. The objective of this overview paper is to provide the background for more detailed papers in the session on bagpipes.

1:30

3pMUa2. A brief history and acoustical analysis of the great highland bagpipe. Stanley A. Cheyne (Dept. of Phys. and Astronomy, Hampden-Sydney Coll., Hampden-Sydney, VA 23943)

A brief history and analysis of the great highland bagpipe will be discussed. Although the bagpipe may have originated several thousands of years ago, the great highland bagpipe, distinguished by three drones and a chanter, is only a few hundred years old. A discussion of the components and operation will be given. In addition, spectral analysis of the drones and chanter will be discussed and how the harmonic content of the drones support the notes played on the chanter. A spectral analysis and sound pressure levels of chanter reeds of varying ages, strengths, and materials will also be presented.

2:00

3pMUa3. Tuning and tone quality of bagpipe drones. R. Dean Ayers (Phys. Dept., Southern Oregon Univ., 1250 Siskiyou Blvd., Ashland, OR 97520, ayersr@sou.edu) and Peter R. Nordquist (Southern Oregon Univ., Ashland, OR 97520)

Tunes are played on the Great Highland bagpipe using the tone holes of its conical chanter. The much quieter practice chanter has holes with the same spacings on a narrow cylindrical bore. Differences between spherical waves in a cone and plane waves in a cylinder give rise to striking differences in pitch and tone quality. Drone pipes do not need to fit into either the conical family or the closed-pipe family of reed woodwinds, because each drone produces only one note. A bass drone has three cylindrical segments, with diameters that increase in sequence, followed by an expansion chamber (bell and constricting cap) at the output end. Tuning slides between the cylinders create two additional expansion chambers with large diameters and adjustable lengths. (A tenor drone has two cylinders and one tuning slide.) Sound waves incident from either direction experience strong reflections at each jump in diameter, resulting in uneven standing waves and irregular input impedance curves that would be impractical for pipes with tone holes. Experimental results and computer models are used to relate the shape of a drone's air column to its tuning and tone quality. [Work supported by the Paul S. Veneklasen Research Foundation.]

Session 3pMUb

Musical Acoustics: Bagpipe Lecture and Concert

D. Murray Campbell, Chair
School of Physics, Univ. of Edinburgh, Edinburgh EH7 3JE, UK

Kevin Carr, a bagpipe performer will demonstrate and discuss various bagpipes from around the world.

Session 3pPA

Physical Acoustics: Influence of Temperature on Sound in Condensed Matter

Albert Migliori, Chair
Los Alamos National Lab., Los Alamos, NM 87545

Chair's Introduction—12:55

Invited Papers

1:00

3pPA1. Precise sound velocity measurements on solids and liquids at high pressure and high temperature with direct length measurement. Baosheng Li (Mineral Phys. Inst., Stony Brook Univ., Stony Brook, NY 11794, Baosheng.Li@sunysb.edu)

Sound velocity measurements at pressure and/or temperature provide important information in the material's structural behavior and physical properties under extreme conditions. With the application of synchrotron X-radiation sources, new developments have emerged to facilitate the study properties and structures of crystalline and amorphous materials. In the last decade, we have developed a unique technique for measuring sound velocity in a cubic type multianvil apparatus installed at X-17B2, National Synchrotron Light Source (NSLS) of Brookhaven National Lab, which allows us to conduct precise velocity measurements on crystalline and noncrystalline materials at various pressure and temperature conditions by conducting simultaneous X-radiation and ultrasonic interferometry measurements. In this paper, sound velocities at high temperatures for some ceramics and metals are measured to study the behavior and property change of these materials undergoing compression/expansion as well as phase transition and structural instabilities. This technique opens new opportunities for the study of materials that are of interest to many disciplines, such as earth science, materials science, and condensed matter physics.

1:25

3pPA2. The influence of grain structures on resonance behavior near phase transitions. Timothy W. Darling, Gunes Kaplan (Phys. Dept.-NTF Univ. of Nevada, 1664 N. Virginia St., Reno, NV 89557), James A. TenCate (Los Alamos Natl. Lab., Los Alamos, NM 87545), Ruth E. A. McKnight, and Michael A. Carpenter (Univ. of Cambridge, Downing St., Cambridge, UK)

Inhomogeneities such as grains or plastically deformed regions in materials locally change sound wave velocities and introduce scatter in the pattern of expected resonance frequencies. The accompanying variation in the components of the free energy may promote, or block, nucleation and growth of new phases near transition temperatures. Lanthanides and martensites are two groups of materials with complex phase structures where control of the phase transformation is important in technological applications. Complex oxide minerals with a wide variety of phase structures are important in understanding the behavior of the earth's crust. The influence on mechanical resonances of both the micro (meso) structures and the appearance and growth of phases near transition temperatures will be discussed. Experimental data on resonance behavior in inhomogeneous materials (largely lanthanides, transition metals, and silicates), where attempts have been made to control the scale and type of microstructure as they approach phase transitions will be presented. [This work receives support from DOE Grant No. DE-FC52-06NA27616 through the University of Nevada Terawatt Facility.]

1:50

3pPA3. Temperature dependence of elastic moduli for polycrystalline Pu: Comparison of alpha and gamma phases. I.R. Stroe (Worcester Polytechnic Inst., 100 Institute Rd., Worcester, MA 01609, izabela@wpi.edu), J. B. Betts, C. Pantea, A. Trugman, J. N. Mitchell, M. Ramos, F. Freibert, C.H. Mielke, and A. Migliori (Los Alamos Natl. Lab., Los Alamos, NM 87544)

The elastic properties of pure polycrystalline Pu were investigated as a function of temperature by resonant ultrasound spectroscopy. For both alpha and gamma phase, shear (G) and longitudinal (CL) elastic moduli were determined simultaneously and the bulk modulus (B) was computed from them. In alpha phase, G and B exhibit the same temperature dependence, but an unusually large change. This behavior together with a high Gruneiser parameter and an almost temperature independent Poisson ratio is attributed to the 5-f electron localization delocalization. In the gamma phase, G and B show anomalous temperature behavior: G decreases with temperature while B is near temperature independent. The Poisson ratio increases with temperature by 4%. This normal behavior of the Poisson ratio is unusual for Pu.

Contributed Papers

2:15

3pPA4. Stability of monitoring weak changes in multiply scattering media with ambient noise correlation: Laboratory experiments. Larose Eric, Hadziioannou Celine, Coutant Olivier, Roux Philippe, and Campillo Michel (Lab. de Geophysique interne et Tectonophysique, CNRS & Univ. J. Fourier, Grenoble, France)

Previous studies have shown that small changes can be monitored in a scattering medium by observing phase shifts in the coda. Passive monitoring of weak changes through ambient noise correlation has already been applied to seismology, acoustics, and engineering. Usually, this is done under the assumption that a properly reconstructed Green function as well as stable background noise sources are necessary. In order to further develop this monitoring technique, we performed a laboratory experiment in the 2.5 MHz range in a gel with scattering inclusions, comparing an active (pulse-echo) form of monitoring to a passive (correlation) one. Our results show that temperature changes in the medium can be observed even if the Green function (GF) of the medium is not reconstructed. Moreover, we establish that the GF reconstruction in the correlations is not a necessary condition: the only condition to monitoring with correlation (passive experiment) is the relative stability of the background noise structure.

2:30

3pPA5. Temperature variation of Young's modulus and elastic wave speed in a mixture of solid-particles in liquid. Hasson M. Tavossi (Dept. of Phys., Astronomy and Geosciences, Valdosta State Univ., 1500 No. Patterson St., Valdosta, GA 31698)

The variation of ultrasonic wave speed in the solid-liquid mixtures as a function of temperature is studied. The goal of this investigation is to determine temperature dependence of the elastic moduli of materials consisting of different size solid particles. The elastic wave speed in solids is assumed to be proportional to the square root of Young's modulus of the material. Elastic wave speed in the material is related to the variation of Young's modulus of the solid constituents. Also considered are temperature dependence of the wave attenuation, by scattering and absorption, and the effects of phonon modes, their amplitude and frequency, on the elastic moduli and wave dispersion in the material. Previous experimental data have shown a decrease in elastic moduli at the contact points of solid particles with increase in elastic wave frequency. Findings on the variations of elastic wave speed in solids with temperature and frequency are compared to analyze any similarity between the effect of wave frequency increase and temperature increase.

2:45

3pPA6. Resonant ultrasound spectroscopy studies of Fe-based superconductors. Veerle Keppens, Lindsey VanBebber, Yanbing Luan (Dept. Mater. Sci. and Eng., The Univ. of Tennessee, Knoxville, TN 37996), Michael A. McGuire, Athena Sefat, Brian C. Sales, and David Mandrus (Oak Ridge Natl. Lab., Oak Ridge, TN 37831)

The discovery of high superconducting transition temperatures in Fe-based compounds has generated a frenzy of experimental and theoretical research activities on these systems. Whereas doping is required to establish superconductivity, careful studies of the undoped materials are important to elucidate the underlying physics. Recently, resonant ultrasound spectroscopy measurements were carried out on the undoped oxypnictide system LaFeAsO as well as the oxygen-free systems $BaFe_2As_2$ and $Ba(Fe, Co)_2As_2$. The elastic response of the parent compounds shows a very gradual softening corresponding to the structural transition that characterizes these systems. Remarkably, this softening persists in the superconducting samples, even though the structural transition in these compounds is suppressed.

Session 3pSC

Speech Communication: Lexical Effects and Perceptual Processing in Speech (Poster Session)

Eric A. Vatikiotis-Bateson, Chair
Dept. of Linguistics, Univ. of British Columbia, Vancouver, BC V6T 1Z1, Canada

All posters will be on display from 1:00 p.m. to 3:20 p.m. To allow contributors an opportunity to see other posters, all contributors of odd-numbered papers will be at their posters from 1:00 p.m. to 2:10 p.m. and contributors of even-numbered papers will be at their posters from 2:10 p.m. to 3:20 p.m.

Contributed Papers

3pSC1. Phonetic experience with specific words affects categorical perception of those words. Mark VanDam (Boys Town Natl Research Hospital, 555 N. 30 St., Omaha, NE 68131, vandamm@boystown.org) and Robert F. Port (Indiana Univ., Bloomington, IN 47405)

How does experience with specific words influence linguistic-phonetic categories? Listeners were trained over a five-session, listen-and-repeat task on a set of target words embedded in continuous speech and altered so that the initial stop consonant voice-onset time (VOT) was 80% longer than natural. Voicing boundaries were estimated before and after training using a two-alternative, forced-choice perceptual task on an eight-step VOT continuum. Stimuli were highly natural tokens by two stimulus talkers. Part 1 of the experiment asked whether exposure to lengthened forms would influence location of the voicing boundary, and, if so, whether that effect would generalize to similar forms. Results showed longer boundaries after exposure to lengthened VOTs for the trained forms, but lengthening did not generalize to new forms. Part 2 investigated voicing boundary locations as a function of lexical status (word, nonword) and usage frequency (high, low). Boundary locations indicated expanded VOT regions both for nonwords over words (opposite to the Ganong effect) and for high-frequency words over low-frequency words; neither lexical status nor usage frequency interacted with training. Results suggest a lexical sensitivity to low-level speech cues, thus offering support for a rich memory language model.

3pSC2. Were we or are we? Perception of reduced function words in spontaneous conversations. Natasha Warner, Dan Brenner, Anna Woods (Box 210028, Univ. of Arizona Dept. of Linguist., Tucson, AZ 85721-0028), Bejamin V. Tucker (Univ. of Alberta, Edmonton, AB, Canada T6G 2E7), and Mirjam Ernestus (Univ. Nijmegen, Nijmegen AH6500, the Netherlands)

Spontaneous, reduced pronunciations diverge greatly from citation forms. The quality of a single segment can change, e.g., /b/ in "about" surfacing as an approximant. But sounds, syllables, and entire words can also be deleted (e.g., "do you have time?" as [djutEm] with no acoustic trace of "have"). This work investigates the perception of reduced function words such as "he was" or "we were." Twenty-two young American English speakers' spontaneous conversations with close acquaintances were recorded. From these, we selected utterances containing items such as "he's/he was, we're/we were, got him/got them." When hearing an entire utterance, native listeners may clearly perceive "we were," but on hearing just the "we were" portion, they perceive an unambiguous "we're." The portion of the signal presented to listeners is manipulated to determine the contributions of local acoustic cues, speech rate and coarticulation, semantic and syntactic information, and overall bias toward present vs past tense. An auditory and a written task are also compared to separate the contribution of intonation from that of syntax/semantics. These results begin to elucidate the interplay of information sources listeners draw upon when parsing spontaneous speech. Future work will compare to non-native listeners' perceptions.

3pSC3. The roles of tone and syllable structure in Mandarin spoken word recognition. Yuwen Lai (Dept. of Linguist., Univ. of British Columbia, 2613 West Mall, Vancouver, BC V6T 1Z4, Canada) and Jie Zhang (Univ. of Kansas, Lawrence, KS 66044-3177)

The present study adopts the gating paradigm to investigate the roles of tone, onset sonorancy, and nasal coda in Mandarin spoken word recognition. Duration-blocked gates generated from eight monosyllabic quadruplets with matching frequencies of occurrence were used as stimuli. The initial consonant of each syllable formed the first gate, with later gates formed by 40 ms increments. Twenty-eight native Mandarin speakers from Beijing were asked to identify each gated stimulus by writing down the Chinese characters. Isolation point (IP) based on correct tone identification as well as overall correct word identification (correct onset, rhyme, and tone) were collected. Results from both conditions showed that tone 1 has an earlier IP than tone 4, which has an earlier IP than tones 2 and 3. Sonorant-initial syllables have an earlier IP than obstruent-initial syllables, but further analyses of covariance indicated that this is due to the fact that IP covariates with the duration of the initial consonant. Syllables without a nasal coda have an earlier IP than syllables with a nasal coda. This effect might be due to the interference of nasalization on tone perception or the delayed tonal contour realization due to the nasal coda [Xu, (1998)].

3pSC4. Duration and context speech rate as cues to lexical perception and word segmentation. Molly J. Henry, Laura C. Dilley, Louis N. Vinke, and Christopher J. Weinland (Dept. of Psychol., Bowling Green State Univ., Bowling Green, OH 43403, mjhenry@bgsu.edu)

Duration and speech rate are traditionally assumed to be filtered out before lexical lookup takes place, although these factors are known to influence phoneme perception. Here, the hypothesis was investigated that duration can affect both perceived lexical identity, as well as the perceived number and implied locations of word boundaries relative to the speech signal. Experiment 1 was a production study which investigated durations of vocalic portions of phonetically similar versions of target word strings which differed in their number of syllables (e.g., cease versus see us); these target word strings were spoken in semantically neutral context sentences. As expected, vocalic durations in target strings with fewer syllables were shorter than those with more syllables. In Experiment 2, the relative durations of vocalic portions of target strings in sentences from Experiment 1, as well as sentential context speech rate, were manipulated using speech resynthesis. Relative duration and context speech rate both affected the words that participants heard, as well as the implied number of phonemes and imputed locations of word boundaries. These findings indicate that duration plays a significant and underinvestigated role in spoken word recognition and word segmentation.

3pSC5. The spread and density of the phonological neighborhood can strongly influence the verbal transformation illusion. James A. Bashford, Jr., Richard M. Warren, and Peter W. Lenz (Dept. of Psychol., Univ. of Wisconsin-Milwaukee, P.O. Box 413, Milwaukee, WI 53201)

When a recorded verbal stimulus repeats over and over, adaptation occurs and listeners hear competing forms. Reports of these "verbal transformations" (VTs) were obtained for 36 consonant-vowel (CV) syllables that varied both in frequency-weighted neighborhood density (ranging from 12.73 to 90.42) and in neighborhood spread [i.e., for 18 CVs, changes at either phoneme position could yield real words (spread = 2) while for the remaining 18 CVs, changes at only one position could yield words (spread

$= 1)$]. The strength of the VT illusion, measured by the amount of time the stimuli were heard nonveridically during the 300-s repetition period, decreased substantially with both increasing neighborhood density [$r=-0.74$, $F(1,34)=42.6$, $p<0.0001$] and increasing spread [$r=-0.75$, $F(1,34) = 44.1$, $p<0.0001$]. Stepwise regression revealed that density and spread collectively accounted for approximately 70% of the variance in illusion strength [$F(1,33)\geqslant 10.0$, $p<0.003$ or better]. These effects are larger than, but generally consistent with, neighborhood effects obtained with other psycholinguistic tasks, and they suggest that VTs can provide a highly sensitive measure of lexical competition. [Work supported by NIH.]

3pSC6. Using auditory feedback during vocalization: Different mechanisms for utterance onset and pitch maintenance. Colin S. Hawco and Jeffery A. Jones (Dept. of Psych., Wilfrid Laurier Univ., 75 University Ave. West, Waterloo, ON N2L 3C5, Canada)

During vocalization, auditory feedback is used to attain and maintain a desired fundamental frequency (F0). The use of auditory feedback to control vocalization has been studied using adaptation studies, in which an F0 feedback alteration is maintained across many trials, and using midutterance perturbations, where a brief F0 change is introduced during an ongoing utterance. Participants vocalized during two blocks. In an adaptation block, a one semitone F0 shift was maintained for 40 trials, and midutterance perturbations were introduced by removing the feedback alteration. In a control block, a midutterance perturbation was introduced in trials, which were either unshifted or shifted randomly by one semitone at before the onset of vocalization (similar to the adaptation trials). F0 compensation to midutterance perturbations was identical in all conditions, and was always smaller than the compensation to a shift at utterance onset. These results are explained by a change in the control strategy at utterance onset and midutterance. At utterance onset, auditory feedback is compared to feedback predicted by a forward model to ensure the pitch goal is achieved. However, after utterance onset, the control strategy switches and stabilization is maintained by comparing feedback to previous F0 production.

3pSC7. Auditory-phonetic projection and lexical structure in the recognition of sine-wave words. Robert E. Remez, Kathryn R. Dubowski, Robin S. Broder, Morgana Davids, Yael S. Grossman, Marina Moskalenko, Jennifer S. Pardo, and Sara Maria Hasbun (Dept. of Psych., Barnard College, Columbia Univ., 3009 Broadway, New York, NY 10027, remez @columbia.edu)

Speech remains intelligible despite the elimination of canonical acoustic correlates of phonemes from the spectrum. Listeners tolerate distortion or spectral blur in tone analogs, noise band vocoded speech, and acoustic chimeras in utterances ranging from syllables to isolated words and sentences. A portion of this flexibility is attributable to short-term perceptual learning in auditory-to-phonetic projection, though exploiting the properties of lexical neighborhoods plays a role with utterances composed of words. New tests were conducted to estimate talker learning, segmental sensitivity, and lexical knowledge in this kind of perceptual versatility. Sine-wave versions of the easy/hard word lists were created, and the performance-level difference between the two lists was used to index the default reliance on lexical processes. Several kinds of preliminary exposure were used to induce sensitivity to a dimension of perceptual learning: sine-wave speech produced by the same talker, sine-wave speech of a different talker, natural speech of the same talker. A comparison of exposure effects on the performance level of easy/hard word recognition offered a clue about the differential contribution of talker-based, segment-based, and lexically-based attention in speech perception without canonical spectra. Implications for perceptual accounts based on cue likelihood will be discussed. [Work supported by NIDCD.]

3pSC8. Function words of lexical bundles: The relation of frequency and reduction. Shannon F. Lemke, Antoine Tremblay, and Benjamin V. Tucker (Dept. of Linguist., Univ. of Alberta, 4-32 Assiniboia Hall, Edmonton, AB, Canada, T6G 2E7, sflemke@ualberta.ca)

Studies of spontaneous speech have shown frequency effects on the amount of reduction produced by speakers, demonstrating that predictability facilitates production of a target word [Shi *et al.* (2005); Jurafsky *et al.* (2001); Bell *et al.* (2003)]. This paper investigates the amount of reduction produced in laboratory recorded speech and considers the effect of frequency on the duration of function words in four-word sequences. It is also found that the influence of frequency has an effect on holistically storing these bundles. An interaction between word position and the third-order transitional probability (ABC $\rightarrow$ D) has been established, indicating that greater third-order transitional probabilities predict shorter function word durations in the first and second positions of a bundle, and, therefore, involve more durational reduction. The current research shows that, just as frequency affects reduction in spontaneous speech, there is an effect in laboratory produced speech as well. These findings indicate that multiword sequences are stored as lexical units.

3pSC9. Basic word segmentation abilities emerge earlier in infancy than previously thought. Elizabeth K. Johnson (Dept. of Psych., Univ. of Toronto Mississauga, 3359 Mississauga Rd. North, Mississauga, ON L5L 1C6, Canada, elizabeth.johnson@utoronto.ca) and Amanda Seidl (Purdue Univ., West Lafayette, IN 47907)

English-learning 7.5- but not 6-month-olds extract word forms from fluent speech (Jusczyk *et al.*, 1999). Thus, English learners are thought to begin segmenting words from speech by 7.5 months. However, recent research has shown that when target words are flanked by a frequent and emotionally salient word (e.g., the infant's name), even 6-month-olds can extract words from speech (e.g., Bortfeld *et al.*, 2005). This suggests that basic word segmentation capabilities may emerge earlier than past studies have suggested. Using the Headturn Preference Procedure, we tested 6-month-olds' ability to segment utterance-flanked words from speech, e.g., "geff" from "At the circus we met a silly geff." Infants were familiarized with passages containing target words in utterance initial and final position, and then tested on their recognition of these words in isolation. A significant looking time difference to familiar versus unfamiliar words was found, indicating that 6-month-olds segmented the target words from speech. Six-month-olds' success at segmenting utterance-flanked words from speech is particularly interesting because infant-directed speech consists of short utterances containing many utterance-flanked words. Segmentation of utterance-flanked words could help infants learn the cues needed to extract harder utterance-medial words from speech (see Seidl and Johnson, 2006).

3pSC10. Phonological competition during the recognition of spontaneous speech: Effects of linguistic context and spectral cues. Susanne Brouwer, Holger Mitterer, and Falk Huettig (MPI for Psycholinguistics, P.O. Box 310, 6500 AH Nijmegen)

How do listeners recognize reduced forms that occur in spontaneous speech, such as "puter" for "computer"? To this end, eye-tracking experiments were performed in which participants heard a sentence and saw four printed words on a computer screen. The auditory stimuli contained canonical and reduced forms from a spontaneous speech corpus in different amounts of linguistic context. The four printed words were a "canonical form" competitor (e.g., "companion", phonologically similar to "computer"), a "reduced form" competitor (e.g., "pupil", phonologically similar to "puter"), and two unrelated distractors. The results showed, first, that reduction inhibits word recognition overall. Second, listeners look more often to the "reduced form" competitor than to the "canonical form" competitor when reduced forms are presented in isolation or in a phonetic context. In full context, however, both competitors attracted looks: early rise of the "reduced form" competitor and late rise of the "canonical form" competitor. This "late rise" of the "canonical form" competitor was not observed when we replaced the original /p/ from "puter" with a real onset /p/. This indicates that phonetic detail and semantic/syntactic context are necessary for the recognition of reduced forms.

3pSC11. Lexical access across different voices. Rochelle S. Newman (Dept. Hearing & Speech Sci., and Program in Neurosci. and Cognit. Sci. Univ. of Maryland, 0100 Lefrak Hall, College Park, MD 20742, rnewman @hesp.umd.edu)

In many real-world situations, listeners may be trying to attend to one individual while other voices are speaking in the background. These separate streams of sound hit the ear simultaneously. Within a single stream, research has investigated the extent to which lexical activation is limited by word boundary information. For example, Gow and Gordon (1995) found that multiple-word sequences such as "two lips" may activate words such as "tulips" despite the presence of acoustic cues to a word boundary in the middle of the sequence. Yet, no studies have examined whether lexical ac-

cess could "cross" signals entirely. In a series of four experiments, we test whether lexical access might (ever) cross talker boundaries. We find that when listeners hear two words spoken by two different voices (for example, a male saying "two" followed by a female saying "lips") they still activate the larger cross-voice word "tulips," despite the presence of strong cues to an acoustic boundary. [Work supported by NSF.]

3pSC12. Speaking rate modulates lexical competition in online speech perception. Eva Reinisch, Alexandra Jesse (Max Planck Inst. for Psycholinguistics, Wundtlaan 1, 6525XD Nijmegen, The Netherlands, Eva.Reinisch@mpi.nl), and James M. McQueen (Radboud Univ. Nijmegen, and Max Planck Inst. for Psycholinguistics, Nijmegen, The Netherlands)

Durational cues are used in online word recognition to disambiguate Dutch phrases such as "een(s) (s)peer" ["on(c)e (s)pear"]: The longer the [s], the more likely listeners consider the target to be [s]-initial [K. E. Shatzman and J. M. McQueen, Perc. Psychophys. **68**, 1–16 (2006)]. Here, a series of eye-tracking experiments show that speaking rate affects perception of duration and thus modulates lexical competition online. Listeners' eye-movements were recorded while they listened to sentences such as "Ze heeft wel eens peer gezegd" ("She once said pear"). Listeners had to click on printed targets (peer) presented on a computer screen with an [s]-initial competitor (speen; "pacifier") and two unrelated distractors. When the preceding context is faster, the critical [s] should sound longer and match better the beginning of "speen." Listeners indeed looked at the [s]-initial competitors more following fast than slow contexts. The opposite was found for [s]-initial targets (sneeuw; "snow") with non-[s]-initial competitors (neef; "nephew"). Context adjacent to the target (i.e., wel eens) influenced target perception more than nonadjacent context. Nonadjacent context, however, was sufficient to modulate competition when adjacent context was spoken at the same rate as the target. Amount of nonadjacent context at a given rate affected only off line categorization.

3pSC13. The nonaccommodation of speech errors. Andrea Gormley (Inst. of Cognit. Sci. Rm. 2222, Dunton Tower, Carleton Univ., 1125 Colonel By Dr. Ottawa, ON K1S 5B6, Canada, agormley@connect.carleton.ca)

Word-form speech errors are assumed to adapt to the unintended environment. For example, in the error 'bads cat' for intended 'bad cats,' the plural marker 's' assimilates to the voicing of the 'd' in 'bad.' This phenomenon, called accommodation, provides evidence that the component responsible for errors is processed before the phonological assimilation component. Previous work on accommodation relies on the researcher to detect accommodation [D. Boomer and J. Laver, Br. J. Disord. Commun. **3**, 1–12 (1968)]. Given that these studies are prone to perceptual bias, the conclusion that accommodation is the norm remains open. An acoustic analysis of errors was conducted to re-address this question. Thirty-two nonword tongue twisters, e.g., 'tiff tivv tivv tiff,' were designed to induce voicing errors on the coda. Because vowel lengthening before voiced codas is a phonological process in English, vowel length can be measured to detect accommodation. Errors were determined for each participant by measuring coda percent voicing and vowel duration in a control condition. Results from six participants (872 errors) show that while errors do accommodate (7.6%), nonaccommodation (40.7%) occurs more frequently. This result shows that errors do occur after phonological processing. [Work supported by OGS and Carleton University.]

3pSC14. Planning time effects of phonological competition: Articulatory and acoustic data. Christine R. Mooshammer (Haskins Labs., 300 George St., New Haven, CT 06511, tine@haskins.yale.edu), Louis Goldstein (USC, CA), Mark Tiede (MIT Res. Lab of Electron., MA), Manisha Kulshreshtha (Haskins Labs.,), Scott McClure, and Argyro Katsika (Haskins Labs.,)

One major cause for speech production variability and errors is competition between phonologically similar sequences in an utterance. Since one recent model of speech production planning [Nam (2004)] also posits a systematic relation between planning time and kinematic variability, we decided to directly investigate whether competition increases planning time, i.e., whether it takes longer to initiate a sequence such as "tape cape" compared with "tape tape." Effects of competition in the onset were compared to competition in the coda (e.g., "tape take"). Results from two studies are reported: articulatory latencies from a delayed naming task recorded using EMA (four speakers), and acoustic latencies from a delayed naming task, a simple naming task, and a picture naming task (ten speakers). Latencies were significantly affected by competition, i.e., latencies were longer for items like "tape cape" and "tape take" than for "tape tape." However, no significant differences were found in competition effects between onset and coda positions. Apart from latency, overall duration increased and clusters formed across words showed less overlap. Observed effects on latency were largest for picture naming, followed by simple naming and least for delayed naming. [Work supported by NIH DC008780.]

3pSC15. Color effects in audiovisual spoken word recognition. Rachael Frush Holt, Tessa Bent (Dept. of Speech and Hearing Sci., Indiana Univ., 200 S Jordan Ave., Bloomington, IN 47405, raholt@indiana.edu), and Luis Hernandez (Indiana Univ., Bloomington, IN 47405)

Although the importance of the visual contribution to speech perception has been known for over 50 years, strong interest in audiovisual speech perception has emerged only recently. In developing a test of audiovisual sentence recognition, white balancing and color correcting (adjusting the whites, mids, and black bandwidths to compensate for the camera's inability to fully reproduce human eyesight color spectrum) improved visual-only spoken word recognition. No differences were found in audiovisual or auditory-only modalities. Although improvement was seen across all key words, those with more visible phonemes showed the greatest improvement. To further examine the effects of color in the audiovisual modality specifically, the original speech signal was replaced with a signal-correlated noise and presented to adults in one of three conditions: non-color-corrected, color-corrected, and color-inverted. Minimal speech cues were sufficient for overcoming performance decrements due to small, but not large, color disturbances. Furthermore, in the color-corrected condition, performance in visual-only and signal-correlated noise conditions were equivalent, whereas in the non-color-corrected condition, signal-correlated noise improved performance over visual-only. The results suggest that consideration of minor color disturbances is warranted if testing visual-only perception; however, significant color disturbances can cause decrements in audiovisual conditions, as well. [Work funded by the AHRF.]

3pSC16. Perception of voiced-only and noise-vocoded speech by a language-trained chimpanzee (*Pan troglodytes*). Lisa A. Heimbauer (1527 Pangborn Station Dr. Decatur, GA 30033, lisa.heimbauer@gmail.com), Michael J. Beran, and Michael J. Owren (Georgia State Univ., Atlanta, GA 30302-5010)

The ability of human listeners to understand speech even in altered or synthetic forms is argued to be evidence of uniquely human processing abilities. However, extensive early experience with speech may also contribute to this capability. To investigate this issue two experiments were designed to test the ability of Panzee, a 22-year-old language-trained chimpanzee, to recognize words in synthetic form. Like a human child, she was reared from infancy by human caregivers who routinely spoke to her. She communicates with humans by identifying words using graphical symbols (lexigrams). Experimental training and testing were conducted with two different sets of 24 familiar words presented one-per-trial in natural, voiced-only, or noise-vocoded forms, with Panzee choosing one of four lexigrams presented on a computer monitor. Experiment 1 showed equivalent performance with words heard in natural form versus voiced-only versions, resynthesized from only voiced components of a word. Noise-vocoded words presented in Experiment 2 simulated effects of hearing using a cochlear implant and were based on amplitude-modulated noise bands. Performance with these sounds was significantly higher than chance, but also lower than with natural words. Results suggest specialized processing mechanisms are not necessary to speech perception in the absence of traditional acoustic cues.

3pSC17. Identifying the common problems of English-to-Japanese consecutive interpretations performed by Japanese intepreting students. Kinuko Takahashi (Sophia Univ. #306, 4-1-10, Dai, Kamakura-city 247-0061 Japan, kinuko@dc4.so-net.ne.jp)

The purpose of the present paper is to identify the problems that Japanese interpreting students may encounter and to establish causes for them in the expectation that they may help devise a training method. It has been long wondered why some students become successful interpreters and others do not. In order to answer this question, the research was launched to identify the problems that interpreting students encountered. For this purpose, nine

interpreting students were asked to consecutively interpret four different English texts. It was discovered that the participants had a tendency for omissions of interpreting, and omissions occurred due to a number of causes. One of them was a problem of speech perception. One of the participants, for example, was not able to distinguish "breeze" from "bleed." To one of the participants, "attendance" sounded like "tendence." These problems seemed to require the participants to take more time to interpret. As a result, the participants failed to listen to the following parts, eventually making further omissions. Therefore, it is necessary for the participants to learn "top-down" processing of comprehension. However, it is necessary to examine the relation between the level of interpreting skills and speech perception ability.

3pSC18. Perceptual normalization for variation in speaking style. Antonia D. Vitela, Sarah C. Sullivan, and Andrew J. Lotto (Speech, Lang. and Hearing Sci., Univ. of Arizona, 1131 E. 2nd St., Tucson, AZ 85721, adv1@email.arizona.edu)

Ladefoged and Broadbent [J. Acoust. Soc. Am. **29**, 98–104 (1957)] demonstrated that listeners will shift their categorization of a target vowel as a function of acoustic characteristics of a preceding carrier phrase. These results have been interpreted as an example of perceptual normalization for variability resulting from differences in talker anatomy. The present study examined whether listeners would normalize for acoustic variability resulting from differences in speaking style within a single talker. Two vowel series were synthesized that varied between central and peripheral vowels (the vowels in "beat"-"bit" and "bod"-"bud"). Each member of the series was appended to one of four carrier phrases that were spoken in either a "clear" or "reduced" speech style. Participants categorized vowels in these eight contexts. A reliable shift in categorization as a function of speaking style was obtained for three of four phrase sets. This demonstrates that phrase context effects can be obtained with a single talker. However, the directions of the obtained shifts are not reliably predicted on the basis of the speaking style of the talker. Instead, it appears that the effect is determined by an interaction of the average spectrum of the phrase with the target vowel. [Work supported by NIH-NIDCD.]

3pSC19. Neural dynamics of speech perception: Phonemic restoration in noise using subsequent context. Sohrob Kazerounian and Stephen Grossberg (Dept. of Cognit. and Neural Systems, Boston Univ., 677 Beacon St., Boston, MA, 02215, sohrob@cns.bu.edu)

Phonemic restoration describes a class of auditory illusions during which broadband noise replacing a deleted phoneme can cause the perceptual restoration of the deleted phoneme. Phonemic restoration exemplifies the brain's ability to complete and understand speech and language in noisy environments. It also clarifies how both past and future acoustical events can contextually guide completion of a percept that is occluded by noise, and highlights that conscious speech is due to bottom-up and top-down contextual interactions that can operate across hundreds of milliseconds. This work develops a neural model that quantitatively simulates restoration phenomena, including the forward development in time of a conscious speech percept even in cases where future events control how previously presented acoustic events are heard. The model clarifies how acoustic items are stored in short-term working memory, and how they interact reciprocally with unitized representations of item sequences, or list chunks, to generate a resonant wave of activation that embodies the consciously heard percept. Model simulations clarify why the presence of noise is necessary for restoration to occur, and why in the absence of noise a silence gap is perceived. These properties are traced to the brain's ability to rapidly and stably learn language.

3pSC20. Towards produtive language mapping: A magnetoencephalography study of letter naming. Yang Zhang (Dept. of Speech-Lang.-Hearing Sci., Univ. of Minnesota, Minneapolis, MN 55455), Wenbo Zhang, and Joel Landsteiner (United Hospital, St. Paul, MN 55102)

This study aims to examine the sensitivity and specificity of magnetoencephalography (MEG) integrated with magnetic resonance imaging (MRI) for productive language mapping using a simple letter naming task. Six healthy adult volunteers participated after screening for handedness and medical history of speech, language, hearing, and vision. The data were collected using a 148-channel whole-head MEG system (Magnes WH2500, 4D Neuroimaging, San Diego) at the Magnetic Source Imaging Laboratory in United Hospital, St. Paul. During the recording session in a magnetically shielded room, the subjects were instructed to pay attention to the visual stimuli and articulate the letter from the English alphabet as soon as it was shown on the screen. The averaged epochs and trial-to-trial raw data were analyzed using Brain Electrical Source Analysis (BESA) and BrainVoyager software. Although visual processing of the letters showed similar temporal and spatial activation patterns, letter naming did not show uniform activation patterns in the Broca's area. Large inter-subject variability was found in terms of superior temporal, inferior parietal, motor, and supplemental motor involvement. The results are discussed with respect to the technical challenges in implementing MEG with millisecond resolution for presurgical productive language mapping and potential risks of sensorimotor and language deficits.

3pSC21. An investigation of brain activation patterns in response to speechreading. Edward T. Auer, Jr. (Dept. of Speech-Lang.-Hearing, Univ. of Kansas, 1000 Sunnyside Ave., Rm. 3001, Lawrence, KS 66045, auer@ku.edu)

The ease of recognizing spoken words on the basis of optical input alone, or speechreading, is known to systematically vary as a function of the properties of the stimulus materials. The current study investigated the relationship between cortical responses and the intelligibility of the stimulus materials. Open-set identification performance outside the magnet was used to directly measure the intelligibility of the stimulus materials presented in the magnet as well as participant speechreading ability. fMRI was used to measure cortical response to viewing spoken word stimuli that were predicted to vary in their ease of identification. Videos of spoken words were contrasted with still face images in a block-design fMRI experiment. Blocks containing sets of words predicted to be easy speechread were contrasted with blocks predicted to be difficult to speechread. Preliminary analyses of cortical response to speechreading are consistent with previous studies [Hall *et al.*, J. Cog. Neuro. **17**(6), 939–953 (2005)]. Furthermore, evidence of increased activation in BA 37 and BA 44 for easy words versus hard words was obtained. These results are consistent with the hypothesis that specific areas are sensitive to the intelligibility of speech read stimuli. [Work supported by a grant from NIH/NIDCD (R01DC04856).]

3pSC22. Domain-specific processing of Mandarin tone. Yue Wang (Dept. of Linguist., Simon Fraser Univ., Burnaby, BC, Canada, V5A 1S6), Dawm Behne (Norwegian Univ. of Sci. and Technol., Trondheim, Norway), Angela Cooper, and Jung-yueh Tu (Simon Fraser Univ., Burnaby, BC, V5A 1S6 Canada)

Lexical tone has generally been found to be processed predominantly in the left hemisphere. However, given that tone is carried by a syllable or a word with segmental information and distinctive meaning, the processing of tone may not be easily disentangled from that of the phonetic segments and word meaning [P. Wong, Brain Res. Bull. **59**, 83–95 (2002)]. Indeed, previous research has not examined the lateralization of tone independent of segmental and lexical semantic information. The present study explores how syllable-based tonal processing in Mandarin Chinese interacts with these different linguistic domains. Using dichotic listening, native Mandarin participants were presented with monosyllabic tonal stimuli constructed with the following different linguistic attributes: (1) real Mandarin words with tonal, segmental phonetic, and lexical semantic information; (2) Mandarin nonwords with tonal and segmental, but no semantic information; (3) nonwords with non-Mandarin segments (i.e., no native segmental or semantic information); and (4) hums of tones (acoustic pitch information) without any segmental or semantic components. Results from these conditions show significant differences in lateralization patterns and are discussed in terms of the integration of acoustic as well as pre- and post-lexical linguistic domains in lexical tone processing. [Work supported by NSERC.]

3pSC23. Mismatch negativity reflects the affect of training on speech perception. McNeel Gordon Jantzen and Katherine Cella (Dept. of Psych., Western Washington Univ., 516 High St., Bellingham, WA 98225)

An adult's ability to perceive speech sounds that do not occur in their native language is influenced by the relationship between the new and native language phonology and by the individual's capacity to perceive acoustic differences. Individual differences are important: even after phonetic train-

ing, adults with similar language backgrounds exhibit significant individual differences in their ability to learn difficult non-native speech sounds [Polka (1991); Pruitt, Strange, Polka, & Aguilar (1990)]. Neurophysiologic changes due to learning are also reflected in the mismatch negativity (MMN) response and are indicative of the effects of training [Naatanen *et al.* (1993) and Kraus *et al.* (1995)]. The present experiment included two groups of six normal-hearing monolingual American-English speakers. The experimental group was trained to identify a voiced, unaspirated, dental stop consonant. The control group received no training on the dental. Electrophysiologic responses were measured for both groups in response to the dental and alveolar contrasts using a perceptual mapping procedure. Training improved the experimental group's ability to perceive the non-native contrast. Training effects were also reflected in the MMN response, as observed by increased duration and decreased onset latency.

3pSC24. The interaction of location with acoustic scale in concurrent speech recognition. David T. Ives, Martin D. Vestergaard, and Roy D. Patterson (Dept. of Physio., Development and Neurosci., Univ. of Cambridge, Downing St., Cambridge CB2 3EG, UK)

Location and acoustic scale cues have been shown to have a significant effect on the recognition of speech in multispeaker environments. The interaction of these two cues is less well understood. In this study, subjects are presented with two triplets of concurrent speech syllables with similar temporal envelopes, and asked to recognize a specific target syllable. The task was made more or less difficult by changing the location of the distracting speaker, the scale difference between the two speakers and the relative level of the two speakers. Scale differences were produced by changing the vocal tract length and glottal pulse rate of resynthesized speech: 32 scale differences were used. Location cues were produced by convolving heat-related transfer functions with the stimulus. The target speaker was located directly to the front of the listener and the distracting/masking speaker located from one of five locations (0, 4, 8, 16, 32 deg) on the 0 deg horizontal plane. Target-to-masker ratios of 0 and −6 dB were used. The results show that direction and scale differences cues do interact and this interaction is greatest when directional and speaker scale cues are small. [Research supported by the U.K. Medical Research Council (G0500221, G9900369).]

3pSC25. Does training improve consistency of roughness judgments in a matching task? David A. Eddins (Dept. of Otolaryngol., Univ. of Rochester, 2365 S. Clinton Ave., Rochester, NY 14618, David_Eddins@URMC.Rochester.edu), Rahul Shrivastav, and Sona A. Patel (Univ. of Florida, Gainesville, FL 32611)

Shrivastav *et al.* [J. Acoust. Soc. Am. **119**(5), 3340 (2006)] reported a matching task in which a square wave modulated sawtooth wave (signal) was matched to a series of vowels (standards) to estimate the magnitude of roughness in voices. Results suggested that listeners found it difficult to isolate roughness from other voice quality dimensions such as breathiness. In the present experiment, a brief training session was added prior to the matching task to ensure that listeners were attending to variations in roughness alone. This training consisted of a rank-ordering task in which listeners sorted the 34 test samples of the vowel /a/ in ascending order of roughness. For feedback, these rankings were compared to the rankings made by expert listeners. This criterion was used to ensure that all participants understood the dimension of voice quality under study. Listeners who met a specific eligibility criterion completed a modulation matching task to familiarize them with the matching task itself. Finally, thresholds for the roughness matching task were obtained and compared to thresholds obtained without training. The extent to which task-related training can help listeners make perceptual judgments for specific dimensions of voice quality will be discussed.

3pSC26. Masking release at low sensation levels. Peggy Nelson, Elizabeth Anderson Crump, Yingjiu Nie, and Michelle Hawkinson-Lewis (Dept. of Speech-Lang.-Hearing Sci., Univ. of Minnesota, 164 Pillsbury Dr. SE, Minneapolis, MN 55455, peggynelson@umn.edu)

Previous results have shown that listeners with sensorineural hearing loss (SNHL) obtain about half of the masking release of their normal-hearing (NH) counterparts. When speech is amplified sufficiently, listeners with SNHL may score like NH listeners in quiet and in steady noise, yet may obtain only half of the expected release from gated noise. We hypothesize that some of that deficiency may occur because of the impaired listeners' low speech sensation levels, which results in decreased usefulness of the speech signal in the noise dips. In the current study, NH listeners were tested for their recognition of IEEE sentences in quiet, in steady noise, and in gated noise with the speech presented at varying sensation levels. At low levels (10–15 dB SL), NH listeners scored nearly 100% correct in quiet. In steady noise (at −10 dB signal-to-noise ratio) scores for low-level stimuli were also similar to those obtained at higher SLs. However, at low SLs in gated noise, NH listeners demonstrated less masking release than expected, suggesting that audibility of speech in the dips of noise is important for masking release even when performance in quiet and in steady noise seems optimized. [Work supported by NIH 5R01DC008306.]

3pSC27. Listening to natural versus cell phone speech on multiple simultaneous tasks. Srinivasan Nirmal Kumar (Dept. of Special Educ. and Commun. Disord., Barkley Memorial Ctr., Univ. of Nebraska-Lincoln, Lincoln, NE 68583) and Carrell Thomas (Univ. of Nebraska-Lincoln, Lincoln, NE 68583)

In typical listening environments, attention is often divided and may have different effects on automatic and controlled processes. Automatic processing is a fast, parallel process not limited by short-term memory, requires little subject effort, but requires extensive consistent training to develop. Controlled processing is a comparatively slow, serial process limited by short-term memory, requires subject effort, and little training to develop [Schneider and Shiffrin (1977)]. In the present study a methodology was developed to examine effects of controlled and automatic distracters on the perception of distorted speech. Specifically, perception of natural and cell phone speech was investigated while listeners performed simultaneous visual and motor tasks. Young, normal-hearing native speakers of English were presented with SPIN sentences [Kalikow *et al.* (1977)] in a background of multitalker babble [Bilger *et al.* (1984)] using natural and cell phone speech. Prior to the start of the experiment, participants had been trained on visual task using either consistent mapping technique or varied mapping technique. Word recognition scores, pursuit rotor performance, and visual task performance were compared for natural and cell phone speech. The relationship between consistently mapped and variably mapped distracters on perceptual and behavioral performance provides information necessary for more detailed models relevant to real-world environments.

3pSC28. Seeing a speaker's face helps stream segregation for younger and elderly adults. Alexandra Jesse (Max Planck Inst. for Psycholinguistics, Wundtlaan 1, 6525 XD Nijmegen, The Netherlands, Alexandra.Jesse@mpi.nl) and Esther Janse (Utrecht Inst. of Linguist. OTS and Max Planck Inst. for Psycholinguistics, Nijmegen, The Netherlands)

Listening to a speaker while hearing one or more competing speakers in the background can be a challenging task, especially for elderly adults. We show that younger and elderly listeners (above the age of 65) with varying degrees of age-related hearing loss benefit in stream segregation and speech processing from seeing the target speaker talk in addition to hearing an audio mix of a target and a competing speaker. This audiovisual benefit was found for response accuracy and speed in a phoneme monitoring task, where participants indicated by button press the occurrence of given target phonemes in the monitored speech of the target speaker. The audiovisual benefit was larger for younger than for older adults, despite their equivalent performance on auditory-only trials and in an off-line phoneme lip-reading task. Better lip-reading performance, however, predicted a larger audiovisual benefit. The audiovisual benefit was found for both highly visible phonemes (/p/) and poorly visible phonemes (/k/), but was modulated in its size by segmental visibility. The audiovisual benefit therefore arises from local segmental visual information but is also at least partially driven by audiovisual synchrony information that aids in attending to the target speaker.

3pSC29. The eyes' footprints on the ears: An investigation of short-term speech intelligibility change. Jing Liang (Dept. of Psych. and Ctr. for Cognit. and Social Neurosci., Univ. of Chicago, 5848 S Univ. Ave., Chicago, IL 60637, liang@uchicago.edu), Steven L. Small, and Howard C. Nusbaum (Univ. of Chicago, Chicago, IL)

Although observation of mouth movements improves auditory speech perception, the extent to which visual information aids speech perceptual learning and affects subsequent audio-only speech perception remains

unknown. The current study investigates whether visual speech information, specifically, the synchronized mouth movements of the talking face during training, helps the listener to perceive audio-only speech more effectively after training. An experimental group was trained to recognize audiovisual words presented in noise, while a control group was trained on the same audio speech signal in noise, but with no accompanying mouth movements. The control group provides a baseline estimate of what listeners can learn from the speech signal alone without visual information from the talker's mouth movements. Both groups were tested on audio-only speech in noise before and after training. All novel words were used in the pretest, training, and posttest. The results demonstrate that visual information aids learning to recognize audio-only speech in noise, suggesting visual information from a talker's mouth movements during training might change auditory coding of acoustic speech signals.

3pSC30. Effects of audio-visual speech information on recognition memory of spoken words. Kauyumari Sanchez, Rachel M. Miller, and Lawrence D. Rosenblum (Dept. of Psych., Univ. of California, Riverside, 900 University Ave., Riverside, CA 92521)

Audio-visual speech has generally been found to contain more usable information than audio-only speech. However, there is conflicting evidence of whether seeing the face of a speaker facilitates memory for spoken words [e.g., Sheffert *et al.*, Cog. Tech. **8**, 42–50 (2003)]. To address this issue, three experiments examined whether an audio-visual benefit would be observed on a word recognition task. Experiment 1 compared recognition of spoken words both presented and tested in audio-visual versus audio-only forms. Audio-visual word stimuli were recognized significantly better than audio-only words. Experiment 2 tested whether this benefit was due to the presence of visible articulatory information or simply more information in general. Recognition of words presented (and tested) in audio-only, audio-visual, and audio with accompanying static face image conditions were compared. Words presented in audio-visual (dynamic face) form were recognized better than audio-only and audio-static face stimuli. To test whether the benefit of audio-visual presentation was due to encoding, retrieval, or both, Experiment 3 crossed presentation modality (audio-only versus audio-visual) from presentation to test phases. Results showed that the audio-visual form is required in both encoding and retrieval to be beneficial.

3pSC31. Influence of visual speech information on the identification of foreign accented speech. Rebecca K. Reed and Edward T. Auer, Jr (Dept. of Speech-Lang.-Hearing, Univ. of Kansas, 1000 Sunnyside Ave., Rm. 3001, Lawrence, KS 66045, rxxr@ku.edu)

Seeing a native talker's face improves speech intelligibility in noise for native perceivers. The intelligibility of foreign accented speech (English spoken by native talkers of Mandarin) is more susceptible to the effects of noise than the speech of native talkers. [Rogers *et al.*, Lang Speech 47(2), 139–154 (2004)]. The current experiment investigated the influence of seeing the non-native talker's face on the intelligibility of speech presented in noise. Ten talkers (nine non-native and one native) were recorded producing 155 sentences each. Talker-specific speech shaped noise was mixed with the audio of the sentences. Eighty-one native perceivers of English (nine per non-native talker) responded to 20 sentences spoken by the native talker and 28 by the non-native talker in each condition (audio-alone, visual-alone, audiovisual). Open set identification responses were scored as percent words correct for each condition and talker. Preliminary analyses demonstrate that although seeing the non-native talker increases intelligibility, the gain is significantly reduced compared to the native talker. Results will be discussed in terms of potential sources of the audiovisual gain. These sources are hypothesized to be differentially sensitive to the distortions arising in non-native speech. [Work supported in part by NIH/NIDCD DC04856 and the University of Kansas, UGRA.]

Session 3pUW

Underwater Acoustics and Acoustical Oceanography: Physics-Based Undersea Clutter Model Verification and Validation II

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Contributed Paper

1:00

3pUW1. Propagation focusing in the context of clutter statistics. Chris Harrison (NURC, Viale S. Bartolomeo, 400, 19126 La Spezia, Italy, harrison @nurc.nato.int)

Fluctuations in reverberation (clutter) from scatterers at long range in shallow water can be affected by many mechanisms. Their statistics, in particular the scintillation index, depend not only on the statistics of the scatterers (their physical distribution, shape, orientation, etc.) but on the outward and return propagation paths. Focusing effects due to forward scattering from weak undulations in the seabed will be presented. Existing Fresnel–Kirchhoff theory for monostatic, vertical incidence on a two-dimensional surface is adapted to demonstrate the behavior of the intensity's scintillation index in bistatic geometry. In addition, using a simulation of bistatic geometry and a one-dimensional surface, the intensity statistics are extended to include autocorrelation function and probability distribution. Bistatic geometries include source and receiver moving with constant separation, and moving source with fixed receiver. Fairly modest vertical undulations can result in significant fluctuation due to reflection focusing with scintillation indices possibly greater than unity.

Invited Paper

1:15

3pUW2. Estimating higher moments of shallow water reverbation for non-Gaussian scatterer distributions. Kevin D. LePage (NATO Undersea Res. Ctr., Viale San Bartolomeo 400, 19126 La Spezia, Italy)

Reverberation is described as a random process by which deterministic propagation components weight and sum scattering amplitudes over the sonar footprint. A method of estimating the second, third, and fourth monents of the scattered field pressure is described for scatterers which have a Chi Squared model for the amplitude pdf. Comparison of theoretical estimates of the fourth moment to Monte Carlo estimates of the same quantity obtained using a NRL 2-way parabolic equation PERM show good agreement. [Work supported by ONR.]

Contributed Papers

1:35

3pUW3. Measurement and modeling of broadband Bragg scattering from a sinusoidal surface. Dajun Tang and Darrell R. Jackson (Appl. Phys. Lab., Univ. of Washington, 1013 NE 40th St., Seattle, WA 98105, djtang @apl.washington.edu)

While the mechanism of Bragg scattering is well known, most experimental work has been concentrated in the area of narrow band sound sources and in the far-field. Motivated by underwater detection problems in the presence of sediment ripple fields, we report laboratory measurements of broadband sound scattering from a sinusoidal surface machined on a polyurethane board. The surface has a wavelength of 8 mm and peak-to-peak height of 2 mm. Coherently scattered sound data were taken in near-field geometries and in the frequency band of 150–400 kHz. The measurement geometry is such that a broad range of Bragg angles corresponding to the frequency band are covered. We observe that the scattered sound demonstrates a down chirp time dependence when the incident sound is a short pulse. Models based on first order perturbation theory were developed which explain the observed scattered sound in both magnitude and phase. In addition, we also measured second order Bragg scattering. This motivates modeling efforts on higher order Bragg scatter. [Work supported by ONR.]

1:50

3pUW4. Validation of a physical model for surface clutter. Trudy L. Philip, Bruce K. Newhall, and Juan I. Arvelo (Johns Hopkins Univ. Appl. Phys. Lab., 11100 Johns Hopkins Rd., MS 8-220, Laurel, MD 20723)

There is a strong need to more accurately represent active sonar system false contacts in various environments and conditions for the purpose of active acoustic simulation and synthetic training. A computationally viable approach for the generation of physics-based false contacts in a raw beamformed time series that can be injected into a sonar processor was previously developed for bottom clutter. That model is now extended for clutter due to rough ocean surface scattering, and is compared with ASIAEX01 data. Considerations in extending the existing model include: characterizing appropriate statistics of the rough surface, adding surface scattering clutter to the sonar model, evaluating the realism of the simulation, and evaluating the computational burden (for real-time trainers). The output of the simulation was analyzed for those considerations and then compared to the data. The use of a vertical line array allowed physical mechanisms in the data to be isolated, and their clutter data statistics separately determined. After comparing data statistics to predictions, the need for additional modeled clutter mechanisms was assessed. This effort was conducted under the auspices of the Undersea Warfare Business Area Independent Research and Development program of the Johns Hopkins University Applied Physics Laboratory.

Plenary Session and Awards Ceremony

Mark F. Hamilton, Chair
President, Acoustical Society of America

Business Meeting of the Acoustical Society of America

Presentation of Certificates to New Fellows

Russell E. Berger, II
Suzanne E. Boyce
Douglas S. Brungart
Richard S. McGowan
Luc Mongeau
Patrick W. Moore
Trevor R. T. Nightingale
D. Lloyd Rice
Christine H. Shadle
Martin Siderius
Aaron M. Thode
Doug H. Whalen
Lisa M. Zurk

Presentation of Acoustical Society Awards

Medwin Prize in Acoustical Oceanography to Martin Siderius

R. Bruce Lindsay Award to Kelly J. Benoit Bird

2008 Silver Medal in Speech Communication to Winifred Strange

Gold Medal to Thomas D. Rossing

Presentation of Vice President's Gavel

Presentation of President's Tuning Fork