Session 3aAA

Architectural Acoustics: Relating Perception to Room Acoustics Measurements and Metrics in Performing Arts Venues I

Michelle C. Vigeant, Cochair
Graduate Program in Acoustics, The Pennsylvania State University, 201 Applied Science Bldg., University Park, PA 16802

Gregory A. Miller, Cochair
Threshold Acoustics, LLC, 53 W. Jackson Boulevard, Suite 815, Chicago, IL 60604

Chair's Introduction—8:30

Invited Papers

8:35

3aAA1. Insights from three profiling studies of auralized concert hall acoustics: Support for a three dimensional perceptual space? Antti Kuusinen, Tapio Lokki, Jukka Pätynen, and Sakari Tervo (Comput. Sci., Aalto Univ., Otaniementie 17, Espoo FI-00076, Finland, antti.kuusinen@aalto.fi)

Since 2009, we have now completed three individual vocabulary profiling studies of auralized concert hall acoustics. In-line with the work of others, these studies have verified that the main perceptual aspects describing acoustic differences are, more or less, loudness, reverberance, width, envelopment, definition/clarity, brightness, bass, and proximity/intimacy. Our studies, however, do not indicate that these aspects would vary independently when moving from hall of to hall, but that the perceptual changes in many aspects generally co-occur. While independency can be understood in terms of attention, and the number of perceptual aspects by considering the different "tastes" of listeners, it seems that the perceptual differences between halls are actually governed by three main factors. The interpretation of these factors depends on the viewpoint and here we discuss some possible interpretations based on these three profiling experiments and the literature as well as the implications concerning the objective parameters.

8:55

3aAA2. Objective metrics, subjective descriptors, and their elasticity in the face of experience. Jonah Sacks (Acentech, 33 Moulton St., Cambridge, MA 02138, jsacks@acentech.com)

Acousticians have long associated certain objective metrics with subjective aural qualities: C80 with clarity, for example. But the subjective quality of sonic clarity is complex and nuanced, and the descriptor means different things to different people. C80 describes the strength of early reflections relative to overall reflected sound energy. But these reflections may either help or hinder perceived musical clarity in different halls, different conditions of use, and to different listeners. New research, listening experience, and developments in room acoustics design challenge us to update our understanding and use both of subjective aural qualities and descriptors (such as clarity), and of objective metrics (such as C80). This talk will cite research (Lokki *et al*., Griesinger, etc.), project examples, and the author's own listening observations.

9:15

3aAA3. Multimodal perception in concert halls: Where do we look when we listen? Anne L. Minors (Sound Space Vision, Studio 2 Tay House, 23 Enterprise Way, London SW18 1FZ, United Kingdom, anne.minors@ampcstudio.com)

Concert hall design is at a crossroads between its origins, which have been unamplified orchestral music and singing, and the forces of popular music, which depend mostly on amplified sound and multimedia accompaniment. Concurrently, there has been a revolution in the way that the buildings are designed in the last 25 years. Computer modeling techniques enable architects and engineers to conceive and build complex geometrical forms and acoustic engineers to analyze future building interiors to promote a rich sound experience. However, despite a concert being a multisensory experience, relatively little work has been done on investigating how the visual aspects of the concert hall may impact on the acoustical experience. This paper investigates multisensory perception in different concert halls by examining where people look when actively listening to music and whether this affects how they perceive the experience.

9:35

3aAA4. How reproducible are psychoacoustic listening tests on spatial impression in auditoria? Ingo B. Witew, Michael Vorlaender (ITA, RWTH Aachen Univ., Kopernikusstr. 5, Aachen 52056, Germany, mvo@akustik.rwth-aachen.de), and Aleksandra Pieczykolan (Dept. of Psych., Univ. of Wuerzburg, Würzburg, Germany)

In three psychoacoustic experiments, it was shown that changes in frequency (pitch) and level (loudness) of stimuli lead to significant differences in the perception of apparent source width (ASW). Due to partially identical test conditions in two of the experiments, it is possible to analyze the collected data in regard to stability of ASW perception over repeated testing sessions and to study inter-individual differences. This analysis shows that intra-individual effects of stimulus loudness and pitch are consistent across participants, whereas the absolute level of ASW perception varies between individuals and between experimental sessions. Using this data, possible influences such as listener training effect over repetition of test sessions are discussed. The presented results provide insights into possible improvements of investigating ASW in future studies.

9:55–10:10 Break

10:10

3aAA5. Perception of spatial impression changes due to source movement. Sungbeen Cho and Lily Wang (Durham School of Architectural Eng. and Construction, Univ. of Nebraska-Lincoln, 1110 S. 67th St., Omaha, NE 68182-0816, sungbeen@huskers.unl.edu)

Few investigations have studied how spatial impression at a receiver position in a performing arts venue varies as a source moves across the stage. This paper reviews an evaluation method for spatial impression by studying the relative change in received sound energy due to source movement, using a proposed metric called the Interaural Level Difference Correlation Range (ILD-CR). Previous work by the authors indicated that this metric is able to quantify varying spatial impression changes as a source moves across a stage, better than standard spatial impression metrics. A subjective study is now being conducted to assess perception of different ILD-CR in assorted spaces. Can listeners perceive different ILD-CR, and consequently differentiate between spatial impressions linked to different performing arts venues as source position changes? Results from the preliminary study are presented.

10:30

3aAA6. Relating listener envelopment to specific time segments in early and late portions of sound fields. David A. Dick and Michelle C. Vigeant (Graduate Program in Acoust., The Penn State Univ., 201 Appl. Sci. Bldg., University Park, PA 16802, dad325@psu.edu)

Listener envelopment (LEV) in concert halls is a function of both the spatial and temporal properties of the room impulse response (IR). This study used measured spatial IRs that were modified to study which segments of the early and late parts of the IRs contribute the most to the perception of LEV. Measurements were obtained in the Peter Kiewit Concert Hall in Omaha, NE, using an Eigenmike 32-element spherical microphone array, and processed for third-order Ambisonic reproduction over a 30-loudspeaker array. A subset of the IRs were identified with either an exceptionally high or low amount of LEV. These IRs were modified such that some time segments of the IRs were reproduced in full 3D (e.g., the early energy), while other segments were played only through a single loudspeaker in front of the listener (e.g., the late energy). Additional stimuli were generated that contain time portions of both the highly enveloping IRs and the unenveloping IRs. A subjective listening test was conducted in which listeners rated the LEV of the modified IRs convolved with anechoic music. Results will be presented that compare the LEV ratings to objective measurements of the sound fields. [Work supported by NSF Grant 1302741.]

10:50

3aAA7. Using individually equalized playback of binaural recordings from an electronic orchestra to determine the effects of early reflections on proximity, localization, and loudness. David H. Griesinger (Res., David Griesinger Acoust., 221 Mt. Auburn St. #504, Cambridge, MA 02138, dgriesinger@verizon.net)

Reflections in the first 50 ms are often assumed to enhance sound quality, but data supporting the assumption are lacking. We need to know when reflections are beneficial, and when they are not. Work by Lokki *et al*. may help to answer this question, but we have developed a binaural recording and playback technique that yields as good or better results. The key is individual equalization from the microphone to the eardrum of a listener. We have developed a quick and non-invasive method of headphone equalization that produces accurate timbre and frontal localization without head-tracking. This enables binaural impulse responses from a number of instrument positions in real halls to be manipulated by adding or deleting individual reflections and then evaluated with blind listening tests. Data from Boston Symphony show that early lateral reflections in the front of the hall are typically inaudible, but early medial and lateral reflections in the rear of the hall can reduce or eliminate proximity, clarity, impact, envelopment, and the ability to localize individual instruments. Deleting one or two of the earliest and strongest reflections improves all of those perceptions with no effect on loudness.

Session 3aAB

Animal Bioacoustics, Noise, and ASA Committee on Standards: Effects of Noise on Animals

John Hildebrand, Cochair
Scripps Institution of Oceanography, University of California San Diego, Mail Code 0205, La Jolla, CA 92093

David K. Mellinger, Cochair
Coop. Inst. for Marine Resources Studies, Oregon State University, 2030 SE Marine Science Dr., Newport, OR 97365

Chair's Introduction—8:15

Invited Papers

8:20

3aAB1. Characterizing ambient noise in marine and terrestrial settings. John Hildebrand (Scripps Inst. of Oceanogr., Univ. of California San Diego, Mail Code 0205, La Jolla, CA 92093, jhildebrand@ucsd.edu)

Ambient noise results from both anthropogenic and natural sources. In a marine setting, low frequency ambient noise is dominated by anthropogenic sources: commercial shipping and seismic exploration. Marine ambient noise in the mid-frequency band is primarily due to sea surface agitation: breaking waves, spray, bubble formation and collapse, and rainfall. Various sonars (e.g., military and mapping), as well as small vessels, contribute anthropogenic noise at mid-frequencies. At high frequencies, acoustic attenuation becomes extreme so that all noise sources are confined to an area close to the receiver. In a terrestrial setting, ambient noise is often dominated by anthropogenic sources, from aircraft and traffic. Most terrestrial measurements of ambient noise are conducted at or near the ground surface, where temperature and wind gradients create complex sound propagation environments. Likewise, obstacles such as vegetation are important for sound propagation, as well as absorption and reflection from the ground surface. Flowing water and wind are natural sources of terrestrial ambient noise. The relationship between animal bioacoustics and ambient noise will be discussed, as a background against which studies of the impact of anthropogenic noise on animals are conducted.

8:40

3aAB2. Overview of the behavioral effects of noise on animals. David K. Mellinger (Coop. Inst. for Marine Resources Studies, Oregon State Univ., 2030 SE Marine Sci. Dr., Newport, OR 97365, David.Mellinger@oregonstate.edu)

Animal responses to noise vary with both the noise itself and with the condition, and especially the behavioral state, of the animal. Responses include movement away from or toward the noise source on time scales from seconds (immediate response) to minutes (changes in breathing rates of marine mammals) to months or years (abandonment or adoption of habitats); changing the frequency, duration, intensity, or rate of occurrence of vocalizations; non-response due to masking of sounds important for mate-finding, predator detection, prey detection, navigation, socialization, parent-offspring bonds, etc.; increases in stress responses; and so on. Responses are mediated by a host of condition of the receiving animal, including its behavioral state (feeding, resting/sleeping, traveling, advertising for mates, etc.), its age/sex class, its mating status, its location within its habitat, past exposure to noise, presence of conspecifics, presence of predators, and many more factors. An overview of these topics is presented. [Work supported by ONR and LMR.]

9:00

3aAB3. Noise, national parks, and the wildlife therein. Kurt M. Fristrup, Megan F. McKenna (Natural Sounds and Night Skies Div., National Park Service, 1201 Oakridge Dr., Ste. 100, Fort Collins, CO 80525, kurt_fristrup@nps.gov), and Rachel Buxton (Fish, Wildlife, and Conservation Biology, Colorado State Univ., Fort Collins, CO)

Monitoring at more than 600 sites in National Park Service (NPS) units has shown that noise poses widespread concerns: a contaminant to the physical environment, an infringement on superlative visitor experience, and a sensory burden for wildlife. NPS acoustical data were generalized into maps predicting sound levels for the coterminous U.S. These maps document the spatial scope and intensity of noise burdens on wildlife for park and other protected areas in the U.S. Although NPS units and other protected areas generally have sound levels a few decibels lower than adjacent unprotected land, 15% of all protected areas have sound levels 10 dB higher than predicted natural levels (median A-weighted levels). Designated critical habitat for 20 threatened animal species (US Fish and Wildlife Service) also exceed this 10 dB noise exposure criterion. Wildlife responses to noise have been documented in a wide range of taxa and habitats, with the past six years witnessing rapid growth in this research. Notably, controlled playback studies have been performed in otherwise pristine habitats to demonstrate that noise alone affects habitat utilization, foraging effectiveness, and breeding success. Noise may still present underestimated threats to wildlife; it certainly presents underutilized opportunities for habitat restoration.

9:20–9:35 Break

9:35

3aAB4. Insights into airplane overflight effects on bioacoustic activity levels from long-term acoustic monitoring. Susan Parks, Samuel L. Denes, Leanna P. Matthews (Biology, Syracuse Univ., 107 College Pl., Rm. 114, Syracuse, NY 13244, sparks@syr.edu), Pramod K. Varshney (Dept. of Elec. Eng. and Comput. Sci., Syracuse Univ., Syracuse, NY), and Kurt M. Fristrup (Natural Sounds and Night Skies Div., National Park Service, Fort Collins, CO)

The National Ecological Observatory Network (NEON) has established a framework through which a variety of environmental metrics will be continuously monitored measured for multiple decades at stations located across the United States. We describe a multiyear project that demonstrates the benefits of continuous acoustic monitoring at NEON sites. By utilizing long-term recordings, a wealth of data relating to species presence, animal behavior, and anthropogenic disturbance can be collected without the presence of human researchers. These recordings allow the measurement of contributions of anthropogenic activity to the cumulative sound energy at these locations and the response of all acoustically active species in the environment to individual events. Data from the NEON site at Harvard Forest, MA, were analyzed to assess the number of aircraft overflights detected at the location over the course of one year. The bioacoustic activity levels before, during and after were quantified for a subset of these events. Adding acoustics to the measurements already collected under NEON protocol can provide high-resolution information on the acoustic impact of human activities at these locations and allow for long-term monitoring with ground truth assessment of acoustic biodiversity. [Project supported by NSF award #1340669.]

9:50

3aAB5. Recent advances in scientific understanding of the effects of sound from seismic surveys. Robert Gisiner (Int.. Assoc. of Geophysical Contractors, 1225 North Loop West, Ste. 220, Houston, TX 77008, bob.gisiner@iagc.org), Jennifer Miksis-Olds (The Penn State Univ., State College, PA), and Sarah L. Tsoflias (Chevron North America E&P Co., Houston, TX)

The E&P Sound & Marine Life Joint Industry Programme (SML JIP), a partnership of 13 oil and gas companies and associations, funds independent scientific research to increase understanding of the potential effects of E&P sound on marine life. To advance understanding of the interaction between sound from oil and gas operations and marine life, the JIP identifies and commissions research to: (1) support planning of E&P projects and risk assessments, (2) provide the basis for appropriate operational measures that are protective of marine life, and (3) inform policy and regulatory development. SML JIP research categories include sound source characterization and propagation, physical and physiological effects and hearing, behavioral impacts and biological significant effects, and technologies for monitoring and mitigation. Highlights of projects to better characterize the source properties of seismic air sources, understand the hearing of Arctic pinnipeds, assess hearing recovery in marine mammals exposed to impulse sounds, and advance monitoring and mitigation technologies such as passive acoustic monitoring and alternative sound sources will be presented.

10:05

3aAB6. Relating the decreasing frequency of Sri Lankan pygmy blue whale calls to the local soundscape. Jennifer L. Miksis-Olds (Appl. Res. Lab, Penn State, PO Box 30, Mailstop 3510D, State College, PA 16804, jlm91@psu.edu) and Sharon Nieukirk (Oregon State Univ., Newport, OR)

Sri Lankan pygmy blue whale calls consist of three components: (1) low frequency pulsive unit, (2) frequency modulated upsweep, and (3) long tonal downsweep. The (~100 Hz) tonal downsweep is the most distinct of the call units and lasts 20–30 s. Spectral characteristics of the tonal downsweep and long-term patterns of environmental sound levels were analyzed from the Comprehensive Nuclear-Test-Ban Treaty International Monitoring Station at Diego Garcia in the Indian Ocean from 2002 to 2012. Average weekly spectral frequency peaks and ambient sound levels were computed. The peak frequency of Sri Lankan pygmy blue whale calls decreased from approximately 107 Hz to 100 Hz over a decade corresponding to a 0.55 Hz/year rate of decrease. To date, this is the largest rate of decrease observed for any blue whale call. Analysis of the ambient sound levels in the vocalization and adjacent bands did not exhibit equivalent patterns in source level trends. Potential drivers of the observed trends will be discussed. [Work supported by the Office of Naval Research.]

10:20

3aAB7. Construction noise impact on wild birds. Pasquale Bottalico (Communicative Sci. and Disord., Michigan State Univ., 1026 Red Cedar Rd., Lansing, MI 48910, pb@msu.edu)

Almost all bird species use acoustic signals to communicate between conspecifics or recognize biological signals, to mate, to detect the sounds of predators and/or prey, to perform mate selection, to defend their territory, and to perform social activities. Noise generated from human activities (in particular by infrastructure and construction sites) has a strong impact on the physiology and behavior of birds. In this work, a quantitative method for evaluating the impact of noise on wild birds is proposed. The method combines the results of previous studies that considered the effect of noise on birds and involved noise mapping evaluations. A forecast noise simulation was used to generate maps of (1) masking-annoyance areas and (2) potential density variation. The results permit a localization of the areas with greater impacts on birds. The mitigation interventions should be focused on these areas in order to balance bird habitat conservation and human use of land. The forecast results should be interpreted by ornithologists and merged with information collected during the monitoring of the areas and with the habitat suitability maps.

Session 3aBA

Biomedical Acoustics: Controlled Drug Delivery and Release with Focused Ultrasound

Costas Arvanitis, Cochair
Radiology, Harvard Medical School, Brigham and Women's Hospital, 221 Longwood Avenue, Room 514a, Boston, MA 02115

Alexander Kilbanov, Cochair
Univ. of Virginia, Cardiovascular Div., CVRC, MR4RM3147, 409 Lane Rd., Charlottesville, VA 22908-1394

Invited Papers

8:15

3aBA1. Ultrasound-mediated drug targeting to tumors: Revision of paradigms through intravital imaging. Natalya Rapoport (BioEng., Univ. of Utah, 36 S. Wasatch Dr., Rm. 3100, Salt Lake City, UT 84112, natasha.rapoport@utah.edu)

In collaboration with Dr. Brian O'Neill (Houston Methodist Research Institute), the intravital fluorescence microscopy was performed using a customized Nikon A1R system to monitor the effect of ultrasound on the extravasation and tissue diffusion of various potential drug carriers including individual polymeric molecules, polymeric micelles, phase-shift nanoemulsions, and nanoemulsion-encapsulated drug. Carrier and drug extravasation and tissue accumulation was compared for the normal and tumor tissue upon intravenous injections to pancreatic tumor bearing mice. This approach allowed for the first time discriminating vascular and tissue compartments in the processes of the ultrasound-mediated drug delivery. Nanoemulsion accumulation in the tumor tissue was much faster than in the normal tissue. Without ultrasound, extravasation coefficient was threefold lower while tissue accumulation rate was two orders of magnitude lower for perfluorocarbon nanodroplets than for polymeric micelles. However, ultrasound application induced a 4.7-fold local enhancement of nanodroplet extravasation (to be compared with a 1.5-fold enhancement for micelles) and resulted in higher nanodroplet concentration and more uniform distribution in the tumor tissue. A kinetic model was suggested that allowed discriminating between various kinetic regimes of nanocarrier internalization in tumors of various sizes, cell density, and rigidity.

8:35

3aBA2. Triggered drug release from liposome-microbubble pendant complexes: From model systems to tumor therapy in a murine adenocarcinoma model. Alexander Kilbanov, Zhongmin Du, Galina Diakova (Cardiovascular Res. Ctr., Univ. of Virginia, Cardiovascular Div., CVRC, MR4RM3147, 409 Ln. Rd., Charlottesville, VA 22908-1394, alk6n@virginia.edu), Chien Ting Chin, William Shi, Balasundar Raju, and Ralf Seip (Philips Res. North America, Briarcliff Manor, NY)

Liposome-microbubble complexes allow delivery of drugs that cannot be otherwise associated with the bubble shell: water-soluble drugs and proteins. We prepared liposome-microbubble pendants by decorating biotinylated microbubbles with biotinylated liposomes via streptavidin. A model dye calcein was used as a model release marker. Using focused ultrasound (Philips TIPS, 1 MHz, 7 MPa) we were able to release ~30% of the entrapped dye. For an enzyme thrombin, ~11% of the entrapped material was released following pendant insonation. *In vivo* tumor therapy was performed with doxorubicin-liposome-microbubble pendants in a subcutaneous MC38 murine adenocarcinoma model. Doxorubicin was loaded in liposomes via an ammonium citrate gradient procedure. By using larger liposomes, >>80nm (as in Doxil/Lipodox), we prepared pendants carrying ~1 pg doxorubicin per particle. To avoid tumor blood flow stoppage caused by high-power insonation of microbubbles in tumor vasculature, we applied continuous sine wave ultrasound (Birtcher Megason, 1 MHz, 0.6 W/cm^2, 3 s on/10 s off, for 10 min) immediately following iv administration of doxorubicin-liposome-microbubble pendants (6mg/kg mouse body mass) under isoflurane anesthesia. Treatments were performed for two weeks, 2–3 times a week. Suppression of tumor growth in the experimental group was observed. All of control animals demonstrated rapid tumor growth. Overall, pendant structures may become new tools for ultrasound-triggered drug delivery. [Study supported in part via NIH R21/33 CA102880, EB016752.]

8:55

3aBA3. Low-frequency ultrasound for the delivery of therapeutics to the gastrointestinal tract. Carl M. Schoellhammer, Avi Schroeder, Ruby Maa (Chemical Eng., Massachusetts Inst. of Technol., 77 Massachusetts Ave., Rm. 76-661D, Cambridge, MA 02139, cschoell@mit.edu), Gregory Y. Lauwers (Massachusetts General Hospital, Boston, MA), Albert Swiston, Michael Zervas, Ross Barman, Angela M. DiCiccio (Chemical Eng., Massachusetts Inst. of Technol., Cambridge, MA), William R. Brugge (Massachusetts General Hospital, Boston, MA), Daniel G. Anderson, Daniel Blankschtein, Robert Langer, and Giovanni Traverso (Chemical Eng., Massachusetts Inst. of Technol., Cambridge, MA)

Rapid and effective drug delivery to the gastrointestinal (GI) tract can be a significant challenge. This is because of the harsh environment present in the GI tract and fast transit times in disease states. Physical enhancers, such as ultrasound (US), may enable the rapid delivery of therapeutics while circumventing the need for formulation development. Despite being investigated for other uses, low frequency US has not been studied for GI-based delivery previously. Our group has developed a hand-held device for the rapid delivery of

therapeutics to the colonic mucosa. The device utilizes low-frequency US, which is able to painlessly and reversibly permeabilize the tissue. Short, 1-minute treatments in 80 kg Yorkshire pigs were found to enhance the delivery of mesalamine, a drug used for the treatment of inflammatory bowel disease, 22.4-fold over a conventional enema. The safety and efficacy of US were further validated in a rodent colitis model. The delivery of proteins was also possible. US-mediated GI delivery has many potential applications ranging from localized treatment with anti-inflammatories to the more broad delivery of macromolecules. This new technology could prove invaluable in both clinical and research settings, enabling improved therapies and expansion of research techniques applied to the GI tract.

9:15

3aBA4. *In vitro* and *in vivo* platforms for focused ultrasound-controlled drug delivery and release. Costas Arvanitis (Radiology, Harvard Med. School, Brigham and Women's Hospital, 221 Longwood Ave., Rm. 514a, Boston, MA 02115, cda@bwh.harvard.edu)

Focused ultrasound (FUS) holds great promise for the development of effective and safe anticancer treatment protocols. FUS does not only allow to modulate the permeability of tumor vessels and enhance the extravasation of large molecules but to also locally trigger the release of their highly penetrating cargo. To utilize this potential *in vitro* and *in vivo,* platforms that allow for detailed assessment and optimization of the FUS-controlled drug delivery and release protocols are essential. We will present two such platforms for FUS-controlled drug delivery and release. First, we will introduce a novel acoustofluidic system with temperature and pressure sensor embedded that enables the accurate control of drug-release and the establishment of chemotherapeutic agent concentration gradients in a physiologically relevant 3D tumor model. Next, we will present an integrated US- and MR-guided FUS system for controlling the mechanical and thermal effects of FUS *in vivo*. Fast methods to visualize and control microbubble oscillations along with real time FUS-induced mild hyperthermia with this system will be shown in brain tumors of rodents. The FUS-induced release of the chemotherapeutic agent doxorubicin from a liposomal carrier is used to demonstrate the utility of the two systems for developing and optimizing new therapeutic protocols.

9:35

3aBA5. MRI-targeted delivery of brain-penetrating non-viral gene nanoparticles across the blood–brain barrier with focused ultrasound: Neurodegenerative disease application. Richard J. Price (Biomedical Eng., Univ. of Virginia, Box 800759, Health System, Charlottesville, VA 22908, rprice@virginia.edu)

The delivery of systemically administered nanoparticles to the brain is impeded by both the blood–brain barrier (BBB) and the nanoporous electrostatically charged extracellular matrix. However, we have previously shown that these barriers may be overcome by opening the BBB with MRI-guided focused ultrasound (FUS) and microbubbles (MBs) and engineering the nanoparticles to have "brain penetrating" properties via the addition of a dense PEG corona. Here, we first delivered non-viral reporter gene-bearing brain-penetrating nanoparticles (BPN) to rat brain using FUS and MBs, resulting in robust dose-dependent gene expression in the FUS-targeted region through day 28 and a transfection efficiency $>40\%$. Neurons and astrocytes were transfected equally, and neither toxicity nor gliosis were evident. We then tested whether the approach had therapeutic potential for treating Parkinson's disease by delivering neurotrophic (GDNF) gene BPN to the striatum of 6-OHDA treated (i.e., Parkinson's) rats. For GDNF BPN treated 6-OHDA rats, motor impairment tests (apomorphine-induced rotation and cylinder) revealed significant improvement and dopaminergic neuron density was fully restored in both striatum and substantia nigra pars compacta. We conclude that MRI-guided BPN delivery with FUS and MBs is a safe and effective strategy for brain transfection that has potential as a non-invasive treatment for Parkinson's neurodegeneration.

9:55–10:10 Break

10:10

3aBA6. Ultrasound- and microbubble-enhanced chemotherapy for treating pancreatic cancer: A phase I clinical trial. Spiros Kotopoulis, Georg Dimcevski (National Ctr. for Ultrasound in Gastroenterology, Haukeland Univ. Hospital, Jonas Lies vei 65, Bergen 5021, Norway, spiros.kotopoulis@gmail.com), Emmet Mc Cormack (Dept. of Clinical Sci., Univ. of Bergen, Bergen, Norway), Michiel Postema (Dept. of Phys. and Technol., Univ. of Bergen, Bergen, Norway), Bjorn Tore Gjertsen (Dept. of Internal Medicine,Haematology Section, Haukeland Univ. Hospital, Bergen, Norway), and Odd Helge Gilja (National Ctr. for Ultrasound in Gastroenterology, Haukeland Univ. Hospital, Bergen, Norway)

Experimental research of ultrasound to induce or improve delivery has snowballed in the past decade. In our work, we investigate the use of low-intensity ultrasound in combination with clinically approved microbubbles to enhance the therapeutic efficacy of chemotherapy. Ten voluntary patients with locally advanced or metastatic pancreatic adenocarcinoma were consecutively recruited. Following standard chemotherapy protocol (intravenous infusion of gemcitabine over 30 min), a clinical ultrasound scanner was targeted at the largest slice of the tumour using modified non-linear contrast imaging settings (1.9 MHz center frequency, 0.27 MPa peak-negative pressure), and SonoVue® was injected intravenously. Ultrasound and microbubble treatment duration was 31.5 min. The combined therapy did not induce any additional toxicity or increase side effect frequency when compared to chemotherapy alone. Combination treated patients were able to tolerate an increased amount treatment cycles when compare historical controls ($n=63$); average of 8.3 ± 6.0 cycles, versus 13.8 ± 5.6 cycles. The median survival also increased from 7.0 months to 17.6 months ($p=0.0044$). In addition, five patients showed a primary tumor diameter decrease. Combined treatment of ultrasound, microbubbles, and gemcitabine does not increase side effects and may have the potential to increase the therapeutic efficacy of chemotherapy in patients with pancreatic adenocarcinoma.

10:30

3aBA7. Ultrasound-mediated transport of nanoparticles and the influence of particle density. Harriet Lea-Banks, Eleanor Stride, and Constantin C. Coussios (Eng. Sci., Univ. of Oxford, Inst. of Biomedical Eng., Univ. of Oxford, Old Rd. Campus Res. Bldg., Oxford OX3 7DQ, United Kingdom, harriet.lea-banks@eng.ox.ac.uk)

A significant barrier to successful drug delivery in cancer therapy is the limited penetration of nanoscale therapeutics deep into tumors. Ultrasound mediated cavitation has been shown to promote nanoparticle transport, but achieving tumor wide distribution still represents a considerable challenge. The current study investigates the way in which nanoparticle drug-carriers may be designed to enhance penetration under ultrasound exposure. A computational model has been developed to predict the transport of a nanoparticle in an ultrasonic field in the presence of an oscillating microbubble, by a combination of primary and secondary acoustic radiation forces, acoustic streaming, and microstreaming. Experimental investigations were also performed in a tissue-mimicking phantom to study the transport of different types of particle, in the presence or absence of a microbubble ultrasound contrast agent, at ultrasound frequencies of 0.5 MHz and 1.6 MHz with peak pressures in the range of 0–2.0 MPa. Micro- and nanoparticles with contrasting density cores ranging from 1.0 g/cm^3 to 19.3 g/cm^3 were used for the study. Both the theoretical and experimental results showed that the denser particles exhibit significantly greater ultrasound-mediated transport than their lower density counterparts, indicating that this is a key consideration in the design of nanoscale therapeutics.

10:45

3aBA8. Ultrasound-mediated delivery of gadolinium and fluorescent-labeled liposomes through the blood-brain barrier. Muna Aryal (Radiology, Brigham and Women's Hospital, 221 Longwood Ave., Boston, MA 02115, muna@bwh.harvard.edu), Jason Papademetriou (Biomedical Eng., Boston Univ., Boston, MA), Yong-Zhi Zhang, Chanikarn Power, Nathan McDannold (Radiology, Brigham and Women's Hospital, Boston, MA), and Tyrone Porter (Biomedical Eng., Boston Univ., Boston, MA)

The main objective of this study was to examine liposome extravasation across the BBB as a function of size after disruption via ultrasound and microbubbles. The liposomes were labeled with gadolinium (Gd) and fluorophore, thus enabling detection of extravasated liposomes via MRI *in vivo* and fluorescence methods in tissue, respectively. Liposomes labeled with gadolinium and fluorophore were prepared using lipid film hydration and extrusion to two different sizes (~80 nm and ~140 nm). Animals were divided into two groups based on the use of particle sizes. FUS–BBB disruption was produced in one hemisphere in 10 mice. Particles were injected before sonication. Sonications (0.69 MHz at 0.68 MPa) were performed in two locations combine with Definity (10 μl/kg). Acoustic emissions were recorded during FUS. T1 & T2*-weighted MRI were used to confirm Gd leakage and damage detection respectively. Mice were euthanized 5–24 h after FUS and post-process for fluorescence measurement. In sonicated area, Gd-leakage was detected in both groups at 5–24 after FUS but not on non-sonicated area. Fluorescence measurements from brain tissue homogenates suggest enhanced accumulation of liposomes in FUS versus non-FUS brain regions. These findings reveal that liposomes were able to extravasate via FUS-BBB disruption.

11:00

3aBA9. Thrombolytic efficacy of echogenic liposomes that co-encapsulate rt-PA and octafluoropropane gas. Himanshu Shekhar (Dept. of Internal Medicine, Univ. of Cincinnati, 3933 Cardiovascular Ctr.,, 231 Albert Sabin Way, Cincinnati, OH 45267, himanshu.shekhar@uc.edu), Shenwen Huang (Biomedical Eng. Program, Univ. of Cincinnati, Cincinnati, OH), Tao Peng, Melvin E. Klegerman, Shao- L. Huang, David D. McPherson (Dept. of Internal Medicine, Univ. of Texas Heath Sci. Center-Houston, Houston, TX), and Christy K. Holland (Dept. of Internal Medicine, Univ. of Cincinnati, Cincinnati, OH)

Echogenic liposomes loaded with recombinant tissue-type plasminogen activator, rt-PA (tELIP), are under development for treatment of thromboocclusive disease. However, tELIP filled with air nucleate low stable cavitation activity when exposed to 120-kHz ultrasound, which limits the thrombolytic efficacy. We hypothesize that encapsulating octafluoropropane (OFP) gas in ELIP (OFP-tELIP) will enhance ultrasound-mediated stable cavitation activity and thrombolytic efficacy. A spectrophotometric method was used to assess the enzymatic activity of the rt-PA associated with OFP-tELIP. An *in vitro* flow model equipped with a time-lapse microscopy system was employed to observe human whole blood clots exposed to fresh-frozen plasma, rt-PA (0, 0.32, 1.58, and 3.15 μg/mL), and OFP-tELIP with and without ultrasound (120 kHz, 0.44 MPa peak-to-peak pressure). Ultraharmonic emissions indicating stable cavitation were measured using a passive cavitation detector. Sustained ultraharmonic activity was nucleated from OFP-tELIP when exposed to ultrasound, resulting in enhanced thrombolytic efficacy at an rt-PA concentration of 1.58 μg/mL. The results of this study demonstrate the advantages of encapsulating OFP within tELIP for use as a sonothrombolysis agent.

11:15

3aBA10. Shape mode stability of lipid-coated ultrasound contrast agent microbubbles. John T. Brlansky and Michael L. Calvisi (Dept. of Mech. and Aerosp. Eng., Univ. of Colorado, 1420 Austin Bluffs Parkway, Colorado Springs, CO 80918, mcalvisi@uccs.edu)

Ultrasound contrast agents (UCAs) are shell encapsulated microbubbles developed originally for ultrasound imaging enhancement. More recently, UCAs are being exploited for therapeutic applications such as drug and gene delivery. Ultrasound transducer pulses can induce spherical (radial) UCA oscillations, translation, and nonspherical shape oscillations, the latter of which can lead to breakup. Breakup can facilitate drug or gene delivery, but should be minimized for imaging purposes to increase residence time and maximize diagnostic effect. Therefore, an understanding of the interplay between the acoustic driving and shape mode stability of UCAs is important for both diagnostic and therapeutic applications. The present work couples a radial model of a lipid-coated microbubble with a model for bubble translation and nonspherical shape oscillation to predict shape mode stability for ultrasound driving frequencies and pressure amplitudes of clinical interest. In addition, calculations of the stability of individual shape modes, residence time, maximum radius, and translation are provided with respect to acoustic driving parameters and compared to an unshelled bubble. The effects of shell elasticity, shell viscosity, and initial radius on stability are investigated. The results show greater stability at higher values of shell elasticity and viscosity and at smaller radius, and provide guidance for optimizing shell design and ultrasound driving parameters with respect to shape stability.

Session 3aED

Education in Acoustics: Education in Acoustics: Student Posters

Murray S. Korman, Chair
Physics Department, U.S. Naval Academy, 572 C Holloway Road, Chauvenet Hall Room 295, Annapolis, MD 21402

All posters will be on display and all authors will be at their posters from 8:00 a.m. to 10:00 a.m.

Contributed Papers

3aED1. Nonlinear vibration experiment: Clamped circular elastic plate with granular material loading. Emily V. Santos (Phys. Dept., U.S. Naval Acad., 572 C Holloway Rd., Annapolis, MD 21402, korman@usna.edu) and Murray S. Korman (Phys. Dept., U.S. Naval Acad., Annapolis, MD)

Experiments using a soil-plate-oscillator (SPO) involve a vertical cylindrical column of granular medium (masonry sand, glass spheres, uncooked brown rice, un-popped popcorn kernels, or even "Toasty Oats" ™ cereal) that is supported by an air-backed thin circular elastic acrylic plate (20.3 cm diameter and 3.2 mm thick) that is rigidly clamped to the bottom of a thick-walled aluminum tube. The soil column is driven from below using an electrodynamic system. Here, an AC coil placed on axis and below the plate, drives a 1 cm diameter 1.5 cm long rare earth magnet that is fastened to the underside center of the plate. The coil is electrically driven by an amplified swept sinusoidal slowly varying chirp. A small accelerometer attached to the magnet is used to measure the vibration. In nonlinear tuning curve experiments the resonant frequency decreases significantly with increased amplitude—representing a softening in the nonlinear system. For fixed amplitude the resonant frequency vs. the granular medium mass loading (over the plate) reaches a minimum and then increases with increased loading due to the granular medium's flexural stiffness—which overcomes the mass loading effects. For water loading, the frequency always decreases since there is no bending stiffness.

3aED2. Vibration experiments using a clamped circular elastic plate with edible granular material loading. Blair E. Lewis, Ebonie Smith, and Murray S. Korman (Phys. Dept., U.S. Naval Acad., 572 C Holloway Rd., Annapolis, MD 21402, korman@usna.edu)

An apparatus called the soil-plate-oscillator (SPO), designed to study flexural vibration of a soil loaded plate, consists of a thin circular elastic (acrylic) plate (8 in. diam, 1/8 in. thick) clamped below a thick-wall cylindrical aluminum tube supporting a vertical soil (or sand) column or other granular material. A small accelerometer attached to a 1 cm diam rare earth magnet (which is fastened to the center of the plate from below) is used to detect the plate vibration response. The plate is driven from below by an AC coil (located coaxially below the plate and securely fastened) using an amplified swept sinusoidal current. The charge amplified accelerometer signal is measured versus frequency by a spectrum analyzer. With interest in studying light density granular media (with various grain sizes) experiments were performed with uncooked brown rice, quick oats, un-popped popcorn kernels pretzel gold fish crackers, and pretzel nuggets. The resonant frequency reaches a minimum and then increases with increased granular medium loading due to the material's flexural stiffness which overcomes the mass loading effects. Results (normalized to the unloaded frequency and clamped plate mass) are compared with dry sifted masonry sand. A theoretical model is used to help describe the effects.

3aED3. A soil-plate-oscillator apparatus for research projects and student demonstrations. Melissa Pineda Brown, Brianna D. Taliaferro, and Murray S. Korman (Phys. Dept., U.S. Naval Acad., 572 C Holloway Rd., Annapolis, MD 21402, korman@usna.edu)

In studying the complex vibration of compliant buried objects in soils, a simplified model apparatus called the "soil-plate-oscillator" (SPO) has been useful in understanding resonant behavior. The SPO is an open column of granular medium supported at the bottom by a thin circular clamped elastic plate. A rigid vertical circular sleeve (sidewall) keeps the soil in a circular column. Two 4.5 in. I.D. plastic PVC closet flanges are used to clamp a 1/8 in. thick acrylic plate. The elastic plate is driven from below by an AC coil located coaxially below a rare earth magnet (fastened to the plate's underside at the center). An amplified swept sinusoidal chirp drives the coil. A small accelerometer, attached to the magnet, generates a charge amplified signal fed into a spectrum analyzer placed in the swept sine mode. Results for (a) dry sifted masonry sand and (b) 6 mm glass spheres are compared. In both experiments, the resonant frequency versus granular mass loading first decreases (reaching a minimum) and then increases with further loading due to the granular flexural stiffness which overcomes the mass loading effects. [R. A. Guyer and P. A. Johnson, *Nonlinear Mesoscopic Elasticity*, Wiley, 2009] discusses spherical granular media in Hertzian contact.

3aED4. Modeling acoustic landmine detection using a soil-plate oscillator. Miahanna K. Nguyen, Joshua M. Lewis, and Murray S. Korman (Phys. Dept., U.S. Naval Acad., 572 C Holloway Rd., Annapolis, MD 21402, korman@usna.edu)

In laboratory acoustic landmine detection experiments a plastic cylindrical drum-like simulant is buried in a soil (or sand) tank. Airborne sound, generated from two subwoofer loudspeakers (located above the soil), drive the soil particles and subsequent particle vibration over the compliant top plate of the simulant. Measurements of tuning curve soil surface vibration particle velocity versus frequency are recorded for various scan locations across the soil surface in an effort to profile the buried simulant. Measurements of resonances "off the target" are also included in this study. The results can be modeled using a soil-plate-oscillator (SPO) apparatus. The SPO involves a vertical thick-wall cylindrical column of granular medium (sand, soil, pebbles, light density edible granular material like wheat germ or even uncooked brown rice) that is supported by a thin circular elastic (acrylic) plate (8 in. diameter, 1/8 in. thick) that is rigidly clamped at the bottom of the column. A small accelerometer placed on the granular surface (or a laser Doppler vibrometer) measures tuning curve results across the surface using a sweep spectrum analyzer. Profiles are compared for both the SPO and the simulant in an effort to model the results in the later—more complicated case.

3aED5. Ultrasonic scattering at 25 kilohertz in air by a hexagonal array of slender long rigid rods arranged to form a porous cylindrical target. Joshua R. Gong, Adela S. Rivera, and Murray S. Korman (Phys. Dept., U.S. Naval Acad., 572 C Holloway Rd., Annapolis, MD 21402, korman@usna.edu)

Experiments were performed in the USNA Acoustics Lab using 30 cycle transient-bursts at 25.8 kHz in air (c = 340 m/s, $\rho = 1.2$ kg/m^3) to measure the backscattering of the ultrasonic pulse from a hexagonal array of stainless steel rods (diam d = 0.089 cm, length l = 91 cm). The lattice parameter was a = 0.22 cm. To construct the array, the rods were placed within the holes of two 30.5 cm square thin perforated aluminum sheets suspended 88 cm apart. A third non-perforated sheet hung 1 cm below prevented the rods from falling through. The diameter of the cluster was D = 10 cm. The filling fraction of the lattice was f = 0.15.The transmitting array (located 1.5 m from the cluster) was an eight-element discrete ring of diam 5.5 cm that produced an interference null at +/− 10 degrees and a −10 dB down minor lobe at +/− 17 degrees. A single 1 cm diam receiver element was located at the center of the ring. In a strip-map configuration, the transmitted beam translated 60 cm across the target recording echoes at 1 cm increments. The target's effective speed and density were 0.93c and 1.35ρ, respectively. See D. Torrent *et. al.* [Phys. Rev. Lett., **96**, 204302 (2006)].

Session 3aMU

Musical Acoustics and Education in Acoustics: Teaching Musical Acoustics Courses and Laboratories at any Level

Jack Dostal, Cochair
Physics, Wake Forest University, P.O. Box 7507, Winston-Salem, NC 27109

Martin S. Lawless, Cochair
Graduate Program in Acoustics, The Pennsylvania State University, 201 Applied Science Building, University Park, PA 16802

Chair's Introduction—9:00

Invited Papers

9:05

3aMU1. Teaching the descriptive physics of string instruments at the undergraduate level. Brian E. Anderson, Kent L. Gee, and Tracianne B. Neilsen (Dept. of Phys. and Astronomy, Brigham Young Univ., BYU, N283 ESC, Provo, UT 84602, bea@byu.edu)

At Brigham Young University, a general education course introduces students to the basic descriptive acoustic principles of music, speech, and audio. A third of this course focuses on the physics of musical instrument families. Three of these families include bowed string, plucked string, and struck string instruments. The concepts of driven systems and freely vibrating systems are taught, including the consequences of these excitation conditions. A hands-on lab for the course enables students to explore how the length, density, and tension of the string change the fundamental frequency. An in-class demonstration highlights the role of inharmonicity on the partial frequency values for these string instrument families. The combination of hands-on activity and demonstration aids the students in comprehending the basic acoustic principles behind string instruments and the reason for varying levels of inharmonicity between these instrument families.

9:25

3aMU2. A case study approach involving string harmonics to reinforce concepts of standing waves, superposition, and musical intervals... as well as the scientific process. Andrew A. Piacsek (Phys., Central Washington Univ., 400 E. University Way, Ellensburg, WA 98926, piacsek@cwu.edu)

A combined classroom/lab activity is described that employs a modified Interrupted Case Study approach to reinforce concepts of standing waves, superposition, and musical intervals. Students work cooperatively, with guidance from the instructor, to investigate the behavior of a plucked string. The activity is structured as a sequence of tasks that encapsulate the scientific process, requiring the application of critical thinking skills and knowledge from earlier classes. Students working in small groups propose a hypothesis about the behavior of a string that is plucked, drawing upon previous studies of superposition and standing wave behavior in a driven string. After a class discussion, one hypothesis is chosen as the basis for further inquiry. Each group then formulates specific testable predictions, with the constraint that only a mounted string (sonometer), finger, and ears be used in any experiment. After discussion, the class chooses a subset of these predictions to test. Groups formulate a detailed procedure (generally involving creating harmonics on the string), carry out the experiment, and interpret their results. Conclusions are shared among the class.

9:45

3aMU3. Things I learned while teaching a graduate level course on the acoustics of musical instruments. Daniel A. Russell (Graduate Program in Acoust., Penn State Univ., 201 Appl. Sci. Bldg., University Park, PA 16802, drussell@engr.psu.edu)

In spring 2013, I taught a graduate level course on the acoustics of musical instruments. A prerequisite of two courses on the fundamentals of acoustics and vibration allowed us to explore details and mathematical complexities. Due to time constraints and the decision to delve deep into details rather than provide a broad overview, the course focused on wind and stringed instruments. Both types of instruments were explored through the generator-resonator-radiator paradigm. We discussed nonlinear generators for winds (lip reed, mechanical reed, and air-reed) and realistic initial conditions for strings (finger plucked, struck by a nonlinear hammer, and the stick-slip bowing action); realistic resonators for winds (input impedance and the effects of holes, horns, and viscous losses) and strings (realistic boundary conditions and coupled motion); and radiation (bells and soundboards). This paper will describe some of the Mathematica animations used to illustrate the effect of tone holes on the input impedance of a woodwind instrument, the effect of mouthpiece volume on the input impedance of brass instruments, and the motion of plucked, struck, and bowed strings. We will discuss the challenges of teaching a graduate level course, and what I would do differently the next time I teach it.

10:05

3aMU4. Explaining microphones and loudspeakers in a musical acoustics course for non-scientists. Robert C. Maher (Elec. & Comput. Eng., Montana State Univ., 610 Cobleigh Hall, PO Box 173780, Bozeman, MT 59717-3780, rob.maher@montana.edu)

Contemporary courses in the field of musical acoustics rely upon basic audio engineering components such as acoustical transducers: microphones, accelerometers, and loudspeakers. Most students are very aware of the practical use and behavior of such devices, but they seldom have a useful understanding of the physical and engineering principles behind the design of these essential components. This paper presents a lesson example explaining microphones and loudspeakers for a general-interest undergraduate college course entitled "The Science of Sound." The lesson includes a descriptive lecture component, examples and discussion, and a hands-on demonstration.

10:25–10:40 Break

10:40

3aMU5. Developing and teaching an interdisciplinary musical instrument design course at the Cooper Union. Martin S. Lawless (Dept. of Mech. Eng., The Cooper Union for the Advancement of Sci. and Art, 201 Appl. Sci. Bldg., University Park, Pennsylvania 16802, msl224@psu.edu), Melody Baglione, and George W. Sidebotham (Dept. of Mech. Eng., The Cooper Union for the Advancement of Sci. and Art, New York, NY)

Design is a major component of every student's educational experience at the Cooper Union, a small university in New York City with architecture, art, and engineering schools, and yet, design courses including students from all three schools are uncommon. In the 2012–2013 academic year, a Musical Instrument Design course was proposed to encourage the collaboration of architecture, art, and engineering students. Musical acoustics appealed to these three types of students since the subject inherently combines aesthetic and physical principles. The course intended to accommodate the students' wide range of music and physics backgrounds with lectures on music theory, acoustics and vibration, and the design of traditional instruments. Live demonstrations attempted to inspire hands-on learning, and in-class presentations facilitated the discussion of the diverse perspectives of the class. The course also included an outing to the machine shop where the class collaborated on making PVC flutes for each student. For a final project, the students were required to design and create a musical instrument. The Musical Instrument Design class was offered for zero credits in the Spring 2013 semester to gauge overall interest. Fourteen students enrolled in the course and maintained a good attendance throughout the semester.

Contributed Papers

11:00

3aMU6. Students and power tools: Lessons learned from building recorders in a Physics of Music class. Jack Dostal (Dept. of Phys., Wake Forest Univ., P.O. Box 7507, Winston-Salem, NC 27109, dostalja@wfu.edu)

In my divisional (general education) course "The Physics of Music," my students each design and build a simple recorder using PVC pipe. The process is borrowed from "Flute Design" and "Flute Construction" labs by Peter Hoekje at Baldwin-Wallace University, as well as Pete Kosel's flute hole calculator. The lab has been modified slightly to fit the constraints of our class, and is done over the course of two lab periods. We have tried several variations on the process and made plenty of mistakes. Typically, our students have little to no experience using power tools or shop equipment. Consequently, this tends to be one of the most adventurous labs of the term. In this talk, I describe some of the practical things I've learned and mistakes I've made while watching and helping my students build recorders. Among these are difficulties in creating fipples and knife edges, adventures in hole-drilling, finding reasonable finger hole positions, and student reaction to the finished product.

11:15

3aMU7. Engaging musical acoustics instructors beyond the members of the Acoustical Society of America. Andrew C. Morrison (Natural Sci. Dept., Joliet Junior College, 1215 Houbolt Rd., Joliet, IL 60431, amorrison@jjc.edu)

The members of the Technical Committee on Musical Acoustics (TCMU) of the Acoustical Society of America (ASA) have demonstrated their commitment to education in acoustics regularly by organizing and cosponsoring numerous education-related sessions at ASA meetings. Musical acoustics as a topic for general education science courses is a popular offering at many colleges and universities. A brief survey of the musical acoustics course offerings at various colleges is presented. Many of these courses are taught by instructors who have not interacted with TCMU members or attended ASA meetings. It is possible that the musical acoustics community is missing out on opportunities to interact with a population of educators who share our interests. Our community should be looking for ways to engage the instructors of musical acoustics courses in dialogue which is mutually beneficial; members of the TCMU may find that they will discover new ideas for teaching musical acoustics from beyond the ASA membership.

11:30

3aMU8. Electroacoustics laboratory assignments for computer music students. Edgar Berdahl and Stephen D. Beck (Music, Louisiana State Univ., 102 New Music Bldg., Baton Rouge, LA 70803, eberdahl@ccrma.stanford.edu)

A series of pedagogical exercises are described that integrate concepts from traditional musical acoustics laboratory assignments with the fundamentals of computer music. Students are asked to rapidly prototype hybrid devices that contain both musical acoustic components as well as sensors, embedded audio signal processing, and loudspeaker drivers. To help students rapidly complete working prototypes, students are provided with working audio effects and sound synthesizer programs. Students learn the programming language (Pure Data) only by example for making small changes to the previously designed programs, as they are integrated with custom-made, physical acoustics components (e.g., D-I-Y vibrating strings, drums, columns of air, rattles, etc.). Music students first learned that building quality acoustic instrument components is harder than they originally thought. Although out-of-the-box thinking is regarded as an important factor in devising novel electroacoustic prototypes, students starting from previously existing designs and making small changes tended to be more successful (at least initially) than students striking out on completely new paths. Several pictures of completed instruments will be shown, and one or two example prototypes of electroacoustic instruments and electroacoustic audio effects will be presented live. The example "starter" programs in Pure Data will be made available for community members wishing to run them on the Raspberry Pi 2, as supported by the author's Satellite CCRMA platform.

WEDNESDAY MORNING, 25 MAY 2016 SALON J, 8:30 A.M. TO 11:25 A.M.

Session 3aPA

Physical Acoustics: Atmospheric Acoustic Phenomena I

John Paul R. Abbott, Cochair
Department of Physics and Astronomy, National Center for Physical Acoustics, University of Mississippi, 1 Coliseum Dr., Room 1044, Oxford, MS 38677

Gregory Lyons, Cochair
Aeroacoustics, National Center for Physical Acoustics, University, MS 38677-1848

Invited Papers

8:30

3aPA1. Accuracy requirements for unmanned aerial vehicle-based acoustic atmospheric tomography. Anthony Finn and Kevin Rogers (Defence & Systems Inst., Univ. of South Australia, Bldg. W, Mawson Lakes, Mawson Lakes, SA 5095, Australia, anthony.finn@unisa.edu.au)

If the acoustic signature is measured onboard a propeller-driven unmanned aerial vehicle and by an array of microphones on the ground, comparison between the projected and observed signals allows the propagation delays—and hence effective sound speed values of the intervening medium—to be determined. As the ray paths along which energy travels intersect within the atmosphere at multiple locations and angles, temperature and wind velocity fields may be estimated using tomography. This paper describes signal processing strategies for determining propagation delays at sub-millisecond levels of precision; the inverse problem and a model that allows meteorological observations to be incorporated into the tomographic solution; and the algebraic iterative reconstruction technique used to overcome the ill-posed nature of the inversion. A weakly sheared daytime convective atmospheric boundary layer—synthesised through use of large eddy simulation code that utilises pseudo-spectral differencing and solves an elliptic pressure equation—is used to show sub-millisecond levels of observation noise permits faithful reconstruction of target atmospheres. Particular attention is paid to the atmospheric layer below 100 m as this region typically experiences the greatest spatio-temporal variation in temperature and wind speed.

8:50

3aPA2. Acoustic travel-time tomography of the atmospheric surface layer at the Boulder Atmospheric Observatory. Vladimir E. Ostashev (Cooperative Inst. for Res. in Environ. Sci., Univ. of Colorado Boulder, 72 Lyme Rd., Hanover, NH 03755, vladimir.ostashev@noaa.gov), Sergey N. Vecherin, D. K. Wilson (U.S. Army Engineer Res. and Development Ctr., Hanover, NH), and Alfred J. Bedard (Cooperative Inst. for Res. in Environ. Sci., Univ. of Colorado Boulder, Boulder, CO)

Acoustic tomography of the atmospheric surface layer (ASL) is based on travel-time measurements between speakers and microphones in a spatial array, which are arranged so as to create propagation paths through the region to be sampled. Then, the temperature and wind velocity fields inside the tomographic region are reconstructed by inverting the travel times. Tomography has certain advantages over conventional point measurements, such as spatial averaging and a quadratic growth of the observations relative to the number of sensors. An array built at the Boulder Atmospheric Observatory (BAO) enables horizontal-slice tomography of the ASL at a height of

8 m above the ground, in an 80 m x 80 m region. The instrumentation and principle of operation of the BAO tomography array are explained. Inverse algorithms for reconstruction of the temperature and wind velocity fields from the travel times are reviewed. Results in numerical simulations of the BAO tomography array and reconstruction of turbulence fields in tomography experiments are presented. Acoustic tomography of the atmosphere can also be performed at other spatial scales, ranging from a size of an ultrasonic anemometer/thermometer to the height of the atmospheric boundary layer and even in the stratosphere and thermosphere.

9:10

3aPA3. Pulse scattering in a turbulent atmosphere with applications to acoustic remote sensing of the atmosphere with sodars. Vladimir E. Ostashev (U.S. Army Engineer Res. and Development Ctr., 72 Lyme Rd., Hanover, NH 03755, vladimir.ostashev@noaa.gov), Stuart Bradley (Phys. Dept., Univ. of Auckland, Auckland, New Zealand), and D. K. Wilson (U.S. Army Engineer Res. and Development Ctr., Hanover, NH)

A new, rigorous theory of acoustic pulse scattering in a turbulent atmosphere with spatial-temporal fluctuations in temperature and wind velocity is developed. The theory generalizes the classical theory of sound scattering to broadband signals and coupled spatial-temporal fluctuations of random fields. The scattered sound field is obtained as a Born approximation of a set of equations for the sound pressure and acoustic particle velocity. The spatial-temporal correlation function of the scattered field is calculated. These results are obtained without using the quasi-static approximation, which is employed in the classical theory, and enable analysis of this approximation. The spatial, temporal, and frequency coherences of the scattered signal are studied. The results obtained are applied to acoustic remote sensing of the atmosphere with sodars. It is proposed that the frequency spectrum of the temporal correlation function could be used to measure the wind velocity and the variance of the convective velocity fluctuations. An *ad hoc* approach for increasing the spatial resolution in acoustic sounding of the atmosphere is suggested. The theory developed is rather general and applicable to acoustic pulse scattering in other media such as the ocean with temperature, salinity, and current velocity fluctuations.

9:30

3aPA4. Automated detection and cataloging of global explosive volcanism using the International Monitoring System infrasound network. Robin S. Matoza (Dept. of Earth Sci., Univ. of California, Santa Barbara, Webb Hall MC 9630, Santa Barbara, CA 93106, matoza@geol.ucsb.edu), David N. Green (AWE Blacknest, Reading, United Kingdom), Alexis Le Pichon (CEA/DAM/DIF, Arpajon, France), David Fee (Wilson Alaska Tech. Ctr. and Alaska Volcano Observatory, Univ. of Alaska Fairbanks, Fairbanks, AK), Peter Shearer (Scripps Inst. of Oceanogr., Univ. of California, San Diego, La Jolla, CA), Pierrick Mialle (CTBTO, Vienna, Austria), and Lars Ceranna (BGR, Hannover, Germany)

Explosive volcanic eruptions are among the most powerful sources of infrasound observed on earth, with recordings routinely made at ranges of hundreds to thousands of kilometers. These eruptions can also inject large volumes of ash into heavily traveled aviation corridors, thus posing a significant societal and economic hazard. Detecting and counting the global occurrence of explosive volcanism helps with progress toward several goals in earth sciences and has direct applications in volcanic hazard mitigation. This project aims to build a quantitative catalog of global explosive volcanic activity using the International Monitoring System (IMS) infrasound network. We are developing methodologies to search systematically through IMS infrasound array detection bulletins to identify signals of volcanic origin. We combine infrasound signal association and source location using a brute-force, grid-search, cross-bearings approach. The algorithm corrects for a background prior rate of coherent infrasound signals in a global grid. When volcanic signals are identified, we extract metrics such as location, origin time, acoustic intensity, signal duration, and frequency content, compiling the results into a catalog. This work represents a step toward the goal of integrating IMS data products into global volcanic eruption early warning and notification systems.

9:50–10:10 Break

10:10

3aPA5. An innovative technique to probe the middle and upper atmosphere. Jelle D. Assink, Pieter Smets, Läslo Evers (R&D Seismology and Acoust., KNMI, PO Box 201, De Bilt 3730 AE, Netherlands, jelle.assink@knmi.nl), and Alexis Le Pichon (CEA, DAM, DIF, Arpajon, France)

The middle atmosphere has gained more and more importance for the purpose of weather and climate prediction, since increasing evidence indicates that the troposphere and stratosphere are more closely coupled than assumed before. Significant effort has been made toward a more comprehensive representation of the atmosphere to better capture the stratospheric variability as well as the stratospheric-tropospheric interactions, for example, during Sudden Stratospheric Warming (SSW) events. Despite these advances, the upper layers of the atmosphere have remained a region that is difficult to monitor. Over recent years, new developments in the field of infrasound have lead to an innovative method for evaluating numerical weather prediction models. In this presentation, the general technique will be described and a case study will be presented in which stratospheric forecasts of the 2013 major SSW are evaluated.

10:30

3aPA6. Comparison of surface wind noise predictions from mirror flow and rapid-distortion models of atmospheric turbulence. Gregory W. Lyons (National Ctr. for Physical Acoust., The Univ. of MS, 145 Hill Dr., P.O. Box 1848, University, MS 38677-1848, gwlyons@go.olemiss.edu), Jiao Yu (Dept. of Phys., Liaoning Shihua Univ., Fushun, Liaoning, China), and Richard Raspet (National Ctr. for Physical Acoust., The Univ. of MS, University, MS)

For atmospheric acoustic measurements at the ground surface, the principal source of the intrinsic wind noise is shearing of the turbulence by the mean flow. The pressure spectra from this turbulence-shear mechanism depend on two-point statistics of the anisotropic, inhomogeneous atmospheric turbulence. The inhomogeneity of the surface-normal velocity component can be realistically modeled by the mirror flow, which is a superposition of two correlated isotropic turbulent fields in transformed coordinates. Another analytical framework is rapid-distortion theory, which approximates the turbulence as the result of linearized distortion of an initially

homogeneous field by the mean flow. This study compares turbulence-shear spectra calculated with the mirror flow model and rapid-distortion models for both surface blocking effects and mean shear distortion. For each case, the model parameters are estimated by fits to the single-point velocity spectra recorded in a recent experiment near Laramie, Wyoming. The subsequent model predictions for the wind noise spectra are compared with simultaneous measurements from flush-mounted infrasound sensors. [Work supported by the U.S. Army Research Laboratory (Grant No. W911NF-13-2-0021) and the National Natural Science Foundation of China (Grant No. 11304137).]

10:50

3aPA7. Results from the Humming Roadrunner ground truth experiment. Roger M. Waxler, Carrick Talmadge (NCPA, Univ. of MS, 1 Coliseum Dr., University, MS 38677, rwax@olemiss.edu), David Green (AWE Blacknest, Reading, United Kingdom), Jean-Marie LaLande (NCPA, Univ. of MS, University, MS), and Doru Velea (Leidos, Inc., Reston, VA)

In August 2012, a ground truth infrasound experiment was performed in the American Southwest. Six large chemical explosions were detonated at the White Sands Missile Range in New Mexico. In TNT equivalents, there were two 10 ton charges, two 20 ton charges, and two 50 ton charges. In addition to an extensive near-field deployment to capture source waveforms, a large network of infrasound sensor arrays was deployed at ranges from about 50 km to about 500 km and along a variety of azimuths. Results from the experiment will be discussed.

Contributed Paper

11:10

3aPA8. Development of an anechoic wind tunnel. Salvador Mayoral and Syed Zeeshan Khader (Mech. Eng., California State Univ., Fullerton, 800 N State College Blvd., Fullerton, CA 92831, smayoral@fullerton.edu)

The development of an anechoic wind tunnel is presented. The test section walls of a low-speed open-circuit wind tunnel have been acoustically treated in order to simulate an acoustically free field environment with forward flight. The dimensions of the test section are 0.86 m wide by 0.56 m tall and 1.32 m long. The four walls of the test section are lined with pretensioned Kevlar panels that permit the transmission of sound with less than 2 dB of attenuation. The top and bottom walls of the test section sandwich 4-in. thick acoustic foam between the pretensioned Kevlar and a wooden frame. The side walls of the test section consists of pretensioned Kevlar screens that separate the test section flow from adjacent anechoic chambers. In this fashion, the acoustic measuring equipment is not subjected to the flow inside the test section. Noise sources are modeled with a small loudspeaker that is connected to a signal generator and acoustic measurements are taken with quarter-inch condenser microphones. Preliminary results indicate that the test section is anechoic for frequencies greater than 1 kHz. This work ultimately aims to experimentally investigate the interaction between aeroacoustic noise sources and a momentum wake.

Session 3aPP

Psychological and Physiological Acoustics: Quantitative Methodology in Both Physiological and Psychophysical Data Analysis Workshop

Daniel McCloy, Cochair
Institute for Learning and Brain Sciences, University of Washington, Box 357988, Seattle, WA 98115-7988

Ross K. Maddox, Cochair
Univ. of Washington

Hari M. Bharadwaj, Cochair
Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, 149 Thirteenth Street, Boston, MA 02129

Chair's Introduction—7:55

Invited Papers

8:00

3aPP1. Using detection theory to analyze human decision making and sensory processing. Frederick J. Gallun (National Ctr. for Rehabilitative Auditory Res., VA Portland Health Care System, 3710 SW US Veterans Hospital Rd., Portland, OR 97239, Frederick.Gallun@va.gov)

On the 50th anniversary of the publication of Green and Swets' book "Signal Detection Theory and Psychophysics," it is fitting to revisit the question of how detection theory models of human decision making can improve our understanding of sensory processing. Classical psychophysics, as conceived by Fechner in 1850, trusts the observer to report sensory experiences without bias. The innovation of signal detection theory (SDT) was to develop methods that do not require the observer to have introspective awareness of internal sensations. Since its introduction, SDT has inspired experimentalists in many fields, and so now it is appropriate to simply refer to "detection theory" (DT) as the models are appropriate to a wide range of experiments, many of which do not involve signals in noise per se. Data from a previously published intensity discrimination task relying upon working memory (Gallun *et al*., 2012) will be examined in greater detail to show the techniques and benefits of a detection theory approach to the analysis of human decision making.

8:30

3aPP2. Monte-Carlo analysis of two logical premises to avoid the Probit algorithm for determination of sensory threshold by psychophysics. Amitava Biswas (Speech and Hearing Sci., Univ. of Southern MS, 118 College Dr. #5092, USM-CHS-SHS, Hattiesburg, MS 39406-0001, Amitava.Biswas@usm.edu)

An often confusing and usually avoided, Probit algorithm, is traditionally needed to iteratively calculate an optimal regression line for stimulus strength versus detection rate for psychophysical data that actually appears non-monotonous but supposed to be monotonous. Two logical premises are presented that enable monotonicity even with non-monotonous observed rates: (1) If a trial stimulus is above the threshold then a set of higher stimuli are detectable. (2) If a trial stimulus is below the threshold then a set of lower stimuli are undetectable. The time series in Fig1 has 15 trials of a conventional audiometric threshold tracking session, with 10 dB down for detecting and 5 dB up for missing a stimulus. Following from the two premises, the set of additional points are the predicted responses. Monte-Carlo simulation demonstrated that this strategy not only finds a monotonic relation between detection rate versus stimulus intensity, but also significantly improves accuracy of estimation of the 50% threshold level. In conclusion, two logical premises can help to obtain uniform monotonicity of the sigmoid shaped psychometric regression curve, even without using conventional probit iterations, leading to faster and simplified estimation of the 50% threshold point with greater accuracy. Further research is needed to evaluate clinical impact of this concept for improving current procedures of threshold estimation without increasing the number of actual observations for various psychophysical assessment of sensory thresholds.

9:00

3aPP3. Unified analysis of accuracy and reaction times via models of decision making. Samuel R. Mathias (Dept. of Psychiatry, School of Medicine, Yale Univ., 2 Church St. South, New Haven, CT 06519, samuel.mathias@yale.edu)

"Sequential-sampling" models aim to characterize decision making during forced-choice experiments. These models decompose the decision process into its constituent elements, and can explain not only the probabilities with which subjects make each possible response, but the full distributions of reaction times associated with each of the response alternatives. Thus, such models provide a powerful framework for the analysis of behavioral data. However, despite being extremely popular in the cognitive sciences, they are almost never used in psychoacoustics. By way of example experiments, I will discuss how to fit these kinds of models to psychoacoustical data, using traditional maximum likelihood and hierarchical Bayesian inference, and how to interpret their results in terms of the underlying decision processes.

9:30

3aPP4. Generalized linear mixed models in hearing science. Hari M. Bharadwaj (Athinoula A. Martinos Ctr. for Biomedical Imaging, Massachusetts General Hospital, 149 Thirteenth St., Boston, MA 02129, hari@nmr.mgh.harvard.edu)

Linear mixed-effects models (LMEs), by virtue of allowing for the quantification of both random effects (e.g., associated with sampling of subjects) and the effects of fixed predictor variables, provide a powerful statistical modeling framework that can accommodate a large number of common experimental designs used in hearing science. Examples of designs for which LMEs are suitable include repeated-measures designs, longitudinal studies, and multilevel designs. An extensive literature of robust methods exists for fitting such models for normally distributed responses. On the other hand, often, data in hearing science experiments are binary (e.g., detected or missed), proportions, or counts (number of correct responses) and are better modeled using non-normal distributions (e.g., binomial). Generalized linear mixed models (GLMMs) provide a framework to retain the advantages of LMEs in modeling random effects by modeling the non-normal response variables using LMEs through (nonlinear) link functions. In this presentation, using example simulated and real psychophysical (attention task performance) and physiological data (OAEs, EFRs), I will introduce GLMMs and discuss the great flexibility they offer, and the challenges involved in parameter estimation and inference. I will also point to emerging methodological options and software packages for using GLMMs.

10:00–10:15 Break

10:15

3aPP5. Advances in quantifying listening effort: Growth curve analyses of pupillometry data. Stefanie E. Kuchinsky (Ctr. for Adv. Study of Lang., Maryland Neuroimaging Ctr., Univ. of Maryland, Maryland Neuroimaging Ctr., 8077 Greenmead Dr., Bldg. #795, College Park, MD 20740, skuchins@umd.edu), Judy R. Dubno, and Mark A. Eckert (Dept. of Otolaryngol. - Head and Neck Surgery, Medical Univ. of South Carolina, Charleston, SC)

Understanding speech in background noise often requires substantial mental effort, especially in adverse signal-to-noise ratios (SNRs) and for older adults with hearing loss. Pupillometry has been used to index listening-related effort, because pupil dilation is an autonomic response that is modulated by changes in cognitive demands, such as when recognizing speech in decreasing SNRs. This presentation will focus on our approach to quantifying the pupil response through growth curve analysis (GCA), a multilevel modeling technique in which orthogonalized polynomials are fit to time series data to capture its shape. We will provide an overview of our pupillometry research that employed GCA to characterize (1) changes in the pupil response across varying listening conditions and (2) individual differences in the pupil response among older adults with hearing loss. Discussion will include statistical advantages of this approach compared to commonly used peak-picking analyses, implementation of GCA in R, and the theoretical interpretation of model results. We will conclude by demonstrating that GCA results can be linked to functional neuroimaging data in order to further our understanding of the neural mechanisms that underlie listening effort. [Work supported, in part, by NIH/NIDCD and a Hearing Health Foundation Centurion Clinical Research Award.]

10:45

3aPP6. Individual differences in hearing-impaired data: Stats, troubles, and approaches. Sarah Verhulst (Medizinische Physik and Cluster of Excellence Hearing4all, Oldenburg Univ., 677 Beacon St., Boston, MA 02215, save@bu.edu)

Individual differences in hearing ability might be dominated by subcomponents of hearing loss, e.g., cochlear gain loss, cochlear neuropathy, temporal coding deficits in low/high frequency regions, or combinations of these components. Unfortunately, we can only rely on indirect and hypothesis-driven objective (e.g., OAE/ABR/EFR) and psychoacoustic threshold metrics that aim to quantify these subcomponents of hearing loss, complicating a straightforward explanation of study results. Because correlations statistics often rely on small listener groups in which each data point could have resulted from different SNRs, metric-specific variability, it is not always clear which correlations are significant and meaningful. Additionally, multiple measures provide a multitude of correlations that should all support the common underlying hypothesis before conclusions can be drawn. In this tutorial, I provide some examples and approaches to more *(and less)* meaningful correlations based on recently collected objective and psychoacoustic measures in a group of normal and hearing-impaired listeners. Finally, I will introduce how computational model approaches might direct the interpretation of experimental results when several interacting sources of hearing impairment impact outcome measures unexpectedly.

11:15

3aPP7. Nonparametric statistical approaches to neuroimaging data. Abigail L. Noyce (Boston Univ., 2 Cummington Mall, Boston, MA 02215, anoyce@bu.edu) and Robert Sekuler (Brandeis Univ., Waltham, MA)

Neuroimaging, including electroencephalography (EEG), magnetoencephalography (MEG), and functional magnetic resonance imaging (fMRI), is a rich source of information, allowing perceptual researchers measure neural responses to sensory inputs. Scalp EEG's high temporal resolution makes it a method of particular interest to auditory scientists who want to identify (and possibly model) the spatial and temporal extent of a difference between the two conditions. Analyzing neuroimaging data, however, poses several challenges. First, collecting data from tens or even hundreds of sensors and hundreds of time points creates a multiple comparisons problem. Second, neuroimaging data are often quite noisy (as is the brain itself). Finally, imaging data distributions are often incompatible with the assumptions of traditional parametric statistics—most notably, data are often non-normal, and with unequal variance. We illustrate strategies for addressing these challenges in the context of a selective attention study. EEG was recorded while subjects attempted to report a central target in the presence of either standard or oddball distractors. Using clustering and Monte Carlo permutation, we showed that neural responses to the distractors elicit an oddball effect.

WEDNESDAY MORNING, 25 MAY 2016 SNOWBIRD/BRIGHTON, 8:30 A.M. TO 11:55 A.M.

Session 3aSA

Structural Acoustics and Vibration: Computational Methods in Structural Acoustics and Vibration

Robert M. Koch, Chair
Chief Technology Office, Naval Undersea Warfare Center, Code 1176 Howell Street, Bldg. 1346/4, Code 01CTO, Newport, RI 02841-1708

Chair's Introduction—8:30

Invited Papers

8:35

3aSA1. Design optimization of a stiffened flexible panel under turbulent boundary layer excitation. Kuangcheng Wu, Nicholas Stowe, and Eric Brown (Ship Survivability, Newport News ShipBldg., 4101 Washington Ave., Newport News, VA 23693, kcwu@msn.com)

The vibration and noise generated from turbulent boundary layer (TBL) flow are main design considerations in the Automotive, Aerospace, Shipbuilding industries, as well as many others. Simulation has been widely applied to help reduce TBL-induced vibration and noise; however, a fully coupled CFD + FEA analysis is still a computational challenge for high-fidelity models. On the other hand, when the block pressure assumption is applicable, a general approach applies the fluctuating pressure underneath the TBL as excitation to the structure to predict its vibratory response and noise. This paper first uses the general approach to predict the vibration and noise of a stiffened flat panel subjected to TBL excitation. The various methods, both empirical and numerical, that are used to estimate the TBL wall spectrum are outlined. Structural transfer functions from Energy Finite Element Analysis (N. Vlahopoulos, K. Wu, MAST Americas 2010) are calculated for the panel. The calculated TBL excitation (M. Goody, AIAA, 2004) and structural transfer functions are combined to predict the flow-induced vibration and noise. In addition, optimization algorithms are applied to evaluate the impacts of several parameters (i.e., varied plating thickness and local damping) and determine the best design of the panel within the set of parameters.

8:55

3aSA2. Direct and transient analyses of the Schur complement for complex vibrating systems. James G. McDaniel, Andrew S. Wixom, and Rodolfo Rodriguez (Dept. of Mech. Eng., Boston Univ., 110 Cummington Mall, Boston, MA 02215, jgm@bu.edu)

We are interested in computing the steady-state response of coupled vibrating systems over a frequency band. For each system, the present coupling analysis requires the impedance matrix that relates forces and velocities at the coupled or externally forced degrees of freedom at all frequencies of interest. Algebraic manipulation of each system's full impedance matrix yields the desired impedance matrix in the form of a Schur complement. The present work surveys and compares two approaches for computing the Schur complement, with a particular focus on the effects of damping. The direct analysis computes the Schur complement in the frequency domain, which requires a linear solve of a large system with several forcing vectors at each frequency. The transient analysis computes the impulse responses of the coupled degrees of freedom by numerical integration. This is followed by a Fourier transform that yields the Schur complement. Approaches for choosing the most efficient analysis are presented, along with numerical examples that illustrate and compare both approaches.

9:15

3aSA3. Anticlastic bending of rectangular plates and inference of Poisson's ratio. Micah R. Shepherd and Stephen A. Hambric (Appl. Res. Lab, Penn State Univ., PO Box 30, Mailstop 3220B, State College, PA 16801, mrs30@psu.edu)

Elastic plates will exhibit anticlastic behavior due to the Poisson effect. This effect is often overlooked in the analysis of rectangular plates. However, the effect can be substantial for when the boundary conditions are free, causing nodal lines of certain mode shapes to be curved rather than straight. A rectangular plate finite element model comprised of quadratic solid elements was exercised to determine the dependency of the anticlastic bending on plate thickness, aspect ratio, and elastic modulus. A metric to quantify anticlastic behavior was then developed for both bending modes and axial modes. Finally, experimentally obtained mode shapes were used to infer the Poisson's ratio of a rectangular section of hard foam using the derived dependencies.

9:30

3aSA4. Prediction of broadband high-frequency acoustic reflection and transmission from elastic plates with structural discontinuities. Mauricio Villa and Donald Bliss (Dept. of Mech. Eng. and Mater. Sci., Duke Univ., Box 90300 Hudson Hall, Durham, NC 27708, mauricio.villa@duke.edu)

A model for the acoustic reflection and transmission for flexible boundaries with structural discontinuities is developed. The system studied is an infinite, fluid loaded plate with periodically fixed constraints that is driven by an incident acoustic field. To treat the local discontinuities of the plate, the coupled structural/acoustic problem is treated by applying the method of Analytical-Numerical Matching (ANM). The ANM framework, which separates the problem into a global numerical solution and a local analytical solution, offers an approach to handle mathematical difficulties associated with the coincidence frequencies of the system. Accurately treating the rapid spatial variation around the discontinuities improves the overall accuracy and convergence of the computational analysis to predict the resulting pressure levels. Results for an infinite plate with discontinuities are compared to a baffled plate with a fluid loading correction introduced to the structural wavenumber. Simple closed-form band-averaged directivity patterns are determined. This approach facilitates an energy-intensity reformulation of the structural and acoustic equations, allowing for the possibility of formalizing the couplingbetween energy flows in the acoustic and structural systems. The overall goal is to develop efficient first principles computational models for more accurate modeling of broadband structural-acoustic reflection and transmission between coupled acoustic spaces.

9:45

3aSA5. Partial differential equation-constrained optimization framework for inverse design of acoustic damping layers. Clay Sanders, Wilkins Aquino (Dept. of Civil and Environ. Eng., Duke Univ., Durham, NC, clay.sanders@duke.edu), and Timothy F. Walsh (Computational Solid Mech. and Structural Dynam., Sandia National Labs., Albuquerque, NM)

We present a partial differential equation-constrained framework for the design of viscoelastic damping layer assemblies in one and two dimensions. Viscoelastic foams' responses to loads not only provide stiffness and damping, but also vary with frequency. In a finite-element formulation, a viscoelastic solid's structural stiffness is determined by its complex valued shear and bulk moduli. By optimally selecting the moduli values of a layered assembly, we demonstrate an effective design of graded foam that minimizes its acoustic scattering in a fluid waveguide. We define a cost functional based on the scattered field from the acoustic-structural interaction of the viscoelastic inclusion in a fluid medium. In the optimization calculations, the complex valued moduli were modified to minimize the objective functional representing the scattered field energy. Models used in numerical simulations featured circular inclusions with distinct concentric rings. This talk will focus on the convergence of optimal designs and effects of frequency and solver algorithms. Numerical results suggest the potential for optimally designed viscoelastic foams to minimize acoustic scattering. [Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL850000.]

10:00

3aSA6. Modeling and design of lightweight, hyperdamping metamaterials for large, broadband vibroacoustic energy attenuation. Ryan L. Harne, Yu Song, and Quanqi Dai (Mech. and Aerosp. Eng., The Ohio State Univ., 201 W 19th Ave., E540 Scott Lab, Columbus, OH 43210, harne.3@osu.edu)

The absorption and dissipation of spectrally broadband vibration and wave energy are long-standing pursuits for researchers and engineers. In vehicular applications, light-weighting demands have led to the common use of flexible structural components that exacerbate concerns of low frequency energy transmission and radiation while joints and geometrical features result in higher frequency vibrations that produce adverse noise fields for occupants. To address the needs for broadband vibroacoustic energy attenuation via a lightweight material solution, this research integrates concepts from recent studies on elastic and poroelastic composite materials and investigates a new idea to cultivate hyperdamping effects in an engineered metamaterial. A finite element (FE) model is developed to identify ways in which to effect hyperdamping properties by virtue of controlled instability mechanisms embedded within the metamaterial. Throughout the design space, the simulations predict numerous design parameter selections that generate hyperdamping properties for large, broadband energy trapping and dissipation. Experimental studies verify the trends of FE model predictions and exemplify the potentials for hyperdamping phenomena once leveraged in practice.

10:15–10:25 Break

10:25

3aSA7. When an offshore cylindrical pile is impacted axially, the resulting wall vibration and underwater radiated sound pressure are insensitive to which thin shell theory is selected. Marshall V. Hall ((retired), 9 Moya Crescent, Kingsgrove, NSW 2208, Australia, marshallhall@optushome.com.au)

When a pile is impacted axially, a pulse of axial and radial vibration travels downwards and undergoes continued reflections at the toe and head. If a pile is to be treated as a thin cylindrical shell then producing a model for radiated sound pressure requires a particular "thin shell theory" to be selected. There are 12 such theories, as catalogued in Leissa's monograph "Vibration of shells." Four have been selected: the Membrane, Donnell-Mushtari, Flugge, and Epstein-Kennard theories (the last is the most intricate of the 12). An offshore pile with 25.4-mm wall thickness and 381-mm radius (6.7%-ratio) is modeled. Since the pile head is above the water surface, aerial radiation strongly attenuates the vibration of the immersed pile near the pile's ring frequency (2.1 kHz). Spectra of radial vibration and underwater radiated sound pressure are computed up to 10 kHz using each of the four theories and found to be the same, except near the ring frequency. When the calculations are repeated for a similar pile with a wall three times thicker (no longer a thin shell), the Flugge results are higher than the other three by an amount that increases to 2 dB as frequency increases to 10 kHz.

10:40

3aSA8. Effects of internal acoustic coupling on the response of a base-excited hollow structure. Ryan Schultz and Greg Tipton (Analytical Structural Dynam., Sandia National Labs., 1701 Singletary Dr. NE, Albuquerque, NM 87112, rschult@sandia.gov)

Traditionally, structural dynamic simulation predictions for hollow structures do not include internal acoustic volumes. This is the case for two reasons. First, it can be difficult to create a volume mesh of complicated

internal cavities, and this additional volume would drastically increase the size of the model. Second, it is often blindly assumed that acoustic coupling is not important for structures with anything but thin walls. However, if the structural and acoustic modes are compatible, that is, the modes have similar frequencies and shapes, then the interaction between the structure and the enclosed acoustic volume will occur and can have an effect on structural response. The magnitude of this coupling effect is demonstrated here by examining the structural response predictions for a finite element model of a hollow structure with and without the acoustic volume in place. When a base excitation is applied at a frequency and location to excite compatible modes, the response predictions are seen to be drastically different if the acoustic volume is included. The frequency response results of the coupled finite element simulations will be compared with those of the classic two degree of freedom dynamic vibration absorber, showing the effect of frequency ratio and damping on the structural response.

10:55

3aSA9. Energy flux streamlines for an ensonified fluid sphere near a rigid boundary: Implementation and testing. Cleon E. Dean (Phys., Georgia Southern Univ., PO Box 8031, Math/Phys. Bldg., Statesboro, GA 30461-8031, cdean@georgiasouthern.edu) and James P. Braselton (Mathematical Sci., Georgia Southern Univ., Statesboro, GA)

Progress in the implementation and testing of routines to compute the energy flux [J. A. Mann III, *et al.*, J. Acoust. Soc. Am. **82**, 17–30 (1987)] and energy flux streamlines [D. M. F. Chapman, J. Acoust. Soc. **124**, 48–56 (2008)] for the problem of an ensonified fluid sphere near a rigid boundary are presented. The problem is isomorphic via the method of images to the problem of interactive scattering between two identical fluid spheres. Trinks provided an analytical solution to this problem in 1935 [W. Trinks, Ann. Phys. **414**, 561–590 (1935)]. However, his solution is mathematically intractable for larger spheres due to the complexity of his translational addition theorem for spherical harmonics. Later, researchers Cruzan [Quart. Appl. Math. **20**, 33–40 (1962)] and Liang and Lo [Radio Science 2, 1481 (1967)] simplified this translational addition theorem, making it feasible to solve the problem with larger spheres. This work follows Bruning and Lo [Tech. Rep. 69-5 (Antenna Laboratory, Univ. of Illinois, Urbana, IL 1969)], correcting typos in that work to implement efficient algorithms for acoustical scattering.

11:10

3aSA10. Numerical prediction and analysis of electromagnetic vibration and noise of claw pole alternator. Shuanglong Wu, Shuguang Zuo, and Xudong Wu (Clean Energy Automotive Eng. Ctr., Tongji Univ., No.4800 Cao'an Rd., Jiading District, Shanghai 201804, China, zymwgl@foxmail.com)

With the improvement of internal combustion engine noise, the noise of claw pole alternator which is universally used on modern automobiles is becoming more distinct. Extensive experimental results show that the noise of claw pole alternator is annoying at low to middle speed and mainly originates from the electromagnetic noise. In this paper, a complete methodology for electromagnetic vibration and noise prediction of claw pole alternator is presented. It is a three-step multiphysics simulation. The first step is to calculate the magnetic force exerted on the inner surface of the stator using 3D FEM. The second step is the structural analysis, which is to investigate the natural resonant frequencies and modal shapes of the alternator system taking into account the real mechanical boundary conditions. The third is the electromagnetic vibration and noise calculation by using modal superposition method and boundary-element method, respectively. Simulation results agree well with those measured by experiments. Furthermore, the mechanisms of electromagnetic vibration and noise are analyzed by using the electromagnetic theory. The method can be used in the initial design stage of claw pole alternator and is also suitable for other types of motor.

11:25

3aSA11. Calculation of sound radiation in infinite domain using a meshless method. Shaowei Wu and Yang Xiang (School of Energy and Power Eng., Wuhan Univ. of Technol., Peace Ave., Wuhan, Hubei Province, No. 1040, Wuhan, Hubei 430063, China, thinkwsw@qq.com)

A meshless method coupling with a variable order infinite acoustic wave envelope element for sound radiation calculation in infinite domain is presented with the aim of accurately calculating the acoustic radiation and improving computational efficiency. It is based on using the element-free Galerkin method in the inner region enclosing the radiator and a variable order infinite acoustic wave envelope element in the outer region for the proper modeling of the pressure amplitude decay. The details are provided for the derivation and implementation of this method. The factors of influencing the performance of the method, which include the shape function constructing, the number of integration points, the weight functions, and the support domain, are discussed. A hybrid adaptive Gauss-Legendre quadrature is devised to obtain good integration accuracy. The suitable radius of the support domain for the acoustic field calculation in free space is also determined by use of numerical experiments. A complex structure is designed for simulation to validate the method. The results illustrate the accuracy, applicability, and effectiveness of this method.

11:40

3aSA12. Analytical prediction of radiation from a multi-element variable-directivity spherical loudspeaker array and construction and measurement of a prototype. Taylor R. Laub and Donald B. Bliss (Mech. Eng., Duke Univ., 148B Hudson Hall, Duke University, Durham, NC 27705, dbb@duke.edu)

An analysis of radiation from a spherical surface with twelve radiating spherical caps oriented in a dodecahedral arrangement is performed. The approach generalizes the classical single cap solution by utilizing spherical trigonometry transformations to create many spherical caps in different orientations. The calculations include far-field directivity, surface impedances, and net radiated power for a variety of cap motions within the spherical array. Simulations show how well the discrete caps can produce monopole, dipole, and higher mode directivity patterns. Relative motions of the caps are calculated that best simulate these individual radiation modes. The frequency ranges for accurate reproduction of these radiation modes using discrete caps are quantified, and the role of large cap sizes to extend the range is shown. At higher frequencies, the phase interference between discrete cap radiators cause the intended radiation patterns to break down in complicated ways. A prototype 12-element spherical speaker enclosure has been constructed, with the help of a 3-D printer, and tested in an anechoic chamber. The configuration of typical cone loudspeakers creates constraints on the practical design of spherical speakers, limiting the radiating area fraction. Driver design changes to allow more compact spherical speakers with extended frequency range are suggested.

Session 3aSC

Speech Communication and Psychological and Physiological Acoustics: Gender Effects in Speech Production and Perception

Sarah H. Ferguson, Cochair
Communication Sciences and Disorders, University of Utah, 390 South 1530 East, Room 1201, Salt Lake City, UT 84112

Eric J. Hunter, Cochair
Department of Communicative Sci., Michigan State University, 1026 Red Cedar Road, East Lansing, MI 48824

Chair's Introduction—8:00

Invited Papers

8:05

3aSC1. Gender differences and speech accommodation in occupational settings. Eric J. Hunter (Dept. of Communicative Sci., Michigan State Univ., 1026 Red Cedar Rd., East Lansing, MI 48824, ejhunter@msu.edu), Sarah Hargus Ferguson (Dept. of Commun. Sci. and Disord., Univ. of Utah, Salt Lake City, UT), Tim Leishman (Phys. and Astronomy, Brigham Young Univ., Provo, UT), Lynn Maxfield (National Ctr. for Voice and Speech, Univ. of Utah, Salt Lake City, UT), Simone Graetzer, and Pasquale Bottalico (Dept. of Communicative Sci., Michigan State Univ., East Lansing, MI)

Nearly one quarter of the U.S. workforce depends on a healthy, versatile voice as a tool for their profession. These are individuals who, lose voice quality and/or vocal endurance, would not be able to perform their job effectively. These *occupational voice users* include professionals such as teachers, counselors, emergency dispatchers, air traffic controllers, performers, and telephone workers. Women tend to have a disproportionate incidence of reported voice problems compared to men. They also make up the majority of several of these high voice-use occupations (e.g., public school teachers, call center workers). This presentation will provide an overview of our current understanding of gender discrepancy in vocal health issues as well as a discussion of recent results identifying underlying causes, which may contribute to their heightened risk. Such results include compensatory adjustments women use in different communication environments, speech accommodation to stress, and the relationship between vocal fatigue and pulmonary function.

8:25

3aSC2. The effect of compromised pulmonary function on speech production among female school teachers. Lynn M. Maxfield (National Ctr. for Voice and Speech, Univ. of Utah, 136 S Main St., Ste #320, Salt Lake City, UT 84101, lynn.maxfield@utah.edu), Eric Hunter, and Simone Greatzer (Dept. of Communicative Sci. and Disord., Michigan State Univ., East Lansing, MI)

Females face a significantly higher risk than males of developing long-term voice problems with lifetime instances occurring in 46% of females compared to 37% of males. The higher incidence of prolonged problems among women has been associated with a number of gender differences, including physiological differences in the laryngeal system, differences in the endocrine system, and differences in pulmonary usage. Additionally, inefficient pulmonary utilization and reduced lung volume have been linked with vocal health concerns. Our study sought to use established spirometry measures and a relatively new questionnaire, the Vocal Fatigue Index (VFI), to determine if there is a relationship between pulmonary function and vocal fatigue among teachers. Additionally, if there is a relationship, to determine if that relationship is stronger in females than in males. **122** (96 females, 26 males) elementary and middle school teachers from the Jordan School District in northern Utah participated in this research. For females, VFI was a predictor of several spirometry measures; however, the same correlation was not found among male participants. These results indicate that reduced pulmonary function in combination with other gender differences in speech production may lead to increased incidences of vocal fatigue among female teachers than their male counterparts.

8:45

3aSC3. Phonetic convergence and talker sex: It's complicated. Jennifer Pardo, Adelya Urmanche, Sherilyn Wilman, and Jaclyn Wiener (Psych., Montclair State Univ., 1 Normal Ave., Montclair, NJ 07043, pardo@optonline.net)

Investigations of phonetic convergence report conflicting results with respect to talker sex. Some studies report that females converge to a greater degree than males, while others find no difference or the opposite pattern. These discrepancies frustrate attempts to characterize the impact of talker sex on phonetic variation and convergence in a straightforward manor. The current investigation reveals that talker sex interacts with other variables, both lexical and phonological. A set of 92 talkers (47 females) shadowed monosyllabic words that manipulated word frequency within eight vowels. Phonetic convergence was assessed in an AXB perceptual similarity task and in F1 x F2 vowel space. Convergence in F1 x F2 vowel space did not differ between males and females on average, but female

talkers converged to front vowels (/i/, /ɛi/, /ɛ/, /æ/) more than to back vowels (/ɑ/, /ou/, /ʊ/, /u/), and male talkers showed the opposite pattern. Furthermore, higher vowels (/i/, /ɛi/, /ʊ/, and /u/) showed the largest differences in convergence between men and women. These patterns were largely driven by convergence on F2 alone. These findings relate to broader sociolinguistic concerns about the impact of gender on phonetic variation and sound change.

9:05

3aSC4. Same versus opposite-sex accommodation in digital media speech. Tanya Flores (Lang. and Lit., Univ. of Utah, 255 S Central Campus Dr., LNCO 1400, Salt Lake City, UT 84109, Tanya.Flores@utah.edu)

This presentation focuses on the linguistic and social factors that motivate phonetic variation of the /tɾ/ cluster in Chilean Spanish, specifically producing the cluster as an alveo-palatal affricate [tʃ] (or with rhotic [tʃɾ]). The data consist of 1,596 tokens produced by 72 Santiago speakers in a corpus of digital radio recordings. Results from a mixed-effects logistic regression analysis confirm that several linguistic and social factors, including speakers' sex and age, affect /tɾ/ cluster variation in this dataset. Using a speech accommodation analysis, the study allows for an examination of the effect that social traits of the direct addressee (co-host or in-studio guest) have on speakers' variant choice and usage rates. Results from the two-population binomial tests on speaker-listener pairings reveal that the affricated variant [tʃ] is significantly affected by the age of the addressee. Moreover, opposite-sex pairs had a significantly higher [tʃ] production rate than same-sex pairs or solo hosts of either sex. Specific patterns by sex will be elaborated in this presentation.

9:25

3aSC5. Quantity of mothers' and fathers' speech to sons and daughters. Mark VanDam (Dept. of Speech and Hearing Sci., Elson S. Floyd College of Medicine, Washington State Univ., PO BOX 1495, Spokane, WA 99202, mark.vandam@wsu.edu) and Tracy Tully (Dept. of Commun. Disord., Eastern Washington Univ., Spokane, WA)

The literature on child-directed speech has shown that mothers, on average, talk to their children with higher token frequency than fathers, but fathers may use more complex language or more variable word types. Other recent research has shown that mothers may use greater fundamental frequency variability and range when talking to their children, as compared with fathers who showed no fundamental frequency differences between child- and adult-directed speech. There is also some evidence that mothers may talk more often with their daughters than sons. Whether fathers are sensitive to the sex of their children is unknown. This work looks at the quantity of fathers' and mothers' speech to their sons and daughters from a large database of daylong recordings collected from a body-worn recorder on preschool boys and girls in their natural daily environments. The recordings were analyzed offline with automatic speech processing software which tallied the quantity of syllables produced for all individual talkers and the conversational exchanges among mothers and fathers with their sons and daughters. Contrary to previous findings, results indicate that fathers may engage more often with their sons than daughters, but mothers are not sensitive to child sex.

9:45

3aSC6. Talker gender effects in the Ferguson Clear Speech Database. Sarah H. Ferguson (Commun. Sci. and Disord., Univ. of Utah, 390 South 1530 East, Rm. 1201, Salt Lake City, UT 84112, sarah.ferguson@hsc.utah.edu)

The Ferguson Clear Speech Database (FCSD; Ferguson, 2004) was designed to support a talker-differences approach to the investigation of the acoustic characteristics that underlie the superior intelligibility of clear speech. However, its size (41 talkers) and balanced gender composition (21 females and 20 males) have made it useful for exploring talker gender effects on a wide array of acoustic and perceptual measures. In this talk, I will present comparisons of male and female talkers from previous studies as well as more recent ones, along with new analyses of old data. I will also consider how the magnitude of any talker gender differences compares to the variability observed within each gender.

10:05–10:20 Break

10:20

3aSC7. Effects of auditory training on cochlear implant users' gender categorization. Bomjun J. Kwon (Hearing, Speech and Lang., Gallaudet University, 800 Florida Ave. NE, Washington, DC 20002, bomjun.kwon@gallaudet.edu) and Qian-Jie Fu (Dept. of Head and Neck Surgery, Univ. of California, Los Angeles, CA)

Nowadays, the benefits of cochlear implants (CIs) for individuals with a substantial degree of hearing loss are widely demonstrated in clinical applications in terms of both speech recognition and speech production. However, a body of evidence indicates CI users' compromised ability to accurately categorize gender of the voice (e.g., Fuller *et al.*, J. Assoc. Res. Otol. **15**, 1037–1048, 2014), which may be an obstacle to overcome to improve executive functions for communication with the device. While it has been known that CI users are capable of utilizing the fundamental frequency (F0) of the voice as the primary determinant of gender categorization, poor differential selectivity in F0 with the device attributes to the compromised ability. Another vocal characteristic, vocal tract length (VTL), which is known to play an important role in gender categorization in normal hearing (NH) listeners, is largely ignored in CI users. Considering that the VTL information, grossly reflected on formants, may be transmitted through the device and perceived by CI users when presented in isolation, and that CI users, in general, highly utilize episodic context, proper auditory training of CI users with voice stimuli with F0 and formants covaried or independently varied might improve their gender categorization.

10:40

3aSC8. Perceived gender in clear and conversational speech. Jaime A. Booz and Sarah H. Ferguson (Commun. Sci. and Disord., Univ. of Utah, 2808 S 2700 E, Salt Lake City, UT 84109, jaime.booz@utah.edu)

Much of our understanding of gender perception in voice and speech is based on sustained vowels or single words, which eliminates temporal, prosodic, and articulatory cues available in more natural, connected speech. Further, while many studies have examined acoustic and sociolinguistic differences between male and female voices, the relationship between talker speaking style and perception of gender has not yet been explored. Clear speech, adopted by talkers who perceive some barrier to effective communication, is one such speaking style change. The present study examines the relationship between clear speech and talker gender perception. Clear and conversational neutral sentences produced by all 41 talkers from the Ferguson Clear Speech Database (Ferguson, 2004) were presented to young listeners with normal hearing. They rated the gender of the talker using a visual analog scale with endpoints labeled masculine and feminine, chosen to capture small within-category changes in perceived gender. Acoustic analyses of these sentences, including fundamental frequency, formant frequencies, speaking rate, fundamental frequency range, and cepstral peak prominence will be undertaken to determine the relationship between acoustic correlates of clear speech and listener ratings of femininity or masculinity. Applications to transgender voice therapy will be discussed.

11:00

3aSC9. Jimmy Scott and the problem of gender in singing. Nina Eidsheim and Jody E. Kreiman (UCLA, 31-24 Rehab Ctr., 1000 Veteran Ave., Los Angeles, CA 90403, jkreiman@ucla.edu)

The voice of jazz performer Jimmy Scott raises interesting questions of how gender is marked (or not marked) in singing voice. Scott was born with Kallman's Syndrome, which affects male hormonal levels and prevents the onset of puberty. Although he self-identified as a "regular guy," in his career he was presented as a novelty act—a boy who sounded like an adult woman—or paired with gender-ambiguous images. This paper explores Scott's voice in comparison to male and female peers, with emphasis on the paradoxical role of falsetto in creating a male vocal image.

11:20

3aSC10. Are women more unstable than men? Shaky topics. Julie M. Barkmeier-Kraemer (Otolaryngol., Univ. of Utah, 50 N Medical Dr., 3C120, Salt Lake City, UT 84132, JulieB.Kraemer@hsc.utah.edu)

Essential vocal tremor was reported by Sulica and Louis (2010) to predominantly occur in females (90%) compared to males (10%) even though the overall diagnosis of essential tremor demonstrates equal representation of both groups. Interestingly, vocal tremor manifests in 30% of individuals diagnosed with essential tremor as well as spasmodic dysphonia. However, information regarding the proportion of females and males exhibiting vocal tremor in those diagnosed with spasmodic dysphonia remains unclear. A predominance of females represented with isolated vocal tremor and in those diagnosed with spasmodic dysphonia could suggest either a genetic or endocrine system link to the onset of vocal tremor. The purpose of this study was to compare and contrast the representation and characteristics of males and females diagnosed with isolated vocal tremor to spasmodic dysphonia with vocal tremor. Comparisons will be made between speech structures exhibiting tremor on endoscopic examination and vocal tremor acoustic patterns. A preponderance of females with vocal tremor in both groups supports a genetic link to the onset of vocal tremor. Differences in acoustic patterns and structural involvement profiles between males and females would support the possible influence of the endocrine system in the development of vocal tremor.

11:40

3aSC11. The influence of linguistic complexity and gender identity on /s/ variation in children. Benjamin Munson (Speech-Language-Hearing Sci., Univ. of Minnesota, 115 Shevlin Hall, 164 Pillsbury Dr., SE, Minneapolis, MN 55455, munso005@umn.edu)

Children, like adults, vary in the extent to which their speech conforms to stereotypical expectations for their biological sex. Previous research has examined this in boys with and without gender dysphoria (GD) [Munson *et al*., J. Acoust. Soc. Am. **137**, 1995–2003 (2015); Munson, J. Acoust. Soc. Am. **138**, 1895 (2015)]. Munson (2015) showed that 5–13 year old boys with GD were more likely than age-matched boys without GD to produce tokens of /s/ with a diffuse spectrum, consistent with a frontal, i.e., /θ/-like, /s/. This was based on an analysis of /s/ tokens from single word productions and from fluent sentence repetitions. The purpose of this presentation is to further examine the /s/ differences between these two groups of boys in single words, sentence repetitions, and spoken narratives elicited through a picture-description task. Analyses will examine whether the differences between the boys with and without GD are exaggerated in the narrative data, which offer more freedom for gender performativity than do single words and sentences. We will also examine whether the differences between groups are mediated by individual children's language expressive language abilities, as measured by the objective complexity of their narratives, and by the overall accuracy of sentence repetition.

Session 3aSP

Signal Processing in Acoustics, Engineering Acoustics, and Underwater Acoustics: Acoustic Array Systems and Signal Processing II

John R. Buck, Cochair
ECE, UMass Dartmouth, 285 Old Westport Rd., North Dartmouth, MA 02747

Mingsian R. Bai, Cochair
Power Mechanical Engineering, National Tsing Hua University, No. 101, Section 2, Kuang-Fu Road, Hsinchu 30013, Taiwan

Chair's Introduction—8:30

Contributed Papers

8:35

3aSP1. Recording of extended sound fields using spherical microphone arrays and a-priori knowledge of the sound source positions. Jorge A. Trevino Lopez (Res. Inst. of Elec. Commun. and Graduate School of Information Sci., Tohoku Univ., 2-1-1 Katahira, Aoba-ku, Sendai, Miyagi 9808577, Japan, jorge@ais.riec.tohoku.ac.jp), Keigo Wakayama (NTT Media Intelligence Labs., NTT Corp., Musashino, Tokyo, Japan), Shuichi Sakamoto, Yo-iti Suzuki (Res. Inst. of Elec. Commun. and Graduate School of Information Sci., Tohoku Univ., Sendai, Miyagi, Japan), Hideaki Takada, and Manabu Okamoto (NTT Media Intelligence Labs., NTT Corp., Musashino, Tokyo, Japan)

The acquisition of comprehensive sound field information is a central topic in spatial acoustics. In conventional systems, recording devices must be located at the listener's viewpoint. This research introduces a sound field recording technique for spherical microphone arrays which makes use of *a-priori* information regarding the distribution of sound sources. The proposal generates sound field descriptions for viewpoints that are located away from the recording device, as long as there are no sound sources between the target viewpoint and the microphone array. Sound field descriptions, a set of spherical harmonic expansion coefficients, are generated from the array signals. A translation operator, calculated from approximate source positions known in advance, is defined so as to shift the plane wave decomposition of the partial fields associated with each expansion coefficient. The proposed method is compared with an existing technique based on a different kind of translation operator traditionally used in implementations of the boundary element method. These operators require no a-priori information, but their region of validity is limited by the spherical harmonic expansion order. The conventional method achieves greater accuracy in the proximity of the recording array; however, the proposed method can generate sound field descriptions covering a much larger region.

8:50

3aSP2. Maximum likelihood estimation to denoising channels in beamforming circular array. Fabricio A. Bozzi, José Manoel de Seixas (Sonar Group, Brazilian Navy Res. Inst., Rua Hugo Leal, Rio de Janeiro 21931250, Brazil, bozzi@ipqm.mar.mil.br), Thiago C. Xavier (LabSonar, Federal Univ. of Rio de Janeiro, Rio de Janeiro, Brazil), and Leonardo M. Barreira (Sonar Group, Brazilian Navy Res. Inst., Rio de Janeiro, Brazil)

The delay and sum beamforming is the most simple technique in direction of arrival (DOA) Estimation. Although its performance on spatial discrimination is poor, compared to other beamforming, delay and sum still is used in large operating sound navigation and ranging (SONAR) because of its low computational cost. A circular hydrophone array (CHA), commonly used in SONAR system, is an attractive alternative to provide a more uniform directive response over all azimuth angle. This array is analyzed here, working with experimental data, acquired in a acoustic tank and in the sea. Maximum likelihood estimation (MLE) is applied to denoising noisy channels, summing up them after in delay-and-sum. First of all, a noise in an acoustic tank is considered to represent the hydrophones, cables, and acquisition system noises. Then, an environmental noise is collected in the sea. The MLE use both of them to calculate the weights in the beamforming. A boat is used to running around the array, and the DOA of the uniformly weight and MLE in delay-and-sum shows the performance improvement.

9:05

3aSP3. Simultaneous tracking and counting of targets in a sensor network. Pritthi Chattopadhyay, Asok Ray (Mech. Eng., The Penn State Univ., University Park, PA), and Thyagaraju Damarla (Army Res. Lab., Networked Sensing and Fusion Branch, U.S. Army Res. Lab., Adelphi, MD 20783, thyagaraju.damarla.civ@mail.mil)

Unattended ground sensors (UGS) are widely used to monitor human activities, such as pedestrian motion and detection of intruders in a secure region. This paper presents an algorithm for counting and tracking humans moving through a UGS network. Each node of this sensor network is equipped with a geophone (i.e., seismic sensor) and a microphone (i.e., acoustic sensor). The proposed method analyzes the relational dependence among the responses of sensors at various nodes as the targets walk through the network. The energy distribution across the network for different number of targets walking at different distances from the nodes has been analyzed to predict the number and location of targets in the sensor network field. The proposed concept has the advantages of having fast execution time and low memory requirements and is potentially well-suited for real-time implementation on *in-situ* computational platforms. Keywords—Personnel detection, seismic sensing, acoustic sensing, sensor-network-based fusion.

9:20

3aSP4. Experimental research on acoustic array sonde in borehole azimuthal reflection logging tool. Xiaolong Hao, Xiaodong Ju, Xiling Wu, Junqiang Lu, Baiyong Men, and Zhijun Yu (State Key Lab. of Petroleum Resources and Prospecting, China Univ. of Petroleum, China University of Petroleum, No. 18 Fuxue Rd., Changping, Beijing, China, haoxl315024@163.com)

Phased combined arc array technology was adopted when designing acoustic sonde to enhance 3D detection capability and resolution in borehole azimuthal reflection logging tool. After constructing experimental

measurement system, horizontal and vertical radiation characteristics of the transmitter with different phased excitation delays were tested in a 5 m*5 m*4 m water tank as well as consistency and phased combined effects for 80 array elements in 10 stations of the receiver. Also, this tool was placed in an open waters to explore the response of reflector including size, placed radial distance, and azimuth with optional phased excitation delay. Experimental results show that when the phased excitation delay is 30 us, the main lobe direction of vertical radiation energy of the transmitter could be updeflected by 150 and less side lobe energy. The −3 dB width of main lobe is obviously narrowed using 3 array elements combination in receiver. This tool possesses the ability of recognizing a 2 m*1 m*0.05 m aluminum plate at 10 m radial distance which means about 40 m in real formation, the reflected wave energy intensity distributes symmetrically in eight directions. This work is helpful for acquiring performance of the tool and data processing.

9:35

3aSP5. Research on detection technology for aligned array acoustic sonde of acoustic logging tool. Dong Liu, Xiaodong Ju, Junqiang Lu, Baiyong Men, and Zhijun Yu (China Univ. of Petroleum, No.18, Fuxue Rd., Changping District, Beijing, China, teamo_0911@sina.com)

While aligned array transmitting and receiving acoustic sonde helps in improving the acquisition accuracy and 3D resolution of signals, it also increases the difficulty of detecting and maintaining the sound sonde. A debugging framework based on embedded ARM7&uclinux platform is built; a functional board is designed to simulate the process of transmitting and receiving acoustic sonde, and an evaluation method on the validity and consistency of aligned array probes is proposed. In this design, ARM front terminal is interconnected with host computer through network, and test function board communicates with front terminal through an imitation PC104 bus. The test function board comprises a signal sampling and processing module and an analog signal transmitting module. When debugging the transmitting acoustic sonde, the sampling and processing module with built-in receiver simulates the receiving acoustic sonde, processes the signal by sampling, amplifying, filtering, and analog-digital converting, and then uploads to the host computer. When debugging the receiving acoustic sonde, the analog signal transmitting module, based on DDS technology, simulates periodical sound fields with power horn, which include imitation strata longitudinal wave, shear wave, and stoneley wave. The experiment shows that this design would reduce failure rate of acoustic sonde and improve work efficiency.

9:50–10:05 Break

10:05

3aSP6. A sparse recovery technique for the turbulent boundary layer wavenumber-frequency spectrum with non-uniformly spaced array of pressure transducers. Shaun D. Anderson and Philip W. Gillett (Naval Surface Warfare Ctr. Carderock Div., 9500 MacArthur Blvd., West Bethesda, MD 20817, shaun.d.anderson@navy.mil)

Historically, determination of wavenumber-frequency spectra of turbulent wall pressure fluctuations has employed the use of evenly spaced linear arrays of sensors. The reason for this is that even spacing of pressure samples in both the temporal and spatial domains facilitates analysis by direct application of 2-D Fourier transforms. The spacing of pressure measurements directly impacts the resolution of the resulting wavenumber-frequency spectra. This rigid spacing requirements of traditional methods may preclude analysis altogether with even a single sensor failure within the array. Rather than determining sensor locations based on the simplest analysis method, the sparseness of the wavenumber-frequency spectra can be leveraged to allow non-uniform sampling in both temporal and spatial domains. Sparse recovery techniques as an analysis tool for wavenumber-frequency spectra will be demonstrated both theoretically and experimentally for uniformly spaced arrays, uniformly spaced arrays with missing measurements, and randomly spaced arrays.

10:20

3aSP7. Dynamic time warping: Compensating for temperature variations. Alexander C. Douglass (Mech. Eng., Univ. of Utah, 1444 S Beacon Dr., Salt Lake City, UT 84108, u0992315@utah.edu) and Joel B. Harley (Elec. Eng., Univ. of Utah, Salt Lake City, UT)

Guided wave structural health monitoring has the potential to monitor large structural areas. Yet, temperature variations are known to misalign measurement data and cause false alarms. Current popular temperature compensation methods include the optimal signal stretch method and interpolation method. While these methods perform well for small temperature changes, they fail in large temperature variations. In this paper, dynamic time warping is used to realign signal responses that have been distorted by temperature. Baseline subtraction between the realigned signal and the baseline can then be used to detect and identify damage responses. We demonstrate dynamic time warping with guided wave measurements taken from an aluminum plate that is heated in cycles from roughly 75°F to 125°F. Dynamic time warping achieves a correlation between the chosen baseline and the pre-damage measurements greater than 90%. Applying no temperature compensation or more traditional methods, such as optimal signal stretch, demonstrate correlations of 0% and 30%, respectively. This shows that dynamic time warping removes temperature effects more accurately than other current approaches.

10:35

3aSP8. Modifying nearfield acoustic holography for use in building leak detection. Ralph T. Muehleisen (Energy Systems, Argonne National Lab., 9700 S. Cass Ave., Bldg. 221, Lemont, IL 60439, rmuehleisen@anl.gov), Kasanthamy Chelliah, Hirenkumar Patel, and Ganesh Raman (Mech, Mat, and Aero, Engr, Illinois Inst. of Technol., Chicago, IL)

The use of nearfield acoustic holography (NAH) for locating and sizing leaks in building envelops has been previously presented [J. Acoust. Soc. Am. **137**, 2233 (2015); J. Acoust. Soc. Am. **137**, 2325 (2015), and J. Acoust. Soc. Am. **136**, 2172 (2014)]. Standard NAH algorithms are fairly limited in the distance from the sources at which reconstruction can be made. In this paper, the authors present new research that shows that with judicious choices of matrix regularization, the distance from source to NAH measurement can be greatly increased making use of NAH for estimating building leakage much more practical. The application several different NAH matrix regularization methods are compared.

10:50

3aSP9. Method for effective implementation of an acoustic based Hostile Fire Detection System on moving vehicles. Wayne E. Prather (NCPA, Univ. of MS, P.O. Box 1848, 145 Hill Dr., University, MS 38677-1848, wayne@olemiss.edu) and William G. Frazier (Hyperion Technol. Group, Inc., Tupelo, MS)

Due to background noise issues, effective implementation of an acoustic array as part of a Hostile Fire Detection System on moving vehicles has been a significant challenge to date. A new method utilizing both software and hardware design parameters has been developed and successfully demonstrated to be very effective at high speeds on various vehicles. This method has been shown to be effective against both flow based noise sources and acoustic wave based noise sources in low signal to noise ratio conditions. The technology will be discussed and results from measurements utilizing conformally mounted acoustic sensors on moving ground vehicles will be shown.

11:05

3aSP10. Spatial power spectral estimation using coprime sensor array with the min processor. Yang Liu, John R. Buck, and Radienxe Bautista (Dept. of Elec. and Comput. Eng., Univ. of Massachusetts Dartmouth, 285 Old Westport Rd., North Dartmouth, MA 02747, yang.liu@umassd.edu)

A coprime sensor array (CSA) commonly estimates the spatial power spectral density (PSD) of the observed signal by multiplying one conventionally beamformed subarray scanned response with the complex conjugate of the other [Vaidyanathan and Pal, 2011]. This product processor removes the CSA subarray spatial aliasing ambiguities, but has a peak sidelobe

higher than the peak sidelobe of a fully populated uniform linear array (ULA) [Adhikari *et al*., 2014]. Moreover, the resulting spatial PSD estimate is not guaranteed positive semi-definite, and as a result, weak sources can be masked by the negative side lobes of strong interferers. This paper proposes choosing the minimum between the two CSA subarray periodograms at each bearing to resolve the spatial aliasing ambiguities. This min processor achieves lower peak sidelobe height and total sidelobe area than the product processor and preserves the PSD positive semi-definite characteristic. Closed-form expressions for the first two moments of the CSA min PSD estimator are available. Simulations and real data show that the min processor achieves a lower PSD estimate variance than the product processor while keeping the PSD estimate approximately unbiased. [Work supported by ONR BRC Program.]

11:20

3aSP11. Azimuthal evaluation of formations near borehole: Numerical simulations and field examples. Peng Liu, Wenxiao Qiao, Xiaohua Che, Xiaodong Ju, and Junqiang Lu (China Univ. of Petroleum (Beijing), No. 18,Fuxue Rd., Changping District, Beijing, Beijing 102249, China, liupeng198712@126.com)

Azimuthal evaluation of formation properties near borehole is an important research direction of well logging technology, and we develop an innovative 3D sonic logging tool for that purpose. Except conventional measurements of monopole and dipole, this tool is added into an azimuthal transmitter station and a set of azimuthal receiver stations, all of which consist of eight piezoelectric vibrators in circumference to excite or acquire sonic waves. Our numerical simulation results show it can detect the heterogeneity of formations by using the measurement mode of azimuthal transmission and azimuthal reception that two types of P-wave with different velocities are found in the waveforms from some azimuths, but only one P-wave exists in other azimuths. Even two types of S-waves in one waveform are discovered when the formations are very hard. Similar phenomena for both P- and S-waves are also observed in field examples.

WEDNESDAY MORNING, 25 MAY 2016 SALON A, 8:00 A.M. TO 11:50 A.M.

Session 3aUW

Underwater Acoustics, Acoustical Oceanography, and Signal Processing in Acoustics: Sediment Characterization Using Direct and Inverse Techniques I

David P. Knobles, Cochair
none, KSA LLC, PO Box 27200, Austin, TX 78755

Preston S. Wilson, Cochair
Mech. Eng., Univ. of Texas at Austin, 1 University Station, C2200, Austin, TX 78712-0292

Chair's Introduction—8:00

Invited Papers

8:05

3aUW1. An overview of the Sediment Characterization Experiment 2015 survey cruise. Preston S. Wilson and David P. Kmobles (Dept. of Mech. Eng. and Appl. Res. Labs., The Univ. of Texas at Austin, 1 University Station, C2200, Austin, TX 78712-0292, pswilson@mail.utexas.edu)

The acoustics of fine grained marine sediments, how they impact shallow water acoustic propagation, and the use of inverse and statistical inference techniques for sediment characterization are being studied in this multi-year, multi-institutional project, which is focused on an area of the Southern New England continental shelf known as the New England Mud Patch. An overview of the first survey cruise associated with this project, which took place in July and August of 2015, will be presented. Measurements during that cruise included sub-bottom profiling and multi-beam bathymetry surveys of the experimental area, as well as CTD and gravity core, box core, and multicore sampling. A limited number of acoustic propagation measurements were made along with ship-board laboratory measurements of recovered sediment sound speed and attenuation measurements. A preliminary assessment of the presence and effect of ocean bottom biology was conducted. In this talk, an overview of the survey cruise will be presented. Later in the session, a number of other more detailed presentations on the individual measurements conducted during the survey will appear, along with talks on various other aspects of the acoustics of fine-grained marine sediments, and their impact on underwater acoustics. [Work supported by ONR.]

8:25

3aUW2. Oceanographic constraints on seafloor surveys of the New England continental shelf. Christian de Moustier (10dBx LLC, PO Box 81777, San Diego, CA 92138, cpm@ieee.org)

In July 2015, a seafloor survey of a 30 km x 10 km area of the New England continental shelf, centered at about 40.4750 N, 70.6030 W with an average depth of 74 m, highlighted constraints imposed by the locally dynamic oceanography. Variability in time and space of the water column in the survey area was observed in CTD casts, in underway temperature and salinity data, and in pervasive refraction correction errors symptomatic of internal waves. Depth profiles of temperature and practical salinity show evidence of sporadic continental slope water intrusion on the shelf between 50 m below sea level and the bottom. Underway data reveal a front responsible for an abrupt 10-m/s drop in sound speed along track at 5-m depth. Short of restricting soundings to ± 300 about nadir, there is no mitigation for seafloor surveying through internal waves because frequent sampling of the sound-speed profile along track, e.g., with an underway sound-speed profiling system, provides no information on the water masses on either side of the track, which if different due to internal waves cause refraction correction errors because the assumption of a local horizontally stratified water column is violated. [Work funded by ONR-32OA.]

8:45

3aUW3. Recent oceanographic variability and warming of the continental shelf south of New England and implications for acoustic propagation and sub-bottom characterization. Glen Gawarkiewicz (Woods Hole Oceanographic Inst., M.S. #21, Woods Hole, MA 02543, ggawarkiewicz@whoi.edu)

The continental shelf south of New England is a complex oceanographic environment for underwater acoustics. The combination of large seasonal changes in stratification, complicated frontal phenomena associated with the shelfbreak front, and small spatial scales of variability for soundspeed results in important effects on acoustic propagation and sub-bottom characterization. Two recent trends have also become important. Longer-term warming, on the decadal scale, is affecting shelf water temperatures and soundspeed profiles. In addition, from April 2014 to December 2015, there was a substantial influence on shelf water mass properties from Gulf Stream warm core rings impinging on the continental shelf. The rings also diverted the shelfbreak front onshore at times as well. Some implications for propagation and sub-bottom characterization will be discussed.

9:05

3aUW4. Preliminary characterization of surficial sediment acoustic properties and infauna in the New England Mud Patch. Kevin M. Lee, Megan S. Ballard (Appl. Res. Labs., The Univ. of Texas at Austin, 10000 Burnet Rd., Austin, TX 78758, klee@arlut.utexas.edu), Gabriel R. Venegas, Preston S. Wilson (Dept. of Mech. Eng. and Appl. Res. Labs., The Univ. of Texas at Austin, Austin, TX), Kelly M. Dorgan (Dauphin Island Sea Lab, Dauphin, AL), Allen H. Reed (Marine GeoSci. Div., Naval Res. Lab., Tennis Space Ctr., MS), and Ellen Roosen (Wood's Hole Oceanographic Inst., Wood's Hole, MA)

Biology is prevalent on and within many ocean bottom sediments. Organisms can include animals dwelling at or near the water-sediment interface or infauna living within surficial sediments. Bioturbation from burrowing, tube building, or other activities can have physical effects on the sediment acoustic properties. As part of the Sediment Characterization Experiment, a survey cruise was conducted in August 2015 in the New England Mud Patch, a region in the Atlantic continental shelf characterized by a layer of mud up to 12 m thick overlying a sandy subbottom. In addition to gravity coring operations to determine the properties of the mud layer, box cores and multicores were collected to examine the surficial sediment properties. Infauna were prevalent in the surficial sediment samples and were collected and characterized for body size, hardness, and potential for bioturbation or structuring. Shipboard measurements of shear and compressional waves were performed on the box core samples using time-of-flight measurements. Preliminary results from the infauna analysis and the shipboard acoustic measurements will be presented. [Work supported by ONR.]

Contributed Papers

9:25

3aUW5. Shipboard low frequency sound speed measurements in the New England Mud Patch. Gabriel R. Venegas, Preston S. Wilson (Dept. of Mech. Eng. and Appl. Res. Labs., Univ. of Texas at Austin, 204 E Dean Keeton St., Austin, TX 78712-1591, gvenegas@utexas.edu), Kevin M. Lee, Megan S. Ballard (Appl. Res. Labs., Austin, TX), Allen H. Reed (Marine GeoSci. Div., Naval Res. Lab., Austin, Texas), Ellen Roosen (Geology and Geophys. Dept., Woods Hole Oceanographic Inst., Woods Hole, MA), Daniel Ecker, Kyle Fringer, and Joseph P. Smith (Oceanogr. Dept., U. S. Naval Acad., Annapolis, MD)

Muddy ocean bottoms have been shown to be acoustically softer than the water column, presenting challenges in resolving inverse problems such as in remote parameter sensing and target detection. In addition, the acoustic properties of mud are less adequately understood compared to sandy sediments. As part of the Sediment Characterization Experiment, a survey cruise was conducted in August 2015 in the New England Mud Patch, in order to further study the acoustic properties of mud. In addition to gravity coring operations to determine the properties of the mud layer, box cores and multicores were collected to examine the surficial sediment properties. Samples were extracted from within the multicores and transferred to a resonator tube, where shipboard low frequency laboratory measurements of sound speed were performed. Before discarding the sample, it was perturbed and allowed to settle in the resonator over a period of two days, during which low frequency sound speed measurements were taken. Experimental challenges and preliminary results from the acoustic measurements and settling experiment will be presented. [Work supported by ONR.]

9:40

3aUW6. Estimation of sound speed and attenuation in mud sediments using combustive sound source signals measured on the New England continental shelf. Lin Wan, Mohsen Badiey (College of Earth, Ocean, and Environment, Univ. of Delaware, 104 Robinson Hall, 261 S. College Ave., Newark, DE 19716, wan@udel.edu), David Knobles (Knobles Sci. and Anal., LLC, Austin, TX), Preston Wilson (Appl. Res. Labs., Univ. of Texas at Austin, Austin, TX), and John Goff (Inst. for Geophys., Univ. of Texas at Austin, Austin, TX)

Acoustical measurements were made in coincidence with an environmental survey for future sediment characterization experiments in the mud patch region of the New England continental shelf from July 22 to August 3, 2015. One vertical line array (VLA) containing six hydrophones and 15

environmental sensors was deployed in 75-m water at the center of the survey (40.477°, −70.604°) in order to record noise data and the acoustic signals generated by the combustive sound source (CSS) [McNeese *et al*., J. Acoust. Soc. Am., 2014]. Fifteen CSS shots detonated at various ranges (2.5 km and 14.5 km) and depths (5 m, 10 m, and 20 m) were recorded by the VLA. The sub-bottom layering structure with a mud layer overlaying a sand bottom was obtained from the CHIRP sonar survey. This paper utilizes the modal dispersion characteristics to invert the sound speed in the bottom. Then, the sound attenuation in mud as a function of frequency is estimated using the transmission loss (TL) data. Measured modal dispersion curves are compared with modeled dispersion curves based on the inverted bottom acoustic parameters. [Work supported by ONR.]

9:55–10:10 Break

Invited Papers

10:10

3aUW7. Suggested methodology for direct and inverse characterization of marine sediments that contain mud. Allan D. Pierce (Retired, PO Box 339, 399 Quaker Meeting House Rd., East Sandwich, MA 02537, allanpierce@verizon.net), William L. Siegmann, and Elisabeth Brown (Mathematical Sci., Rensselaer Polytechnic Inst., Troy, NY)

Mud consists mostly of particles of clay minerals: kaolinite, illite, and smectite. Particles are hexagonally shaped platelets and have widths of the order of microns. In contrast, sandy/silty sediments are composed of silicate particles that are spheroidal is shape and have sizes of the order of millimeters. One distinction is that the platelets commonly carry electrical charges that repel each other. Relevant physics underlying their acoustic properties is considerably different than that for sandy/silty sediments. Naturally occurring mud also contains sandy/silty content, biological matter, and gaseous bubbles. The present paper discusses various techniques by which one can estimate quantitative information about mud sediments. Much can be learned from detailed geochemical analysis and microscopic observation of core samples, but enough is known about mud's general properties so that indirect methods can be used. These can estimate the density and sound speed as functions of depth into the sediment. The sound speed in mud is better approximated by the Mallock-Wood equations than for sandy/silty sediments. Density gradients in conjunction with statistical mechanics considerations yield information on how much of the mud is clay. Measurement of compressional wave attenuation can give information about the forces between platelets. [Work supported by ONR.]

10:30

3aUW8. Geoacoustic inference and the search for ground truth. Charles W. Holland (Appl. Res. Lab., The Penn State Univ., P.O. Box 30, State College, PA 16804, cwh10@psu.edu), Jan Dettmer, and Stan D. Dosso (School of Earth and Ocean Sci., Univ. of Victoria, Victoria, BC, Canada)

A variety of commercial, military, and scientific applications require knowledge of seabed properties. In the ocean acoustics community, the properties typically of interest are sound speed, density, and attenuation and sometimes shear speed and attenuation. Numerous approaches have been developed to estimate these by geoacoustic inference, i.e., by measuring a quantity (e.g., reflection coefficient, transmission loss, or pressure across a hydrophone array) and estimating the seabed properties from the data. Inference requires a large number of assumptions on the depth, range, and frequency dependencies of ocean and seabed properties. These assumptions are widely, and often necessarily, made with minimal supporting information. In cases where the actual physical seabed properties are of interest there is an important requirement to validate the result. Measurements on sediment cores are widely called "ground truth." However, these data frequently contain bias errors and exhibit rather large uncertainties, sometimes larger than those from geoacoustic inference. Here, difficulties and opportunities associated with collecting, conducting, and interpreting measurements on cores are discussed. Cores can be a useful independent measurement of sediment properties, but should not be termed as "ground truth." [Work supported by the Office of Naval Research and the Centre for Maritime Research and Experimentation.]

10:50

3aUW9. Marine sediment core collection methods and analytical techniques for shallow water sub-seafloor acoustic characterization. Jason D. Chaytor (U.S. Geological Survey, 384 Woods Hole Rd., Woods Hole, MA 02543, jchaytor@usgs.gov)

Collection of intact sub-seafloor sediment samples from aqueous environments requires a suite of coring and drilling tools that vary in complexity, size, and cost as a function of the location, thickness, and analysis requirements of the sediment to be recovered. In shallow water, continental shelf environments such as the Mud Patch offshore southern New England, piston-, gravity-, and vibra-coring techniques allow for the collection of continuous sediment cores that can exceed 10 m in length through a variety of fine- and coarse-grained sediments. Piston and gravity corers, which penetrate the seafloor through a combination of system weight and velocity, operate most effectively in clay and silt dominated materials, recovering relatively undisturbed cores suitable for a wide range of sedimentological, geotechnical, and acoustical analyses. Recovered cores proceed through a series of non-destructive and destructive testing stages to fully characterize the sediments, beginning with physical properties logging (e.g., wet bulk density, p-wave velocity, and magnetic susceptibility), visual stratigraphic description, shear-wave velocity, and photographic and x-ray/CT imaging. Laboratory testing of extracted sub-samples includes, but is not limited to, geotechnical index properties (e.g., water content, undrained shear strength, and density), grain size analysis, carbonate and organic material concentrations, and mineral content (via x-ray diffraction).

11:10

3aUW10. Estimation of shear wave properties using Scholte wave inversions. Gopu R. Potty and James H. Miller (Dept. of Ocean Eng., Univ. of Rhode Island, 115 Middleton Bldg., Narragansett, RI 02882, potty@egr.uri.edu)

Shear speeds in semi-consolidated and consolidated shallow water sediments can significantly impact compressional wave attenuation and arrival times of acoustic normal modes. One of the most promising approaches to estimate shear speed is to invert the shear speed profile using the dispersion of interface waves (Scholte waves). The propagation speed of the Scholte waves is closely related to the shear wave speed over a depth of 1–2 wavelengths into the seabed. A geophone system for the measurement of these interface waves, along with an inversion scheme that inverts the Scholte wave dispersion data for sediment shear speed profiles and shear attenuation has been developed. A forward model based on the dynamic stiffness method has been developed and implemented in the inversion. A new Interface Wave Sediment Profiler (iWaSP) is being currently developed for the measurement of bottom properties such as shear speed and attenuation in the top 1–2 m of a variety of sediment types (including mud) with a wideband, vibratory source, and accelerometers with bandwidth up to 1 kHz. Inversions using data from previous deployments will be presented and proposed experimental designs for the proposed seabed experiment will be discussed. [Work supported by Office of Naval Research.]

11:30

3aUW11. *In situ* measurements of sediment sound speed and attenuation in the frequency band of 0.5–10 kilohertz. Jie Yang (Acoust. Dept., APL-UW, 1013 NE 40th St., Seattle, WA 98105, jieyang@apl.washington.edu)

Knowledge of sediment sound speed and attenuation is crucial for predicting sound propagation. The sediment Acoustic-speed Measurement System (SAMS) was designed to measure frequency dependence of sound speed and attenuation within the surficial 3 m in the frequency band of 2–50 kHz. SAMS has two independent and interchangeable drill systems: one employs suction and the other a water jet. The suction system has minimal disturbance on the medium around the penetrating probe while the water jet system can help penetrate consolidated shell/sand layers. Depending on sediment types encountered, the two systems can be interchanged on site in less than 4 h. SAMS was successfully deployed during the Shallow Water 2006 experiment on the New Jersey continental shelf. It was also deployed during the Gulf Experiments 2011, 2012, and the Target and Reverberation Experiment 2013, all conducted off Panama City, FL, where sediment types range from mud to coarse sand. Sediment sound speed and attenuation results from the two experiments are presented. In preparation for the upcoming Seabed Characterization Experiment, the effort to extend measurements down to 500–1500 Hz, where dispersion is of particular importance, will be discussed as well. [Work supported by ONR.]

WEDNESDAY AFTERNOON, 25 MAY 2016 SALON B/C, 1:15 P.M. TO 3:00 P.M.

Session 3pAA

Architectural Acoustics: Relating Perception to Room Acoustics Measurements and Metrics in Performing Arts Venues II

Michelle C. Vigeant, Cochair
Graduate Program in Acoustics, The Pennsylvania State University, 201 Applied Science Bldg., University Park, PA 16802

Gregory A. Miller, Cochair
Threshold Acoustics, LLC, 53 W. Jackson Boulevard, Suite 815, Chicago, IL 60604

Chair's Introduction—1:15

Invited Papers

1:20

3pAA1. Comparison of assorted diffusive room conditions. Jay Bliefnick and Lily M. Wang (Durham School of Architectural Eng. and Construction, Univ. of Nebraska - Lincoln, 1110 S. 67th St., Omaha, NE 68182-0816, jbliefnick@huskers.unl.edu)

A number of objective metrics have been proposed to quantify diffusive conditions in rooms, but less has been discovered about how perception of diffusion links to those metrics. In this project room impulse responses from a range of diffusive room conditions were recorded in the Mocap variable acoustics facility at Columbia College Chicago, which features 1200 sq. ft. of reversible absorptive/diffusive panels. Modifications to these surfaces were implemented to conduct two tests under multiple wall configurations. The first test concentrated on a direct reflection off of a 16 ft. x 8 ft. test wall, which was progressively changed from fully absorptive to fully

diffusive. The second test utilized the entire facility by arranging the diffusers in multiple coverage percentages (10%–100%) and in three unique arrangements. A number of metrics have been calculated from the gathered impulse responses and compared, including those proposed to account for room diffusivity. Measured binaural room impulse responses are being used to generate auralizations for use in testing to discern when changes in the sound field become perceptible. Results to date will be presented.

1:40

3pAA2. Design consideration of sound diffusers for wall surfaces in concert halls. Jin Y. Jeon, Hyung S. Jang, and Hansol Lim (Dept. of Architectural Eng., Hanyang Univ., Seoul 133-791, South Korea, jyjeon@hanyang.ac.kr)

A wall diffuser has been designed for high scattering and diffusion coefficients using tenth-scale models. The diffuser profiles of the diffuser were designed based on using the Voronoi diagrams to create a randomized pattern with a plane surface with a particular structural height. The intaglio and embossed patterns of these profiles were compared by measuring the scattering and the diffusion coefficients. The intaglio diffusers showed higher scattering and diffusion coefficients than the embossed diffusers. Moreover, random arrays of the profiles presented resulted in higher scattering and diffusion coefficients than the sequential arrays ordered sequentially in terms of the profile in the structural height. The effects of diffusers on sound-field diffuseness were also investigated, and it was found that the diffusive surfaces tend to produce more diffused early reflections than the fine reflective surfaces.

2:00

3pAA3. Comparisons between room acoustics preferences of musicians and non-musicians regarding solo-instrument and orchestral motifs in auralizations. Martin S. Lawless (Graduate Program in Acoust., The Penn State Univ., 201 Appl. Sci. Bldg., University Park, PA 16802, msl224@psu.edu) and Michelle C. Vigeant (Graduate Program in Acoust., The Penn State Univ., University Park, New York)

Musicians are good candidates for room acoustics subjective testing since they regularly practice critical listening skills, but recent work suggests that non-musicians should also be included as the two groups may have diverse room acoustics preferences. A study was conducted to evaluate these two participant groups to ensure the representation of the entire population in room acoustics studies. The specific goal of the present work was to investigate preference differences between musicians and non-musicians in the evaluation of musical stimuli with varying reverberation time (RT). Preliminary data introduced at a prior meeting demonstrated that on average musicians and non-musicians displayed similar preference trends for auralizations of two solo-instrument motifs. However, a k-means clustering analysis revealed that a greater percentage of non-musicians exhibited statistically indistinct preference ratings across the stimuli, denoted as the "no preference" group. This result may indicate that non-musicians are not good candidates for room acoustics testing. The present study expands upon the preliminary work with additional participants that assessed both the solo-instrument motifs and two new orchestral motifs simulated in a concert hall with RT ranging from 0.0 to 7.2 s. The preference trends were also compared to the types of musicians tested.

2:20

3pAA4. Acoustical performance of a completely renovated music recital hall from subjective and objective points-of-view. Abigail Davis and Robert C. Coffeen (Architecture, Univ. of Kansas, Marvin Hall, 1465 Jayhawk Blvd., Lawrence, KS 66045, a849d414@ku.edu)

Swarthout Recital Hall located in Murphy Hall at the University of Kansas was initially constructed in the 1950s, with the original interior remaining largely intact until extensive renovations were completed in 2015. Two major complaints regarding the original hall were a lack of feedback from the hall to the performers onstage, and the acoustical coldness of the hall. With excellent cooperation between the School of Music Dean and the music faculty, the project architect, and the acoustic consultant and through the use of computer modeling, a new interior envelope was designed and interior materials selected which addressed these issues. In response, the renovated hall has received highly positive feedback from performers and patrons in both of these respects. This paper will address the measurable acoustic parameters of the renovated hall and how they correlate to both the digitally modeled versions of the hall and the hall acoustic perceptions by performers and audience.

2:40

3pAA5. Real & virtual: Lessons learned from modeling, measuring, and listening in a multi-purpose hall. William Chu and Brandon Cudequest (McKay Conant Hoover, 5655 LIindero Canyon Rd., Ste#325, Westlake Village, CA 91362, wchu@mchinc.com)

McKay Conant Hoover has guided a 2300-seat multipurpose venue through a series of modest renovations, each with tangible improvements, including expansion of the orchestra pit, provision for a proscenium eyebrow, reconfiguration and replacement of the orchestra shell, HVAC noise reduction, sidewall shaping, and finish selections to improve hall response for unamplified acoustics. However, much of the distinctive geometry of the hall by the renowned acoustician, Vern Knudsen, such as the broad, curved ceilings and walls, and the arching flying balcony, has remained unchanged since its opening in 1972. In 2014, an opportunity arose to investigate the acoustics of this space through a series of critical listening exercises, *in-situ* impulse response measurements, and virtual 3-D CATT modeling and auralizations. This paper will explore the challenges of comparing measured data, subjective preferences from actual music performances, computational model results, and listening tests through auralizations.

Session 3pAB

Animal Bioacoustics: Airborne/Automatic Animal Bioacoustics

Rolf Mueller, Chair
Mechanical Engineering, Virginia Tech, ICTAS Life Sciences District (Mail Code 0917), Virginia Tech, Blacksburg, VA 24061

Contributed Papers

1:30

3pAB1. Asymmetric multi-frequency biosonar beam pattern of tongue-clicking bat, *Rousettus aegyptiacus*. Wu-Jung Lee (Appl. Phys. Lab., Univ. of Washington, 1013 NE 40th St., Seattle, WA 98105, wjlee@apl.washington.edu), Benjamin Falk, Chen Chiu, Anand Krishnan, and Cynthia F. Moss (Dept. of Psychol. and Brain Sci., Johns Hopkins Univ., Baltimore, MD)

The beam pattern of sonar signals emitted by echolocating animals, such as bats and toothed whales, directly influences the acoustic information available for guiding task-specific behaviors. The lingual echolocating bat, *Rousettus aegyptiacus*, emits broadband transient sonar clicks that resemble those of dolphins. The clicks are emitted in left-right pairs, with the maximum intensity slope of each signal pointing toward the target during navigation. However, detailed beam pattern characteristics of these lingual sonar clicks remain unknown. Using a loosely populated three-dimensional microphone array, we systematically characterize the multi-frequency beam structure of *R. aegyptiacus* in the entire azimuth-elevation domain. The bat's head aim was recorded by an infrared high-speed motion-capture camera system. We show that the sonar beam of *R. aegyptiacus* tongue clicks is vertically elongated and exhibits an unusual multi-frequency structure that has not been described previously in the literature. Specifically, the high-intensity portion of the beam shifts medial in azimuth from the left and right click directions and downward in elevation with increasing frequency. Combined with close-up videos of mouth movement as the bats click, these results suggest a more sophisticated beam formation and steering mechanism than conventional simple aperture models.

1:45

3pAB2. A biomimetic perspective on the dynamics in horseshoe bat biosonar. Rolf Müller (Mech. Eng., Virginia Tech, ICTAS Life Sci. District (Mail Code 0917), Virginia Tech, Blacksburg, VA 24061, rolf.mueller@vt.edu), Joseph Sutlive (Translational Biology, Medicine, and Health, Virginia Tech, Blacksburg, VA), Philip Caspers (Mech. Eng., Virginia Tech, Blacksburg, VA), and Yanqing Fu (Biomedical Eng. and Mech., Virginia Tech, Blacksburg, VA)

Research with behaving horseshoe bats has suggested that the animals' biosonar system is characterized by pervasive dynamics at the interfaces for ultrasound emission and reception. Baffle shapes that diffract the outgoing and incoming ultrasonic pulses change their geometries during emission and reception. However, it remains unclear if and how this dynamics could affect the function of bats' biosonar system. To investigate this question, biomimetic reproduction of this peripheral dynamics have been used to obtain system characterizations as well as echo recordings. The data obtained with these biomimetic sonar systems have yielded the following key results: If the static and dynamic geometries of the diffracting baffles as well as their coupling to the transducers is suitable, time-variant device characteristics can be produced—even for small and geometrically simple changes to the shapes. These characteristics depend on direction and frequency (like a static beampattern) as well as on time. Furthermore, the time-variant device characteristics were found to result in likewise time-variant signatures imposed on echoes from targets with simple geometries as well as natural targets such as foliages. It remains to be investigated whether and how horseshoe bats could make use of these time-variant echo signatures for the encoding of sensory information.

2:00

3pAB3. Quantifying the noseleaf and pulse dynamics in rhinolophid and hipposiderid bats. Luhui Yang, Liujun Zhang, Ru Zhang (Shandong Univ. - Virginia Tech Int.. Lab., Shandong Univ., Shanda South Rd. 27, Jinan, Shandong 250100, China, 913022794@qq.com), and Rolf Müller (Mech. Eng., Virginia Tech, Blacksburg, VA)

Horseshoe bats (Rhinolophidae) and Old-World leaf-nosed bats (Hipposideridae) are two related bat families that emit their biosonar pulses nasally and diffract the outgoing wave-packets with elaborate baffle shapes ("noseleaves"). Since the noseleaf surfaces are frequently in motion during pulse emission, an experimental setup has been established to characterize the dynamics in their geometry in conjunction with the effects that this dynamics may have on the ultrasonic pulses. To achieve this goal, greater horseshoe bats (*Rhinolophus ferrumequinum*), great roundleaf bats (*Hipposideros armiger*), and Pratt's roundleaf bats (*Hipposideros pratti*) were trained to emit biosonar pulses while seated on a platform. At least 10 landmarks were placed on the noseleaves of the animals to track the dynamic geometry of these structures with an array of four high-speed video cameras (frame rate 400 Hz). Pairs of video frames were used to reconstruct the 3d trajectories of the noseleaf landmarks, and from these trajectories, shape changes were assessed based on point-distances and measures derived from them. The emitted ultrasonic pulses were measured as a function of direction with a cross-shaped array of ultrasonic microphones. The dynamics in pulse waveforms that were emitted concurrent with noseleaf motions was assessed using correlation and variability measures within and across channels.

2:15

3pAB4. Automatic fish sounds classification. Marielle Malfante, Mauro Dalla Mura, Jerome I. Mars (GIPSA-Lab, UGA, 11 rue des Mathematiques, Grenoble 38402, France, marielle.malfante@gipsa-lab.grenoble-inp.fr), and Cedric Gervaise (Chaire CHORUS, Fondation Grenoble-INP, Grenoble, France)

The context of this work is environmental monitoring. Specifically, we focus on acoustic systems for monitoring fish populations. By investigating the recorded sounds of fishes, it is possible to monitor the spatial and temporal evolution of fish populations. The aim of this work is to present an automatic fish sounds classification system. The solution we propose is new and based upon supervised machine learning (in particular, classification is performed by Random Forest). The features used in input of the learning algorithm come from an extensive state of the art in various domains of classification such as speech, music, animal calls, environmental acoustic landscape, and human induced noises. Our system is trained and tested on nighttime recordings from a 20 m depth seagrass habitat (Calvi, Corsica, France). From this study, we propose to consider 66 different features

(shape and/or statistical description in time and frequency). Fish sounds are automatically classified into four different classes (drums, grunt, impulse, and FM), and our system reaches 94% of correct classification rate compared to 77% when considering MFFC features. In order to deal with large datasets and to study the evolution of fish populations, we are currently developing an approach based on dynamic classification with rejection (negative class).

2:30

3pAB5. Animal aeroacoustics: Fluttering feathers and humming hummingbird wings. Christopher J. Clark and Emily Mistick (Dept. of Biology, Univ. of California Riverside, Riverside, CA 92521, cclark@ucr.edu)

Hummingbirds are so-named for the humming sounds their wings produce in flight. We review prior research on aerodynamic mechanisms that produce hummingbird wing sounds, such as aeroelastic flutter. We then present a new aeroacoustic model of the humming of hummingbird wings. This model was tested over a range of flight speeds on hummingbirds flying in an acoustic wind tunnel, and filming them with an Optinav acoustic camera. Possible implications of this model for the sounds produced by micro-air vehicles ("drones") are discussed.

WEDNESDAY AFTERNOON, 25 MAY 2016 SALON H, 1:00 P.M. TO 2:55 P.M.

Session 3pBA

Biomedical Acoustics: Focused Ultrasound for Brain Treatments

Nathan McDannold, Cochair
Radiology, Brigham and Women, 75 Francis St., Boston, MA

Kullervo Hynynen, Cochair
Medical Biophysics, University of Toronto, Sunnybrook Health Sciences Centre, Toronto, ON M4N 3M5, Canada

Chair's Introduction—1:00

Invited Papers

1:05

3pBA1. Acoustically controlled ultrasound-mediated drug delivery to the central nervous system. Meaghan A. O'Reilly, Ryan M. Jones, Olivia Hough, and Kullervo Hynynen (Sunnybrook Res. Inst., 2075 Bayview Ave., Rm. C713, Toronto, ON M4N3M5, Canada, moreilly@sri.utoronto.ca)

The barriers of the central nervous system (CNS), including the blood-brain barrier (BBB) and blood-spinal cord barrier ((BSCB), prevent most drugs from reaching therapeutically significant concentrations in these tissues. Thus, the BBB and BSCB are significant obstacles in the treatment of CNS disorders. When combined with microbubbles, ultrasound can be used to transiently open these barriers to facilitate the delivery of drug, gene and cell therapies. There exists a regime of microbubble excitation where a completely reversible opening effect can be achieved without damaging the tissue. We, and others, have previously presented methods to control the acoustic exposures during treatment to target this regime, and thus ensure efficacy and safety. This talk will present recent work in ultrasound-mediated drug delivery to the CNS. New findings of the role of microbubble emissions in controlling these exposures will be discussed, including dose-dependency and the temporal characteristics of stable cavitation signatures.

1:25

3pBA2. Transcranial thermal ablation with a 230 kHz MRI-guided focused ultrasound system in a large animal mode. Nathan McDannold, Jonathan Sutton, Natalia Vykhodtseva (Radiology, Brigham and Women, 75 Francis St., Boston, MA, njm@bwh.harvard.edu), and Margaret Livingstone (Neurobiology, Harvard Med. School, Boston, MA)

We evaluated the feasibility of thermal ablation in using a 230 kHz transcranial MRI-guided Focused Ultrasound (TcMRgFUS) system in three rhesus macaques. Thalamic targets were sonicated at 40–50s at 90–560 acoustic Watts. Focal heating sufficient to create an MRI-evident lesion was achieved in 4/6 targets where thermal dose exceeded 240 CEM43°C. Focal heating increased linearly as a function of the applied energy at a rate of 3.2 ± 0.4°C/kJ (R^2:0.81). Lesion sizes were consistent with 240 CEM43°C contours. The findings suggest that the lesions were consistent with thermal mechanisms. No evidence of cavitation-related petechiae were evident after sonication. Similar tests in macaques with a version of this system operating at 670 kHz (Hynynen *et al*., Eur. J. Radiol. 2006) measured skull-induced heating of 130°C/kJ/cm^2 of outer skull surface, more than twice of that measured here (63°C per kJ/cm^2). While no or minimal focal heating was observed at 670 kHz, we reached ablation-level thermal dose values at 230 kHz. Thus, these preliminary results thus suggest that this low frequency system can expand the "treatment envelope" for TcMRgFUS.

1:45

3pBA3. Neuroprotection and neurorestoration through the opened blood-brain barrier using focused ultrasound and microbubbles. Elisa Konofagou (Columbia Univ., 1210 Amsterdam Ave., ET351, New York, NY 10027, ek2191@columbia.edu)

After cancer and heart disease, neurodegenerative diseases, such as Alzheimer's, Parkinson's, multiple sclerosis (MS) and amyotrophic lateral sclerosis (ALS), take more lives each year than any other illness. Although some effective treatments are available, most of those diseases remain undertreated. The blood-brain barrier (BBB) has been proclaimed as the "bottleneck" of brain drug delivery. Focused ultrasound (FUS) in conjunction with microbubbles is currently the only technique that can open the BBB locally, transiently, and noninvasively. Our group has demonstrated that pharmacological compounds of variable sizes can not only traverse the BBB but also induce therapeutic effects in the presence of neurodegenerative disease. In this paper, the trans-BBB neurotherapeutic delivery with FUS is shown to **(1)** be safely facilitated within a specific pressure range in both mice and non-human primates through the mechanism of cavitation, **(2)** be controlled through the pressure amplitude and microbubble characteristics, **(3)** induce downstream signaling effects in the neuronal cell, **(4)** trigger neuroprotection and neurorestoration relevant in the treatment of neurodegeneration, **(5)** be localized and monitored in real time through cavitation monitoring and mapping. BBB opening is combined with systemic administration of neurotrophic molecules or adeno-associated viruses that allow for neuronal protection and growth in the BBB-opened regions.

2:05

3pBA4. Performance of a simulation-based phase aberration correction technique in transcranial ultrasound modeling. Douglas Christensen (BioEng., Univ. of Utah, 50 So Central Campus Dr., Salt Lake City, UT 84112, christen@ee.utah.edu), Dennis Parker (Utah Ctr. for Adv. Imaging Res., Univ. of Utah, Salt Lake City, UT), and Scott Almquist (School of Computing, Univ. of Utah, Salt Lake City, UT)

Due to its irregular geometry and acoustic properties, the presence of the skull in transcranial focused ultrasound therapies can lead to considerable beam phase aberration, resulting in distorted focal spots. There are several possible techniques for correcting this phase aberration with a phased-array transducer, the most accurate of which (although invasive) is hydrophone-based time reversal. There are also simulation-based approaches, and here we exploit the time-advantages of the Hybrid Angular Spectrum (HAS) numerical method and apply it to two models of the skull: a 3D-printed plastic skull analog and a segment of a human skull for which a CT scan has been obtained. We compare the focused pressure patterns—obtained via hydrophone scans—for the cases of no phase correction, hydrophone-based phase correction, and simulation-based (HAS) phase correction. We show the degree to which the correction methods improve the focal spot quality, pressure amplitude, and localization accuracy. The very good results for the analog model compared to results for the skull segment indicate that better mapping of CT Hounsfield units to acoustic properties of the bone is needed. In addition, we use the simulation technique to predict the effects of beam steering and transducer/model misregistration on the effectiveness of aberration correction.

Contributed Papers

2:25

3pBA5. Computation of ultrasonic pressure fields in feline brain. Nazanin Omidi, Cecille Labuda, and Charles C. Church (Dept. of Phys. and Astronomy and National Ctr. for Physical Acoust., The Univ. of MS, 145 Hill Dr., P.O. Box 1848, University, MS 38677-1848, nomidi@go.olemiss.edu)

In 1975, Dunn *et al.* (JASA **58**, 512–514) showed that a simple relation describes the ultrasonic threshold for cavitation-induced changes in the mammalian brain. The thresholds for tissue damage were estimated for a variety of acoustic parameters in exposed feline brain. The goal of this study was to improve the estimates for acoustic pressures and intensities present *in vivo* during experimental exposures rather than estimating them using linear theory. In our current project, the acoustic pressure waveforms produced in the brains of anesthetized felines were numerically simulated for a spherically focused, nominally f1-transducer (focal length = 13 cm) at increasing values of the source pressure at frequencies of 1, 3, and 9 MHz. The corresponding focal intensities were correlated with the experimental data of Dunn *et al.* The focal pressure waveforms were also computed at the location of the true maximum. For low source pressures, the computed waveforms were the same as those determined using linear theory, and the focal intensities matched experimentally determined values. For higher source pressures, the focal pressure waveforms became increasingly distorted; similar results were obtained with increasing frequency.

2:40

3pBA6. Phased array techniques for multiple focus synthesis in transcranial focused ultrasound. Alec Hughes and Kullervo Hynynen (Dept. of Medical Biophys., Univ. of Toronto, 101 College St., Rm. 15-701, Toronto, ON M5G 1L7, Canada, ahughes@sri.utoronto.ca)

Recent clinical successes of transcranial focused ultrasound have occurred in the treatments of essential tremor, neuropathic pain, and Parkinson's disease, among others. We will present results of an investigation into the synthesis of multiple foci using iterative steering through multiple points and phased array controls for multiple focus acoustic patterns. In this numerical study, exported computed tomography (CT) imaging data of the skull was segmented and positioned inside a hemispherical phased array. A combination of full-wave and ray acoustic models were used to simulate the calculation of phased array controls and the resultant acoustic field. Using techniques from previous work on simultaneous multiple focus synthesis and rapidly steered foci in homogeneous media, it is shown that it is possible to elevate the temperature in the brain to therapeutic hyperthermia levels. In addition, potential applications for microbubble-mediated therapies using these techniques are discussed. These results indicate that transcranial hyperthermia over large volumes using focused ultrasound is possible and may have applications to future thermal therapies.

Session 3pID

Interdisciplinary: Hot Topics in Acoustics

Frederick J. Gallun, Chair
National Center for Rehabilitative Auditory Research, VA Portland Health Care System, 3710 SW US Veterans Hospital Rd., Portland, OR 97239

Chair's Introduction—1:30

Invited Papers

1:35

3pID1. Acoustics on YouTube: Using the internet to improve and inspire learning. Michael B. Wilson (Phys., North Carolina State Univ., 247 RidDC Hall, Raleigh, NC 27695, mbwilson@ncsu.edu)

More people have access to more information than ever before, and programs are organizing and providing educational content for free to millions of internet users worldwide. Popular video, blog, and social media websites have creators devoted to engaging an audience through education. This content ranges from interesting facts and demonstrations that introduce a topic to entire university courses. While styles and target audiences vary greatly, the focus is education, clarifying misconceptions, and sparking an interest in learning. Presented will be a survey of current online education, resources, and outreach, as well as ways the acoustics community can get involved in improving education in and out of the classroom.

1:55

3pID2. The state of the art in worship space acoustics. David T. Bradley (Phys. + Astronomy, Vassar College, 124 Raymond Ave., #745, Poughkeepsie, NY 12604, dabradley@vassar.edu), Erica E. Ryherd (Durham School of Architectural Eng. & Construction, Univ. of Nebraska - Lincoln, Omaha, NE), and Lauren M. Ronsse (Audio Arts & Acoust. Dept., Columbia College Chicago, Chicago, IL)

Thoughtful acoustic design is essential for creating a worship experience full of awe and wonder. Worship space acousticians must grapple with differing acoustic requirements for speech and music, including a diversity of typologies across religions, cultures, and regions. Even a single worship space may require multi-functionality if used for a variety of service types or events. In addition to supporting the speech and/or music delivered as part of a service, the space must be supportive of congregant participation—ranging from lively exaltation to quiet reflection. The result is a richly complex and diverse set of acoustic approaches in the realm of worship space design. The new book, *Worship Space Acoustics: 3 Decades of Design* (Eds. Bradley, Ryherd, + Ronsse, Springer/ASA Press, 2016) provides a wide-ranging tour through churches, synagogues, mosques, and other worship spaces designed during the past 30 years. Acoustical consulting firms, architects, and worship space designers from across the world contributed their recent innovative works, including detailed renderings and architectural drawings, acoustic data graphs, and space descriptions. The content paints a picture of key worship space acoustic design goals and strategies from the last three decades. Case studies and overall themes from the book will be presented.

2:15

3pID3. An example of dissociation between speech intelligibility and perceived reverberation. Pavel Zahorik and Gregory M. Ellis (Dept. of Otolaryngol. and Communicative Disord. & Dept. of Psychol. and Brain Sci., Univ. of Louisville, Louisville, KY 40292, pavel.zahorik@louisville.edu)

It is well known that reverberation can affect the intelligibility of speech. Psychophysical and computational results have demonstrated that the relationship is inverse: an increase in the amount of reverberation results in a decrease in intelligibility. From the architectural acoustics literature, it is also well known that there is a direct relationship between the physical amount of reverberation and perceived reverberation. It therefore might be assumed that perceived reverberation and intelligibility are inversely related, although here a situation is demonstrated in which the two are effectively independent of one another. Using virtual auditory space techniques to simulate reverberant sound field listening, it is shown that when reverberant sound level is artificially decreased in the ipsilateral ear and naturally preserved in the contralateral ear, perceived reverberation is unaffected, but speech intelligibility is markedly improved. This dissociation likely results from the differential monaural and binaural aspects of reverberation, and is consistent with the idea that perceived reverberation is multidimensional. These results also suggest a potential binaural approach to the application of improving speech intelligibility in reverberation that does not limit the positive sound quality benefits of reverberation.

2:35

3pID4. Detailed measurements on lingual organ pipes for developing innovative methods and software for the pipe design. Judit Angster (Acoust., Fraunhofer IBP, Nobel Str. 12., Stuttgart, 70569, Germany, Judit.Angster@ibp.fraunhofer.de), Peter Rucz (Dept. of Networked Systems and Services, Budapest Univ. of Technol. and Economics, Budapest, Hungary), and Andras Miklos (Steinbeis Transfer Ctr. of Appl. Acoust., Stuttgart, Germany)

Within the framework of a European research project exciting new results have been achieved recently in the research of lingual organ pipes. The main objectives of the project are to solve practical problems of the dimensioning of reed organ pipes, to develop innovative methods and software for helping the sound design work of organ builder enterprises. A better understanding of the role of the shallot and resonator on the attack and the timbre of reed pipes is necessary for this reason. Visualization of reed motion by high speed camera and measurements of reed velocity, wind pressure in the boot and shallot, and sound pressure in the shallot and at the end of the resonator have revealed interesting details about the very complex process of sound generation of lingual organ pipes. These experiments have been carried out in close cooperation with the participating organ builder firms. As examples, a few results of the measurements of Crumhorn and Vox Humana pipes are presented. These results, combined with computer simulations of resonators, can be used for optimizing shallots and resonators. Moreover, the extended knowledge of sound generation can serve as a physical model of sound synthesis.

WEDNESDAY AFTERNOON, 25 MAY 2016 SALON J, 1:15 P.M. TO 2:45 P.M.

Session 3pPA

Physical Acoustics: Atmospheric Acoustic Phenomena II

JohnPaul R. Abbott, Cochair
Department of Physics and Astronomy, National Center for Physical Acoustics, University of Mississippi, 1 Coliseum Dr., Room 1044, Oxford, MS 38677

Gregory Lyons, Cochair
Aeroacoustics, National Center for Physical Acoustics, University, MS 38677-1848

3p WED. PM

Contributed Papers

1:15

3pPA1. Sound transmission measurements through porous screens. Sarah M. Young, Brian E. Anderson (Dept. of Phys. and Astronomy, Brigham Young Univ., BYU, N283 ESC, Provo, UT 84602, sarahmyoung24@gmail.com), Nicholas B. Morrill (Precision Membranes, Provo, UT), Robert C. Davis, and Richard R. Vanfleet (Dept. of Phys. and Astronomy, Brigham Young Univ., Provo, UT)

The two microphone transfer function technique is used to measure sound transmission properties of porous screens or membranes in a plane wave tube. This presentation will compare sound transmission of porous screens from several manufacturers. Measurements are made with two different plane wave tubes, one of diameter 10.2 cm to measure frequencies between 100 Hz and 2 kHz, and the other of diameter 1.3 cm to measure frequencies between 2 kHz and 16 kHz. Special considerations are made to account for the intrinsic losses in the smaller diameter tube.

1:30

3pPA2. A highly portable, lightweight windscreen for infrasound sensors. William G. Frazier (Hyperion Technol. Group, Inc., 3248 West Jackson St., Tupelo, MS 38804, gfrazier@hyperiontg.com) and David Harris (Hyperion Technol. Group, Inc., Tueplo, MS)

It is often desired to deploy infrasound sensors in remote locations for short periods of time. Because of noise created by wind flow past the sensor in the atmosphere at infrasound frequencies, it is also desirable to employ a mechanical windscreen with the goal of reducing the effect of the wind so as to enhance the acoustic signal-to-noise ratio. One of the challenges in wind screen design for temporary applications is to achieve reasonable portability in addition to adequate wind noise filtering. In this presentation, we report the performance a new windscreen design that is highly portable and that achieves performance on par with a commonly used dome-shaped windscreen. Performance comparisons of this newly designed windscreen, a typical porous hose windscreen, and a commonly used dome windscreen are investigated. Specifically, wind noise reduction of these three windscreens compared with a un-screened sensor are presented as a function of frequency and wavenumber using the measured wind speed as a proxy for wave speed. Additionally, acoustic signal noise attenuation is also examined so as to compare signal-to-noise ratio gains. This investigation is similar to the one presented by Alberts, Ludwig, and Talmadge (J. Acoust. Soc. Am. **137**, 2261 (2015)) for other small windscreens.

1:45

3pPA3. Using the Matérn covariance function to enhance detection and estimation of transient infrasound. William G. Frazier (Hyperion Technol. Group, Inc., 3248 West Jackson St., Tupelo, MS 38804, gfrazier@hyperiontg.com)

Adaptive filtering techniques are well known to enhance detection of anomolous events in the presence of slowly changing (quasi-stationary), autocorrelated noise backgrounds such as those occurring in measurements of infrasound signals in the atmosphere. The noise in this case is dominated by the effect of the turbulent wind blowing over the sensing element. While mechanical windscreens can provide significant signal-to-noise ratio gains,

additional benefits can be obtained by employing adaptive filters. In this presentation, a kernel-based adaptive filter based on the Matérn Covariance Function is demonstrated to improve the probability of detection of transient infrasound signals as well as improve signal estimation errors without increasing false alarm rates in the presence of wind noise. The choice of the Matérn Covaraiance Function to represent the wind noise process is motivated by its roots in fractional-order stochastic differential equations. Because the wind noise at infrasound frequencies can be influenced by shear-turbulence interaction and turbulence-turbulence interaction more than one kernel is required to obtain optimal performance for the filter. Results are presented under a range wind noise conditions.

2:00

3pPA4. Calculated wind noise for semi-porous fabric domes. JohnPaul R. Abbott (NCPA, Univ. of MS, 100 Bureau Dr. Stop 8361, Gaithersburg, MD 20899-8361, johnpaul.abbott@gmail.com), Richard Raspet (Dept. of Phys. and Astronomy, National Ctr. for Physical Acoust., Univ. of MS, Oxford, MS), John Noble, W. C. Kirkpatrick Alberts, and Sandra Collier (US Army Res. Lab., Adelphi, MD)

A simple calculation of the wind noise measured at the center of three 2 m diameter semi-porous fabric domes is developed. The calculation provides a model of the measured wind noise and is based on the model for a large porous wind fence enclosure. The model combines the wind noise contributions from (a) the turbulence-turbulence and turbulence-shear interactions inside the domes, (b) the turbulence interactions on the surface of the domes, and (c) the turbulence-shear interactions outside of the domes. Each wind noise contribution is calculated from the appropriate measured turbulence spectra, velocity profiles, correlation lengths, and the mean velocity at the center, surface, and outside of the enclosure. The model is verified by comparisons of the measured wind noise to the calculated estimates of the differing noise contributions and their sum. The calculated estimates indicate that the principle source of low frequency wind noise at the center of the domes is due to the turbulence interactions on the surface of the domes while the turbulence interactions inside the domes and outside of the domes are minimal, and in some cases negligible.

2:15

3pPA5. An acoustic model of NIST's long-wavelength acoustic flowmeter for gas flow in large-diameter pipes. JohnPaul R. Abbott (National Ctr. for Physical Acoust., Univ. of MS, Oxford, MS), Keith A. Gillis (National Inst. of Standards and Technol., 100 Bureau Dr. STOP 8360, Gaithersburg, MD 20899-8360, keith.gillis@nist.gov), Lee J. Gorny (None, Mountain View, CA), and Michael R. Moldover (National Inst. of Standards and Technol., Gaithersburg, MD)

NIST is investigating long-wavelength acoustic flowmeter (LWAF) technology to accurately measure gas flow in large-diameter pipes, such as smokestacks used by coal-burning power plants. To aid in the data analysis and development of the method, we constructed a lumped-element acoustic model of the LWAF based on existing theory for sound propagation in circular ducts, modified to include flow. The model calculates the ratio of the acoustic pressure amplitudes and phase differences between two locations in a partial standing wave downstream of a continuous sound source up to the duct's cut-on frequency. We used the numerical calculations of the reflection coefficient by Munt [J. Sound Vibration **142**, 413–436 (1990)] to model the radiation impedance as a function of flow speed. In the absence of flow, the model was used to calibrate the positions of several microphones in the LWAF. In the presence of flow, the model predicts qualitatively the measured amplitude ratios and phase differences as a function of flow rate. Quantitative comparison is limited by the uncertainty of the radiation impedance and its flow dependence. This limitation prompts us to investigate ways to either measure the radiation impedance or eliminate it by using multiple coherent sound sources.

2:30

3pPA6. Feasibility of a long-wavelength acoustic flowmeter for measuring smokestack emissions. John Paul R. Abbott (National Ctr. for Physical Acoust., Univ. of MS, 1 Coliseum Dr., Rm. 1044, Oxford, MS 38677, johnpaul.abbott@gmail.com), Keith A. Gillis (National Inst. of Standards and Technol., Gaithersburg, MD), Lee J. Gorny (None, Mountain View, CA), and Michael R. Moldover (National Inst. of Standards and Technol., Gaithersburg, MD)

Conventional gas flow measurements in large ducts, such as power plant smokestacks, have uncertainties of 5–20%. As part of its Greenhouse Gas and Climate Science Measurements Program, the National Institute of Standards and Technology (NIST) is testing long-wavelength acoustic flowmeters (LWAFs) as an alternative method to reduce this uncertainty. A LWAF uses the Doppler Effect to determine the speed of sound c and the average flow speed V. Theory predicts that, for plane waves in a duct, corrections due to flow irregularities, such as swirl and turbulence, are proportional to $(V/c)^2$ £ 0.01. To investigate the feasibility of using an LWAF in a smokestack, we constructed a 1:100 scale model (10 cm diameter) test facility that generated flows up to 25 m/s using ambient air. The model LWAF simultaneously determined the speed of sound in air with a standard uncertainty of 0.01%, relative to NIST's standard reference database, and measured the average flow velocity with a standard uncertainty of $\pm 1\%$ relative to a NIST-calibrated flow standard upstream from the LWAF. Similar results were obtained when the flows were highly distorted by elbows and obstructions, or when water was sprayed into the air, and for flows through larger diameter model LWAFs.

Session 3pPP

Psychological and Physiological Acoustics: Beyond the Audiogram: Influence of Supra-Threshold Deficits

Agnes C. Leger, Cochair
School of Psychology, University of Manchester, Ellen Wilkinson Building, Oxford Road, Manchester M13 9PL, United Kingdom

Christopher Plack, Cochair
School of Psychological Sciences, University of Manchester, Ellen Wilkinson Building, Oxford Road, Manchester M13 9PL, United Kingdom

Chair's Introduction—1:00

Invited Papers

1:05

3pPP1. Spectrotemporal modulation sensitivity as a predictor of speech intelligibility in noise for hearing-impaired listeners. Joshua G. Bernstein (National Military Audiol. and Speech Pathol. Ctr., Walter Reed National Military Medical Ctr., 8901 Wisconsin Ave., Bethesda, MD 20889, joshua.g.bernstein.civ@mail.mil)

The audiogram accounts for only a portion of the variance in speech-reception performance in noise for hearing-impaired listeners. The remaining variance is often attributed to a combination of suprathreshold auditory distortion and non-auditory factors such as cognitive processing. This talk describes a series of studies demonstrating that a suprathreshold measure of sensitivity to spectro-temporal modulation (STM) can account for individual differences in speech-reception scores that are not predicted by the audiogram. STM stimuli are spectrally rippled noises with spectral-peak frequencies that shift over time, akin to modulations in a speech signal. The results show that STM sensitivity correlates to speech-reception performance in noise; that the correlation is ascribed mainly to the low-frequency portion of the stimulus (<2 kHz); and that STM sensitivity can account for individual differences in speech-reception thresholds for hearing-impaired listeners properly fit with individualized frequency-dependent gain. Hearing loss has the largest impact on STM sensitivity for low temporal rates and low carrier frequencies, suggesting a reduced ability to use temporal fine-structure information to detect slow-moving spectral peaks. STM detection is a fast, simple test of suprathreshold auditory function that complements the high-frequency audiogram to account for a substantial proportion of individual variability in speech reception in noise.

1:35

3pPP2. Differential effects of noise trauma and diminished endocochlear potential on neural temporal coding of complex sounds: Implications for speech perception. Kenneth S. Henry (Biomedical Eng., Univ. of Rochester, 601 Elmwood Ave., Box 603, Rochester, NY 14642, kenneth_henry@urmc.rochester.edu) and Michael G. Heinz (Speech, Lang., and Hearing Sci., Purdue Univ., West Lafayette, IN)

Communication problems due to cochlear hearing loss are pervasive in today's society, even with amplification from digital hearing aids. Threshold elevation may arise from noise-induced trauma to hair cells or, as an alternative mechanism, through age-related depletion of the endocochlear potential (EP; the power supply driving hair-cell function). While both noise trauma and diminished EP may frequently underlie hearing loss in older people, it is unclear whether these pathologies have different effects on neural coding of complex sounds, and ultimately, on speech perception. Here, we describe several recent neurophysiological studies of this question based on Wiener-kernel analyses of chinchilla auditory-nerve fiber responses to Gaussian noise. We find that noise trauma causes pronounced distortions in tonotopic coding of temporal fine structure and slower envelope cues, occurring with as little as 20 dB threshold elevation. Similar changes in neural coding occur with diminished EP, but only when thresholds exceed 60–70 dB SPL. More pronounced changes in temporal coding with noise trauma compared to diminished EP are likely to translate into greater deficits in speech perception (e.g., for noise-induced compared to age-related hearing loss). These results may help explain differences in speech perception abilities across individuals with the same degree of threshold elevation.

2:05

3pPP3. Investigating the role of supra-threshold auditory processing and cognitive abilities in presbyacusis. Christian Fullgrabe (Inst. of Hearing Res., Medical Res. Council, Sci. Rd., Nottingham NG7 2RD, United Kingdom, c.fullgrabe@ihr.mrc.ac.uk)

Anecdotal evidence and experimental investigations indicate that older people experience increased speech-perception difficulties, especially in noisy environments. Since peripheral hearing sensitivity declines with age, lower speech intelligibility can often be explained by a reduction in audibility. However, aided speech-perception in hearing-impaired listeners frequently falls short of the

performance level that would be expected based on the audibility of the speech signal. Given that many of these listeners are older, poor performance may be partly caused by age-related changes in supra-threshold auditory and/or cognitive processes that are not captured by an audiometric assessment. The presentation will discuss experimental evidence obtained from clinically normal-hearing adult listeners showing that auditory temporal processing, cognition, and speech-in-noise perception are indeed linked and, independently of hearing loss, decline across the adult lifespan. These findings highlight the need to take into account audibility-unrelated factors in the prediction and rehabilitation of speech intelligibility across adulthood.

2:35

3pPP4. Evidence that hidden hearing loss does not vary systematically as a function of noise exposure in young adults with normal audiometric hearing. Garreth Prendergast, Hannah Guest, Agnès Léger, Kevin Munro, Karolina Kluk, and Christopher Plack (School of Psychol. Sci., Univ. of Manchester, Ellen Wilkinson Bldg., Oxford Rd., Manchester M13 9PL, United Kingdom, chris.plack@manchester.ac.uk)

Cochlear synaptopathy, or "hidden hearing loss," refers to a loss of synapses between inner hair cells and auditory nerve fibers, and is observed in rodent models as a consequence of noise exposure and/or aging. In humans, cochlear synaptopathy is not thought to be detectable by pure tone audiometry, as thresholds to soft sounds in the rodent models are not permanently elevated. One hundred and forty audiometrically normal participants below the age of 35 and with a range of lifetime noise exposures performed an extensive battery of tests, including electrophysiological measures, psychophysical tests, and speech-in-noise tests. Inter-aural phase discrimination, amplitude modulation detection, and spatial release from masking on a speech task were found to be sensitive to noise exposure; however, these trends are weak and only the phase discrimination task followed the predicted direction (i.e., high noise exposed individuals showing elevated thresholds). None of the electrophysiological measures, including wave I of the ABR, showed a strong relation with noise exposure. The results suggest that either: (i) hidden hearing loss is not prevalent in young normally hearing adults, or (ii) even listeners with comparatively low levels of noise exposure have the disorder and that there is no additional consequence of high levels of exposure.

WEDNESDAY AFTERNOON, 25 MAY 2016 SALON G, 1:00 P.M. TO 3:00 P.M.

Session 3pSC

Speech Communication: Variation and Gender Effects (Poster Session)

Simone Graetzer, Chair
Communicative Sciences and Disorders, Michigan State University, 1026 Red Cedar Road, Michigan State University, East Lansing, MI 48824

All posters will be on display and all authors will be at their posters from 1:00 p.m. to 3:00 p.m.

Contributed Papers

3pSC1. Effects of low-pass filtering on dialect and gender perception. Robert A. Fox, Ewa Jacewicz, and Zane T. Smith (Speech and Hearing Sci., The Ohio State Univ., 110 Pressey Hall, 1070 Carmack Rd., Columbus, OH 43210-1002, fox.2@osu.edu)

In addition to linguistic (message-related) information, spoken language includes indexical information related to the speaker characteristics (e.g., gender, social status, and regional identity). This study is an extension of Jacewicz *et al*. (2015, *JASA*, **137**, 2417–2418) which explored the nature of acoustic cues signaling indexical information. That study demonstrated that listeners were quite accurate in making decisions regarding the regional dialect and gender of a speaker when responding to short unprocessed phrases from 40 speakers (male and female) from two different dialects spoken in central Ohio and western North Carolina. However, when the signal was low-pass filtered at 400 Hz, sensitivity to both dropped significantly. The current study examined performance on the same phrases when the signal was low-pass filtered at progressively higher cutoff frequencies (500, 700, 900, and 1100 Hz). These stimuli were played to 20 listeners (10 males and 10 females) who identified the sex and dialect of the speaker. As expected, listener sensitivity improved with each wider low-pass filter condition. Performance in the 1100-Hz cutoff condition was very similar to that in the unprocessed condition. Discussion will focus on the nature of the acoustic cues utilized by listeners across the four low-pass filter conditions.

3pSC2. Gender-based variation in the phonetic representation of boundary tones in Persian declarative and interrogative utterances. Marziye Eshghi (Speech, Lang. and Hearing Sci., Univ. of North Carolina at Chapel Hill, 002 Brauer Hall, Craniofacial Ctr., Chapel Hill, NC 27599, marziye_eshghi@med.unc.edu) and Moharram Eslami (Persian Lang. & Lit., Univ. of Zanjan, Zanjan, Iran)

This study investigated the phonetic representation of boundary tones in Persian declarative and interrogative utterances. Speech samples of the study were selected from Persian speech database, i.e., FARSDAT. These samples were produced by adult Persian speakers ranged in age from 20 to 45 years. PRAAT software was used for measuring the variation of F0 per millisecond at boundary tones. For investigating the phonetic representation

of declarative sentences, a group of ten men and ten women were selected and each speaker produced 10 declarative utterances. Another group of ten men and ten women were selected for the investigation of phonetic representation of boundary tones in interrogative utterances. Each participant produced a yes-no question and a wh-question. Statistical analysis revealed significant difference ($p < 0.05$) between men and women regarding the variation of F0 at the boundary tones of declarative sentences and wh-questions. F0 was observed to fall faster at the boundary tones of declarative sentences and wh-questions produced by women. However, there was no statistically significant difference between men and women for variation of F0 at the boundary tones of yes-no questions. Results could be applied in speech recognition, text-to-speech synthesis, and other areas of speech processing.

3pSC3. The acoustics of charismatic voices in Korean political speech: A cross-gender study. Nari Rhee and Rosario Signorello (Head and Neck Surgery, Univ. of California, Los Angeles, 31-20 Rehab Ctr., 1000 Veteran Ave., Los Angeles, CA 90095-1794, n.rhee94@gmail.com)

A previous study (JASA **136**(4), 2295) investigated cross-cultural (Italian, French, and Brazilian) acoustic voice profiles in political speech to discern innate versus learned factors underlying the acoustics of charismatic voices. To further extend the study to other cultures and to both genders the present study investigates how Korean leaders manipulate their voices to exhibit charisma. The voice acoustic profiles of South Korean female (Geunhye Park) and male (Jae-in Moon) politicians were analyzed. Results support previous findings showing a significant cross-culture and cross-gender similarity in communication context-specific (political campaign monologue, political peers-addressed speech, and non-political interview) use of voice F0 and SPL ranges. Data also confirm significant cross-gender differences in speakers' F0 average frequencies (higher for the female speaker) within communication contexts. Finally, results confirm speaker-specific manipulations of F0 and SPL over time. The cross-cultural similarities in charismatic voice showed by the data support our hypothesis of several ongoing cross-cultural/gender processes of integration among some innate and cultural/linguistic vocal habits to convey leadership status: leaders estimate audience's biological and social traits, manipulate vocal ranges of F0 and SPL accordingly, while maintaining women's and men's particular acoustic average features of F0 and SPL significantly different. [Work supported by NIH grant DC01797.]

3pSC4. Region, gender, and within-category variation in American English voiced stops. Abigail H. Elston, Katherine Blake, Kelly Berkson (Linguist, Indiana Univ., 1021 E. 3rd St., Memorial Hall 322 E, Bloomington, IN 47405, abelston@indiana.edu), Wendy Herd, Joy Cariño (English, MS State Univ., Starkville, MS), Max Nelson, Alyssa Strickler (Linguist, Indiana Univ., Bloomington, IN), and Devan Torrence (English, MS State Univ., Starkville, MS)

The two-way voicing contrast in American English stops—particularly in initial position—is often described as a long-lag (e.g., long positive VOT for /p/) versus short-lag (e.g., short positive VOT for /b/) distinction, with less frequent instances of lead voicing (e.g., negative VOT for /b/) attributed to individual variation. Systematic within-category gender and region differences have been reported, however, with more closure voicing found for male than for female speakers (Ryalls, Zipprer, and Baldauff, 1997), and more fully voiced closures for /b/ in female speakers from North Carolina than those from Wisconsin (Jacewicz, Fox, and Lyle, 2009). With this in mind, we investigate the interaction of gender and region in the prevoicing of word-initial voiced stops by comparing the VOTs of male and female speakers from Indiana and Mississippi. Participants were recorded reading three repetitions of a pseudo-randomized list of words including *bot*, *dot*, and *got*. Regional—but no gender—differences were found: speakers from Mississippi produced stops with negative VOT more often (~35% of the time) than speakers from Indiana (~15%), suggesting that southern varieties of English are indeed more heavily prevoiced than other varieties of English.

3pSC5. The voice acoustics of the 2016 United States presidential election candidates: A cross-gender study. Rosario Signorello and Nari Rhee (Head and Neck Surgery, Univ. of California, Los Angeles, 31-24 Rehab Ctr., 1000 Veteran Ave., Los Angeles, CA 90095, rsignorello@ucla.edu)

The present study investigates the acoustic voice profiles (vocal fundamental frequency and intensity) of two female (Hillary Clinton and Carly Fiorina) and two male (Bernie Sanders and Donald Trump) candidates to the 2016 United States presidential election. The criteria used for choosing the speakers were based on: (a) an online survey we conducted in 2015; (b) the prediction markets' statistics; (c) the number of endorsements from party elites; (d) the Iowa and the New Hampshire polls; (e) the amount of money raised by the candidate; and (f) the candidates' gender from both Democratic and Republican parties. Voice stimuli for each of these speakers were collected for three different communication contexts: a political campaign monologue; a political peers-addressed speech; and non-political interview. Results confirm and expand previous findings [JASA **136**(4), 2295] showing cross-cultural and gender similarities in voice acoustics supporting the hypothesis of several ongoing cross-cultural/gender processes of integration among some innate and cultural/linguistic vocal habits to convey leadership status: leaders estimate audience's biological and social traits, manipulate vocal ranges of F0 and SPL accordingly, while maintaining women's and men's particular acoustic average features of F0 and SPL significantly different. [Supported by NIH grant DC01797.]

3pSC6. Stylistic variation in children's vowel production. Ewa Jacewicz, Robert A. Fox, and Jill M. Deatherage (Dept. and Speech and Hearing Sci., The Ohio State Univ., 1070 Carmack Rd., 110 Pressey Hall, Columbus, OH 43210, jacewicz.1@osu.edu)

The monophthongization of the diphthong [ai] to [a] is possibly the most stereotyped feature of Southern American English. This feature can be observed to varying degrees across the American South. Although monophthongization represents an important social symbol in the South, its pervasiveness has begun to recede in recent generations. This sound change has been brought on by multiple factors including population mobility, education, and urbanization, which have promoted acceptance of a more standardized variety of American English, including diphthongal realizations of [ai]. The current study examines the change in progress toward [ai] in 20 children aged 8–10 from western North Carolina in three different speaking styles: citation-form words, read sentences, and informal, unscripted talks. In addition to acoustic analysis, stylistic variation was evaluated by 20 central Ohio listeners (10 males and 10 females). Participants were asked to listen to individual words and to rate the degree of perceived monophthongization on a seven-point scale. Results showed an increase in perceived monophthongization from citation forms to informal talks. Compared to girls, boys had a higher occurrence of the monophthongal variants and lower occurrence of the full diphthongs across all production types. Discussion will focus on the advancement of the sound change.

3pSC7. Canadian raising in Fort Wayne, Indiana. Alyssa Strickler, Kelly Berkson, and Stuart Davis (Linguist, Indiana Univ., 1021 E. Third St., Memorial Hall 322E, Bloomington, IN 47405, arstrick@indiana.edu)

The phenomenon often referred to as Canadian Raising, wherein speakers raise the diphthongs /aɪ/ and /aʊ/ to [ʌɪ] and [ʌʊ], respectively, when preceding voiceless sounds, is attested not only in Canada but also in places in the Northern periphery of the U.S. (e.g., Ann Arbor and the Upper Peninsula, in Michigan). Raising has also been documented in locations distant from the border, such as Philadelphia. The current study examines the spread of raising farther south from Michigan into northeast Indiana, specifically Fort Wayne. Acoustic analysis of preliminary data from Fort Wayne area speakers was conducted to determine whether raising indeed occurs and to explore the effect of contextual factors such as speaker sex, age, and prosodic structure. The results confirm that while this raising does in fact happen around Fort Wayne, there is an age effect: younger speakers (<25 yr) show raising across the board in the expected environments but older speakers (>60 yr) do not. This suggests that vowel raising is a relatively new characteristic of Fort Wayne English.

3pSC8. The effect of structural context on phonetic accommodation. Jonathan T. Manker (Dept. of Linguist, Univ. of California, Berkeley, Berkeley, CA 94720, jtmanker@berkeley.edu)

Phonetic accommodation is a linguistic phenomenon whereby phonetic characteristics of one's speech are influenced by perceiving the speech of others. The last decade has seen a multitude of studies which have induced the phenomenon in a lab setting, considering the social environments necessary for facilitating or inhibiting it. No studies, however, have investigated how the perception and production of speech in different structural contexts affects phonetic accommodation. This presentation analyzes the results of an experiment that compared the frequency of phonetic accommodation in three speech settings. In condition one, subjects read aloud and shadowed entire sentences which contained artificially lengthened VOT. In condition two, subjects read short phrases and shadowed sentences, and in condition three, both read and shadowed phrases. Our results showed that speakers accommodated lengthened VOT but often also showed modified burst intensities, suggesting imprecise accommodation. More accurate VOT accommodation was observed in conditions 2 and 3 (9/12 subjects for both) compared to condition 1 (5/12 subjects). "Inaccurate" burst accommodation was more common in condition 1 (8/12) and 2 (8/12) compared to condition 3 (4/12). The results suggest that higher levels of syntactic and semantic processing (both in production and perception) may impede processing of phonetic details.

3pSC9. Dissociating contributions of talker gender and acoustic variability for spectral contrast effects in vowel categorization. Ashley Assgari, Asim Mohiuddin (Univ. of Louisville, 317 Life Sci. Bldg., Louisville, KY 40292, ashley.assgari@louisville.edu), Rachel Theodore (Univ. of Connecticut, Storrs, CT), and Christian Stilp (Univ. of Louisville, Louisville, KY)

Speech categorization is influenced by spectral contrast effects (SCEs), the perceptual magnification of spectral differences between successive sounds. Through SCEs, preceding acoustic contexts can bias categorization of following sounds away from reliable spectral properties. Recent findings (Assgari & Stilp, 2015 JASA) show that SCEs in vowel categorization can be modulated by talker characteristics: a clear SCE when the preceding context was 200 sentences spoken by a single talker was diminished when the context featured 200 talkers. This result was attributed to variability in mean pitch of the preceding sentences. However, neither mean sentence pitch nor talker gender was explicitly controlled, which challenges identification of the locus of the talker effect. The current study examined whether gender and pitch variability yield separable contributions to SCEs. Listeners heard precursor sentences then categorized a target vowel from an /ɪ/ to /ɛ/ continuum. Sentences were processed to add a modest low-F1 or high-F1 spectral peak to encourage "eh" or "ih" responses, respectively. Critically, talker gender was crossed with pitch variability in these sentences. Results will isolate the property responsible for attenuating SCEs if gender and pitch variability have dissociable effects. Failure to observe this pattern suggests similar effects of these properties on SCEs.

3pSC10. Gender and rate effects on speech intelligibility. Eric M. Johnson and Sarah H. Ferguson (Dept. of Commun. Sci. and Disord., Univ. of Utah, 390 South 1530 East, Rm. 1201, Salt Lake City, UT 84112, eric.martin.johnson@utah.edu)

Older adults seeking hearing help often complain of particular difficulty understanding female voices. This contrasts with studies using young listeners with normal hearing in which female talkers have been found to be generally more intelligible than male talkers (e.g., Bradlow *et al*., 1996). Could some factor in addition to talker gender be causing older adults to have increased difficulty understanding female voices? Speech that has been time-compressed has been shown to be less intelligible than unprocessed speech (e.g., Gordon-Salant and Friedman, 2011), but few data exist to show whether an increased presentation rate causes an equal loss of intelligibility for male and female talkers. The present study will explore whether an increased playback rate has a greater negative effect on the intelligibility of speech produced by female versus male talkers. Subjects will listen to sentences produced by two female and two male speakers from the Utah Speaking Style Corpus presented at either their original rate or at an increased rate (1.5 times faster) and type out what they heard. The resulting data will show whether, for young normal-hearing listeners, an increased rate of speech affects the intelligibility of female talkers more than it affects the intelligibility of male talkers.

3pSC11. Time dose and fundamental frequency of male and female speakers in different style and reverberation times. Pasquale Bottalico, Eric J. Hunter (Communicative Sci. and Disord., Michigan State Univ., 1026 Red Cedar Rd., East Lansing, MI 48910, pb@msu.edu), and Eric J. Hunter (Communicative Sci. and Disord., Michigan State Univ., East Lansing, MI)

Speakers adjust their vocal production when communicating in different room acoustics, when instructed to speak at different volumes and when experiencing vocal fatigue. The present paper reports on the effects of speech style, reverberation time, and external auditory feedback on time dose and fundamental frequency. Ten male and ten female subjects were recorded while reading a text in normal and loud styles, in three rooms—anechoic, semi-reverberant, and reverberant—and with and without acrylic glass panels at 0.5 m from the mouth, which increased external auditory feedback. Longer time doses were accumulated in more reverberant rooms, especially when loud voice was used. Higher fundamental frequency was measured in less reverberant rooms. Subjects increased their fundamental frequency in the loud speech style versus the normal style, but this effect was weaker when the level of external auditory feedback was high. A larger fundamental frequency range was detected for females than males and for the loud style than the normal style. These results contribute to understanding how the effect of room acoustics on speech changes as a function of speaking time.

3pSC12. Perception of voice gender in cochlear implant simulations of children's speech. Daniel R. Guest, Michelle R. Kapolowicz, Shaikat Hossain, Vahid Montazeri, and Peter F. Assmann (School of Behavioral and Brain Sci., Univ. of Texas at Dallas, GR41 The University of Texas at Dallas, Box 830688, Richardson, TX 75083, daniel.guest@utdallas.edu)

Previous studies [Assmann *et al*., *J. Acoust. Soc. Am.* **135**, 2424 (2014) and Assmann *et al*., *J. Acoust. Soc. Am.* **138**, 1811 (2015)] investigated normal-hearing listeners' ability to discriminate gender and age in children's speech. The speech stimuli were /hVd/ syllables produced by 140 speakers, ages 5 through 18, and processed using the STRAIGHT vocoder to simulate a change in speaker gender. Experimental conditions involved swapping the fundamental frequency contour (F0) and/or the formant frequencies (FF) to the opposite-sex average within each age group. The present study extended these previous experiments by presenting the stimuli to normal-hearing listeners through a cochlear implant simulation implemented as a sine wave vocoder. Supporting findings reported at previous meetings, swapping F0 has a larger effect on perceived gender than swapping FF for older voices, and single-parameter changes (swapping either F0 or FF), had relatively small effects on older male voices but pronounced effects on older female voices. Overall, the present findings indicate that gender recognition is more difficult in a cochlear implant simulation. Furthermore, gender recognition in a cochlear implant simulation is particularly difficult with ambiguous voices, such as those of young children.

Session 3pUW

Underwater Acoustics, Acoustical Oceanography, and Signal Processing in Acoustics: Sediment Characterization Using Direct and Inverse Techniques II

David P. Knobles, Cochair
None, KSA LLC, PO Box 27200, Austin, TX 78755

Preston S. Wilson, Cochair
Mech. Eng., Univ. of Texas at Austin, 1 University Station, C2200, Austin, TX 78712-0292

Contributed Papers

1:30

3pUW1. Field measurements of interface waves and geoacoustic characterization of near surface sediment and soil. Jennifer Giard, Gopu R. Potty, James Miller, Christopher Baxter (Ocean Eng. Dept., Univ. of Rhode Island, 215 S Ferry Rd., Narragansett, RI 02882, jennifer_giard@my.uri.edu), and Aaron Bradshaw (Civil and Environ. Eng., Univ. of Rhode Island, Narragansett, RI)

There is a need for rapid and nondestructive sensing of near-surface shear properties of the ground and seafloor. Our approach is to measure interface wave dispersion and invert these measurements to extract a shear wave speed profile. Field measurements of interface waves using geophones and accelerometers will be presented. A laser Doppler vibrometer (LDV) will also be incorporated in the suite of sensors for the measurement of wave properties. Data from these sensors will be compared to understand the coupling of the sensors into the soil or sediment and its effect on the measurements. Geoacoustic and geotechnical properties will be estimated using the interface wave data. The uncertainty and resolution of the estimates in different sediment/soil types will be explored. The Interface Wave Testing Facility at the University of Rhode Island will also be used to understand the surface wave propagation characteristics in different type of sediments/soils. [Work supported by Army Research Office and the Office of Naval Research.]

1:45

3pUW2. Development of a system for *in situ* measurements of geoacoustic properties during sediment coring. Megan S. Ballard, Kevin M. Lee, Andrew R. McNeese (Appl. Res. Labs. at the Univ. of Texas at Austin, P.O. Box 8029, Austin, TX 78758, meganb@arlut.utexas.edu), and Preston S. Wilson (Dept. of Mech. Eng. and Appl. Res. Labs., The Univ. of Texas at Austin, Austin, TX)

Sediment cores provide valuable insight on the physical properties of the seabed, and laboratory measurements of sediment wave speed from cores are often considered "ground truth." However, sound-speed estimates obtained from cores can be inaccurate due to changes in pressure, temperature, and mechanical properties of the sediment caused by removal of the core from the seabed and its subsequent transport to the laboratory. To begin to address this deficiency, we report on the development of a system for obtaining *in situ* measurements of geoacoustic properties. The system mounts on the nose of a coring barrel to obtain an *in situ* record of compressional and shear wave speed and attenuation as the core penetrates the seabed. The depth of the *in situ* record is limited only by the penetration of the core. The compressional wave measurements are obtained with rod-mounted piezoelectric cylinders, and the shear wave measurements are obtained with bender elements mounted in flat blades. For both the compressional and shear wave measurements, wave speed and attenuation are estimated from differential measurements made with two receivers. [Work supported by ONR.]

2:00

3pUW3. Geoacoustic inversion based on particle velocity. David R. Dall'Osto and Peter H. Dahl (Appl. Phys. Lab., Univ. of Washington, 1013 NE 40th, Seattle, WA 98115, dallosto@uw.edu)

An approach to geoacoustic inversion using a non-dimensional vector quantity, known as circularity, is discussed. This quantity corresponds to the difference in phase and magnitude of the vertical and horizontal components of particle velocity, and is also the normalized curl of the active intensity vector. As such, it is highly dependent on the phase, amplitude, and arrival angle of interfering multipath arrivals, with value as a function of source depth that depends on both frequency and bottom type. We first show results from the Targets and Reverberation Experiment (TREX) which took place off Panama City, where frequencies in the range of 1–4 kHz are used to study sandy sediments [Dall'Osto *et al*., J. Acoust. Soc. Am. **139**, 311–319, 2016]. The approach is next applied hypothetically at lower frequencies for which fewer modes are supported in the waveguide, and to different seabed conditions to demonstrate how a range of sediments from sand to mud are distinguished.

2:15

3pUW4. Sediment characterization from normal incidence bottom loss at the GLISTEN sea test. Marcia J. Isakson, James Piper, and Roger Banks (Appl. Res. Labs., The Univ. of Texas at Austin, 10000 Burnet Rd., Austin, TX 78713, misakson@arlut.utexas.edu)

The GLider Sensors and payloads for Tactical characterization of the ENvironment (GLISTEN) sea test was conducted off the west coast of Italy in August of 2015. Led by the Centre for Maritime Research and Experimentation (CMRE), the effort included seven other international organizations including the Applied Research Laboratories from The University of Texas at Austin (ARL:UT). The mission of the sea test was to improve and understand long-range acoustic methods of environmental characterization in shallow waters. As part of the test, a team from ARL:UT deployed a remotely operated vehicle (ROV) which collected normal incidence bottom loss data from 6 to 20 kHz along with video and laser line profiling data. These data were taken along the propagation paths of the CMRE low-frequency transmission loss experiment. In this presentation, results will be shown from the bottom loss measurements for a variety of sediments that included both layering and entrained gas pockets. The acoustic data will be compared with models that include such frequency dependent effects as interface roughness and volume scattering. [Work supported by ONR, Ocean Acoustics.]

2:30

3pUW5. Spatial variability of sediment roughness and its effect on reverberation. Brian T. Hefner (Appl. Phys. Lab., Univ. of Washington, 1013 NE 40th St., Seattle, WA 98105, hefner@apl.washington.edu)

As part of the environmental characterization supporting the Target and Reverberation Experiment in 2013 (TREX13), the Seafloor Laser-line Scanner (SLS) was deployed to measure sediment roughness at locations throughout the experiment site. The SLS uses structured light to create a two-dimensional digital elevation map of the seafloor over a 0.3 × 3.5 m area. This map is processed to determine the seafloor roughness power spectrum which is used to model backscatter from the seafloor. While a relatively shallow site for TREX13 was chosen to limit the area within which environmental characterization was required, there was significant variability in the sediment roughness which could not be sufficiently measured in the time available. To overcome this difficulty, data from a 400 kHz multibeam backscatter survey collected by de Moustier and Kraft have been combined with the SLS measurements to infer the roughness throughout the site. Although the reverberation modeling focuses on scattering wavenumbers that affect the 2–4 kHz acoustic measurements, the 400 kHz backscatter strengths are correlated to the spectral strengths at the mid-frequency wavenumbers of interest. The implications of these results for reverberation modeling as well as the limits of this approach will be discussed. [Work supported by ONR.]

Plenary Session and Awards Ceremony

Christy K. Holland, Chair
President, Acoustical Society of America

Annual Membership Meeting

Presentation of Certificates to New Fellows

Ian C. Bruce – For contributions to models of auditory-nerve fibers

Micheal L. Dent – For contributions to spatial hearing in animals

Christine Erbe – For contributions to the effects of anthropogenic noise on marine mammals

Kent L. Gee – For contributions to jet-noise and nonlinear propagation

Karen S. Helfer – For contributions to speech perception in aging

Eric J. Hunter – For contributions to laryngeal function for voice production

G. Christopher Stecker – For multidisciplinary contributions to binaural hearing

Introduction of Award Recipients and Presentation of Awards

William and Christine Hartmann Prize in Auditory Neuroscience to Alan R. Palmer

Distinguished Service Citation to Susan B. Blaeser

R. Bruce Lindsay Award to Megan S. Ballard

Helmholtz-Rayleigh Interdisciplinary Silver Medal to Armen Sarvazyan

Gold Medal to Whitlow W. L. Au

Vice President's Gavel to Lily M. Wang

President's Tuning Fork to Christy K. Holland

OPEN MEETINGS OF TECHNICAL COMMITTEES

The Technical Committees of the Acoustical Society of America will hold open meetings on Tuesday, Wednesday, and Thursday evenings. All meetings will begin at 7:30 p.m., except for Engineering Acoustics which will hold its meeting starting at 4:30 p.m. These are working, collegial meetings. Much of the work of the Society is accomplished by actions that originate and are taken in these meetings including proposals for special sessions, workshops, and technical initiatives. All meeting participants are cordially invited to attend these meetings and to participate actively in the discussion.

Committees meeting on Wednesday are as follows:

Committee	Room
Biomedical Acoustics	Salon H
Musical Acoustics	Salon B/C
Signal Processing in Acoustics	Salon G