Session 3aAA

Architectural Acoustics: Restaurant Acoustics

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Chair's Introduction—7:45

Invited Papers

7:50

3aAA1. Analyses of crowd-sourced sound levels, logged from more than 2250 restaurants and bars in New York City. Gregory Farber (SoundPrint, PO Box 533, Lincoln, MA 01773, greg@soundprint.co) and Lily M. Wang (Architectural Eng. & Construction, Univ. of Nebraska - Lincoln, Lincoln, NE)

Media reports in the United States and the United Kingdom have reported increasingly high sound levels in restaurants and bars over the past ten years, but accurate sound measurements are lacking. The Zagat survey found noise to be the second most common complaint among diners, barely behind poor service. This paper presents sound level measurements from more than 2250 restaurants and bars in New York City, using the novel SoundPrint smartphone app. The average sound level was found to be 78 dBA in restaurants and 81 dBA in bars. These sound levels do not allow ready conversation and pose a auditory health danger for noise-induced hearing loss and other non-auditory health issues. The reported sound levels by venue managers generally underestimated actual sound levels. Of interest are the findings that venues in certain neighborhoods and also of certain types of cuisine tend to be louder or quieter than others. The sound level values measured by the SoundPrint app have been tested against class 1 sound level meters and found to be reasonably close (within 1–2 dB). This report is a proof-of-concept study of crowd-sourced sound measurements, which can provide valuable data for the general public and health officials.

8:10

3aAA2. Study on influence factors of popular Chinese restaurants. Yude Zhou, Weichen Zhang, Zhiyue Shao, and Wenying Zhu (Shanghai Acad. of Environ. Sci. and Shanghai Eng. Res. Ctr. of Urban Environ. Noise Control, 508,Qinzhou Rd., Shanghai 200233, People's Republic of China, zhouyd@saes.sh.cn)

There are great differences in restaurant soundscape between China and the United States, as Chinese people prefer to be engaged in an animated conversation during dining. This study emphasizes on revealing the relationship between restaurant soundscape and local culture, dining custom and restaurant arrangement, etc., and identifying the unique characteristic of the restaurant soundscape in China. Typical Chinese restaurants are selected to investigate the dining culture in China, and to further analyze the relationship between Chinese restaurant soundscape and people's opinion toward it by both objective and subjective soundscape parametric study. It is shown that the high sound pressure lever, for instance, 70–80 dBA in dining lobby with capacity crowd, in Chinese restaurant is mainly due to a long reverberation time. Meanwhile, since dining in restaurant is regarded as a popular social activity, and people like to gather in a restaurant and chat merrily when dining, the larger table people sit by, the louder voice people have to speak in. It is also found that for the most of the time, people enjoy in the conversation, not bothered by the high sound pressure level, and if a silent dining environment is required, a private room is often available. Therefore, there is a close connection between the local culture and restaurant soundscape in China, of which better understanding can be obtained only if you are involved in.

8:30

3aAA3. Case studies that explore the soundscape of dining. Keely Siebein and Gary W. Siebein (Siebein Assoc., Inc., 625 NW 60th St., Ste. C, Gainesville, FL 32607, ksiebein@siebeinacoustic.com)

The acoustics of restaurants is related to the soundscape of dining. The goal of this study is to better understand and document the soundscape of dining as a method to analyze communication paths among diners. This will be used to determine possible acoustical interventions based on the perceived acoustical qualities of the spaces by the local experts, i.e., diners, staff, and operators of the facilities. This study compares case studies of three restaurants using the soundscape method to explore links between qualitative evaluations

of the soundscape by users, staff, and operators of the facilities and acoustical metrics including analysis of impulse response measurements between occupants in the rooms, and acoustical measurements calculated from the impulse responses including STI and RT. Using the soundscape methods, along with impulse response measurements based on actual communication paths, allows for diagnosis of surfaces to be treated and allows acoustical metrics to be derived that reflect the qualitative analysis of the space as it is heard by diners, staff, and owners of the restaurants.

8:50

3aAA4. Describing sonic environment of Chinese restaurants using a mathematical model. Andy Chung (Smart City Maker, Hong Kong Plaza, Hong Kong HKSAR, Hong Kong, ac@smartcitymaker.com) and W. M. To (Macao Polytechnic Inst., Macao, Macao, Macao)

A restaurant is commonly chosen as a venue for gathering because it serves both the dining and meeting purposes in one go, and is good for people who are busy and keen on balancing social, work, and family lives with limited time. Depending on the anticipating nature of meeting, people tend to choose a restaurant with the right mood for communication as well as the general perception of the sonic environment in whether it favors quiet conversations or louder chats. This paper presents the results of a survey on the sonic environment of a number of Chinese restaurants in Hong Kong and a mathematical model for the associated description.

9:10

3aAA5. Restaurants, bars, and dives—Can you hear me now?? Kenneth P. Roy (Armstrong, 2500 Columbia Ave., Lancaster, PA 17603, kproy@armstrongceilings.com)

The acoustics of "places of public accommodation" including restaurants, bars, and dives have been an ongoing issue with the users of such places for many years. ASTM International once considered writing a standard for the measurement/performance of such spaces, but it died an uncertain death during development. More recently, the ASA was requested to look at the possibility of writing such a standard, and to that end a special session on "restaurant acoustics" sponsored by the ASA Panel on Public Policy was conducted in Boston. So what to do?? More data are obviously needed—but to what end?? It may be possible to write a measurement standard, probably at ASTM, and it may be possible to write a performance standard, probably at ASA. But, this would be a tall task given the variety of such places and the diffused focus between entertainment and "hunger and thirst" … maybe a rating system would be a more appropriate starting point. A proposal for that approach will be made herewith.

9:30

3aAA6. Speech intelligibility in restaurants—A reverberation or early reflection problem? Peter Mapp (PMA, 101 London Rd., Copford, Colchester co61lg, United Kingdom, petermapp@btinternet.com)

Several acoustic factors coincide to create hostile sonic environments in restaurants—including noise & reverberation. Reverberation time is often cited as the cause of noise build up and resultant lack of speech ineligibility in restaurants and similar spaces. This paper suggests that in smaller dining rooms and spaces for socializing, it is the generation of strong early reflections and occupation density rather than reverberation time that are the key factors. Ceiling height is also shown to be a significant factor. The paper presents an acoustic analysis of three dining/socializing spaces and the effect that the application of acoustic treatment has on the ambient noise levels and potential intelligibility. A rough rule of thumb for the volume per person required for satisfactory speech conditions is also presented together with case history data.

9:50–10:05 Break

10:05

3aAA7. Speech recognition in reverberation and background chatter. Paul Battaglia (Architecture, Univ. at Buffalo, 31 Rose Ct Apt. 4, Snyder, NY 14226, plb@buffalo.edu)

The subjective impression of acoustical comfort, as shown by previous surveys of restaurant patrons, can be achieved within a narrow range of reverberation time. These surveys also indicated that acoustical comfort is relatively unrelated to the level of background noise. In order to more fully understand the relative effects of reverberation time and noise levels, an experiment was conducted by undergraduate architecture students for speech intelligibility, not acoustical comfort, in a test space where reverberation times and levels of background chatter could be varied. The resulting data suggest that there is a threshold level of reverberation time for speech intelligibility when signal-to-noise ratios are very low, and even negative in value. This finding has consequences for the acoustical design of restaurants where the sounds of social activity are welcomed, but where background chatter should not overwhelm the ability to discern and understand nearby speech.

10:25

3aAA8. Sounds delicious: A crossmodal perspective on restaurant atmospherics and acoustical design. Steve Keller (iV, 622 Hamilton Ave., Nashville, TN 37203, skeller@ivaudiobranding.com) and Charles Spence (Crossmodal Res. Lab., Univ. of Oxford, Oxford, Oxfordshire, United Kingdom)

Recent advances in crossmodal science have demonstrated that our perception of the world around us is an amalgam of sensory experiences. Nowhere is this more evident than in the emerging discipline of Gastrophysics: the new science of eating, which blends gastronomy (the "art of the table") with psychophysics (the relationship between physical stimuli and mental phenomena). Examining restaurant atmospherics and acoustical design through the lens of crossmodalism and gastrophysics, it soon becomes clear that, when it comes to the pleasures of the table (i.e., of eating and drinking), what we put into our ears (i.e., what we hear) can be just as important as what we put into our mouths. This presentation highlights the latest research into the ways that sound and its application in restaurants

can create expectations, shape perceptions, and influence the behavior of patrons. From sonic seasonings and sensplorations, to sound systems and acoustical treatments, we will explore how sonic environments will continue to play an increasingly important role in the dining experience.

10:45

3aAA9. A comparative study of sound environment of restaurants in Singapore, Macao, and Hong Kong. Siu Kit Lau (Dept. of Architecture, National Univ. of Singapore, Block SDE3, #01-06, 4 Architecture Dr., Singapore 117566, Singapore, slau@acousticsresearch.com), W M To (Macao Polytechnic Inst., Macao, Macao), and Andy Chung (Smart City Maker, Copenhagen, Denmark)

Some of the key elements affecting the indoor sonic environment of a restaurant depend on its size, room configuration, architecture features, and occupancy rate. Whether the languages of people speak in the same venue or a combination of theirs have an impact remains unsure. Surveys have been conducted in three tourist cities, namely, Singapore, Macao, and Hong Kong, to collect the audio, visual, and quantitative data of the indoor sound environment of selected restaurants. This paper presents the results and comparative analytics of the surveys.

Contributed Papers

11:05

3aAA10. Quantifying the acoustic environment for restaurant consultation. Justin T. Dubin and Eli Willard (Dept. of Mech. Eng., The Univ. of Texas at Austin, 10000 Burnet Rd., Austin, TX 78713, justin.dubin@utexas.edu)

This talk presents a case study in which methodology for the diagnosis and treatment of poor restaurant acoustics is discussed. The subject of this case study is Uchi, an upscale Japanese restaurant in Austin, Texas. While revered for their excellent cuisine, Uchi's reputation is marred by its excessively loud dining room at peak business hours. The discussion details how the restaurant's acoustical quality was evaluated through strategic integrated impulse response measurements, along with finite element and analytical models. The measurements and models provide strong evidence of acoustical problems such as room modes, focusing gain, and excessive reverberance. Once diagnosed, improvement criteria are defined using well-established metrics for restaurants, such as "acoustic capacity" and "preferred signal-to-noise ratios." Treatment options are assessed based on their potential effectiveness as well as their feasibility to be implemented by restaurant management.

11:20

3aAA11. Sound pressures generated by exploding eggs. Anthony Nash and Lauren von Blohn (Charles M. Salter Assoc., 130 Sutter St., Ste. 500, San Francisco, CA 94104, anthony.nash@cmsalter.com)

Manufacturers of microwave ovens caution people to avoid re-heating certain food products because the rapid heating process can pose a danger to the user. Examples of such products are potatoes and eggs. Heating a potato in a microwave can generate steam under pressure. The internal steam pressure induces high tensile stresses in the potato skin, sometimes leading to its sudden (and unpredictable) bursting. A re-heated hard-boiled egg can also explode unpredictably but its bursting mechanism works differently than the potato. It is now believed that the egg yolk develops many small pockets of superheated water, leading to an increasingly unstable condition. When the egg yolk is disturbed by an internal or external stimulus, the pockets spontaneously boil, thereby releasing considerable energy (i.e., an explosion). An acoustical investigation was conducted using nearly 100 eggs that were re-heated under controlled conditions in a calibrated microwave oven. About a third of the re-heated, boiled eggs exploded outside the oven. For those eggs that did explode, their peak sound pressure levels ranged from 86 up to 133 decibels at a distance of 300 mm. The paper will describe the test protocols and discuss the results.

11:35–12:00 Panel Discussion

Session 3aAB

Animal Bioacoustics: General Bioacoustics

Aaron Thode, Chair
SIO, UCSD, 9500 Gilman Dr., MC 0238, La Jolla, CA 92093-0238

Contributed Papers

8:30

3aAB1. Exposure-induced changes in laboratory mouse ultrasonic vocalizations. Kali Burke, Laurel A. Screven, and Micheal L. Dent (Psychology, Univ. at Buffalo, SUNY, 246 Park Hall, Buffalo, NY 14260, kaliburk@buffalo.edu)

Mouse ultrasonic vocalizations (USVs) have been categorized by researchers based on their variable spectrotemporal features, including frequency, intensity, and duration. These USVs may be important for communication, but it is unclear whether the categories that researchers have developed are relevant to mice when trying to understand their USVs, or if it is other properties such as the number, rate, peak frequency, or bandwidth of the calls that are significant. The current study aims to create a comprehensive catalog of the USVs that mice are producing in order to better understand if and how these animals are using their USVs for communication. Forty male and female adult CBA/CaJ mice were recorded for five minutes following either a one-hour period of isolation or exposure with a same- or opposite-sex mouse. Vocalizations were categorized into nine categories and quantified based on the bandwidth, duration, peak frequency, and total number of calls across those categories. There were significant differences in how mice produced their vocalizations when they were alone compared to following a social encounter. Further, this study provides critical data from female mice producing calls, an often overlooked phenomenon in mouse vocalization research.

8:45

3aAB2. The whistled source of Gibbon vocalizations. Shi Yu and Didier Demolin (ILPGA, LPP sorbonne nouvelle, 19 Rue des Bernardins, Paris 75005, France, camillus.shi.yu@gmail.com)

Gibbons vocalizations are often referred to as “songs” because of their pitch modulations. The elements composing Gibbons vocalizations are often called notes. Here, we discuss how they are generated. The audio waveform of some characteristic song notes of gibbons (*espèce*) show that they are produced with a high fundamental frequency (F0), often above 500 Hz, and a set of harmonic components. The F0 of these notes can also be modulated across large intervals of pitch. Spectrograms and the shape of the audio waveform suggest that they are the outcome of a whistled source. This is confirmed by the observation of audio wave from which is not complex. This also explains why there are no formants in most of their vocalizations. The high F0 source makes that the distance between harmonics and the short vocal tract length prevents the presence of resonance modes. One way to explain this whistle source is to consider that the airflow passes through stiff nonvibrating vocal folds. This setting also suggests that pitch modulations of Gibbons songs might be produced by changing the vocal folds length during their vocalizations. The effect of this change in length is increase or decrease F0.

9:00

3aAB3. Song bird vivaria considerations. Christopher L. Barnobi (Noise and Air Quality, Dudek, 1102 R St., Sacramento, CA 95816, cbarnobi@dudek.com), Katherine Snyder, and Nicole Creanza (Biological Sci., Vanderbilt Univ., Nashville, TN)

The design of laboratory animal vivaria should include consideration of factors that may impact the results of intended experiments. Two examples where the acoustic environment of birds could significantly affect experimental results include (1) song learning accuracy in isolated juvenile songbirds and (2) the preferences for bird songs by mates. We conducted a detailed analysis of a proposed vivarium design in a laboratory setting to assess important acoustical factors. We analyzed vivaria for room acoustics and sound isolation properties. Sound isolation and reverberation were primary concerns since bird song learning accuracy was an aim of the laboratory research. The environments are planned to be used to research juvenile birds learning a single model song during development. We tested the effects of treating the vivaria with sound absorbing foam, including the reverberation in enclosures and associated impacts on results comparing recorded bird songs. In addition, we tested the existing background sound levels observed in the laboratory and the sound isolation properties of the vivaria. Sound isolation results for the initial isolated environments shows transmission loss values from the exterior to the interior of the vivaria were significantly less than the expected 30 dB. Reverberation results reveal a distinct reduction when the interior of the vivarium enclosures were treated with a sound absorber.

9:15

3aAB4. Behavioral and electrophysiological assessment of hearing in the Japanese quail (*Coturnix japonica*). Sarah N. Strawn and Evan M. Hill (Psych., Univ. of Nebraska-Kearney, 2507 11th Ave., Psych. - COPH, Kearney, NE 68849, strawnsn@lopers.unk.edu)

Presented are the behavioral audiogram and auditory brainstem response (ABR) recordings from the Japanese quail (*Coturnix japonica*). This study was particularly interested in the sensitivity of this species to infrasound (i.e., frequencies below 20 Hz). Previous histological research found that the basilar papilla of gallinaceous species tends to be specifically tuned to frequencies below 1 kHz. Consistent with this finding, previous behavioral tests of chickens demonstrated exceptional sensitivity to low-frequency sounds, especially infrasound. The results of this study show that the Japanese quail has a sensitivity to 16 Hz that is equivalent to that of humans, and thus their infrasound sensitivity is far less than that of the chicken. The ABR recordings did not match the sensitivity or frequency range of the behavioral audiogram, though they provided a reasonable estimate of the high-frequency limit of the animal’s hearing range and frequency of best sensitivity. These findings are consistent with histological evaluations of the inner-ear physiology of gallinaceous birds that suggest the low-frequency end of the Japanese quail’s hearing range is shifted slightly away from that of other birds of this order, though they would still possess good sensitivity below 1 kHz.

9:30

3aAB5. An information-theoretic approach to choosing spectrogram resolutions for analyzing different biological and musical sounds. Benjamin N. Taft (Landmark Acoust. LLC, 1301 Cleveland Ave., Racine, WI 53405, ben.taft@landmarkacoustics.com)

The great diversity and abundance of animal sounds have been portrayed by spectrograms for more than 75 years. Until recently, the time- and frequency-resolution of spectrograms was dictated by hardware limitations such as the number of filter banks in a spectrograph, the sample rate of a digitizer, or the storage capacity of a computer's memory. Improvements in these technologies, especially in the sample rate, has expanded the range of practical time- and frequency-resolutions that spectrograms can display, even if it is still necessarily caught in a tradeoff between resolving temporal or frequency details at each given sample rate. The region of this tradeoff, however, may now actually exceed the time- or frequency-resolving ability of the auditory systems of the animals that emit and perceive biological sounds. Animals are also bound by the fundamental time versus frequency tradeoff. Therefore, if we can measure the best time- and frequency-resolution to analyze a signal, we can both increase analytical efficiency and gain insight into the perceptual abilities of the receivers of the signal. An information metric is proposed for determining the optimal time- and frequency-resolution to analyze a sound. It consists of the frequency excursion of the sound across time windows, divided by the autocorrelation among adjacent spectrogram time windows. The metric is evaluated by applying it to several species of bird song, as well as whale calls, human speech, and musical notes,

9:45

3aAB6. Simulated anthropogenic noise exposure to marine invertebrates using a standing wave tube. Georges Dossot (NUWC, 1176 Howell St., Bldg. 1320, Code 1524, Rm. 260, Newport, RI 02841, georges.dossot@navy.mil), Jason Krumholz (McLaughlin Res. Corp., Newport, RI), David Hudson (The Maritime Aquarium at Norwalk, Norwalk, CT), and Darby Pochtar (Univ. of Rhode Island, Kingston, RI)

The experimental design of a standing wave tube suitable for monitoring the impact of anthropogenic noise upon marine invertebrates is presented. Human usage of coastal water bodies continues to increase and many commercially harvested invertebrates face a broad suite of anthropogenic stressors (e.g., warming, pollution, acidification, and fishing pressure). Underwater noise is one such stressor that exists in coastal areas, but the potential impact on invertebrates, including sublethal effects such as masking, behavioral, and physiological impacts, is not well understood. A major obstacle to further progress in this field is that *in-situ* experiments using high sound levels require extensive permitting and can be difficult to monitor, while ex-situ laboratory experiments do not often account for acoustic artifacts likely present in closed tank environments. We demonstrate the design and implementation of a relatively inexpensive standing wave tube approach, which creates a uniform sound field large enough to allow simultaneous exposure of multiple invertebrates per trial. We exposed juvenile and sub-adult blue crabs (*Callinectes sapidus*) and American lobsters (*Homarus americanus*) to simulated low-frequency boat noise and mid-frequency sonar, and measured behavioral and physiological responses, as well as acoustic pressure and particle motion to fully quantify the impacts of the sound field.

10:00

3aAB7. Examination of behavioral response of wild river herring to sonar signals using acoustic telemetry. Joseph Iafrate, Stephanie L. Watwood (Navy, 1176 Howell St., Newport, RI 02717, joseph.iafrate@navy.mil), Jessica Kutcher (McLaughlin Res. Corp., Middletown, RI), and Georges Dossot (Navy, Newport, RI)

The potential effect of high-intensity noise and disturbance to fish populations is of growing concern. Adult river herring were exposed to mid-frequency (1–10 kHz) sonar signals to assess behavioral response in their natural environment. In this case study, acoustic telemetry was employed to measure fine scale movement of free-ranging river herring released in Dodge Pond, Connecticut, in response to a controlled sound exposure experiment. Alewife (*Alosa pseudoharengus)* was selected as the target species due to natural occurrence in the study area and documented hearing specializations in this species. An acoustic telemetry array was used to examine movement, spatial distribution, and schooling behavior of the fish before, during, and after exposure to mid-frequency sonar or similar sonar signals. Movement parameters examined include directional response, distance moved, swim speed, and distribution of the school. The sound field was mapped to assess received levels including both sound pressure level (SPL) and particle velocity within full extent of the telemetry array. Preliminary results will be presented including novel methods for gastric tagging, baseline behavior, performance of the array, and measurements supporting sound field mapping.

10:15

3aAB8. Opportunistic underwater recording of what might be a distress call of *Chelonya mydas agassizii*. Amaury Cordero Tapia and Eduardo Vivas (CIBNOR, Av Instituto Politecnico Nacional 195, Playa Palo de Santa Rita Sur, La Paz, Baja California Sur 23096, Mexico, evivas@cibnor.mx)

All around the world, sea turtles are considered endangered species since their population has declined in the last two decades. In Baja California Sur Mexico, there is a conservation program run by Government Authorities, Industry, and Non-Governmental Agencies focused on vulnerable, threatened, and endangered marine species. In zones of high density of sea turtles, special nets, which allow them to surface for breathing, are deployed monthly for monitoring purposes. Nets are checked every 2 hours during the 24 hours of the census. During one of these checks, a female specimen of *Chelonya mydas agassizii* was video recorded using an action cam. Posterior analysis of the recording showed a clear pattern of pulsed sound when the diver was at close proximity to the turtle. The signal covers a frequency range of 300 to 800 Hz, which is within the ABRs average audiogram range reported by Ketten and Bartol for *Chelonya mydas* and within the behavioral Audiogram for *Chelonya mydas agassizii* that we have previously reported. The video and the sound analyses of this opportunistic recording, which might be a distress call, are presented.

Session 3aAO

Acoustical Oceanography: Munk Award Lecture

John A. Colosi, Chair
Department of Oceanography, Naval Postgraduate School, 833 Dyer Road, Monterey, CA 93943

Chair's Introduction—11:00

Invited Paper

11:05

3aAO1. New platforms, technologies, and approaches for remote inference of physical and biological parameters using acoustic scattering techniques. Andone C. Lavery (Appl. Ocean Phys. and Eng., Woods Hole Oceanographic Inst., 98 Water St., MS 11, Bigelow 211, Woods Hole, MA 02536, alavery@whoi.edu)

Active narrowband acoustic scattering techniques have been used for decades to study the distribution of marine organisms, such as fish and zooplankton, and to image physical oceanographic processes, such as internal waves and microstructure. In the last decade or so, these techniques have been extended to the use broadband acoustic scattering techniques for more accurate inference of relevant biological and physical parameters, such as size or abundance of organisms or intensity of mixing. Rapid advances in instrumentation and deployment platforms have also enabled new insights to be gained. In this presentation, a brief overview of this research area is given. Then, results from a decade of work on the development and implementation of broadband scattering techniques for studying physical and biological processes over relevant spatial and temporal scales are presented. Finally, recent data from an estuarine plume, collected with a broadband sonar integrated onto a Remus-100 Autonomous Underwater Vehicle, are presented. Advances and limitations of new platforms and sensors to the future of acoustical oceanography are considered.

Session 3aBA

Biomedical Acoustics, Structural Acoustics and Vibration, and Physical Acoustics: Wave Propagation in Complex Media: From Theory to Applications III

Pierre Belanger, Cochair
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Guillaume Haiat, Cochair
Multiscale Modeling and Simulation Laboratory, CNRS, Laboratoire MSMS, Faculté des Sciences, UPEC, 61 avenue du gal de Gaulle, Creteil 94010, France

Chair's Introduction—8:25

Invited Papers

8:30

3aBA1. Numerical simulation of the ultrasonic propagation in bone tissue. Yoshiki Nagatani (Dept. of Electronics, Kobe City College of Technol., 8-3, Gakuen-higashi-machi, Nishi-ku, Kobe, Hyogo 651-2194, Japan, nagatani@ultrasonics.jp)

Since bone has a complex structure, it is difficult to model analytically the behavior of ultrasound propagating in bone although ultrasound is useful for the diagnosis of not only bone density but also bone quality. Our group, therefore, had been working on simulating ultrasound propagation inside cancellous bones and models with cortical bones using actual mammal bones. In this paper, the basis and the results of the 3-D elastic FDTD (finite-difference time domain) method will be presented. The FDTD simulation only requires the 3-D geometry of the model and the distribution of acoustic parameters (density, speed of longitudinal wave, and shear wave) of the media such as bone and bone marrow, so that the effect of the each acoustic parameter or the geometry (e.g., BV/TV) can be easily investigated by changing these values. In addition, the effect of the frequency-dependent absorption caused by the viscosity and the piezoelectricity of bone also can be considered in the viscoelastic FDTD and the piezoelastic FDTD, respectively. The effects of these characteristics are not negligible. Moreover, thanks to the recent progress of the PC resource, a real-size simulation of human radius model is realized. Some preliminary data will also be presented. [JSPS KAKENHI 16K01431.]

8:50

3aBA2. Two ultrasound longitudinal waves in cancellous bone acquired using a fast decomposition method with a phase rotation parameter for bone quality assessment. Hirofumi Taki (Biomedical Eng. for Health and Welfare, Graduate School of Biomedical Eng., Tohoku Univ., 2-1 Seiryo-machi, Aoba-ku, Sendai, Miyagi 980-8575, Japan, hirofumi.taki.a1@tohoku.ac.jp), Yoshiki Nagatani (Dept. of Electronics, Kobe City College of Technol., Kobe, Hyogo, Japan), Mami Matsukawa (Faculty of Sci. and Eng., Doshisha Univ., Kyotanabe, Kyoto, Japan), and Shin-Ichi Izumi (Biomedical Eng. for Health and Welfare, Graduate School of Biomedical Eng., Tohoku Univ., Sendai, Miyagi, Japan)

Ultrasound signal passing through cancellous bone consists of two longitudinal waves: fast and slow waves. Accurate decomposition of the fast and slow waves is supposed to be highly beneficial in order to determine the characteristics of cancellous bone. We applied a fast decomposition method using adaptive beamforming technique with a phase rotation parameter to ultrasound signals that passed through bone specimens with various bone volume to total volume (BV/TV) ratios in a simulation study. The decomposition method accurately characterized the two waves with the normalized residual intensity of less than −19.5 dB when the specimen thickness ranged from 4 to 7 mm and the BV/TV ratio was from 0.144 to 0.226. The ratio of the peak envelope amplitude of the fast wave to that of slow wave increased monotonically as BV/TV ratio increased. The result also indicates a strong relationship between the phase rotation value and BV/TV ratio, where the variation of the phase rotation value increased as specimen thickness increased. These findings show that the decomposition method using adaptive beamforming technique with a phase rotation parameter has the high potential in estimating the BV/TV ratio in cancellous bone.

9:10

3aBA3. Bone repair and ultrasound stimulation: An insight into the interaction of LIPUS with the bone callus through a multi-scale computational study. Cécile Baron (ISM AMU-CNRS, 163 Ave. de Luminy, Marseille 13288, France, cecile.baron@univ-amu.fr), Carine Guivier-Curien (IRPHE CNRS-AMU, Marseille, France), Vu-Hieu Nguyen, and Salah Naili (MSME CNRS-UPEC, Créteil, France)

In the 1950s, the effect of ultrasound stimulation on bone healing has been discovered. Nowadays, Low Intensity Pulsed Ultrasound Stimulation (LIPUS) is admitted to influence the mechanotransduction of bone. Nevertheless, despite a growing literature—cell cultures, animal models, and clinical studies—the underlying physical and biological mechanisms of LIPUS on bone healing are still misunderstood. Inspired from previous studies on the mechanotransduction induced by physiological loading, this work focuses on the effect of LIPUS on the osteocytes. These bone cells are thought to be the principal mechanosensors of bone. They are ubiquitous inside the bone matrix, immersed in the lacuno-canalicular network (LCN) filled with interstitial fluid (IF). The goal is to relate the ultrasound stimulation applied at the tissue scale, to the biological response at the cell scale. To tackle this question, two finite element models were implemented in the commercial software Comsol Multiphysics. The tissue-scale model considers an anisotropic poroelastic matrix to evaluate the IF pressure gradient induced by LIPUS into the LCN. Then, in the cell-scale model, the IF shear stress magnitude and the induced drag forces applied on osteocyte process are calculated and compared with levels of cell activation recorded in literature.

Contributed Paper

9:30

3aBA4. Semi-analytical finite-element based method for inverse characterization of cortical bone using low-frequency guided waves. Daniel Pereira (Dept. of Mech. Eng., École de technologie supérieure, 100 Rue Notre-Dame O, Montreal, QC H3C 1K3, Canada, pereira.ufrgs@gmail.com), Julio Fernandes (Dept. of Surgery, Univ. of Montreal, Montreal, QC, Canada), and Pierre Belanger (Dept. of Mech. Eng., École de technologie supérieure, Montreal, QC, Canada)

Axial transmission research has demonstrated that low-frequency ultrasonic guided waves are sensitive to changes in the intracortical bone, which is of interest since the resorption in the endosteal region is associated to early-stage osteoporosis. Current methods rely on inversion schemes used to match experimental data with the theoretical data obtained from simplified models. However, due to the importance of the cross-sectional curvature of the cortical bone at low-frequency (e.g., $<$200 kHz), the implementation of a more elaborate model remains an open issue. Thus, the aim of this paper is to introduce a semi-analytical finite-element (SAFE) model to be used along with a genetic algorithm for the inverse characterization of cortical bone. Our proposal is to validate an inverse scheme using laboratory-controlled measurements on bone-mimicking phantoms at low frequency. An arbitrary cross-sectional geometry, instead of a plate or cylinder simplification, was implemented. Despite a computationally expensive SAFE routine, the results show that the model outputs estimated by the genetic algorithm are in good agreement with the reference values obtained by μCT images. The possibility of implementing parallel computation using graphics processing units in order to increase the level of complexity of the SAFE model may now be investigated.

Invited Papers

9:45

3aBA5. Ultrasonic bandgaps and interlaminar interface echoes of composite laminates: Analysis and experiments. Shiro Biwa (Dept. of Aeronautics and Astronautics, Kyoto Univ., C-Cluster III, Katsura, Nishikyo-ku, Kyoto 615-8540, Japan, biwa@kuaero.kyoto-u.ac.jp) and Yosuke Ishii (Dept. of Mech. Eng., Toyohashi Univ. of Technol., Toyohashi, Japan)

Increasing applications of carbon fiber reinforced plastics (CFRP) in aerospace industry highlight the importance of nondestructive methods to characterize their mechanical properties as well as defect concentrations. In CFRP laminate structures, thin resin layers, typically of a few micron thickness, are present between plies. Their spatially periodic nature causes bandgaps for ultrasonic waves having wavelengths comparable to the ply thickness. Features of the reflection and transmission spectra of ultrasonic waves including such bandgaps can be utilized for nondestructive characterization of CFRP laminates. In particular, the oscillatory frequency dependence of the reflection or transmission spectra of ultrasonic waves near the band gaps can be used to identify the equivalent stiffnesses of interlaminar interfaces. These interfacial stiffnesses contain rich information of the mechanical soundness of the interlaminar interfaces which are otherwise difficult to evaluate with traditional ultrasonic methods working in relatively low frequencies. The evidence of ultrasonic bandgaps of CFRP laminates can also be observed as long-standing signals following the surface echo in the temporal reflection waveforms of CFRP laminates (interlaminar interface echoes). In this presentation, the physical phenomena behind the ultrasonic bandgaps and interlaminar interface echoes of CFRP laminates are discussed together with their applications to nondestructive characterization of these materials.

10:05–10:25 Break

10:25

3aBA6. Remote sparse distributed sensors to image bondline defects between a composite panel and a stiffener. Sreedhar Puliyakote (I2M, Univ. of Bordeaux, 351 cours Liberation, I2M (A4) - Univ. of Bordeaux, Talence 33400, France), Xudong Yu, Zheng Fan (Nanyang Technolog. Univ., Singapore, Singapore), and Michel Castaings (I2M, Univ. of Bordeaux, Talence, France, michel.castaings@u-bordeaux.fr)

Adhesive bonding is widely used to fix skins to reinforcing elements, like stiffeners, in aerospace composite structures. A well-cured bond offers uniform stresses, good joint strength, and improved fatigue and impact resistance, and is therefore crucial to the performance of the entire structure. In the previous work by the authors, ultrasonic feature guided wave (FGW) has been discussed as a screening tool for quick inspection of the bondline between a CFRP panel and stiffener. However, it was found that material damping and weak reflections by defects along the feature makes the use of a single transducer in pulse echo mode quite inefficient. In this study, a structural health monitoring (SHM) technique is proposed to inspect the bondline, based on the radiation of plate modes into the CFRP panel when an incident FGW interacts with a defect in that bondline. A sparse array of sensors organized on the CFRP panel away from the stiffener was used to capture the waves radiating into the panel. A synthetic focusing method was applied to process the recorded signals for imaging the damaged area in the bond. Adhesive defects with varying dimensions were successfully identified in 3D FE simulations, with supporting experimental results to validate this method.

10:45

3aBA7. Simulation of wave propagation in polycrystalline materials. Gaofeng Sha (Mater. Sci. and Eng., Ohio State Univ., Columbus, OH), Anton Van Pamel, Ming Huang (Mech. Eng., Imperial College London, South Kensington, London SW7 2AZ, United Kingdom), Stanislav I. Rokhlin (Mater. Sci. and Eng., Ohio State Univ., Columbus, OH), and Michael J. Lowe (Mech. Eng., Imperial College London, South Kensington, London, United Kingdom, m.lowe@imperial.ac.uk)

The propagation and scattering of elastic waves within heterogeneous materials is of wide interest in seismology, medical ultrasound, and non-destructive evaluation. Accurate models of the behavior of the waves are important for the development of methods to characterize the materials using this information, as well as for the development of methods pursuing other information about the materials for which the attenuation and scattering are a nuisance to be minimized. Until recently, the leading models have been limited to analytical methods based on low-order scattering assumptions. However, it has now become possible to perform accurate three-dimensional Finite Element simulations, using spatial representation at grain scale, in significant sample volumes of large numbers of grains. Recent work by the authors has demonstrated that this approach can deliver attenuation and wave speed predictions that are good enough to enable evaluations of the features and approximations of the analytical models. Current work is addressing the use of this approach, in combination with analytical models, to investigate the physical phenomena of the scattering attenuation and wave speed dispersion, including the influences of materials symmetries and degree of anisotropy, and the effects of metal forming such as grain elongation.

11:05

3aBA8. Ultrasound measurement of texture in bulk polycrystalline materials. Bo Lan, Michael J. Lowe (Mech. Eng., Imperial College London, South Kensington, London SW7 2AZ, United Kingdom, m.lowe@imperial.ac.uk), T. B. Britton, and Fionn P. Dunne (Materials, Imperial College London, London, United Kingdom)

Manufacturing of metal components often results in significant texture, that is, to say, preferred orientations of their polycrystals. Since each crystal can be strongly anisotropic, this can give the component orientation-dependent material properties, affecting stiffness, thermal expansion, strength, and fatigue and creep resistance. So, it is important to be able to measure texture, especially for high-value safety-critical components. Typically, the Orientation Distribution Function (ODF) of the crystals can be measured on exposed surfaces using EBSD, or in thin samples using neutron diffraction. But both are expensive, and until recently there has not been a means to measure ODFs internally in bulk materials. However, the authors have recently developed a method to determine internal texture from measurements of wave speeds at selected angles through the volume of the material. This is based on a convolution of wave speeds in a single crystal with the ODF, giving the resultant polycrystal wave speed angular function. The principles of the method have been established and validated for single phase hexagonal and cubic materials. Ongoing work is investigating the use of multiple wave modes (shear and compressional) to identify further information; the extraction of volume fraction and texture of two-phase materials; and the pursuit of further refinement of the texture results by improved knowledge of the single crystal properties.

Contributed Paper

11:25

3aBA9. Impact of sol-gel transition on the acoustic properties of complex model foods: Application to agar/gelatin gels and emulsion filled gels. Mathieu Mantelet, Maud Panouillé, François Boué (UMR 782 GMPA, INRA - AgroParisTech - Université Paris Saclay, UMR 782 GMPA, 1 Ave. Lucien Brétignières, Thiverval-Grignon 78850, France, mathieu.mantelet@inra.fr), Frédéric Restagno (UMR 8502 LPS, CNRS - Université Paris Sud - Université Paris Saclay, Orsay, France), Isabelle Souchon, and Vincent Mathieu (UMR 782 GMPA, INRA - AgroParisTech - Université Paris Saclay, Thiverval-Grignon, France)

Quantitative Ultrasound techniques are good candidates for the *in situ* and real-time mechanical characterization of tongue-food-palate system, and thus to improve the understanding of the determinants of texture perception of food. Different model foods (consisting in gels and emulsion filled gels composed of agar and/or gelatin) have been designed for their contrasting properties in terms of texture perceptions. Prior to the feasibility study of a Quantitative Ultrasound method to monitor their mechanical breakdown during a compression, the aim of this study is to determine the respective roles of structure and mechanical properties of the different model foods in the variations of ultrasonic wave properties. Ultrasonic velocity, reflectivity, and attenuation were monitored during the sol-gel transition (from 50°C to 20°C) at 1 MHz in pulse-echo mode, and were confronted to visco-elastic moduli and mass density measurements. The results put in evidence the role of biopolymer concentration (independently from Young's and shear moduli) on the variations of velocity and reflectivity, resulting from joint variations of mass density and bulk modulus. Moreover, the ultrasonic attenuation was confirmed to depend on molecular relaxation phenomena of water, which are important in high-concentration gelatin samples.

Session 3aED

Education in Acoustics: Hands-On Acoustics Demonstrations for Middle- and High-School Students

Keeta Jones, Cochair
Acoustical Society of America, 1305 Walt Whitman Rd., Suite 300, Melville, NY 11787

Tracianne B. Neilsen, Cochair
Brigham Young University, N311 ESC, Provo, UT 84602

Acoustics has a long and rich history of physical demonstrations of fundamental (and not so fundamental) acoustics principles and phenomena. In this session, "Hands-On" demonstrations will be set-up for a group of middle- and high-school students from the New Orleans area. The goal is to foster curiosity and excitement in science and acoustics at this critical stage in the students' educational development and is part of the larger "Listen Up" education outreach effort by the ASA. Each station will be manned by an experienced acoustician who will help the students understand the principle being illustrated in each demo. Any acousticians wanting to participate in this fun event should e-mail Keeta Jones (kjones@acousticalsociety.org).

WEDNESDAY MORNING, 6 DECEMBER 2017 STUDIO 7, 7:40 A.M. TO 12:00 NOON

Session 3aID

Interdisciplinary and ASA Committee on Standards: Standards: Practical Applications in Acoustics

Christopher J. Struck, Cochair
CJS Labs, 57 States St., San Francisco, CA 94114

Robert D. Hellweg, Cochair
Hellweg Acoustics, 13 Pine Tree Road, Wellesley, MA 02482

Chair's Introduction—7:40

Invited Papers

7:45

3aID1. A history of noise exposure standards. William J. Murphy (Hearing Loss Prevention Team, Centers for Disease Control and Prevention, National Inst. for Occupational Safety and Health, 1090 Tusculum Ave., Mailstop C-27, Cincinnati, OH 45226-1998, wjm4@cdc.gov), Amanda Azman (Pittsburgh Mining Res. Div., National Inst. for Occupational Safety and Health, Pittsburgh, PA), and Mark R. Stephenson (Stephenson and Stephenson Res. and Consulting, LLC, Loveland, OH)

In the 1950s, the Committee on Hearing, Bioacoustics and Biomechanics (CHABA) investigated and developed recommendations for a variety of noise exposures. In 1956, the United States Air Force published AF Regulation 160-3, generally considered to be the first hearing conservation program in the US. The Walsh-Healy Act regulations [41 CFR 50-204.10] defined noise limits for occupational noise exposure for government supply contracts and the Federal Coal Mine Health and Safety Act of 1969 (Public Law 91-173) adopted these limits for underground and surface coal mine operations. The Occupational Safety and Health Act of 1970 (Public Law 91-596) created the Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH). NIOSH published *Criteria for a Recommended Standard: Occupational Exposure to Noise* in 1972. OSHA promulgated a regulation for occupational noise exposure and updated that with the Hearing Conservation Amendment 29 CFR Part 1910.95. The Mine Safety Administration has regulations for noise exposure that were updated in 1999, 30 CFR part 62. The military developed the materiel acquisition standard MIL-STD 1474E for high-level impulse noise. Existing and future needs for noise exposure standards for continuous, intermittent, and impulsive noise exposures will be discussed in this paper.

8:10

3aID2. An overview of ANSI/ASA S3.7-2016: Method for measurement and calibration of earphones. Christopher J. Struck (CJS Labs, 57 States St., San Francisco, CA 94114, cjs@cjs-labs.com)

An overview of the recent revision of "ANSI/ASA S3.7-2016 Method for Measurement and Calibration of Earphones" is given. Guidance for the selection of the appropriate coupler or ear simulator for a given earphone and application is provided. The various clauses within the standard describing measurements of calibrated frequency response, input-output linearity, electrical impedance, and non-linear distortion are presented. The method in the standard for dealing with issues related to positioning and test repeatability when using a head and torso simulator is described. The different standard coupling configurations for insert earphones and receivers are detailed. Intermodulation and difference frequency distortion test methods and their use to overcome the bandwidth limitations of the measurement system are also described. A method for measuring and quantifying left-right balance in a stereo headphone is also presented.

8:35

3aID3. Anechoic and hemi-anechoic chamber performance qualification—Review of recent standards changes. Douglas Winker (ETS-Lindgren, Inc., 1301 Arrow Point Dr., Cedar Park, TX 78613, douglas.winker@ets-lindgren.com)

Historically, anechoic and hemi-anechoic chamber qualification has been governed by ISO 3745 Annex A. In 2017, a revised version of ISO 26101 was published. A simultaneous update to ISO 3745 Annex A, now refers to the method described in ISO 26101. Many differences exist between the previous versions of ISO 3745 Annex A and the new ISO 26101 method including curve fit, traverse direction and quantity, traverse length, measurement spatial resolution, and others. These changes will impact qualification distances and frequency ranges for anechoic and hemi-anechoic chambers. A comparison between the previous method and the new method will be presented. The impacts of those changes on existing chambers and new chamber designs will be discussed.

9:00

3aID4. Recent developments in sound power level measurement standards. Robert D. Hellweg (Hellweg Acoust., 13 Pine Tree Rd., Wellesley, MA 02482, hellweg@hellwegacoustics.com)

The Acoustical Society of America ANSI accredited standards committee (S12) and the ISO committee TC43 SC1 (Noise) have developed a series of standards for measuring sound power levels of products. The engineering method to determine sound power levels in a free field over a reflecting plane is ANSI/ASA S12.54, which is the national adoption of ISO 3744. This is the standard "of choice" for a large majority of manufacturers of equipment—from consumer products to industrial machinery. In order to address issues found by using the standard over the years, some of which rarely occur, ANSI/ASA S12.54 (ISO 3744) has become larger and more complex. The ISO working group began a project to simplify ISO 3744 in order to make it simpler, easier to use, and more understandable. Instead of attempting to cover 99% of the situations that could arise during testing, the main body of the revised standard will address 90% of the cases. The issues that occur infrequently will be moved into annexes, and some parts will be consolidated into other standards. The current status of these changes to ISO 3744 and plans for the other sound power level standards will be discussed.

9:25

3aID5. Introduction to S12.70 speech privacy in healthcare. Kenneth W. Good (Armstrong, 2500 Columbia Ave., Lancaster, PA 17601, kwgoodjr@armstrong.com) and Eric L. Reuter (Reuter Assoc., Portsmouth, NH)

The Privacy Rule within HIPAA requires that personal identifiable information be kept private. Reasonable safeguards must be taken for electronic, paper, and oral (speech) communications. The S12.70 standard provides a means to design, operate, and enforce to this requirement. We will explore the background and practical application of this standard.

9:50

3aID6. Acoustical measurements with mobile devices and the challenge of standards compliance. Benjamin Faber (Faber Acoust., LLC, 277 S 2035 W, Lehi, UT 84043, ben@faberacoustical.com)

With more attention being brought to the use of mobile devices for acoustical measurements, questions of measurement quality and standards compliance continue to be raised. What kinds of acoustical measurements are realistic with a mobile device? Can a smartphone or tablet be used as a properly qualified sound level meter? If not, under what conditions might it be appropriate to rely on a mobile measurement solution? For the purposes of this presentation, the IEC 61672 standard for sound level meters will be discussed with respect to mobile measurement apps and devices.

10:15–10:30 Break

10:30

3aID7. Measurement uncertainty and its application to standards in acoustics. Christopher J. Struck (CJS Labs, 57 States St., San Francisco, CA 94114, cjs@cjs-labs.com)

The basic theory of measurement uncertainty as found in IEC and ISO standards is reviewed. Random error, bias error, confidence interval, coverage factor, and expanded uncertainty are defined. The concept of acceptance intervals applied to tolerance limits on the performance of electroacoustical systems for outgoing quality control and incoming inspection is presented. Calculation of the

maximum permitted uncertainty is detailed and its application in the development of an uncertainty budget for a given electroacoustical measurement is shown. Example uncertainty budgets are developed for response measurements on a number of common electroacoustical devices including loudspeakers, microphones, telephones, earphones, and hearing aids. In addition to using this method to develop an uncertainty budget, it is shown how it can also be used as a diagnostic tool to find problems in the specification of various components in a measurement chain. An example of its diagnostic use on the current version of the ANSI S3.22 hearing aid standard is shown. Last, the uncertainty is calculated for a measurement of random noise and its dependence on bandwidth and averaging time is examined.

10:55

3aID8. Upcoming international standards in psychoacoustics. Roland Sottek (HEAD Acoust. GmbH, Ebertstr. 30a, Herzogenrath 52134, Germany, roland.sottek@head-acoustics.de)

Besides loudness, other psychoacoustic parameters like tonality and roughness can be used for product noise assessments. Tonality measurement procedures quantify the audibility of prominent tonal components and roughness evaluates modulation characteristics. In June 2017, two new ISO standards for loudness were published: ISO 532-1 (Zwicker method, based on DIN 45631/A1:2010-03) for stationary and time-varying sounds and ISO 532-2 (Moore/Glasberg method, based on ANSI S3.4-2007) for stationary sounds only. Additionally, ISO TC 43/WG 9 started now to work on ISO 532-3 for time-varying loudness based on the TVL model of Moore/Glasberg. For many years, tonality measurement procedures such as the Tone-to-Noise Ratio (TNR) and Prominence Ratio (PR) have been applied to identify prominent discrete tones. Recently, a new perceptually accurate tonality assessment method based on a hearing model of Sottek was developed which evaluates the nonlinear and time-dependent loudness of both tonal and broadband components, separating them via the autocorrelation function. This new perception-model-based procedure, suitable for identifying and ranking tonalities from any sources, is proposed for the next edition of ECMA-74 as an alternative to TNR and PR. Furthermore, it is planned to extend ECMA-74 by a roughness calculation procedure based on the same hearing model approach together with some post processing (such as a weighted modulation spectral analysis). The paper gives an overview of recent developments of psychoacoustic standards.

11:20

3aID9. Development of an S3/SC1 standard for auditory evoked potential hearing tests in toothed whales. Dorian S. Houser (National Marine Mammal Foundation, 2240 Shelter Island Dr., San Diego, CA 92106, dorian.houser@nmmfoundation.org)

The National Marine Fisheries service regulates the impact of anthropogenic ocean noise to marine mammals. Other government and commercial groups that produce ocean noise are subject to regulation. Both groups desire greater knowledge of hearing in marine mammals to better predict, mitigate, and regulate noise exposure. Auditory evoked potential (AEP) hearing tests have become a primary method by which hearing tests are performed in toothed whales (e.g., dolphins, porpoises). The synthesis of AEP data to address noise impacts to marine mammals is limited, in part, because of the variability between AEP thresholds measured by different researchers and laboratories using different methodologies. Methodological differences exist for AEP detection, threshold estimation, calibration, and stimulus delivery. Threshold variability could be reduced through standardization of AEP hearing test methods, which is desired by regulatory agencies and sound producers. An S3/SC1 standard for AEP hearing test methods in toothed whales has been initiated to address this need. The draft standard will be submitted to ANSI for consideration by the end of 2017. Adoption of the standard internationally would further improve threshold comparability by ensuring researchers globally utilize the same methods. The process should increase AEP data reliability for purposes of addressing ocean noise issues.

Contributed Paper

11:45

3aID10. A primary method for the complex calibration of a hydrophone from 1 Hz to 2 kHz. William H. Slater, Steven E. Crocker (Naval Undersea Warfare Ctr. Div. Newport, 1176 Howell St., Newport, RI 02841, william.h.slater@navy.mil), and Steven R. Baker (Naval Postgrad. School, Marina, CA)

Primary calibrations of hydrophones at frequencies less than about 1 kHz are typically performed in a coupler reciprocity chamber ("coupler"); a closed test chamber where time harmonic oscillations in pressure can be achieved and the reciprocity conditions required for a primary calibration can be realized. The closed and controlled environment in the coupler allows for the performance of primary calibrations over the temperature and hydrostatic pressure range found in the ocean. The coupler reciprocity system employed by the United States, in service since the 1960s, provides only the magnitude of the pressure sensitivity and not the phase. Recent work has demonstrated a method for the primary calibration of both the magnitude and phase of the complex sensitivity for a hydrophone at frequencies ranging from 1 Hz to 2 kHz. The combined expanded uncertainties of the magnitude and phase of the complex sensitivity at 1 Hz were 0.1 dB re 1V/μPa and $\pm 1^{\circ}$, respectively.

Session 3aMU

Musical Acoustics: General Topics in Musical Acoustics

Whitney L. Coyle, Chair
Department of Physics, Rollins College, 1000 Holt Ave., Winter Park, FL 32789

Contributed Papers

8:45

3aMU1. Signal analysis of New Orleans jazz clarinet sounds. Joshua Veillon, Juliette W. Ioup (Dept. of Phys., Univ. of New Orleans, New Orleans, LA 70148, jveillon@uno.edu), and Michael White (Xavier Univ., New Orleans, LA)

Many have noted the remarkable variety in clarinet tones produced by one player as compared to another, for example, in New Orleans jazz performances. To understand and interpret these differences, they are often described qualitatively in musical terms. These descriptions have potentially loose interpretations from one musician to another. The research presented here is an attempt to quantify such differences using acoustical signal processing techniques including Fourier transform analysis, power spectral analysis, spectrograms or time-frequency plots, and energy dependence on frequency. Variables such as recording equipment, instrument design, and performance techniques of individual artists will be considered. Examples from historical and contemporary recordings will be discussed and used to demonstrate conclusions.

9:00

3aMU2. Development process of the grand piano duplex scale. Niko Plath (Inst. of Systematic Musicology, Univ. of Hamburg, Germany, Neue Rabenstr. 13, Hamburg, Hamburg 20354, Germany, niko.plath@uni-hamburg.de) and Katharina Preller (Deutsches Museum, München, Germany)

Acoustical investigations of the earliest examples of implemented duplex schematics allow to shed light on the question of how much of the piano development in the late 19th century was still a trial and error approach or already a methodical process based on empirical findings. Further, it is investigated if the intended effect was instantly perceivable, or if it was first a theoretical concept, which was later refined to enhance a certain tonal character. For a modern grand piano, the influence of the duplex schematic on the vibroacoustic behavior and the aural impression is extensively covered by Öberg and Askenfelt. By performing measurements on several pianos from the late eighteen hundreds, most prominently the so-called Helmholtz piano, a Steinway grand presented as a gift to von Helmholtz in appreciation of the impact of his work on the company's piano development, it is possible to retrace development procedures in the workshop in that specific time period. Design parameters from the respective pianos are obtained, e.g., string length ratios, angles from main string to front duplex, boundary conditions, and string diameters. Acoustical measurements, as proposed by Öberg and Askenfelt, are performed to examine if these constructive changes have any significant effect on the generated sound and to allow a comparative analysis of both historical and contemporary instruments.

9:15

3aMU3. Acoustical nonlinearities in the structural components of the piano. Lauren Neldner, Eric Rokni, Cierra Gibson, and Thomas Moore (Dept. of Phys., Rollins College, Winter Park, FL 32789, lneldner@rollins.edu)

Anomalous frequency components in piano sound, commonly referred to as phantom partials, are generally believed to originate from a geometrical nonlinearity of the string. Recent evidence suggests that phantom partials may also be produced by nonlinearities in the non-string components of the piano such as the soundboard, case, bridge, and frame. We report experimental results indicating that in addition to phantom partials, these nonlinearities associated with the piano structure also generate harmonic frequency components, which may affect the perceived sound more significantly than the phantom partials. The possible origins of this nonlinearity will be discussed.

9:30

3aMU4. An acoustical study focused on the effects of guitar soundboard material on sound propagation. Guido Saccaggi (Mech. Eng., Catholic Univ. of America, 2000 Woods River Ln., Duluth, GA 30097, guidosaccaggi@gmail.com), Josh Capozella, Derek Kuebler, Diego Turo, and Joseph F. Vignola (Mech. Eng., Catholic Univ. of America, Washington, District of Columbia)

This presentation describes a student project that aims to study the effect of a guitar top's material and bracing design on measurable parameters such as radiated sound power and spectrum. To illustrate, two identical, classical guitars were purchased, and the soundboards were replaced. The top of one guitar was replaced with a soundboard composed of two different woods and the other with a carbon fiber composite. Mahogany and spruce were chosen as the two woods, as mahogany is purported to enhance lower notes and spruce to enhance higher notes. Carbon fiber was picked to maximize flexural rigidity of the top. Performances of the two guitars were characterized by measuring the acoustic pressure at a fixed distance from the guitar. Additionally, the vertical acceleration of specific locations of the top was also measured as well as the strain in the pick to make a fair comparison between the sounds radiated by both guitars. Sound recordings were analyzed with time-domain, frequency spectra, and to compare the performance of the two guitars

9:45

3aMU5. Acoustic characterization of a Ukelin. Tyler J. Cottrell, Thomas Gleason, Philip P. Faraci, Eoin A. King, Robert Celmer (Acoust. Program & Lab., Mech. Eng. Dept., Univ. of Hartford, 200 Bloomfied Ave., West Hartford, CT 06117), (faraci@hartford.edu)

An acoustical characterization was performed on a *ukelin*, a wooden hybrid stringed instrument designed to combine features of the ukulele and the violin. This instrument consists of two resonant cavities at opposite ends of the instrument, one supporting sixteen strings that are individually bowed, and the other supporting 16 strings arranged in groups of four-note diatonic chords that are simultaneously plucked with the free hand, allowing

3a WED. AM

an individual player to produce a melody/accompaniment combination. The ukelin design was patented in the early 20th century and sold door-to door as a novelty instrument. Modal Analysis results of a sample instrument are presented and compared with an FEA normal modes solution using ANSYS. Preliminary results show good agreement of the mode shapes for several modes between the modal results and the ANSYS predictions, but a significant difference in mode frequencies for a given mode shape. The differences in frequency are attributed primarily to unknown material properties of the wood of the sample instrument. Implications of the use of a finite-element model and of the Dynamic Modification feature of modal analysis are discussed.

10:00–10:15 Break

10:15

3aMU6. Evaluating the use of crowdsourced data classification in an investigation of the steelpan drum. Joseph A. Garcia (Natural Sci., Joliet Junior College, 2707 Ruth Fitzgerald Dr., Plainfield, IL 60586, jgarcia7713@gmail.com) and Andrew C. Morrison (Natural Sci., Joliet Junior College, Joliet, IL)

The effectiveness and reliability of crowdsourced data classification to study the acoustics of the steelpan was evaluated. A project was developed and hosted on the widely used Zooniverse website. Volunteers on the project's site were asked to identify areas of maximum vibrations (called antinodes) and number of bright rings (fringes) in those areas for each classification. We explored various methods in ensuring volunteers generate successful classifications. The data for classification comes from a high-speed video recording, paired with Electronic Speckle Pattern Interferometry, of a strike on the steelpan's surface, which produces thousands of frames to be analyzed. We developed the project in preparation for a public release. We have analyzed the collected classifications using imported Python libraries. After validation and averaging of volunteer classifications, an Amplitude vs. Time graph was obtained for each antinode region, which included a comparison between using the area of the antinode region or the number of fringes as an indicator of a region's amplitude.

10:30

3aMU7. A study on the sound investigation of wooden gong rock. Bong Young Kim and Myungjin Bae (Sori Sound Eng. Lab, Soongsil Univ., 21-1, Garak-ro 23-gil, Songpa-gu, #203, Seoul 05669, South Korea, bykim8@ssu.ac.kr)

In Korea, there is a rock with a wooden gong sound. It is the wooden gong rock of Pyochungsa Temple in Miryang, Gyeongsangnam-do, and drum rock of Palgongsan Mountain in Daegu. The wooden gong is one of the Buddhist ceremonial tools that make a sound by knocking an empty tree. In this paper, we will investigate which sound component of wooden gong rock and drum rock as a wooden gong sound through sound analysis. The wooden gong resonates at about 600 Hz when tapped and continues to sound for about 0.1 second. However, most stones and rocks have a sound duration of less than 0.3 seconds without any resonance. Pyochungsa Temple's Wooden gong rock resonates at about 600 Hz and shows a duration of 0.6 to 0.9 seconds, depending on the knocking position and strength. Palgongsan Mountain's Drum rock resonates at about 400 Hz and has a duration of about 0.5 seconds. We conducted a MOS test on 30 people to see how much sound like a wooden sound for each sound. The results were as follows: wooden gong 4.5, wooden gong rock 4.1, drum rock 3.4, and common stone 2.0. Thus, the sound component of Pyochungsa Temple's wooden gong rock is closest to the wooden gong sound, so it sounds like a wooden gong sound. Wooden gong rock's wooden gong sound inspires Buddhist believers and tourists with Buddhist aspiration and patriotic loyalty. By investigating the sounds of these cultural heritages, the value and meaning of cultural heritage can be reexamined.

10:45

3aMU8. Time-scaling vibrato tones while preserving vibrato rate. Yang Shi (Elec. Eng. Dept, Univ. of California at Los Angeles, 56-125B Eng. IV Bldg., 420 Westwood Plaza, Los Angeles, CA 90095-1594, mikeshiyang@gmail.com) and James W. Beauchamp (School of Music and Elec. & Comput. Eng., Univ. of Illinois at Urbana-Champaign, Urbana, IL)

Elongation of vibrato tones while preserving vibrato rate is a non-trivial problem in audio processing. It is well known that linear time-scaling in the time domain simply translates duration in lockstep with pitch. In the time/frequency domain, frequencies are preserved under linear time-scaling, but vibrato rates are not. Looping can preserve rate, but there is a problem synchronizing loops with vibrato cycles. Our current method is to parameterize harmonic frequency- and amplitude-vs-time variations so that vibrato rate is one of the parameters, along with vibrato depth and frequency drift. A heterodyne/filter method, where the heterodyne frequency is estimated from an FFT of the full-duration frequency deviation waveform, is used for vibrato analysis. Harmonic amplitude vibrato parameters can be estimated either by using the heterodyne/filter method directly or by using amplitude-vs-frequency relationships. Once the model is completed, the harmonic parameters can be time-scaled while keeping the vibrato rate intact. An exception to this treatment is to keep the attack and decay epochs intact. Once recomputed, the new time-varying harmonic spectrum representation is converted to a time-domain signal via sinusoidal additive synthesis.

11:00

3aMU9. A study on the song feelings change of soprano singers. Sang Bum Park and Myungjin Bae (Soongsil Univ., Sando-ro 369, Dongjak-gu, Seoul, Korea, Seoul 06978, South Korea, sbpark8510@naver.com)

The types of female vocalist are three classified into Soprano, mezzo-Soprano and Contralto according to the register. The Soprano speaks the highest voice of the female Soprano voice. In this study, we analyzed the changes in the sound width of the Coloratura Soprano, which is particularly accurate at the highest register. We measured the extent to which the world famous ten Soprano singers were attracted to the songs and presented the results to MOS SCORE. As MOS SCORE result, the more the change characteristic of the tone of the Soprano voice, the more conspicuous phenomenon becomes conspicuous. Also, the more the change in tone is displayed, the higher the extent that it is attracted by feeling the change of emotion greatly matched. By utilizing the characteristics shown in this research, the Soprano singer's prospect is inferred by referring to the Soprano singer's seamless tone change characteristics according to the correlation between tone change and fascination It became possible to do.

11:15

3aMU10. Time-scaling nonvibrato musical tones while preserving timbral texture. An Zhao (Dept. of Elec. and Comput. Eng., Univ. of Illinois at Urbana-Champaign, Urbana, IL 61801, anzhao2@illinois.edu) and James W. Beauchamp (School of Music and Elec. & Comput. Eng., Univ. of Illinois at Urbana-Champaign, Urbana, IL)

Sounds produced by linear stretching of nonvibrato single tones fail to preserve their original microvariations. While looping is commonly used for elongation with wavetable synthesis, this method requires careful attention to periodic waveform boundaries. Time extension by time reversal ensures continuity in the time domain, but this method causes audible clicks due to waveform phase reversals. This problem is overcome by using a pitch-synchronous phase vocoder method that generates time-varying harmonic amplitude and frequency envelopes. Applying the time-reversal looping method to these envelopes and converting to the time domain via sinusoidal additive synthesis can generate elongated versions of the original sound without audible clicks. To retain realism, original attack and decay time data are preserved. For shortening, envelopes are cross-faded between the attack-end and decay-begin points. As an application, the algorithm has been implemented in a score-processing music synthesis program.

11:30

3aMU11. Evaluation of complex stimuli and resulting distortion product spectrum in auditory distortion product synthesis. Alex Chechile (CCRMA, Stanford Univ., 660 Lomita Ct., Stanford, CA 94305, chechile@ccrma.stanford.edu)

Auditory distortion products are frequency components produced within the listener's ears upon the presentation of simultaneously sounding stimulus tones. Under certain conditions the listener can perceive distortion products as additional frequencies not present in the acoustic space, and the tones appear to be localized within the head. Musicians have been aware of this phenomenon of "combination tones" since the 18th century, but advancements in technology allow for new possibilities in music synthesis. *On the Sensations of Tone* is a series of compositions featuring a separate stream of musical material generated as auditory distortion products. The pieces are built using *The Ear Tone Toolbox*, a collection of open-source instruments for producing combination tones. While a single pair of stimulus frequencies typically elicits a small number of perceivable distortion products, the author puts forth a technique for evoking a spectrum of distortion products using a greater number of frequencies. The technique is informed by a mathematical model and is the basis of the next version of *The Ear Tone Toolbox*. This talk will provide an overview of the updated software, model, and compositions in the series.

11:45

3aMU12. The acoustics of Fundação Iberê Camargo's parking lot. Peter Francis C. Gossweiler (Instituto de Artes, UFRGS, Trav. Nsa. Sra. de Lourdes, 230 apt. 503 D, Porto Alegre, Rio Grande do Sul 91920-040, Brazil, petergossweiler@gmail.com)

Through listening to the audio of a video recording of the acoustics of Fundação Iberê Camargo's parking lot, we propose the writing of a text. From this dependence on reliving past issues and reinterpreting them by a device such as this recording, we evoke the symptom of the void. To that end, we dialogue with Yves Klein's statement of le vide (1961), which proposes to feel and understand simultaneously the possibility of filling the space with our presence and absence, with the wooden doll's head Mechanischer Kopf (1920) by Raoul Hausmann, who, by dependence on multiple devices coupled to it, no longer exercises thinking and with Lygia Clark's Organic Line (1954), which makes us think that art is in the real world, just as the real world is in art. These relationships lead us to an organization of space for something beyond emptiness and our presence.

WEDNESDAY MORNING, 6 DECEMBER 2017 BALCONY L, 8:30 A.M. TO 11:45 A.M.

Session 3aPA

Physical Acoustics and Biomedical Acoustics: Acoustofluidics

Kedar C. Chitale, Cochair
Flodesign Sonics, 380 Main Street, Wilbraham, MA 01095

Max Denis, Cochair
U.S. Army Research Lab., 2800 Powder Mill Road, Adelphi, MD 20783-1197

Invited Papers

8:30

3aPA1. Macro-scale acousto-fluidics using bulk ultrasonic standing waves. Bart Lipkens (Mech. Eng., Western New England Univ., 1215 Wilbraham Rd., Box S-5024, Springfield, MA 01119, blipkens@wne.edu), Kedar C. Chitale, Benjamin P. Ross-Johnsrud, Walter Presz (FloDesign Sonics, Wilbraham, MA), Yurii A. Ilinskii, and Evgenia A. Zabolotskaya (Appl. Res. Labs, Univ. of Texas at Austin, Austin, TX)

Macro-scale acousto-fluidics involves the interaction between acoustic radiation force exerted on a particle by bulk acoustic standing waves spanning many wavelengths, fluid drag force, and the gravitational force of the particle. Parameters are particle size, and ratio of particle to fluid density and particle to fluid compressibility. Different acousto-fluidics configurations can be used to manipulate particles in multiple ways. In cell clarification, the configuration is that of a depth flow filter with the added benefit of separating the cells out of the acoustic field, thereby eliminating any issues with filter clogging or fouling. In perfusion of stirred bioreactors, the configuration resembles that of a tangential flow filter. In a third configuration, the bulk acoustic standing wave is angled relative to the fluid velocity resulting in a label-free fractionation tool. Several underlying theoretical and numerical results of acoustic radiation force and particle trajectory calculations will be presented. A theoretical framework to calculate the acoustic radiation force on spherical, spheroidal, and cylindrical particles has been developed for any particle size relative to wavelength. An analytical solution for particle deflection angle in a planar angled standing wave and uniform flow has been developed. Experimental results will be shown to support the theory.

9:00

3aPA2. Acoustic Rayleigh streaming: Comprehensive analysis of source terms and their evolution with acoustic level. Virginie Daru (Arts et Metiers ParisTech, Paris, France), Diana Baltean-Carlès, Catherine Weisman (Sorbonne Universités, UPMC Univ. Paris 6 and LIMSI-CNRS, Sorbonne Universités, UPMC Univ Paris 06, UFR d'Ingénierie, 4 Pl. Jussieu, LIMSI, CNRS, Université Paris-Saclay, Bât. 508, Rue John Von Neumann, Campus Universitaire, F-91405 Orsay Cedex, France, Paris 75252, France, baltean@limsi.fr), Hélène Bailliet (Institut Pprime, Poitiers, France), and Ida Reyt (Arts et Metiers ParisTech, PARIS, France)

Rayleigh streaming is a second order mean flow generated by the interaction between a standing wave and a solid wall. At moderate acoustic levels, the streaming flow is slow, composed of two cells along a quarter wavelength: an inner cell close to the tube wall and an outer cell in the core. When increasing the acoustic level, the streaming flow inside the inner cells is marginally modified, while the outer cells are strongly distorted. The emergence of an extra cell was observed both in previous numerical simulations and experiments and it has been shown that inertia is not responsible for this behavior, which is rather due to nonlinear interactions between streaming and acoustics. In the present work these interactions are analyzed both numerically and theoretically. The averaged Navier-Stokes equations are numerically solved with acoustic correlation source terms obtained from previous full instantaneous simulations. The effect of each source term is highlighted and the source term responsible for the emergence of the extra cell is identified. The numerical results are successfully compared with the analytical solution of simplified streaming linear equations.

9:30

3aPA3. Standing surface acoustic wave enabled acoustofluidics for bioparticle manipulation. Xiaoyun Ding (Mech. Eng., Univ. of Colorado at Boulder, 1111 Eng. Dr., ECES 158, Boulder, CO 80309, Xiaoyun.Ding@Colorado.edu)

Techniques that can noninvasively and dexterously manipulate cells and other bioparticles in a compact system are invaluable for many applications in life sciences and medicine. The past two decades have witnessed the emerging of acoustofluidics: the fusion of acoustics and microfluidics, due to it numerous advantages such as biocompatibility, miniaturization with lost cost, compatibility with other microfluidic system, and many others. Here, we first demonstrate surface acoustic wave (SAW) enabled acoustic tweezers platform for on-chip particle manipulation. Surface acoustic wave is a kind of ultrasound wave that propagates on the surface of a substrate. By tuning the standing SAW field, we demonstrated the functions of: (1) manipulation of nanoparticles, cells, and C elegance; (2) label free cell separation; (3) multichannel cell/droplet sorting, and (4) tunable cell patterning. Cells viability and proliferation assays were also conducted to confirm the non-invasiveness of our technique. The simple structure/setup of these acoustic tweezers can be integrated with a small radio-frequency power supply and basic electronics to function as a fully integrated, portable, and inexpensive cell-manipulation system. We believe that these unique advantages and functions position our acoustic tweezers to be a useful tool in medical diagnostics and biological/chemical studies.

Contributed Papers

10:00

3aPA4. Bacterial suspensions under acoustic confinement and the impact on biofilm formation. Salomé Gutiérrez (Laboratoire de physique et mécanique des Milieux Hétérogènes, ESPCI- Paris, France, UPMC, Université Paris7., 10 Rue Vauquelin, Paris, Ille de France 75005, France, salome.gutierrez-ramos@espci.fr)

Active matter exhibit plenty intriguing non equilibrium properties while in confinement. Optical and magnetic confinement had helped in the evaluation of rich collective behaviour of active entities. Self-propelled particles in aqueous suspensions can be trapped with acoustic fields generated by acoustic resonators usually at frequencies in the megaHertz. In this work, we give a step forward in the field of confined active matter reporting for the first time experiments of *Escherichia coli* suspensions in acoustic levitation. In particular the implementation of an acoustic levitation technique to manipulate in a contact-less and controlled way the dynamics of the active suspension. The aggregation of living bacteria is monitored as a function of time, where different phases are clearly distinguished. Upon the removal of the acoustic signal, bacteria rapidly disaggregate induced by their own swimming. However, if the levitation time increases, a stable aggregate, that resemble a biofilm, remains even after the withdraw of the acoustic confinement.

10:15–10:30 Break

10:30

3aPA5. Acoustic radiation force moment on non-spherical objects in liquid. Bart Lipkens (FloDesign Sonics, 1215 Wilbraham Rd., Box S-5024, Springfield, MA 01119, blipkens@wne.edu), Yurii A. Ilinskii, and Evgenia A. Zabolotskaya (Appl. Res. Labs, Univ. of Texas at Austin, Austin, TX)

Previously, a study of the acoustic radiation force acting on a spheroidal object in liquid showed that the radiation force depends on the angle between the incident acoustic wave and the main axis of a spheroid. This investigation demonstrated that there is a radiation force moment which acts on the spheroidal object and depends on particle orientation. This contribution is a continuation of the previously reported work. Here, the acoustic radiation force moment on prolate objects in an acoustic field in liquid is investigated analytically, i.e., the equations to describe the moment are derived. The incident acoustic and scattered field are expanded with respect to spherical waves. Analytically, scattering amplitudes are calculated from boundary conditions for spheroidal functions that are solutions of a wave equation in spheroidal coordinates ζ, η, φ. The radiation force moment is analyzed numerically. Randomly oriented spheroidal particles distributed in liquid align in an acoustic field as scattering amplitudes of each particle and therefore the acoustic radiation force acting on them depend on object orientation. The radiation force moments on each particle also depend on their orientation, and the prolate spheroidal objects are turned in such a way to make the torque of them to be equal to zero.

10:45

3aPA6. Fluid dynamical and acoustical fields in the vicinity of small objects reacting to radiation forces and torques. Allan D. Pierce (Cape Cod Inst. for Sci. and Eng., PO Box 339, 399 Quaker Meeting House Rd., East Sandwich, MA 02537, allanpierce@verizon.net), Charles Thompson (Elec. and Comput. Eng., Univ. of Massachusetts at Lowell, Lowell, MA), and Max Denis (Physical and Life Sci. Solutions, Lowell, MA)

The venerable and extensive literature on the theory of acoustic radiation forces and torques on small embedded particles is briefly reviewed, assessed, and criticized. This paper adopts a approach that first concentrates on determining the near field of a non-stationary embedded particle for the case when $ka \ll 1$. The near field is the region where $r < 1/k$. The philosophy of matched asymptotic expansions is adopted and the near field is assumed to consist of (1) an oscillating incident wave, (2) an oscillating reaction wave that goes to zero at large r/a, (3) an oscillating incompressible field that is associated with viscosity, also going to zero at large r/a, and (4) a

quasi-static field that is also associated with viscosity. The latter results in part from a perturbation expansion to take into account non-linear effects of the fluid dynamical equations. The far-field scattered wave results from asymptotic matching to the near-field. The near-field reaction field separates into monopole and dipole portions where the orientation of the dipole is related the detailed natures of incident wave and particle. Forces are obtained by integration of stresses over the surface of the body or over a surface slightly outside the particle. In appropriate limits, the predicted forces agree with results of King (1934) and Gorkov (1962).

11:00

3aPA7. Investigation on a novel photoacoustofluidic effect. Gabriel P. Dumy, Mauricio Hoyos, and Jean-Luc Aider (PMMH, ESPCI Paris, 10 rue Vauquelin, Paris 75005, France, gabriel.dumy@espci.fr)

Acoustic manipulation of micro-objects (particles, cells, and bacteria) can be achieved using ultrasonic standing waves in a fluidic or microfluidic resonator. By matching resonator dimensions and acoustic field frequency, it is possible to use acoustic radiation force (ARF) to gather the particles in the pressure nodal (or anti-nodal) plane, creating one or several aggregates. In standard operating conditions, they can be maintained as long as needed in acoustic levitation at this equilibrium position. In this study, we present a new unexpected phenomenon. After creating a large aggregate of light-absorbing particles, we show that it is possible to force the complete breakup of the aggregate when we enlighten it with an electromagnetic wave of adequate wavelength and intensity. If the particles remain in acoustic levitation, they are quickly rejected and propelled away from the aggregate leading to its fast destruction. We show that this phenomenon strongly depends on both the amplitude of the ultrasonic field and the intensity of the lighting. Various experiments with different types of particles and concentrations are used to discuss the possible explanations of the phenomenon. Moreover, investigations showed that this phenomenon applies to biological compounds such as red blood cells and stem cells, suggesting potential biomedical applications.

11:15

3aPA8. Acoustical deformability of giant unilamellar vesicles. Liangfei Tian (School of Chemistry, Univ. of Bristol, Bristol, Bristol, United Kingdom), Glauber T. Silva (Dept. Phys., Federal Univ. of Alagoas, Av. Lourival Melo Mota, S/N, Maceio, Alagoas 57072-900, Brazil, tomaz.glauber@gmail.com), and Bruce W. Drinkwater (Dept. Mech. Eng., Univ. of Bristol, Bristol, United Kingdom)

An acoustic standing wave is used to trap and deform giant unilamellar vesicles with a diameter ranging from 10 to 50 μm. The giant unilamellar vesicles are prepared in glucose solution with a bi-layer of DOPC membrane with approximately 10 nm-thickness. They are suspended in a 4 cm^2-chamber of an acoustofluidic device. The density of the vesicles is about 98% of the external solution density. The device operates with a single-frequency at 6 MHz producing a standing wave of 250 μm-wavelength, which is much larger than the vesicles' radii. To explain the observed deformability, we propose an acoustic deformation model as follows. The radiation stress, caused by the interaction of the standing wave and a vesicle, is obtained in the long-wavelength limit. Using the deformation theory of thin spherical shells, we show that the aspect ratio of a deformed vesicle is 1 + 2δ, where δ is inversely proportional to Young's modulus and directly proportional to the density contrast between the vesicle and the solution. Our preliminary observations and theoretical results give an aspect ratio of the same order of magnitude, $\delta<1/2$. Additionally, predictions of our model agree with the results for the deformation of an osmotically swollen red blood cell reported by Mishra *et al*. [Biomicrofluidics **8**, 034109 (2014)]. In this case, the relative error is smaller than 6%. [Work partially supported by Newton Advanced Fellowship (NA160200), The Royal Society, UK.]

11:30

3aPA9. Dynamic measurement of blood viscoelasticity by an oscillatory acoustic tweezing technique. Nithya Kasireddy, Erika M. Chelales (Biomedical Eng., TulaneUniv., 440 Lindy Boggs, New Orleans, LA 70118, nkasired@tulane.edu), Vahideh Ansari Hosseinzadeh (Mech. Eng., Boston Univ., Boston, MA), Daishen Luo (Biomedical Eng., TulaneUniv., New Orleans, LA), Ray Holt (Mech. Eng., Boston Univ., Boston, MA), and Damir Khismatullin (Biomedical Eng., TulaneUniv., New Orleans, LA)

Acoustic tweezing rheometry is an innovative technology for low-volume non-contact rheological analysis of complex fluids characterized by increased sensitivity and accuracy as compared to traditional contact techniques. In this method, a small drop of a fluid sample is levitated in air by acoustic radiation forces and its viscoelasticity at different time instants is measured from drop shape changes. The acoustic tweezing rheometer operates in two different modes: quasi-static and oscillatory. This presentation focuses on the oscillatory technique in which the sample drop is forced into freely decaying shape oscillation by transient modulation of the standing acoustic field. Images of oscillating drops acquired by a high-speed camera are analyzed by a custom MATLAB code to obtain the shape amplitude vs. time curves and then the decay factor and resonance frequency of drop shape oscillation. Dynamic viscoelasticity of the sample (viscosity, relaxation time, and elastic modulus) was measured by applying the experimental data to the analytical formulae, derived from normal mode analysis of drop oscillation for viscoelastic fluid (Maxwell model) and viscoelastic solid (Kelvin-Voigt) materials. Using the oscillatory technique, we measured changes in blood viscoelasticity during coagulation and showed that the Kelvin-Voigt model leads to physically consistent results on rheology of coagulating blood.

Session 3aPPa

Psychological and Physiological Acoustics: Exploring the Perception of Sound (Poster Session)

Eric Hoover, Chair
University of South Florida, 16458 Northdale Oaks Dr., Tampa, FL 33624

All posters will be on display from 8:00 a.m. to 12:00 noon. To allow authors an opportunity to view other posters in their session, authors of odd-numbered papers will be at their posters from 8:00 a.m. to 10:00 a.m. and authors of even-numbered papers will be at their posters from 10:00 a.m. to 12:00 noon.

Contributed Papers

3aPPa1. Effects of nonlinear frequency compression on Mandarin speech recognition and sound quality perception in hearing-aid users. Xueqing Chen, Yanyan You (Beijing Tongren Hospital, Capital Medical Univ.; Beijing Inst. of Otolaryngol., 17 HouGouHuTong, DongCheng District, Beijing 100005, China, xueqingchen2006@aliyun.com), Jing Yang (Speech and Hearing Sci., Univ. of Central Arkansas, Conway, AR), and Li Xu (Commun. Sci. and Disord., Ohio Univ., Athens, OH)

The aim of the present study is to evaluate the effects of nonlinear frequency compression (NLFC) on Mandarin speech recognition and sound quality perception. Thirty Chinese-speaking, hearing-impaired adults without hearing-aid experiences participated in the study. They were fitted bilaterally with the Phonak behind-the-ear hearing aids. Each participant was evaluated with the Phoneme Perception Test, Mandarin speech recognition, and sound quality perception at post-fitting 0, 4, and 12 weeks with NLFC-on vs. NLFC-off. The NLFC were active at home. Results show significant differences in detection of phonemes of high-frequency components (such as /sa/) between NLFC on and off. The difference between NLFC on and off was significant for consonant and sentence recognition. Duration of NLFC use had significant effects on the recognition of consonants, vowels, and sentences. Regarding the sound quality perception test, there were significant effects of NLFC conditions (on vs. off), duration of NLFC use, and sound types on the four categories of percepts (i.e., loudness, clarity, naturalness, and overall preference). Therefore, NLFC improves the audibility of high-frequency speech signals and provides better recognition of consonants and sentences and perception of sound quality. The benefit of NLFC on speech recognition and sound quality perception requires certain amount of acclimatization.

3aPPa2. Sensitivity of pure tone versus speech-in-noise hearing screening. Lawrence L. Feth, Evelyn M. Hoglund, Christina M. Roup, and Kaitlin Campbell (Speech and Hearing Sci., Ohio State Univ., 110 Pressey Hall, 1070 Carmack Rd., Columbus, OH 43210, feth.1@osu.edu)

Adults classified as having normal hearing using conventional pure tone hearing screening often report hearing difficulties especially for situations requiring listening for speech or music in a background of noise. The purpose of this project is to compare the sensitivity of a pure tone hearing screener with a Spoken Digits in Noise test. In the first comparison, 20 young adults with normal hearing thresholds documented by a full audiometric test were asked to simulate a conductive hearing loss using an ear plug inserted into one ear. Both screeners were used to detect the simulated conductive hearing loss. In the second comparison, participants with documented mild to moderate sensorineural hearing loss were tested with both screeners. Order of testing with the screeners was counter-balanced, and the degree of hearing loss was categorized into 15 dB intervals based on their three-frequency (500, 1000, and 2000 Hz) averages and labeled Normal, Slight, Mild, or Moderate. A decision theory analysis was used to indicate the sensitivity of the two screening procedures. [Work supported by a grant from NIDCD.]

3aPPa3. Does the right ear advantage persist in mature auditory systems when cognitive demand for processing increases? Danielle M. Sacchinelli (Commun. Disord., Auburn Univ., 67 Waverly Ave., Eastchester, NY 10709, dms0043@auburn.edu), Aurora J. Weaver, and Martha Wilson (Commun. Disord., Auburn Univ., Auburn, AL)

Based on Kimura's (1967) anatomical model of dichotic listening, the right ear has a slight advantage (REA) or performance asymmetry, compared with the left ear. This is due to left hemisphere dominance for language, which receives direct input from the right ear. Accurate performance on dichotic tests relies on sensory organization and memory; however, there is little evidence regarding the impact of increasing cognitive demands (i.e., number of items for recall) on auditory performance asymmetries in mature auditory systems. This study investigated 42 participants' auditory perceptual and working memory abilities (e.g., forward and reverse digit spans, dichotic digits test, and directed ear dichotic digits test) to explore the relationships among cognitive demanded and performance asymmetries. Repeated measures ANOVA showed a significant effect for directed ear and digit list length. In addition, a priori comparison indicated significant performance asymmetry, with persistent REA when listening demands exceeded an individual's auditory memory capacity. No significant performance differences were identified for digit list lengths relative to, or below an individual's simple memory capacity. Overall, the study found the right ear tends to show better performance on dichotic listening tasks, even in adults, when the number of digits exceeded the participants' digit span capacity.

3aPPa4. Development and validation of a portable platform for auditory testing. 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), Aaron Seitz, Trevor Stavropoulos (Univ. of California, Riverside, Riverside, CA), David A. Eddins, Eric Hoover (Univ. of South Florida, Tampa, FL), Samuel Gordon, Michelle R. Molis (National Ctr. for Rehabilitative Auditory Res., VA Portland Health Care System, Portland, OR), Kasey Jakien, and Anna Diedesch (Oregon Health & Sci. Univ., Portland, OR)

This presentation will describe a portable platform for psychoacoustical testing using relatively inexpensive components that can be used outside of the laboratory, making it available for a broad range of research, clinical, and academic uses. This project is based on the concept of leveraging the fact that, due to the support of the tools and community of the $100 billion gaming industry, high-performance interactive audio-visual systems are now easily available in the form of consumer devices. The first task was to develop mobile applications capable of administering tests of multiple psychoacoustics tests such as (1) binaural processing, (2) spectrotemporal sensitivity, and (3) speech intelligibility in competition with and without spatial cues. The second task was to verify that the system performed within design specifications, by acoustic analysis of the sound output and comparison of behavioral thresholds to those obtained using traditional methods. The final task was the creation of experimenter interfaces that facilitate the use of the system by researchers and clinicians without requiring expertise in the

underlying technologies. Data and examples of our success with all three tasks will be presented, implemented with a system based on only two relatively inexpensive devices: an Apple iPad Pro with audio output connected directly to Sennheiser HD 280 Pro headphones. [Funding provided by NIH R01 DC 015051 and VARR&D NCRAR.]

3aPPa5. Effects of residual masker, spectral resolution, and low frequency cues on the perception of ideal binary-masked speech. Vahid Montazeri and Peter F. Assmann (GR 41, School of Behavioral and Brain Sci., Univ. of Texas at Dallas, Richardson, TX 75080, vahid.montazeri@utdallas.edu)

This study investigated the intelligibility of ideal binary-masked (IdBM) stimuli under conditions with limited spectral resolution. In experiment 1, we used different IdBM local thresholds, which retain different amounts of residual masker and target information in the IdBM-stimuli. The stimuli were presented to 30 normal hearing listeners. The results indicated that, with a 6- or 12-channel tone-vocoder, the presence of residual masker in the IdBM-stimuli limits the intelligibility scores, thus preventing IdBM processing from achieving an ideal segregation of target from masker. In experiment 2, we investigated whether introduction of low frequency target information to the tone-vocoded IdBM-stimuli improves the intelligibility scores. Twenty normal hearing listeners participated in this experiment. The results indicated that in contrast to target F0 cues, inclusion of low-pass filtered target information (cutoff = 300 Hz) helped listeners segregate the target from the masker, thus improving the intelligibility of the IdBM-stimuli. These results argue against F0 as a segregation cue in electroacoustic conditions and suggest that target F0 cues do not provide benefits beyond those provided by IdBM.

3aPPa6. Spectrum contrast sharpening by lateral suppression: Comb-filtered noise test. Alexander Supin, Dmitry Nechaev (Institute of Ecology and Evolution, 33 Leninsky Prospect, Moscow 119071, Russian Federation, alex_supin@mail.ru), Vladimir Popov, and Evgeniya Sysueva (Institute of Ecology and Evolution, Moscow, Russian Federation)

Spectrum contrast thresholds were measured in normal listeners using comb-filtered signals. The signal spectrum contained 0.075-oct wide ripples. Spectrum contrast varied from 0 (no ripple on the pedestal) to 1 (zero spectrum level between the ripples). Spectrum contrast thresholds were measured at ripple densities from 1 to 10 oct^{-1} using a two-alternative forced-choice adaptive procedure. The lowest spectrum contrast thresholds of less than 0.1 appeared at a ripple density of 4 oct^{-1}. At lower ripple density down to 1 ocn^{-1}, thresholds increase up to 0.2. At ripple densities above 4 oct^{-1}, thresholds steeply increased up to 1.0 at densities of 8 to 10 oct^{-1}. In agreement with the excitation-pattern model, threshold increase at high ripple densities may be explained by across-frequency integration in critical bands. However, threshold increase at low ripple densities cannot be explained by a simple critical-band model. The lowest spectrum contrast thresholds at a certain inter-ripple interval indicate the presence of lateral suppression zones in equivalent filter forms. According to this interpretation, the results demonstrate sharpening of spectral contrast due to lateral suppression. The lateral suppression zones may reflect either cochlear lateral suppression, or lateral inhibition in neuronal centers, or both. [Work supported by Russian Science Foundation.]

3aPPa7. Predictive denoising of speech in noise using deep neural networks. Manuel Pariente and Daniel Pressnitzer (Laboratoire des Systèmes Perceptifs, CNRS, ENS, PSL, 29 Rue d'Ulm, Paris 75005, France, pariente.mnl@gmail.com)

Deep neural networks have recently been used in several studies to improve speech intelligibility in noise. Here, we tested whether such networks could denoise speech in a predictive manner, which would be highly desirable for potential real-time applications. Training targets for the networks consisted in a mask (ideal binary mask or ideal ratio mask) for the last observed frame (non-predictive) and for one frame ahead in the future (predictive). Frame length was fixed at 48 ms. Training was performed on a target speaker with added speech-shaped noise, using about 25 min of training speech, at different signal to noise ratios ranging from −12 to 3 dB. A behavioral experiment was run to measure intelligibility of semantically unpredictable sentences in speech-shaped noise. For the behavioral experiment, target sentences were different from the learning sentences, and novel exemplars of speech-shaped noise were drawn on each trial. We observed intelligibility gains for both network architectures over a broad range of signal to noise ratios, with a maximum of 13.6 percentage points for the non-predictive network compared to 9.4 percentage points for the predictive network. This shows that a network may successfully be trained to denoise a specific speaker in a predictive manner.

3aPPa8. Pure-tone lateralization revisited. Florian Völk (WindAcoust., Muehlbachstrasse 1, Windach 86949, Germany, voelk@windacoustics.com), Jörg Encke, Jasmin Kreh, and Werner Hemmert (Bio-Inspired Information Processing, Tech. Univ. of Munich, Garching, Germany)

In certain conditions, especially with diotic headphone presentation, hearing sensations are located inside the head. Dichotic headphone presentation can result in lateralization: delaying one of the headphone input signals or reducing its amplitude typically pushes the hearing sensation inside the head toward the contralateral ear. Systematic connections between physical stimulus parameters and hearing-sensation positions provide insight into auditory-localization mechanisms and are helpful in designing and evaluating models thereof. However, typical paradigms of addressing lateral displacement, magnitude estimation or pointing, may suffer from response biases. This study aims at evaluating the suitability of a two-alternative forced choice paradigm: 15 normal-hearing subjects were asked to indicate, by pushing one of two buttons, whether the hearing sensation associated with a pure interaural phase or amplitude difference occurred "left or right," without any reference or further instructions. Posing a notably simple task without internal mapping, this procedure appears advantageous regarding response biases. The results indicate a high intra-individual reproducibility and plausible inter-individual agreement. None of the participants encountered or reported difficulties using the inherently assumed "internal center" in their decision process. The data suggest the existence of an inter-individually similar decision criterion. Descriptively speaking, the results support the existence of a similar lateralization midpoint.

Session 3aPPb

Psychological and Physiological Acoustics: Perception and Physiology: Musicians, Musical Instruments, and the Body (Poster Session)

Eric Hoover, Chair
University of South Florida, 16458 Northdale Oaks Dr., Tampa, FL 33624

All posters will be on display from 8:00 a.m. to 12:00 noon. To allow authors an opportunity to view other posters in their session, authors of odd-numbered papers will be at their posters from 8:00 a.m. to 10:00 a.m. and authors of even-numbered papers will be at their posters from 10:00 a.m. to 12:00 noon.

Contributed Papers

3aPPb1. A study on auditory sensitivity and behavioral cognition changes before and after drinking in psychological acoustics. Seonggeon Bae (Div. of Comput. Media Information Eng., Kangnam Univ., 40, Kangnam-ro, Giheong-gu, Youngin-si, Gyeonggi-do, Korea, Youngin 446-702, South Korea, sgbae@kangnam.ac.kr) and Myungjin Bae (Information and Commun., Soongsil, Seoul, South Korea)

In general, an auditory sensitivity after drinking is becoming insensitive and a perception of behavior becomes very poor. This can be explained by the characteristics of body changes due to alcohol absorption, and this study analyzed and studied these characteristics. This study provides the necessary bases for psychoacoustics and brain cognitive science by obtaining a measured data through cognitive testing of the characteristics of body changes before and after drinking. We analyzed the post-drinking changes in brain waves and performed psychoacoustic analysis of these characteristics.

3aPPb2. Relationship between behavioral and electrophysiological hearing thresholds. Edward L. Goshorn, Charles G. Marx, and Kimberly Ward (Speech and Hearing Sci., Univ. of Southern Mississippi, 118 College Dr. #5092, PsychoAcoust. Res. Lab., Hattiesburg, MS 39401, edward.goshorn@usm.edu)

Clinical applications for hearing thresholds obtained with electrophysiological measures are well established. Bush, Jones, and Shinn (2008) suggested that a diagnostic relationship exists between behavioral and auditory brainstem response (ABR) thresholds. They reported that subjects with MRI-confirmed vestibular schwannomas had differences greater than 30 dB when behavioral thresholds were compared to ABR using a 100 microsecond square wave (click) stimulus. However, there are little data available showing threshold relationships between behavioral and ABR thresholds for frequency specific stimuli. It is conceivable that a frequency specific stimulus may be more sensitive to schwannoma effects. Therefore, this project examined differences in hearing thresholds for normal hearing participants for two threshold methods (behavioral and ABR) and four stimuli: 250, 1000, and 4000 Hz tone bursts, and a 100 microsecond click. The same ABR instrument and stimuli were used for each method to obtain thresholds in twenty eight normal hearing adults in a repeated measures design. Results showed ABR thresholds to be significantly higher than behavioral. Thresholds varied significantly across stimuli for the ABR method but not the behavioral. Differences between methods were less than 30 dB for 93% of participants. These findings are consistent with Bush's findings for a normal hearing control group.

3aPPb3. Electrophysiological determination of backward masking function. Silas Smith and Al Yonovitz (Dept. of Communicative Sci. & Disord., Univ. of Montana, Missoula, MT 59812, silas.smith@umontana.edu)

Backward Masking (BM) functions have been shown to relate to age, lead toxicity, and in children with language disorders. These functions may be indicative of auditory processing deficits. This study investigated if Evoked Potentials (EP) could be utilized to obtain BM functions. The design of this study allowed observation of the early, middle, and late auditory evoked potentials. This process allowed us to observe the differential electrophysiological responses of evoked potentials during the BM effect. This study was randomized using four different stimulus conditions. With a long inter-stimulus interval and high sample rate simultaneous early, middle, and late potentials were obtained. The stimuli were a pure-tone alone, (1) 1000 Hz, (2) a masking noise alone, (3) the pure-tone followed by the masking noise, and (4) a control condition with no auditory stimulus. This approach, using a randomization allowed any adaptation or habituation to the stimuli to be equally distributed within each condition. Using arithmetic operations on the derived evoked potentials allows for localization of brain structures utilized in BM processing. Results indicated the determination of BM functions can be obtained objectively.

3aPPb4. Crowdsourcing the creation of an audio dataset for human and machine medical diagnosis training. Scott H. Hawley (Chemistry & Physics, Belmont Univ., 1900 Belmont Blvd., Nashville, TN 37212, scott.hawley@belmont.edu), Tamara Baird (School of Nursing, Lipscomb Univ., Nashville, TN), and Frank Baird (Recording and Entertainment, Middle Tennessee State Univ., Murfreesboro, TN)

We describe a method for creating and maintaining an open, annotated, community-moderated dataset of audio recordings of heart and lung sounds, with which to train machine listening systems to perform medical diagnosis. This is achieved by partnering with education programs for nursing and medical professionals who will receive training in diagnosis using digital stethoscopes. We developed a low-cost digital stethoscope using a peer-reviewed, open-source, 3-D printed design. With sufficiently numerous examples supplied and tagged by nursing and medical students, it is possible to employ machine learning classifiers such as our convolutional neural network code—originally developed for music information retrieval—to identify diagnosis classes. While primary intent of this dataset-creation and moderation system is for medical audio, the underlying functionality of community moderation could be applied to other waveform content, including a variety of musical datasets.

3aPPb5. Evaluation of reproduction fidelity of acoustic characteristics of auscultation sounds by recordings included in various publicly available databases. Karolina M. Nowak (Dept. of Endocrinology, Ctr. of Postgraduate Medical Education, Ceglowska 80 St., Warsaw 01-809, Poland, karolina.brodowska@gmail.com) and Lukasz Nowak (Dept. of Intelligent Technologies, Inst. of Fundamental Technol. Res. Polish Acad. of Sci., Warszawa, Poland)

Various databases of auscultation sounds recordings are available for teaching purposes for physicians. The sounds included in these databases were recorded using different equipment, and—in some cases—generated artificially. Thus, an important question arises regarding the differences in acoustic parameters between the recordings of bioacoustic signals obtained using different techniques and hardware, and the sounds heard by a physician during an actual patient auscultation through a typical acoustic stethoscope. The acoustic stethoscopes are the most widespread diagnostic devices and are far more popular in clinical practice than the electronic ones. The present study introduces the results of an analysis of acoustic characteristics of sounds included in various databases, compared to the parameters of sounds recorded with a microphone placed in an earpiece of an acoustic stethoscope. It is shown that the differences in time- and frequency characteristics are large enough to question the legitimacy of using various databases for teaching purposes. An alternative method and setup for recording bioacousic signals that could be used for developing auscultation skills is introduced.

3aPPb6. Assessment of acoustic characteristics of the nasal cavity by measuring sound transmission from one nostril to the other by a small speaker and a microphone. Amitava Biswas (Speech and Hearing Sci., Univ. of Southern Mississippi, 118 College Dr. #5092, USM-CHS-SHS, Hattiesburg, MS 39406-0001, Amitava.Biswas@usm.edu)

Sometimes clinicians need to assess aerodynamic and acoustic characteristics of the nasal cavity. Some patients with cranio-facial anomalies such as cleft palates may need such assessments. Certain disease specific pathologies may involve temporary blockage in the nasal cavity. This study will present a simple procedure of computing the transfer function of acoustic energy from one nostril to the other.

3aPPb7. Relationships among musical training and pitch matching in children and adults. Aurora J. Weaver (Commun. Disord., Auburn Univ., 1139-C Haley Ctr., Auburn, AL 36849, ajw0055@auburn.edu), Jeffrey J. DiGiovanni (Commun. Sci. and Disord., Ohio Univ., Athens, OH), and Dennis Ries (Commun. Sci. and Disord., Fort Hays State Univ., Athens, OH)

This experiment attempted to determine if individuals with extensive musical training's pitch perception and memory were more resistant to degradation (e.g., time and interference) than that of individuals with limited musical training. It is known that musical training influences cortical sound processing through learning-based processes, but also at the preattentive level within the brainstem. Pitch memory abilities were investigated in 66 participants with no known hearing, attention, or cognitive impairment. Participants were placed into subgroups based on age (young children, older children, and adults) and their self-reported musical training experience. Two experiments measuring auditory perception and memory skills for pitch were collected, the pitch pattern span (PPS; Weaver, DiGiovanni, & Ries, 2015) and a pitch matching retention task based on Ross, Olsen, and Gore's procedure (2003). We found that individuals with greater musical training exhibited enhanced pitch perception and memory processes and smaller *standard deviation* across pitch matches. Unexpectedly, based on the paradigm, the young children demonstrated significantly sharper (higher) *constant error* across pitch matches than the older participants. These and additional findings will be discussed with reference to task parameters which attempted to remove the typically required knowledge of musical nomenclature in pitch matching tasks

3aPPb8. Patterns procedural learning for pitch matching in adult musicians and non-musicians. Megan M. Barnett, Aurora J. Weaver, and Anne Rankin Cannon (Commun. Disord., Auburn Univ., 1199 Haley Ctr., Auburn, AL 36849, mmb0022@auburn.edu)

This study evaluated the role of active musical training on procedural learning during a pitch perception, memory, and matching task. Twenty-one adults with hearing within normal limits were split into music subgroups (musician and non-musicians) based on active participation in musical training. Ninety pitch-matching trials were completed using a paradigm adapted from Ross, Olsen, and Gore (2003) which assesses pitch-matching precision without requiring knowledge of musical nomenclature. Three blocks of 30 pitch-match trials were collected to evaluate the learning effect on each music subgroup. The semitone half step (HS) distance between the target pitch and the comparison pitch match was calculated for each trial. Constant error (*CE*) and standard deviation (*SD*) were used to quantify performance across blocks. Overall, significant reduction of pitch match *SD* was found for both music subgroups across blocks. Musicians demonstrated more precise pitch matches (smaller *SD*) and demonstrated no significant changes in pitch matching *CE* across blocks, whereas non-musicians *CE* was reduced across blocks. The pattern of results indicates learning effects, which we attribute to procedural memory for both groups, based on task parameters, while the music group's performance across blocks may reflect enhanced selective attention and pitch perception.

3aPPb9. Musical instrument dexterity requirements and its effects on adolescent diotic and dichotic listening performance. Aurora J. Weaver (Commun. Disord., Auburn Univ., 1139-C Haley Ctr., Auburn, AL 36849, ajw0055@auburn.edu), Naveen K. Nagaraj (Audiol. and Speech Pathol., Univ. of Arkansas for Medical Sci., Little Rock, AR), and Abby N. Turnbough (Commun. Disord., Auburn Univ., Auburn, AL)

Research examining the human asymmetry of handedness has included exploring the relationship to the auditory modality (e.g., digit span memory; Bannatyne & Wichiarajote, 1969). Musicians whose instruments require dual dexterity have more symmetric neural processing as a result of the sensory-motor experience with their instrument (Gaser & Schlaug, 2003). Little research translates these neurological differences based on dexterity to determine if more neurologic symmetry manifests into advantages for auditory processing. This study aimed to identify perceptual advantages of instrumental training based on dexterity, during stages when the central auditory nervous system is still developing. Monaural and binaural listening tasks, as well as working memory tasks, were collected on 33 adolescent (14–18 years old) musicians split into subgroups based on their instrument dexterity requirement (mono vs. dual). The outcomes indicate that instrumental choice did not significantly impact diotic digit span performance; however, a performance asymmetry (e.g., right ear advantage) was identified for the mono dexterity group for dichotic listening tasks performance at capacity limits. Overall, the results indicate that individuals choosing musical instruments that require dual dexterity had more symmetric auditory processing which corresponds to previous evidence of more neural symmetry based on instrumental dexterity.

3aPPb10. Analysis of singing bowl's sound. Ik-Soo Ann (Cultural Contents, Soongsil Univ., 369 sangdo-ro, Dongjak-gu, Seoul, Seoul 156-743, South Korea, aisbestman@naver.com) and Myungjin Bae (Information and TeleCommun., Soongsil Univ., Seoul, South Korea)

Studies about the effects of sound on the human body have been proven by various methods. Among them, we researched the sound healing tool known as singing bowl. The singing bowl is a bowl made of bronze and tin. It varies in size and thickness. One or several different singing bowls are placed either on or around the human body. The bowls are then rubbed or knocked using a small rod to produce sound. A singing bowl generates different frequencies depending on its size and thickness. The frequency vibrates the flesh and bone as well as the brain and organs of the human body. By doing so, it recovers the natural frequency of each part of the human body. Finally, we researched how the frequency generates an average frequency of some form as well as how it reacts to the human body through a brain waves analysis and a frequency analysis of the singing bowl sound.

3aPPb11. Sound art with Hertz. Peter Francis C. Gossweiler (Instituto de Artes, UFRGS, Trav. Nsa. Sra. de Lourdes, 230 apt. 503 D, Porto Alegre, Rio Grande do Sul 91920-040, Brazil, petergossweiler@gmail.com)

This article seeks to reflect on personal artistic processes in sound art and acoustic art pieces. It reports experiences, work pieces, and exhibitions where I applied a conventional language of sound measurement (Hertz) to minimize unexpected narratives and interpretations. Finally, we present the exhibition "HERTZ of the place where we are in" (2016), which has been audiodescripted for blind people, and thus we understand a little more of how we can fill these distances between language and its referent with alternative approaches and how we think about what we hear in acoustic environments.

WEDNESDAY MORNING, 6 DECEMBER 2017 BALCONY N, 8:30 A.M. TO 11:05 A.M.

Session 3aSA

Structural Acoustics and Vibration: Applications of Finite Element Analysis, Boundary Element Analysis, and Statistical Element Analysis Computational Methods

Elizabeth A. Magliula, Cochair
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Chair's Introduction—8:30

Invited Papers

8:35

3aSA1. Simplified shell modeling for submerged structures. Jerry H. Ginsberg (School of Mech. Eng., Georgia Inst. of Technol., 5661 Woodsong Dr., Dunwoody, GA 30338-2854, j.h.ginsberg@comcast.net)

Faithful numerical models of the acoustical response of submerged structures are complicated by the necessity to account for the interaction of three fundamentally different systems: the outer pressure hull, the internal substructure, and the surrounding fluid. Standard finite element techniques are the only recourse for a complex substructure, and boundary element or finite element techniques usually are necessary for the fluid. This paper proposes an alternative approach for the pressure hull based on an observation regarding the relative importance of extensional and flexural effects in a curved shell. The formulation entails applying an energy-based correction to membrane theory in order to account for flexural deformation. In some cases doing so enables an analytical representation of the shell's behavior, and it also simplifies a finite element representation. Whereas the interaction laws between the shell and the fluid are enforced conventionally, coupling of the shell and the substructures may be implemented a procedure rooted in analytical dynamics. It imposes constraint equations on the displacement variables, which introduces Lagrange multipliers to the equations of motion. In this manner, explicit consideration of the forces at attachments is avoided.

8:55

3aSA2. Investigation of variance response in energy finite element analysis. Kuangcheng Wu (Naval Surface Warfare Ctr. - Carderock, 9500 MacArthur Blvd., West Bethesda, MD 20817, kuangcheng.wu@navy.mil) and Nickolas Vlahopoulos (Univ. of Michigan, Ann Arbor, MI)

Noise and vibration control are important design features in various industries. Energy Finite Element Analysis (EFEA) and Statistical Energy Analysis (SEA) have been widely used in analyzing realistic structural and acoustic system for mid-to-high frequency regime. The EFEA is derived from the wave equation and uses energy density as its primary variable in its governing equation which is numerically solved in finite element approach. Generally, the EFEA calculates the mean values of given vibro-acoustic systems. This research introduces variance bounds into the EFEA analysis. Specifically, the variance originated from input power and joint matrix is incorporated to the EFEA. The formulation for calculation of the variance in the EFEA will be discussed and followed by several benchmark examples.

9:15

3aSA3. Adaptive manifold interpolation techniques for acoustic metamaterial characterization in HPC environments. Corbin Robeck (Weidlinger Appl. Sci., Thorton Thomasetti, 2000 L St. NW Ste. 600, Washington, DC 20036, CRobeck@ThorntonTomasetti.com), Heather Reed, Alex Kelly, Andrew Shakalis (Weidlinger Appl. Sci., Thorton Thomasetti, New York, NY), Reza Salari (Weidlinger Appl. Sci., Thorton Thomasetti, Cupertino, CA), and Jeffrey Cipolla (Weidlinger Appl. Sci., Thorton Thomasetti, Washington, DC)

Functionally graded acoustic metamaterials (FGAMs) can be designed to have specific waveguide properties dictated by a theory relevant to the application. Frequently, these material properties do not exist naturally, and must be fabricated by gradually layering manufactured unit cell microstructures, resulting in a (usually smooth) variation of properties. Tailoring these microstructures to the demands of the relevant theory requires assembling microstructures with very specific material properties—a process that often requires haphazardly searching a large domain space of unit cells for desirable parameter combinations. Moreover, the process of determining the material tensor of interest for a specific set of metamaterial cell design parameters typically involves solving a costly high dimensional finite element problem for each new microstructure cell of interest. This work presents a gradient-based, manifold interpolation technique to characterize acoustic metamaterial homogenized elastic tensors. An adaptive refinement method is used to seed the interpolation data allowing the method to reliably recover unit cell stiffness tensors within predefined error bounds—allowing for interpolation of a cell with desired properties within specified error tolerances while minimizing the number of unit cells that require high-fidelity, computationally-expensive simulation. Finally, an implementation of the process is presented in a massively parallel computing environment.

9:35

3aSA4. The effect of inertial distribution on dispersive modes in pentamode metamaterials for use in acoustic cloaking. Alex Kelly, Andrew Shakalis (Weidlinger Appl. Sci., Thorton Thomasetti, New York, NY), Reza Salari (Weidlinger Appl. Sci., Thorton Thomasetti, Cupertino, CA), Corbin Robeck (Weidlinger Appl. Sci., Thorton Thomasetti, Washington, DC), Heather Reed (Weidlinger Appl. Sci., Thorton Thomasetti, New York, NY), and Jeffrey Cipolla (Weidlinger Appl. Sci., Thorton Thomasetti, 2000 L St. NW Ste. 600, Washington, DC 20036, JCipolla@ThorntonTomasetti.com)

Transformation acoustics uses invertible maps to transform a cloaked region to a region with a smaller scatterer. The "elastic" or Norris class of acoustic cloaking theory is inherently broadband, in that it does not rely on the presence of resonant effects. To achieve the properties required by the transformation theory, we utilize pentamode materials, which admit the use of finite mass but require anisotropic stiffness throughout the material. These types of materials do not exist naturally and must be fabricated through the use of metamaterials. One of the challenges associated with metamaterials for use in dynamic applications is the distribution of mass in a unit cell and its consequences for frequency-dependent behavior in the metamaterial. Various homogenization techniques for recovering wave speed properties of the metamaterial unit cells may predict contradictory wave speed values for pentamodal structures. These disagreements can be explained through the distribution of inertia in the material and the resulting proliferation of dispersive modes present in the Bloch-Floquet diagrams. This effect will be described within the context of static homogenization, Bloch-Floquet theory, and numerical experiments effected through finite element software PZFlex. An approach for optimization of these metamaterials with respect to the dispersive modes will be discussed.

9:55–10:15 Break

10:15

3aSA5. Microstructure-in-the-loop optimization of acoustic metamaterial structures. Reza Salari (Weidlinger Appl. Sci., Thorton Thomasetti, 19200 Stevens Creek Blvd., Ste. 100, Cupertino, CA, MSalari@ThorntonTomasetti.com), Corbin Robeck (Weidlinger Appl. Sci., Thorton Thomasetti, Washington, DC), Alex Kelly, Heather Reed, Andrew Shakalis (Weidlinger Appl. Sci., Thorton Thomasetti, New York, NY), and Jeffrey Cipolla (Weidlinger Appl. Sci., Thorton Thomasetti, Washington, DC)

The field of acoustic metamaterial research has been driven, first, by transformation acoustics cloaking theory. This and other theoretical approaches optimize an acoustic effect through definition of artificial material properties which at present are only achievable using metamaterial technology. Metamaterials, however, present separate challenges in optimization for any desired acoustic effect: in particular, their dynamic behavior depends on parameters unrelated to acoustics, and exhibits wave propagation behavior more complex than elastic or acoustic continua. Homogenization methods which assume Cartesian symmetry are a staple in metamaterial design, but these only approximate a feasible optimal design. Moreover, total reliance on homogenized continuum models provides no information about the actual microstructure performance, and presents problems in functionally graded applications. To overcome this, we augment our Cartesian homogenization processes with high-resolution finite element models to optimize the design. Comparatively computationally expensive implicit FEM is avoided; specifically tailored time-domain wave propagation codes make the analyses feasible. Examples of the process, combining Cartesian homogenization estimates with high-resolution microstructural wave propagation solutions, will be shown.

Contributed Papers

10:35

3aSA6. Characterizing hysteretic materials in complex systems from vibration measurements. Alyssa T. Liem and James G. McDaniel (Mech. Eng., Boston Univ., 110 Cummington Mall, Boston, MA 02215, atliem@bu.edu)

A new method is proposed for estimating the material properties of a component in a complex system, given vibration measurements taken at points on the system. The method begins by identifying a set of unknown material parameters for each material. A finite element model is constructed using initial estimates of these parameters. A set of error metrics is defined and each metric is assumed to be zero when the correct parameters are used in the model. These error metrics may, for example, include averages of vibrational responses or modal properties. By evaluating the finite element model as the material parameters are varied, relationships between the material parameters and the error metrics are established. The best estimates of the material parameters are found by requiring that all error metrics be zero. The method is particularly valuable when applied to the *in situ* determination of hysteretic material properties, in which the frequency-dependent

constitutive law might contain several unknown parameters. Examples will be presented that illustrate the accuracy and robustness of the method.

10:50

3aSA7. Efficient prediction of the transmission loss of curved systems with attached noise control treatment. Kamal Kesour and Noureddine Atalla (GAUS Mech. Eng., Univ. of Sherbrooke, UdeS, 2500, boulevard de l'Université, Sherbrooke, QC J1K2R1, Canada, kamal.kesour@usherbrooke.ca)

This paper discusses the modeling of the transmission loss of curved panels with attached sound absorbing materials (foam or fiber). Two approaches are compared. The first is a classical coupled FEM/BEM (Finite element/Boundary element) approach wherein the panel and its cavity are modeled using the FEM and the blocked pressure on the excitation side and radiation from the transmission hole are modeled using the BEM. The second is an approximate approach using a Patch Transfer Function (PTF) method to describe the coupling between the panel, the sound package, the cavity and the transmission hole. To compute the PTF relations, the panel and the cavity are described by FEM while the effect of the sound package is described by a Green's function methodology using the Transfer Matrix Method (TMM) to speed up the process. It is shown that this latter approach is quick and accurate enough to estimate the TL of the system. Moreover, it allows for a quick comparison of the performance of various sound packages for a given curved panel. Several examples are presented to demonstrate the validity of this approximation and demonstrate its range of applicability and usefulness.

WEDNESDAY MORNING, 6 DECEMBER 2017 — ACADIA, 8:00 A.M. TO 12:00 NOON

Session 3aSC

Speech Communication and Education in Acoustics: Teaching Phonetics and Speech Science in the New Millennium: Challenges and Opportunities

Catherine L. Rogers, Cochair
Dept. of Communication Sciences and Disorders, University of South Florida, USF, 4202 E. Fowler Ave., PCD1017, Tampa, FL 33620

Benjamin V. Tucker, Cochair
Linguistics, University of Alberta, 4-32 Assiniboia Hall, Edmonton, AB T6G 2E7, Canada

Chair's Introduction—8:00

Invited Papers

8:05

3aSC1. Stories of speech science. Brad H. Story (Speech, Lang., and Hearing Sci., Univ. of Arizona, 1131 E. 2nd St., P.O. Box 210071, Tucson, AZ 85721, bstory@email.arizona.edu)

A fundamental aspect of teaching, on any topic, is the continual pursuit of telling a story. Although technology and advances in teaching methods may facilitate new and exciting forms of presenting course materials, they do not, by themselves, build the context for the content of a course. Every lecture, activity, homework assignment, project, quiz, and examination can be regarded as chapters that build, over the duration of a course, a compelling and engaging story in which students take part. The aim of this talk is to encourage development of speech science courses that weave together history, theory, technology, visual and auditory experience, assessment, and, importantly, the instructor's own research to spin a good tale. [Work supported by NIH R01-DC011275 and NSF BCS-1145011.]

8:25

3aSC2. Teaching phonetics and speech science—What's changed and what hasn't. Fredericka Bell-Berti (Commun. Sci. and Disord., St. John's Univ., 8000 Utopia Parkway, Queens, NY 11439, Fbellberti@gmail.com)

Many topics in articulatory phonetics that have been taught with traditional pedagogical techniques may be enhanced by the addition of acoustic information. However, it can be challenging to provide that information in ways that are accessible to students of Speech and Hearing, who often lack a strong background in physics. The ASA Committee on Education in Acoustics has offered sessions on acoustics demonstrations for ASA members. In meeting cities, the committee has hosted sessions for high school students and has co-sponsored sessions for Girl Scouts with Women in Acoustics. These sessions have resulted in a number of straightforward, accessible demonstrations of acoustics that are appropriate for use in undergraduate phonetics and speech science courses. This presentation will describe several traditional and computer-based demonstrations that may be used to teach speech acoustics to undergraduates in Speech and Hearing.

8:45

3aSC3. Some thoughts on teaching and learning phonetic transcription. James Hillenbrand (Western Michigan Univ., 1903 W Michigan Ave., Kalamazoo, MI 49008, james.hillenbrand@wmich.edu)

Phonetics instructors often observe considerable variability in the ease with which students learn phonetic transcription. As an initial step toward understanding this variability, 50 students were tested on 12 phonological awareness (PA) tasks (e.g., finding the odd vowel, odd consonant, or odd stress pattern in a set of words, determining the word that would result from speech sound substitution, deletion, or reversal, …). Students were tested at the beginning of an introductory phonetics course. PA performance was then compared with student performance on: (1) quizzes and exam items related to transcription, and (2) student performance on all aspects of the course other than transcription. A strong relationship ($\rho = 0.84$) was found between average PA and transcription performance. However, a very strong relationship ($\rho = 0.88$) was also found between average PA and student performance in all areas of the course other than transcription. This finding suggests the possibility of underlying causal relationships that are considerably more complicated—and more general—than a simple dependency on PA skills. In more practical matters, the talk will also describe a collection of computer exercises that were developed to provide students with drill in phonetic transcription.

9:05

3aSC4. Teaching an online phonetics course: One approach. Robert A. Fox (Speech and Hearing Sci., The Ohio State Univ., 110 Pressey Hall, 1070 Carmack Rd., Columbus, OH 43210-1002, fox.2@osu.edu)

Ohio State offers an on-line graduate-level phonetics course for a three-year on-line MA program in speech-language pathology. It is taught using a combination of available power-point presentations (with embedded lectures), high-quality sound files (for transcription exercises), and weekly video chats (using carmenconnect). The course syllabus is an on-line syllabus (in.html format) created using Adobe Dreamweaver. There are links in the syllabus to all readings and links to useful educational sites for description of speech anatomy and physiology, vocal cord physiology (and dynamics of voicing), x-ray cinematography, and acoustic analysis of speech production. In terms of phonetic transcription, students move from relatively easy consonant and vowel transcription (using recorded nonsense words) through narrow transcription using a series of graded downloadable transcription exercises. Students download free phonetic fonts from the internet (and they can use on-line browser-based programs like ipa.typeit). The final two-three weeks of the course involves spectrographic analysis (using programs that are free online including PRAAT, Speech Analyzer 3.1, and Wasp). One of the more challenging issues is to determine programs that will work on both Windows and/or Apple computers) and the first week is dedicated to addressing technology issues. Examples of all materials will be presented.

9:25

3aSC5. Phonetics online. How far is self-study possible? Patricia Ashby (English, Linguist and Cultural Studies, ELCS, Univ. of Westminster, 32-38 Wells St., London WC1T 3UW, United Kingdom, ashbyp@westminster.ac.uk)

Using the *Certificate* examination of the International Phonetic Association as a benchmark, this talk explores the viability of computer-assisted self-study in phonetics. Historically, phonetics and technology have always gone hand in hand. From the 18th century, invention and application of specialist instruments has expanded our knowledge of speech production and perception. Pedagogically, however, until quite recently, this technology was not routinely employed as a learning-aid. Over the first half of the twentieth century, undergraduate phonetics courses delivered through lectures and (costly) face-to-face small group teaching began to be established. Gradually, too, hardware entered the learning environment—phonographs and tape-recorders provided sound recordings, kymographs, oscilloscopes, and spectrographs provided images of waveforms, formants and pitch contours, transforming teaching and learning of both theory and practical skills. Then, computers and the internet revolutionized education, including phonetics education. Audio materials were supplemented and enhanced with visuals and by the 21st century, interactive computer-assisted learning was well established. Today, technology can sometimes even replace the teacher completely. So now, in response to increasing numbers of financially driven course closures: can technology breathe new life into the subject of phonetics?

9:45–10:00 Panel Discussion

10:00–10:15 Break

Contributed Papers

10:15

3aSC6. Teaching phonetics in an active-learning classroom: The role of teaching assistants. Tessa Bent (Dept. of Speech and Hearing Sci., Indiana Univ., 200 S. Jordan Ave., Bloomington, IN 47405, tbent@indiana.edu)

Active-learning classrooms (ALCs) facilitate innovative learner-centered pedagogical approaches. However, ensuring that all students receive appropriate support during learning activities can be challenging. Incorporating teaching assistants (TAs) is one avenue for increasing assistance available to students. Yet, investigations of the interactions among TAs and students in ALCs are lacking. To address this gap, a phonetics course with three TAs was studied. Three class sessions were video taped and students were given surveys to assess their perception of the learning activities and interactions with the TAs. Across sessions, 93% of students reported that their interactions with the TAs allowed them to move forward with the task. Similarly, 89% of students indicated that the TAs were able to guide them to the answer without giving them the answer. The video data suggest that the teaching assistants' interactions during small group activities differ from the instructors'. During the small group activities, the instructor spent 62% of the time in direct consultation with groups while the TAs only spent 30%. Additional analyses of the video and survey data will inform best practices for incorporating TAs into ALCs. [Work supported by a Scholarship of Teaching and Learning Grant from Indiana University.]

3a WED. AM

10:30

3aSC7. Teaching phonetics to undergraduate students majoring speech and hearing sciences and disorders. Makoto Kariyasu (Speech and Hearing, Kyoto Gakuen Univ., 18 Gotanda, Yamanouchi, Ukyou-ku, Kyoto 602-8577, Japan, kariyasu@kyotogakuen.ac.jp)

Phonetics is a fundamental course to provide students key knowledge and skills for understanding speech and hearing disorders. In our university, the students are required to take two courses. In Phonetics, we present the basic anatomy and physiology of speech production with emphasis on the three elements, flow, vibrations, and movement. Historical studies on speech production and perception, such as phonetic invariance, perceptual restoration, are presented. Based on the experimental findings, students learned the nature of human communication. That is, speech production is highly adaptive, but speech signal is somewhat varied. In some situations, the top-down processing helps listeners understand speech code. In Phonetics LAB, phonetic transcription, sound productions with vocal tract aerodynamics and acoustics are covered. The acoustic theory of speech production is presented, then the speech waveform and spectrogram of vowels and consonants are explained. Students are requested to show the understanding how speech is produced in reference to the vocal tract shaping and aerodynamics. For speech therapists, it is essential to demonstrate an automatic processing of hearing sounds and knowing the vocal tract. Disordered speech should be understood for possible mechanisms because speech therapists need to modify the human body and its control mechanisms.

10:45

3aSC8. Variability and invariants: Facilitating deep learning. Chao-Yang Lee (Commun. Sci. and Disord., Ohio Univ., Grover W225, Athens, OH 45701, leec1@ohio.edu)

Discussions of education in acoustics have traditionally focused on content issues such as "demonstration experiments, laboratory exercises, interpretation of basic concepts in acoustics, homework problems, possible exam questions, and tutorial papers" as noted in the announcement for a JASA special issue on education in 2010. However, well-constructed content does not always translate to actual learning. Furthermore, a common sentiment among new and established teachers is that much time and effort end up being spent on classroom management rather than teaching the content. How do students learn best? How do teachers help students understand the nature and progress of their learning? This paper reports a longitudinal study on teaching speech science to undergraduate students majoring in communication sciences and disorders. The course was taught by the author 19 times in a span of 10 years to 994 students at a public university. The relationships between how grades were determined, the actual final grade, and teaching evaluation are examined. The findings are discussed in the context of the author's reflections on teaching philosophy and strategies.

11:00

3aSC9. Flipping the phonetics classroom. Catherine L. Rogers (Dept. of Commun. Sci. and Disord., Univ. of South Florida, USF, 4202 E. Fowler Ave., PCD1017, Tampa, FL 33620, crogers2@usf.edu)

The 21st century has seen a continued expansion of bandwidth, processor speed, and availability of multimedia recording tools for the average PC. Consequently, the flipped classroom model has gained popularity, in both K-12 and higher-level education. In a flipped classroom, the instructor typically records short lectures, to be viewed online by the students prior to class. Classroom time is then devoted to activities that might normally be assigned as homework, such as problem solving, examination of case studies, discussion or other interactive exercises. Advantages of the pre-recorded lecture include the opportunity for students to replay the lectures and the availability of captioning, while disadvantages of this format may include a lack of spontaneity or ability to stop and ask a question. The drawbacks may, however, be compensated for by the increased feedback opportunities for students, allowing teachers more opportunities to gauge gaps in student knowledge. The phonetics classroom seems particularly well suited for the increased opportunity for in-class exercises and feedback offered by the flipped classroom approach. This presentation will describe the author's implementation of the flipped classroom model in an undergraduate phonetics classroom, including a discussion of students' attitudes, technical issues, and other challenges.

11:15

3aSC10. Developing an online phonetics course for a diverse student population. Caroline L. Smith (Univ. of New Mexico, MSC 03 2130, Linguist, 1 University of New Mexico, Albuquerque, NM 87131-0001, caroline@unm.edu)

Approximately 140 students take Introduction to Phonetics each year at the University of New Mexico. They are diverse in several ways: in age (many are returning to school after years away), in ethnicity (UNM is majority-minority), in major (the course serves Linguistics and Speech & Hearing), and in preparation (there are no prerequisites, but many students have some related coursework). This paper reports on design considerations and experience with the first online offering of this course. Studying online requires self-motivation and the ability to work independently, which are difficult for the large number of students with poor study skills and time management. This course attempts to counter these challenges with a high degree of structure, and activities in a variety of formats for learning and assessment. Although some in distance education view structure as a "constraint" for learner and teacher (Farquhar 2013 *Eur. J. e-learning*), this instructor believes that the flexibility and isolation of online learning are overwhelming for many students and risk leading to paralysis. Providing options among different activities coupled with deadlines for completion of those they select, and requiring frequent interaction with classmates and instructor, is the chosen strategy for keeping students engaged and on track.

11:30

3aSC11. Online vs. in-person: Exploring the outcomes and impacts. Benjamin V. Tucker and Timothy Mills (Linguist, Univ. of AB, 4-32 Assiniboia Hall, Edmonton, AB T6G 2E7, Canada, bvtucker@ualberta.ca)

Over the last few decades, the teaching of online courses has grown tremendously, especially with the rise in popularity of massive open online courses. In phonetics, the offerings of online courses has also grown. The University of Alberta has offered an online phonetics course for four years, which is academically equivalent to the in-person course. The University of Alberta online course runs as a standard semester course offered twice a year with the similar deadlines and structure as the in-person course. In this presentation we discuss and explore the advantages and challenges of online versus in-person courses from the instructor's perspective. We report the differences and similarities in student learning outcomes and student success. We discuss methods of student engagement, implementation of laboratory activities (active-learning), and exam invigilation. We also comment on the advantages of combining materials from online and in-person courses in blended learning environments.

11:45

3aSC12. Improving comprehension through team quizzes. Amelia E. Kimball, Patrick Drackley (Linguist, Univ. of Illinois at Urbana Champaign, 4080 Foreign Lang. Bldg. MC-168, 707 s Mathews Ave, Urbana, IL 61801, ameliak@bu.edu), and Jennifer Cole (Linguist, Northwestern Univ., Evanston, IL)

As instructors of a large introductory linguistics course, we face a challenge common to many teachers in the language sciences: we have a large amount of basic knowledge to communicate before moving on to more complex applications, and our students have varying degrees of preparation for our class. We address this challenge by using team-based learning (Michaelsen *et al*., 2001) and team quizzes (Gross Davis, 2009, p. 194). In this presentation, we share our approach to team work through a hands-on demonstration of the Immediate Feedback Assessment Technique, a scratch-off answer sheet that encourages students to work together to find the correct answer during a quiz. Using this technique, students move beyond passive listening as they explain concepts and defend their ideas to team members. We find that this technique works particularly well for introducing new topics that require repetition before "sticking." We also find that by keeping work focused in the classroom and providing peer feedback, students enjoy participating in team activities. Adopting this method has shown positive outcomes in our course, with use of team quizzes correlated with higher test scores, more positive course evaluations, and increases in course enrollment.

Session 3aSP

Signal Processing in Acoustics and Underwater Acoustics: Detection, Classification, Localization, and Tracking (DCLT) Using Acoustics (and Perhaps Other Sensing Modalities) III

Ballard J. Blair, Cochair
Electronic Systems and Technology Division, MITRE Corporation, 202 Burlington Rd., Bedford, MA 01730

R. Lee Culver, Cochair
ARL, Penn State University, PO Box 30, State College, PA 16804

Invited Paper

9:00

3aSP1. Signal processing trade-offs for the quality assessment of acoustic color signatures. Brett E. Bissinger, J. D. Park (Appl. Res. Lab. at Penn State Univ., PO Box 30, State College, PA 16804, beb194@psu.edu), Daniel Cook (Georgia Tech Res. Inst., Smyrna, GA), and Alan J. Hunter (Univ. of Bath, Bath, United Kingdom)

Acoustic color is a representation of the spectral response over aspect, typically in 2-D. The two natural axes for this representation are frequency and the aspect to the object. It is intuitive to assume finer resolution in the two dimensions would lead to more information extractable for improved quality. However, with conventional linear track data collection methods, there is an inherent trade-off between signal processing decisions and the amount of information that can be utilized without loss of quality. In this work, how the information distribution is affected with choices of representation domain will be presented. The quality metrics including resolution, signal-to-noise-ratio, and other metrics will be discussed in the context of various signal processing choices and parameters. Other representation approaches as extensions of acoustic color will also be explored, such as time-evolving acoustic color that shows how the spectral response changes within a ping cycle.

Contributed Papers

9:20

3aSP2. Signature mining and analysis of urban environment data. Morris Fields and Hollis Bennett (Environ. Lab, USACE-ERDC, CEERD-EE-C, 3909 Halls Ferry Rd., Vicksburg, MS 39180, morris.p.fields@usace.army.mil)

When investigating low energy acoustic signatures such as infrasound, determining signal from noise can be complex, particularly in urban environments. Understanding the characteristics of all sources will assist in suppression of signatures deemed to be noise, and in the enhancement of the signatures of items of interest. The first part of the task is to determine the signatures of interest. These signatures will form the basis set for different classifiers. Development of classifiers for these signals of interest will involve categories such as stationary signals, transient signals, and types of infrastructure including utilities. Following classification, an idea of the usage can be determined based on signals from the infrastructure detected. The research to be presented focuses on signal extraction from a data set in order to begin development of classifiers and eventual detection algorithms for infrasound signals in urban environments.

9:35

3aSP3. Improving marine mammal classification using context from multiple hydrophones. Tyler A. Helble (SSC-PAC, 2622 Lincoln Ave., San Diego, CA 92104, tyler.helble@gmail.com), Regina A. Guazzo (Scripps Inst. of Oceanogr., UCSD, Chula Vista, CA), Stephen W. Martin (Marine Mammal Foundation, San Diego, CA), E. E. Henderson (SSC-PAC, San Diego, CA), Gabriela C. Alongi (Marine Mammal Foundation, San Diego, CA), Glenn Ierley (Scripps Inst. of Oceanogr., UCSD, Houghton, MI), and Cameron R. Martin (Marine Mammal Foundation, San Diego, CA)

Detection, classification, localization, and tracking (DCLT) of marine mammals is oftentimes performed in that order. However, in the sonar-signal processing communities and elsewhere, classification is usually the final step. Thus, more appropriately, the working order should be "DLTC." If classification is performed as the final step, the results can be greatly improved by using the *context* of the calls. By grouping likely calls into tracks, a collective of calls can provide much more information for classification than single calls alone. Additionally, when multiple species are calling at the same time, the location of the calls can be used to distinguish confusing signals. The time-series and spectral information of a call can also be enhanced by localizing first, and choosing the nearest hydrophone to the calling animal for signal analysis. If localization is not possible, classification can still be improved if two or more hydrophones are available with overlapping coverage, by using cross-correlograms. Multiple sensors also provide the ability to reduce detections due to sensor self-noise, and noise from fish and snapping shrimp. Collectively, these techniques were applied to vocalizing baleen whales on the Navy's Pacific Missile Range Facility,

and proved to greatly enhance the ability to classify Bryde's, humpback, fin, and minke whales.

9:50

3aSP4. Active learning for acoustic classification. Matthew G. Blevins, Edward T. Nykaza (U.S. Army Engineer Res. and Development Ctr., 2902 Newmark Dr., Champaign, IL 61822, matthew.g.blevins@usace.army.mil), and William M. Nick (Comput. Sci., North Carolina A&T State Univ., Greensboro, NC)

Classification of noise sources based on their acoustic signatures is becoming increasingly necessary due to the increasing prevalence of noise monitoring systems. The intractable amount of data that these systems capture necessitates robust and efficient classification algorithms. However, the process of building a classifier requires manually labeling recorded noise events, which is a time consuming task. In this paper we explore a method for reducing the human burden and making the process more efficient called active learning, or "listener-in-the-loop." This method iteratively improves classifier performance by querying a human listener using optimally chosen observations based on certainty factors, which measure the degree of belief or disbelief based on probability for a particular classification. Classifier performance as well as algorithm efficiency, in terms of computational costs and amount of data required, will be discussed.

10:05–10:20 Break

10:20

3aSP5. Disambiguation of sonar target signatures using graph-based signal processing. Ananya Sen Gupta (Elec. and Comput. Eng., Univ. of Iowa, 4016 Seamans Ctr. for the Eng. Arts and Sci., Iowa City, IA 52242, ananya-sengupta@uiowa.edu) and Ivars P. Kirsteins (Naval Undersea Warfare Ctr., Newport, RI)

Disambiguation and extraction of sonar target features in high-clutter and low signal-to-noise-ratio (SNR) environments have been well-known to be a daunting task. In particular, the elastic wave features evolve with time, aspect angle, sediment type, proud/buried status, among other factors. Furthermore, irregular geometry of buried and partially buried targets renders it challenging to separate target features unique to the target material against multiple reflections due to irregular target geometry, sediment effects, and other physical phenomena. This work attempts to apply the emerging field of graph-based signal processing to study associations between sonar target features unique to target material and target geometry. We will present our graph-based studies of acoustic color features over a complex field, i.e., magnitude and phase, with the objective of disentangling target features against interference introduced by the environment using association graph techniques. The talk will focus on features localized using both geometric and wavelet techniques, and present results on case studies across a variety of sediment types, aspect angles and proud and partially buried targets of different materials.

10:35

3aSP6. Chaos theory and topology for classification of marine mammals. Matthew Firneno, Kirk D. Bienvenu, Jack G. LeBien, Juliette W. Ioup, Nikolas Xiros, and Ralph Saxton (Physics, Univ. of New Orleans, 2000 Lakeshore Dr., 722 Huntlee Dr., New Orleans, LA 70148, mfirneno@uno.edu)

The Littoral Acoustic Demonstration Center–Gulf Ecological Monitoring and Modeling (LADC-GEMM) project collected underwater acoustic data in the northern Gulf of Mexico during the summer of 2015, with passive acoustic data recorded by the LADC-GEMM Environmental Acoustic Recording Systems (EARS). Such data have been widely studied in the past by Fourier/spectral analysis. Although highly useful, there are, however, novel perspectives that may be obtained with techniques from chaos theory and topology. Using a method known as time-delay embedding, a time-series manifold can be constructed from measured data. This manifold will be classified in terms of a topological score (measures of connectedness, compactness, etc.), in conjunction with its fractal and correlation dimensions. These combined features can potentially be used to produce a more robust classification means for the identification of marine mammals heard by the EARS buoys in the LADC-GEMM data. [This research was made possible in part by a grant from The Gulf of Mexico Research Initiative, and in part by an Internal Grant from the University of New Orleans Office of Research and Sponsored Programs. Data are publicly available through the Gulf of Mexico Research Initiative Information & Data Cooperative (GRIIDC) at https://data.gulfresearchinitiative.org.]

Session 3aUWa

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

David P. Knobles, Cochair
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

Invited Papers

7:40

3aUWa1. Nonlinear frequency dependence of sound attenuation in sea bottoms at low frequencies. Jixun Zhou (School of Mech. Eng., Georgia Inst. of Technol., 771 Ferst Dr., Atlanta, GA 30332-0405, jixun.zhou@me.gatech.edu) and Zhenglin Li (State Key Lab. of Acoust., CAS Inst. of Acoust., Beijing, China)

In the 1980s, several papers were published that stressed the importance of non-linear frequency dependence (NLFD) of sound attenuation in marine sediments al low frequencies, and showed experimental evidence that the NLFD can have a significant effect on long-range sound propagation [Zhou *et al.*, *J. Acoust. Soc. Am.*, **78**, 1003–1009 (1985); **79**, Suppl. 1, S68, (1986); **82**, 287–292(1987); **82**, 2068–2074 (1987)]. According to Kibblewhite [*JASA*, **86**, 718–738 (1989)], "the only program directly related to marine sediment attenuation and not identified by Hamilton is that of Zhou *et al*." This analysis of NLFD was extended later to cover 20 locations in different coastal zones around the world, resulting in an effective geoacoustic model for sandy to sand-silt-clay bottoms. [Zhou, Zhang and Knobles, *JASA*, **125**, 2847–2866 (2009)]. However, the attenuation-frequency relationship is still an open issue. There is a pressing need to have quality sound-speed and attenuation data in the low- to high-frequency transition band from one location by using both inverse and direct techniques. Thus, a sea-going experiment in an area with shallower water depth is desirable. This paper will discuss some physical and technical issues related to broadband geoacoustic inversions and examine some data from muddy bottoms.

8:00

3aUWa2. Sediment sound speed inversion at low frequencies in shallow water. Zoi-Heleni Michalopoulou (Mathematical Sci., New Jersey Inst. of Technol., 323 ML King Blvd., Newark, NJ 07102, michalop@njit.edu)

A direct method previously developed for shallow water inversion is presented here along with the assumptions for its convergence and improvements for the solution of a more complex inverse problem. The method estimates sediment sound speed and follows discontinuities as the sediment layer properties change. Sediment thickness is also calculated. The approach is fast in contrast to other techniques that navigate a multi-dimensional search space. Implementation requires low-frequency measurements at a horizontal array and a source anywhere in the water column with only the continuous spectrum available. Several assumptions are made which appear restrictive at first but can be eventually relaxed. Although the approach was first developed considering a constant density profile, we show how realistic density profiles can be considered. [Work supported by ONR.]

8:20

3aUWa3. An experimental benchmark for geoacoustic inversion methods. N. Ross Chapman (School Earth and Ocean Sci., Univ. of Victoria, P.O. Box 3065, Victoria, BC V8P 5C2, Canada, chapman@uvic.ca)

Over the past 25 years, many methods have been developed for estimating parameters of geoacoustic models of the ocean bottom from acoustic field data. The methods involved model-based comparisons between experimental data and calculated fields or field quantities. Benchmarking workshops based on simulated field data confirmed the ability of the methods for inverting geoacoustic model parameters for range-independent and range-dependent ocean environments. Although there are many published examples of geoacoustic inversions in various different ocean environments, the methods have not been tested in an experimental benchmark. This paper describes the design of an experimental benchmark for geoacoustic inversion methods, and presents an analysis of the performance of the methods with experimental data. The benchmark involves application of different inversion methods to data spanning a frequency band from 50to 2500 Hz that were obtained at a single well-surveyed ocean bottom site. The performance metric involves comparisons of: estimated geoacoustic profiles against the ground truth information of the site; modal wavenumbers for the inverted models; and transmission loss calculations based on the estimated models against measured data. The analysis shows that the methods are capable of estimating realistic geoacoustic profiles, with sound speed the most reliable estimated model parameter.

8:40

3aUWa4. Sediment characterization through normal-incidence echo sounding at the SeaBed Characterization Experiment 2017. Michael Rukavina and Marcia J. Isakson (Univ. of Texas at Austin: Appl. Res. Labs., 10000 Burnet Rd., Austin, TX 78758, michael.rukavina@utexas.edu)

The Seabed Characterization Experiment (SBC17) was conducted in February 2017 off the east coast of the United States in the New England Mudpatch. The overall mission of the experiment was to determine the effect of the seabed on acoustic propagation. However, it was determined from pre-surveys that the area also contained a significant concentration of benthic biology. In order to characterize the variability of the sediment and the influence of the biology, the Applied Research Laboratories at the University of Texas (ARL:UT), deployed an acoustic system to collect normal-incidence echo returns from a 6 to 20 kHz chirp. The system was deployed in various locations around the mud patch to obtain a diverse set of data. The data displayed a long coda, which has been previously linked to the presence of benthic biology. The ability of these data to predict and measure sediment type and benthic biology concentration will be assessed. [Work sponsored by ONR, Ocean Acoustics.]

Contributed Papers

9:00

3aUWa5. An application of Bayesian inference techniques to compare three competing sandy sediment models. Anthony L. Bonomo and Marcia J. Isakson (Appl. Res. Labs., The Univ. of Texas at Austin, 10000 Burnet Rd., Austin, TX 78713, anthony.bonomo@gmail.com)

Many competing geoacoustic models exist to represent sandy sediments. In this work, Bayesian inference is employed to compare the sensitivity of the physical input parameters of three competing models: the viscous grain shearing model of Buckingham, the Biot-Stoll model, and the extended Biot model of Chotiros, using previously taken wave speed and attenuation laboratory measurements. Bayesian model selection techniques are then employed to assess the degree to which the predictions of these models can be used to explain the observed data. Since all three geoacoustic models require a large number of input parameters and many of these input parameters are difficult to measure, a main goal of this work is to use Bayesian techniques to determine which parameters can be resolved via inversion and what kinds of data are required for parameter resolution. [Work supported by ONR, Ocean Acoustics.]

9:15

3aUWa6. Inversion of geoacoustic parameters from transmission loss measurements in the presence of swim bladder bearing fish in the Santa Barbara Channel. Orest Diachok (Johns Hopkins Univ. APL, 11100 Johns Hopkins Rd., Laurel, MD 20723, orestdia@aol.com) and Altan Turgut (Naval Res. Lab., Washington, DC)

It is well established that attenuation due to swim bladder bearing fish can have profound effects on transmission loss (TL) in continental shelf and slope environments (Weston, 1967; Diachok, 1999). Realistic estimates of geoacoustic parameters from TL measurements in such environments may be derived by application of the concurrent bio and geo inversion method (Diachok and Wales, 2005; Diachok and Wadsworth, 2014). This method assumes that the biological environment may be characterized by bio-alpha (attenuation coefficient within the layer), layer depth, and layer thickness. Application of this method to broadband TL measurements between 0.3 and 5 kHz in the Santa Barbara Channel resulted in realistic estimates of geo and bioacoustic parameters. Inverted geoacoustic parameters were consistent with coincident core and chirp sonar measurements. Inverted bioacoustic parameters were consistent with concurrent measurements of fish depths and length distributions of dominant species. The latter permitted calculation of swim bladder dimensions and resonance frequencies. Neglect of bio-alpha resulted in unrealistically high values of geo-alpha. These results suggest that some previously reported inversions of geo-alpha from TL measurements at other sites may have been biased by neglect of bio-alpha. [This research was supported by the ONR Ocean Acoustics Program.]

9:30

3aUWa7. Inversion of geoacoustic parameters from transmission loss measurements in the presence of swim bladder bearing fish in the Yellow Sea. Orest Diachok (Johns Hopkins Univ. APL, 11100 Johns Hopkins Rd., Laurel, MD 20723, orestdia@aol.com)

Realistic estimates of geoacoustic parameters from transmission loss (TL) measurements in the presence of swim bladder bearing fish may be derived by application of the concurrent bio and geo inversion method (Diachok and Wales, 2005; Diachok and Wadsworth, 2014). This method was applied to Qiu's, (1999) TL measurements in the Yellow Sea. Qiu's measurements were made in August, south of the Shandong Peninsula, where the bottom is composed of sand, and the concentration of anchovies, the dominant species in the Yellow Sea, is high, at night when anchovies are dispersed near the surface and bio-alpha is relatively high. The measured attenuation coefficient (TS—cylindrical spreading—absorption) was nearly 8 dB/km at the resonance frequency of anchovies. Inverted values of bioacoustic parameters were consistent with bioacoustic parameters of anchovies. Inverted geoacoustic parameters were consistent with geoacoustic properties of sand. Disregard of the effects of bio-alpha on TL resulted in unrealistically high estimates of geo-alpha at frequencies above a few hundred Hz. These observations suggest that some previously reported inferences of geo-alpha from TL measurements in the Yellow Sea may have been biased by neglect of bio-alpha. [This research was supported by the ONR Ocean Acoustics Program.]

9:45

3aUWa8. The development and experimental study of the Ballast *in situ* Sediment Acoustic Measurement System. Guanbao Li (First Inst. of Oceanogr., State Oceanic Administration, Qingdao, China), Baohua Liu (National Deep Sea Ctr., SOA, Qingdao, Shandong, China), Guangming Kan (First Inst. of Oceanogr., State Oceanic Administration, Qinfdao, Shandong, China), Jingqiang Wang, and Xiangmei Meng (First Inst. of Oceanogr., State Oceanic Administration, No. 6 Xianxialing Rd., Laoshan District, Qingdao, Shandong 266061, China, wangjqfio@fio.org.cn)

A ballast *in situ* sediment acoustic measurement system (BISAMS) was newly developed. The mechanical structure, the function modules, the working principles, and a sea trial will be reported in this study. The system relies on its own weight to insert transducers into seafloor sediments and can accurately measure the penetration depth using a specially designed mechanism. The system comprises an underwater position monitoring and working status judgment module and has two operation modes: self-contained measurement and real-time visualization. The designed maximum working water depth of the system is 3000 m, and the maximum measured depth of seafloor sediment is 0.8 m. The system has 1 transmitting transducers and 3 receiving transducers. The transmitting frequency band is 20–120 kHz. The *in situ* acoustic measurement system was tested at 15 stations in the northern South China Sea, and the repeated measurements in seawater demonstrated good working performance. Comparison with predictions from empirical equations indicated that the measured speed of sound and attenuation matched with the predicted values and that the *in situ* measured data were reliable.

10:00

3aUWa9. In situ and laboratory acoustic attenuation measured in the sediments of the southern Yellow Sea. Xiangmei Meng (First Inst. of Oceanogr., No. 6 Xianxialing Rd., Qingdao 266061, China, 780610@sina.com), Jingqiang Wang, Qingfeng Hua, Guanbao Li, and Guangming Kan (First Inst. of Oceanogr., Qingdao, Shandong, China)

Acoustic attenuation directly determines sound propagation distance in seafloor sediments. Moreover, by studying the attenuation law of sound propagation in sediments, much information about sediment properties can be obtained. In June 2009 and June 2010, *in situ* measurements of acoustic attenuation at 30 kHz were made in the sediments of the southern Yellow Sea. Meanwhile, sediment cores were collected and laboratory measurements of acoustic attenuation between 25 and 250 kHz and physical properties were conducted. We compared *in situ* and laboratory attenuation measured in the sediments and analyzed the differences. The frequency dependence of acoustic attenuation of silt, silty clay, and clay is discussed on the basis of laboratory measurements. Combining with sediment physical properties, we analyzed the acoustic attenuation mechanism of silt, silty clay, and clay.

10:15

3aUWa10. Gas-bubble inversion in marine sediments. Guangying Zheng, Yiwang Huang, and Jian Hua (Harbin Eng. Univ., Nantong St. No. 145, Harbin 150001, China, 276454158@qq.com)

The acoustic properties of marine sediments can dramatically change because of the presence of gas-bubbles. Many applications require the detailed information of gas-bubbles, such as gas void fraction and gas-bubble size distribution. It is possible to relate the acoustic transmission measurements with bubble sizes. This study aims toward the development of an acoustic method able to both detect and quantify the gas present in marine sediments. This acoustic method adapts the effective density fluid model corrected by gas-bubble pulsations as a forward model and expands the unknown gas-bubble size distribution by a finite sum of cubit B-splines. The inverse problem can be transformed into solving the equation groups involving the coefficients of cubit B-splines. This method can be verified by testing analytical results and then applied to measurement sound speed and attenuation data which were acquired via transmission experiments.

10:30

3aUWa11. Laboratory measurements of sound speed and attenuation dispersion in calcareous sediments from coral reefs. Jingqiang Wang (First Inst. of Oceanogr., State Oceanic Administration, No. 6 Xianxialing Rd., Laoshan District, Qingdao, Shandong 266061, China, wangjqfio@fio.org.cn), Baohua Liu (National Deep Sea Ctr., SOA, Qingdao, Shandong, China), Guangming Kan, Guanbao Li, and Xiangmei Meng (First Inst. of Oceanogr., State Oceanic Administration, Qingdao, Shandong, China)

The calcareous sediment is an important type seafloor sediment exist in coral reef island sea areas. The acoustic properties of calcareous sediment are significant for modeling sound propagation and underwater reverberation. In order to analyze the frequency dependence of sound speed and attenuation in calcareous sediments, the sediments were firstly screened and remodeled in plexiglass tubes in laboratory, and the sound speed and attenuation were measured at the frequency range of 27–247 kHz. The grain sizes of sediment samples were <0.075 mm, 0.075-0.5 mm, 0.5-1 mm, 1–2 mm, and 2–4 mm, respectively. The sound speeds of different grain-size sample were 1564.83–1607.36 m/s, 1564.82–1607.36 m/s, 1527.76–1553.69 m/s, 1529.40–1594.72 m/s, and 1541.87–1596.51 m/s, respectively. The attenuation were 24.94–206.35 dB/m, 20.78–208.75 dB/m, 9.66–271.94 dB/m, 12.33–310.36 dB/m, and 12.60–293.60 dB/m, respectively. The sound speeds and attenuation were found to increase remarkable with frequency. The fine grained sediments have higher sound speed than the coarser sediments, which due to the higher bulk density and lower porosity of fine grained sediments. The dispersion gradients of sound speed and attenuation in coarser sediments were more remarkable than that in fine-grained sediments, which may due to the higher tortuosity of coarser sediments.

Session 3aUWb

Underwater Acoustics: Session in Honor of Chester McKinney

Thomas G. Muir, Cochair
Applied Research Laboratories, University of Texas at Austin, P/O. Box 8029, Austin, TX 78713

Clark Penrod, Cochair
Applied Research Laboratories, University of Texas at Austin, P/O. Box 8029, Austin, TX 78713

Chair's Introduction—8:00

Invited Papers

8:05

3aUWb1. Chester McKinney, champion in acoustics. David T. Blackstock (Appl. Res. Labs & Dept. of Mech. Eng., Univ. of Texas at Austin, PO Box 8029, Austin, TX 78713-8029, dtb@austin.utexas.edu)

Chester M. McKinney (1920–2017) was born and grew up in Cooper, Texas. Having built radios as a boy, he majored in physics at East Texas State Teachers College, taught high school science back in Cooper, and joined the U.S. Army immediately after Pearl Harbor. As a radar officer in the Army Air Corps, he did course work at Harvard and MIT in radar and electronics, and flew many missions in B-29s over China, India, and the Pacific. After the war he earned M.S. (1947) and Ph.D. (1950) degrees in physics at University of Texas, working primarily in electromagnetics at the University's Defense Research Laboratory (DRL, later renamed Applied Research Laboratories, ARL). In 1948 he married Linda Hooten. After a short stint at Texas Tech University, he returned to DRL in 1953 and switched from electromagnetics to acoustics, primarily underwater sound, which became his life's work. After 15 years as ARL Director, Chester retired in 1980. Having joined the Acoustical Society of America (ASA) in 1953, he chaired the Austin Meeting in 1975. He and Linda were fixtures at ASA Meetings. He became Vice President in 1984–1985 and President in 1987–1988. ASA awarded Chester its Gold Medal in 2005.

8:25

3aUWb2. Chester McKinney and the Acoustical Society of America: Over sixty years of service. Marcia J. Isakson (Appl. Res. Labs., The Univ. of Texas at Austin, 10000 Burnet Rd., Austin, TX 78713, misakson@arlut.utexas.edu)

The impact of Chester McKinney on the Acoustical Society of America cannot be overstated. Chester served as a charter member of the Underwater Acoustics Technical Committee and was its first chair in 1956. He was the driving influence in making the ASA the professional home for underwater acousticians. He established three committees that still serve the society: Archives, Tutorials and Public Relations. He served on the Executive Council, the Medals and Awards Committee, the Committee on Meetings and the Nominating Committee among others. Chester went on to serve as vice-president and president of the society. In 1989, Chester pioneered a census of acousticians. He chaired the census ad-hoc committee, collected and organized the responses and reported the results in JASA [McKinney, Hurdle, and Blue, "A profile of the acoustics community in the United States and Canada," *J. Acous. Soc. Am.*, **91**(2):1169–1179, 1992]. This census can now be compared with the statistics of today to track the growth of the society. Chester received the Gold Medal in 2004, the highest honor the society can bestow.

8:45

3aUWb3. Chester McKinney's legacy at Applied Research Laboratories, The University of Texas. Clark Penrod (Appl. Res. Labs, The Univ. of Texas, PO Box 8029, Austin, TX 78713-8029, penrod@arlut.utexas.edu)

Chester McKinney joined the ARL:UT staff as our first graduate student employee in 1946. Subsequently, he was the prime mover in establishing ARL's high frequency acoustics program, in which he retained a strong interest throughout career. However, Chester's contributions were by no means confined to research in underwater acoustics. Chester served as ARL's second director from 1965-80, and it was certainly the case that his efforts to establish ARL as a great laboratory were as important as anything he did. His thoughts and philosophy about how contract laboratories should operate in a university setting continue to guide ARL today. Chester believed in ARL having strong involvement in scientific research, that staff should participate in scholarly societies such as ASA and publish their work in archival journals, and that we should engage students in research. Alongside these activities, he also believed we should have strong engagement in applications, system development, and prototyping. He felt that the academic and applied areas of emphasis would complement each other, and lead to a more productive lab. ARL's current status as a healthy university laboratory owes much to our continued adherence to the set of guidelines that Chester formulated five decades ago.

9:05

3aUWb4. Chester McKinney: Lessons I learned from a prominent scientist and leader in our acoustics community. William A. Kuperman (Scripps Inst. of Oceanogr., Univ. of California, San Diego, Marine Physical Lab., La Jolla, CA 92093-0238, wkuperman@ucsd.edu)

The impression that was left with me from his speech after he received the ASA's Gold Medal at the 1994 New York City meeting still remains indelible. It was exactly the way someone born in Cooper Texas, population 2,600 should communicate the excitement of his career journey to national and international leadership in science, academia, and the technology associated with national defense. Comfortable in front of a large audience, he walked back and forth on the stage with complete informality reminiscing about his experiences in the multiple worlds he inhabited. As the new director of Marine Physical Lab, SIO/UCSD one generation after his tenure as director of the Applied Research Labs, UT, he reaffirmed to me why he had served as my mentor by example. Here, I review some of the lessons that his career provided

9:25

3aUWb5. Chester McKinney: A legacy of high frequency sonar development at Applied Research Laboratories, The University of Texas at Austin. John Huckabay (Appl. Res. Labs., The Univ. of Texas at Austin, PO Box 8029, Austin, TX 78759, huckabay@utexas.edu)

Following the Korean War, improvements in high frequency, high resolution sonar were needed in order to successfully prosecute naval mines. Chester McKinney led an effort at Applied Research Laboratories (formerly Defense Research Laboratories), The University of Texas at Austin (ARL:UT), to make progress in this important area of research; and began a lifelong passion for Chester to pursue both basic and applied research in high frequency acoustics as applied to mine countermeasures. This research has been performed over many years by numerous scientists and engineers at ARL:UT and continues today. Based on this research, both experimental and operational high frequency, high resolution sonars were constructed, tested, and employed. This paper will explore some of these important sonar developments as well as some of the underlying physics. These developments span from analog implementations of CTFM sonars, pulse sonars, beamformers, and signal processing to early implementations of digital sonars and digital signal processing. Key parts of sonar research will be traced from the AN/UQS-1 to the AN/SQQ-14, AN/SQQ-16, AN/WQS-1, and the Data Collection Test Bed Sonar (development model for the AN/SQQ-32).

9:45

3aUWb6. The McKinney-Anderson paper and its impact on sediment acoustics. Nicholas P. Chotiros (U.S. Office of Naval Res. Global, London, United Kingdom) and Anthony L. Bonomo (Appl. Res. Labs., The Univ. of Texas at Austin, 10000 Burnet Rd., Austin, TX 78713, anthony.bonomo@gmail.com)

The earliest comprehensive, *in-situ* measurements of the acoustic backscattering strength of the seabed as a function of frequency, grazing angle and sediment type were made by McKinney and Anderson, and published in the society's journal in 1964. It was a landmark paper and laid the groundwork for subsequent measurements and models. It is widely referenced in books and papers where seabed scattering and sonar performance prediction are concerned. Scattering strength and sediment classification, usually quantified in terms of the mean grain diameter, were thought to be closely connected. In the laboratory, using pristine samples of sorted sand, this connection was clearly demonstrated, but *in situ* it was overwhelmed by other factors, such as uneven size distributions, biological activity and roughness. The underlying nature of the seabed is also reflected in the scattering strength. For the same roughness, density and sound speed, the solid/fluid model consistently overestimates the scattering strength because it cannot account for the relative motion between grains and pore water. Thus, recent advances in poroelastic modeling can shed new light on the measurements of McKinney and Anderson. [Work supported by ONR, Ocean Acoustics Program.]

10:05–10:20 Break

10:20

3aUWb7. Acoustical research and publications of Chester McKinney. Thomas G. Muir (Appl. Res. Laboratories, Univ. of Texas at Austin, P/O. Box 8029, Austin, TX 78713, muir@arlut.utexas.edu)

Chester McKinney and his students and colleagues began publishing on acoustics research in the early 1950s, in *The Journal of the Acoustical Society of America*, *The Journal of Underwater Acoustics*, and in numerous proceedings of symposia dealing with high resolution sonar for mine hunting. Much of his work involved official studies on major issues, done for and published by the U.S. Navy. A number of his lectures to lay audiences addressed timely topics pertaining to contemporary topics, such as the conduct of classified research on university campuses. He was noted for excellent tutorials and fascinating historical perspectives. Some of Chester's publications are briefly discussed here, including his *Journal* publications on transduction with reflectors, the transition between near and far-field radiation, the target strength of geometric objects and the discovery of creeping or circumferential waves in echoes. [Work supported by Applied Research Laboratories, the University of Texas at Austin.]

10:40

3aUWb8. McKinney Fellowship in acoustics at ARL:UT. Kyle S. Spratt and Mark F. Hamilton (Appl. Res. Labs., The Univ. of Texas at Austin, Austin, TX 78713, sprattkyle@gmail.com)

The McKinney Fellowship in Acoustics is a graduate research fellowship awarded to one student per year by Applied Research Laboratories at The University of Texas at Austin (ARL:UT). Created in 2006 and named after former lab director Chester M. McKinney, the fellowship is meant to foster quality research in acoustics while maintaining the strong connection between ARL:UT and the Graduate Program in Acoustics in the Cockrell School of Engineering. The fellowship provides up to three years of tuition and fees as well as

a graduate research assistantship and travel expenses for the purpose of performing work toward a master's or doctoral degree on a topic related to the acoustics research and development performed at ARL:UT. In this talk, the implementation of the McKinney Fellowship program will be given, as well as an overview of the research that has been done by the 10 McKinney Fellows of the past decade. The first author, a past McKinney Fellow, will also offer some personal perspective on the program.

WEDNESDAY AFTERNOON, 6 DECEMBER 2017 STUDIO 9, 1:15 P.M. TO 3:00 P.M.

Session 3pAA

Architectural Acoustics: Speech Privacy Concerns in Open Plan Spaces

Kenneth W. Good, Chair
Armstrong, 2500 Columbia Ave., Lancaster, PA 17601

Chair's Introduction—1:15

Invited Papers

1:20

3pAA1. Balancing the detrimental effects of office noise annoyance and distraction on work performance. Martin S. Lawless, Michelle C. Vigeant (Graduate Program in Acoust., The Penn State Univ., 201 Appl. Sci. Bldg., University Park, PA 16802, msl224@psu.edu), and Andrew Dittberner (GN Hearing, Glenview, IL)

Broadband, steady-state background noise can improve open office conditions by facilitating speech privacy and reducing distraction caused by intermittent, occupancy-generated noise. The background noise is typically generated by HVAC systems, though can be added with loudspeakers to boost speech masking. However, too high background noise levels can cause annoyance, fatigue, and other noise-related symptoms. It is yet unclear whether noise annoyance or distraction impairs work performance more. This study investigated the trade-off between noise annoyance and distraction, as well as their effects on acoustic dissatisfaction and performance. Subjects performed cognitive tasks while exposed to simulated office acoustic environments reproduced using higher-order Ambisonics. At fixed time intervals, the subjects could change the acoustic environment by adjusting either the background or intermittent noise levels. Lowering background noise caused the intermittent noise to rise, and vice versa. By the end of testing, it was expected that each subject equalized their dissatisfactions of the two noise types. Annoyance and distraction were assessed with a survey at each time interval. Physiological measures, including heart rate variability and skin conductance, were collected to correlate arousal/stress levels with each acoustic environment. The results of the study may provide context to effectively utilize background noise in open-plan offices.

1:40

3pAA2. Using ODEON acoustical modeling software to predict speech privacy in open-plan offices: Part 2. Valerie Smith, Jason R. Duty, and Diego Hernandez (Salter Assoc., 130 Sutter St., Fl. 5, San Francisco, CA 94104, jason.duty@cmsalter.com)

Speech Privacy Index is one of the commonly used metrics to discuss an occupant's acoustical comfort in an open-plan office. This paper continues our discussion from the Boston '17 conference on using the ODEON acoustical modeling software to predict the speech privacy index in open-plan offices. Our original paper examined the effects of using the ODEON provided equation for Articulation Index to calculate Privacy Index, compared these results to "real world" measurements, and attempted to adjust this equation to better fit the Speech Privacy Index (per ASTM 1130-16). In this paper, we will update our analysis to include a larger open-place office floorplate. To continue the discussion, we will also analyze the variation in results, if any, due to changing the scattering coefficients for various materials to determine if this significantly affects the modeled speech privacy results.

2:00

3pAA3. Possible path for speech privacy design and performance approaches. Kenneth P. Roy (Armstrong, 2500 Columbia Ave, Lancaster, PA 17603, kproy@armstrongceilings.com)

Speech privacy (or the lack thereof) is becoming a well-defined issue relating to "acoustic comfort" as a factor in building IEQ. This is the case for commercial offices as well as for healthcare spaces. The drivers for this include worker productivity, and confidentiality of sensitive information. CBE (Center for the Built Environment, UC Berkeley) surveys show the lack of speech privacy as being the most significant factor in disapproval of building IEQ for "green rated," and for all other building types. Healthcare regulations such as HIPAA and HCAHPS are transforming the design of hospital facilities and procedures in part due to oral privacy and annoyance issues. The "WELL Building Standard" is going beyond LEED to consider the occupants health and productivity as affected by the IEQ.

ASHRAE is going beyond "high performance green buildings" to now include an IEQ Global Alliance. So, where are we going with all this work?? Well, the metrics and measurement procedures used to measure and define levels of speech privacy are being updated at ASTM International to provide a basis for evaluation of speech privacy in both open plan and closed plan, and combinations thereof. This work will be outlined herein.

2:20

3pAA4. Evaluation of ambient noise including conversation in medical facilities. Yumi Koyama (School of Pharmacy, Nihon Univ., 7-7-1 Narashinodai, Funabashi, Chiba 274-8555, Japan, koyama.yumee@nihon-u.ac.jp) and Yasushi Shimizu (Sound/Form Design Lab., Hamamatsu, Japan)

We are studying the research focusing on an ambient noise in medical facilities with the aim of improving the acoustical environment, which can make patients comfortable to cure own illness at a medical area such as a patient room. At medical areas, there are many sound sources such as device sounds, personal active sounds, and talker's voices during a conversation. It is necessary to develop a method which can record and analyze an ambient noise without any intelligible contents of conversation voices, since all personal information belonging to a patient should be protected as confidential in medical facilities. In this experiment, acoustical measurement of each environmental sound such as the sound of footsteps, equipment alarm, intravenous stand, and medical cart at the simulated patient room in my school was conducted. Then, recorded ambient noises mixed with conversation voices and the other environmental sounds were fragmented in time, and the fragmented signal components were removed alternately so that the original conversation was unintelligible. The results are presented on the appropriate time duration of fragmentation and audio signal removal processing, and on the also prediction of each environmental sound except conversation voices for the processed audio signal.

2:40

3pAA5. Case study: Open plan "closed" offices or closed plan "open" offices. Kenneth W. Good (Armstrong World Industries, 2500 Columbia Ave., Lancaster, PA 17601, kwgoodjr@armstrong.com)

In today's built environment designers likes to blur the lines between categories and closed and open offices are no exception. Spaces are being built with high walls and doors but no ceilings. The occupants often call these "private" offices but how "private" are they? Are they open spaces or closed spaces, what are the expectations and how should we handle these spaces? Past experiences in these hybrid spaces have led me to question our measurement techniques. This case study will explore back to back measurements using the closed office method of ASTM E 336 vs the open plan method of ASTM E 1130 each calculated for Privacy Index (PI) in the same space and conditions.

WEDNESDAY AFTERNOON, 6 DECEMBER 2017 BALCONY M, 1:00 P.M. TO 2:30 P.M.

Session 3pBA

Biomedical Acoustics: Imaging I

Kausik Sarkar, Chair
George Washington University, 801 22nd Street NW, Washington, DC 20052

Contributed Papers

1:00

3pBA1. Quasi-static acoustic tweezing for low-volume blood coagulation analysis. Daishen Luo (Dept. of Biomedical Eng., TulaneUniv., 6823 St. Charles Ave., 440 Lindy Boggs Bldg. New Orleans, LA 70118, dluo@tulane.edu), Ray Holt (Mech. Eng., Boston Univ., Boston, MA), and Damir Khismatullin (Biomedical Eng., Tulane Univ., New Orleans, LA)

Available contact assays for blood plasma and whole blood coagulation have low predictive power in patients with coagulopathy or take a significant amount of time and blood volume to obtain diagnostic data. We have developed an innovative low-volume non-contact technology for real-time assessment of blood coagulation, referred to as "Quasi-static Acoustic Tweezing Thromboelastometry"(QATT). In our method, human blood drops with volume less than 5 microliter (~100 times smaller than the volume required by current coagulation technologies) are levitated in air by acoustic radiation forces. The sample drop location and deformation are induced by a quasi-static change in the acoustic pressure. By extracting a linear regime slope, the samples exhibit a unique elasticity profile over time (tweezograph) less than 20 minutes, characterized by clot initiation time (CIT), time to firm clot formation (TFCF), and maximum clot strength (MCS). The exposure of blood samples to pro- or anti-thrombotic agents (Fibrinogen and GPRP, respectively) led to significant changes in tweezographs within 10 minutes, thus allowing detection of hyper- or hypo-coagulable states. The advantages of small sample size, non-contact and rapid measurement make this technique desirable for real-time monitoring of blood coagulation in neonatal and pediatric patients with coagulation abnormalities.

1:15

3pBA2. Acoustic and atomic force microscopy characterization of microbubbles with varying shell chemistry. Mitra Aliabouzar (Mech. Eng., George Washington Univ., Mech. and Aerosp. Eng. 801 22nd St., Washington, DC 20052, mitraaali@gwmail.gwu.edu), Babak Eslami (Dept. of Mech. Eng., Univ. of Maryland, College Park, MD), Krishna N. Kumar, Santiago Solares, and Kausik Sarkar (Mech. Eng., George Washington Univ., Washington, DC, DC)

Applications of microbubbles (MBs) in diagnostic and therapeutic interventions critically depend on their stability and scattering properties. The shell chemistry of MBs defines these properties. We investigated the effects of shell chemistry on the size, abundance, acoustic response, and mechanical properties of MBs by varying the poly(ethylene glycol) (PEG) molar ratio (0 to 100%) in a two-lipid (DPPC and DPPE-PEG2000) component shell formulation. Increasing PEG concentration from 0% to 10% resulted in an increase in the number of MBs by at least 10-fold, with adverse effects upon further increases. Microbubbles made with 5–10% PEG generated the strongest fundamental as well as nonlinear (subharmonic and second harmonic) components at the excitation frequency of 2.25 MHz. We used interfacial rheological models to determine the mechanical properties of MB shells as functions of PEG concentration using experimentally measured attenuation values. We also employed atomic force microscopy (AFM) to perform thin planar film characterization of the shells. The correlation between the AFM measurements of film properties and the acoustic responses of the corresponding coated MBs will be discussed.

1:30

3pBA3. Acoustic characterization of 3D printed micro-structured scaffolds for tissue engineering. MITRA ALIABOUZAR (Mech. Eng., George Washington Univ., Mech. and Aerosp. Eng. 801 22nd St., Washington, DC 20052, mitraaali@gwmail.gwu.edu), Lijie Grace Zhang, and Kausik Sarkar (Mech. Eng., George Washington Univ., Washington, DC)

The acoustic and mechanical properties of 3D-printed porous poly-(ethylene glycol)-diacrylate (PEGDA) hydrogel scaffolds, as a widely used biomaterial, with different geometric channels (hexagonal and square) were explored using a pulse echo technique. The measured values of attenuation and speed of sound were found to be within the range of reported values for soft tissues making PEGDA scaffolds a suitable candidate for cartilage tissue engineering. We also showed that these properties as well as Young's modulus can be controlled and adjusted to desired values close to biological tissues by varying the 3D printing parameters. Furthermore, our 5-day proliferation as well as three-week chondrogenic differentiation results revealed that cell growth and tissue formation depend on the geometrical features of the 3D-printed scaffolds as well. Cell adhesion and proliferation greatly improved for scaffolds with square and hexagonal pore geometries compared to nonporous scaffolds. Scaffolds with square pores were determined to be the optimal for hMSC growth as well as chondrogenic differentiation. In addition to cell number, total collagen and Glycosaminoglycan (GAG) synthesis were 35% and 31% higher, respectively, for the square pattern compared to the hydrogel scaffolds with hexagonal pore shapes.

1:45

3pBA4. Ultrasound and lipid-coated microbubbles for osteogenic differentiation of mesenchymal stem cells in 3D printed tissue scaffolds. Jenna Osborne (George Washington Univ., Washington, DC), Mitra Aliabouzar (George Washington Univ., Laurel, MD), Xuan Zhou, Raj Rao, Lijie G. Zhang, and Kausik Sarkar (George Washington Univ., 801 22nd St. NW, Washington, DC 20052, sarkar@gwu.edu)

With increasing incidence of bone disorders in a rapidly aging, sedentary and overweight population, engineered bone tissues promise to be a better alternative for conventional bone grafts. However, bone tissue engineering currently suffers due to the inability to form mechanically strong porous structures that can be grown quickly. In this study, lipid-coated microbubbles (MB), traditionally used for contrast enhanced ultrasound imaging, were applied to harness the beneficial effects of ultrasound stimulation on proliferation and osteogenic differentiation of human mesenchymal stem cells (hMSCs) on 3D printed poly(lactic acid) (PLA) scaffolds. A significant increase in cell number was observed with low intensity pulsed ultrasound (LIPUS) treatment in the presence of MB after 1, 3, and 5 days of culture on scaffolds. Total protein content, alkaline phosphatase activity, and total calcium content were also found to increase with LIPUS with and without MB indicating enhancement in osteogenic differentiation. Integrating LIPUS and MB appears to be a promising strategy for bone tissue engineering and regeneration therapies.

2:00

3pBA5. Mechanism of echogenicity of echogenic liposomes. Krishna N. Kumar (Dept. of Mech. Eng., The George Washington Univ., 800 22nd St. NW, Washington, DC 20052, krishnagwu@gwu.edu), Sanku Mallik (Dept. of Pharmaceutical Sci., North Dakota State Univ., Fargo, North Dakota, Fargo, ND), and Kausik Sarkar (Dept. of Mech. Eng., The George Washington Univ., Washington, DC)

Liposomes prepared by a freeze-drying technique in the presence of mannitol have proved to be echogenic. However, the mechanism of echogenicity is not well understood. Here, we attempt to explain it. It was observed that only freeze-dried mannitol (without lipids) generates a strong scattered response because it generates bubble upon dissolution in water. The bubble generation was confirmed optically under an optical microscope. During the dissolution of the crystalline mannitol, the concentration of mannitol becomes locally very high. As the solute (mannitol) concentration increases, the saturated dissolved gas concentration decreases. Therefore, the dissolved gas in the solution near the dissolving crystal is in a supersaturated state. Upon sufficient supersaturation, bubble nucleation takes place. We found that freeze-dried crystalline excipients such as mannitol facilitate bubble nucleation compared to freeze-dried glassy excipient such as trehalose because of differences in surface morphology.

2:15

3pBA6. Simulation of multi-source external mechanical vibration for shear wave elastography. Heng Yang, Alex Benjamin, and Brian Anthony (Mech. Eng., Massachusetts Inst. of Technol., 77 Massachusetts Ave., Bldg. 35, Rm. 231, Cambridge, MA 02139, hankyang@mit.edu)

Shear wave elastography (SWE) provides clinical diagnostics by probing the mechanical properties of soft tissue. Commercial ultrasound scanners use focused acoustic radiation force (ARF) to generate the requisite shear waves. This technique requires complex front-end electronics and may induce thermal stresses within the tissue and electronics. External mechanical vibration (EMV) based SWE emerges as a viable alternative; in addition to being low-cost and robust, it potentially offers higher local displacements and increased standardization compared to ARF based SWE. We present the simulation and sensitivity analysis of a novel EMV technique that can be adopted in clinical settings. The proposed design involves the use of two solid spheres placed symmetrically across or within the imaging plane of a commercial probe. These spheres can vibrate over a range of frequencies, amplitudes, and phases that are independent of one another. A non-linear, viscoelastic, finite-element model is used to simulate the propagation of induced shear waves within tissue-mimicking domains. A systematic sensitivity analysis is performed to determine the dependence of the amplitude, symmetry, attenuation, and interference of the induced shear waves on the following: spatial placement of the spheres relative to the ROI, distance between the spheres, their individual sizes, frequencies, amplitudes, and relative phases of vibration.

Session 3pIDa

Interdisciplinary: Hot Topics: Hunt Is Still Hot

Christina J. Naify, Chair
Acoustics, Jet Propulsion Lab, 4800 Oak Grove Dr., Pasadena, CA 91109

Chair's Introduction—1:00

Invited Papers

1:05

3pIDa1. Hydronephones: Acoustic receivers on unmanned underwater vehicles. Lora J. Van Uffelen (Ocean Eng., Univ. of Rhode Island, 215 South Ferry Rd., 213 Sheets Lab., Narragansett, RI 02882, loravu@uri.edu)

Noun | hy-drone-phone | \hi-drōn-fōn\ : An Instrument for listening to sound, mounted on an unmanned underwater vehicle. Yes, I made that word up—you heard it here first! The acronyms "UUV" (Unmanned Underwater Vehicle) and "AUV" (Autonomous Underwater Vehicle) have been buzzing around the underwater community recently, along with the term "underwater drone," which gained popularity in the media due to an international incident in December 2016 regarding an ocean glider (a subclass of AUV). Unmanned underwater vehicles are quickly becoming ubiquitous in the world of oceanographic sensing, military operations, and oil and gas exploration. Because sound travels far and fast underwater, it is an enabling mechanism for navigation and communication for these vehicles. "Hydronephones," specifically ocean gliders, are being used by our underwater acoustics community as receivers for long-range acoustics and marine mammal sensing. Key advantages of these vehicles are that they can be deployed for long durations of time in harsh environments and that they are much more cost-effective than traditional ship-based observational methods. An overview of this exciting technology will be presented along with details of some recent and ongoing "hydronephone" projects in underwater acoustics.

1:25

3pIDa2. Virtual reality meets architectural acoustics. Michael Vorlaender (Inst. of Tech. Acoust., RWTH Aachen Univ., Kopernikusstr. 5, Aachen 52056, Germany, mvo@akustik.rwth-aachen.de)

Computer programs for simulation and auralization of sound fields in rooms and of sound transmission in buildings became standard tools for architectural design and consulting. Another field of rapid progress is Virtual Reality—the combination of real-time signal processing with user interaction and multimodal human-machine interfaces. In this contribution, the development of simulation tools in architectural acoustics and further work aiming at real-time Acoustic Virtual Reality systems are reviewed and discussed with emphasis on the challenges and interdisciplinary solutions involving architectural acoustics as well as signal processing and psychoacoustics.

1:45

3pIDa3. Hospital noise: How bad is it? Ilene Busch-Vishniac (BeoGrin Consulting, 200 Westway, Baltimore, MD 21212, buschvi@gmail.com)

The noise in hospitals has been growing monotonically since at least 1960, and noise is now a top complaint of patients, staff, and visitors. Hospital noise sources are of many types, including HVAC noise from required high air flows, equipment noise from machines such as MRI units, alarms from equipment at patient bedsides, pneumatic tube lab transport systems, PA systems, and speech absolutely everywhere. In 2006, the federal government introduced the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) as a standardized survey to measure patient perception of the quality of care received. Results of the survey are publicly available for each of the over 5500 hospitals in the United States. The first analysis of results showed that the lowest score received by U.S. hospitals in aggregate was the single acoustics question which asks whether patients found their room sufficiently quiet to allow for sleep at night. With the threat of decrease of federal compensation unless they show improvement, hospitals have been developing and implementing noise control programs. In this talk, we will review what we know about hospital noise, what we still need to investigate, and the challenges to achieving transformative change.

Session 3pIDb

Interdisciplinary: ASA Hunt Postdoctoral Research Fellows: Through the Years (Poster Session)

Logan Hargrove, Cochair
Marshall, VA

Lily M. Wang, Cochair
Durham School of Architectural Engineering and Construction, University of Nebraska - Lincoln, PKI 100C, 1110 S. 67th St., Omaha, NE 68182-0816

All posters will be on display from 1:15 p.m. to 3:15 p.m.

Invited Papers

3pIDb1. Looking back forty years on the significance of my Hunt fellowship. Steven L. Garrett (Appl. Res. Lab, P. O. Box 30, State College, PA 16804, sxg185@psu.edu)

A postdoctoral fellowship comes at a very important point at the start of a young scientist's career. Since the Hunt Fellowship provides salary and covers incidental expenses, it allows the applicant to select where (s)he will work and with whom. Although it was impossible to know at the time, my year as a Hunt Fellow at the University of Sussex, doing ultra-low temperature acoustics in superfluids, determined the direction of a career in acoustics that has been challenging and fulfilling over four decades. In Sussex, I shared an office with Prof. Richard Packard, on sabbatical from UC-Berkeley. He invited me to spend the following two years in his laboratory where I also had the pleasure of working with Greg Swift. When Greg left to take the Oppenheimer Postdoctoral Fellowship at Los Alamos National Laboratory to work on novel heat engines with John Wheatley, the field of thermoacoustics was born. After doing a Ph.D. degree under the supervision of Izzy Rudnick and Seth Putterman, the Hunt allowed me to continue working with amazingly talented and innovative physicists. Seth and Izzy are a hard act to follow. Having the access that the Hunt provided set me on a path of lifelong learning.

3pIDb2. From acoustic microscopy to quantum computing. Daniel Rugar (IBM Res., 650 Harry Rd., San Jose, CA 95120, rugar@us.ibm.com)

Receiving the 1981 Hunt Postdoctoral Research Fellowship helped launch a fulfilling scientific journey that still continues today. The fellowship enabled me to continue my work on gigahertz frequency acoustic microscopy at Stanford University under Professor Calvin Quate. During my fellowship I succeeded in building a microscope that focused 3 GHz acoustic waves into liquid helium at temperatures below 100 mK. Amazingly, the system actually worked, and imaging resolution below 100 mm was achieved! From this experience I developed a fascination for nanoscale imaging techniques that has guided my Research career. After leaving Stanford I joined IBM Research where I have worked on scanning tunneling microscopy (STM), atomic force microscopy (AFM), magnetic force microscopy (MFM) and, most recently, two different approaches to nanoscale magnetic resonance imaging (nanoMRI). My scientific evolution continues: I now manage a research group focused on superconducting quantum computing devices. Although my scientific journey has taken me far from the world of acoustics, I credit the Hunt Fellowship for giving me a key early opportunity for scientific exploration.

3pIDb3. 1983–1984 Hunt Postdoctoral Research Fellowship in Bergen, Norway. Mark F. Hamilton (Dept. of Mech. Eng., Univ. of Texas at Austin, 204 E. Dean Keeton St., Stop C2200, Austin, TX 78712-1591, hamilton@mail.utexas.edu)

The 1983–1984 Hunt Postdoctoral Research Fellowship in Acoustics took me to the Mathematics Institute at University of Bergen in Norway. My acoustics education began at Columbia University with an undergraduate acoustics course from Cyril Harris, who encouraged me to pursue a Ph.D. degree in Acoustics at Pennsylvania State University. My doctoral advisor at Penn State, Francis Fenlon, introduced me to nonlinear acoustics. Frank succumbed to cancer at age 41, and David Blackstock invited me to Applied Research Laboratories at University of Texas at Austin to complete my Ph.D. degree in his nonlinear acoustics group while remaining a Penn State student. At Texas I encountered another two leaders in nonlinear acoustics, Jacqueline and Sigve Tjøtta on leave from University of Bergen, who invited me to spend my Hunt Fellowship year with them in Norway. I thus had the good fortune to be instructed and mentored by pioneers who approached nonlinear acoustics from three different perspectives: engineering (Fenlon), physics (Blackstock), and mathematics (the Tjøttas). In this way, the Hunt Fellowship contributed substantively to rounding out my postgraduate education both academically and culturally. Following a second postdoctoral year at Texas I accepted a faculty appointment in Mechanical Engineering that continues to this day.

3pIDb4. F.V. Hunt and my travels with fricative consonants. Christine H. Shadle (Haskins Labs., 300 George St., New Haven, CT 06511, shadle@haskins.yale.edu)

My training as an electrical engineer aligned well with the way acoustics of speech was modeled, as I learned when working at Bell Laboratories and then in Ken Stevens' lab at MIT. However, fricative consonants require turbulence noise for their production; studying them for my Ph.D. led me toward aeroacoustics and testing whether circuit models really were adequate for modeling fricatives. The 1984–1985 Hunt and the NATO 1985–1986 postdoctoral fellowships gave me two years in which to learn more. I studied flow measurement methods at MIT's Mechanical Engineering Department (supervised by Prof. Richard Lyon), then used them in experiments on mechanical models of fricatives and of vocal folds at the Institute of Sound and Vibration Research (ISVR) at the University of Southampton, UK (supervised by Dr. Stephen Elliott and Dr. Phil Nelson). At the Department of Speech Communication and Music Acoustics at KTH, Stockholm, Sweden, supervised by Prof. Gunnar Fant, I analyzed human speech and experimented with vocal tract imaging. As academic staff at the University of Southampton I collaborated with ISVR and KTH colleagues and others on the aeroacoustic aspects of speech, vocal tract imaging and speech analysis methods; since 2004 I have continued this research at Haskins Laboratories.

3pIDb5. A career in acoustics nucleated by the 8th Hunt Fellowship (1985–1986). Anthony A. Atchley (Graduate Program in Acoust., Penn State Univ., College of Eng., 101C Hammond Bldg., University Park, PA 16802, atchley@psu.edu)

The 8th Hunt Fellowship enabled the author to work with Professor Robert Apfel and his inspirational research group at Yale University. The proposed research was to use superheated droplets to detect cavitation generated by short pules of megahertz-frequency ultrasound. At the time, it was thought that such cavitation would not produce large enough acoustic signals to be detected directly. Instead, if cavitation occurred on or near superheated droplets, they might erupt and emit a detectable signature. However, as happens in research, this idea was eclipsed by the discovery of a simpler approach. Working closely with Leon Frizzell, on sabbatical leave from the University of Illinois at Urbana-Champaign, Christy Holland, Sameer Madanshetty, and Ron Roy, we noticed that cavitation could be detected passively and used the method to investigate the dependence of cavitation thresholds on various pulse parameters. Also while supported by the Fellowship, the author was introduced to thermoacoustics which consumed the next phase of his career. This interest in high amplitude sound evolved over time into studies of the nonlinear propagation of noise from sub- and supersonic aircraft.
[The author gratefully acknowledges support from the Office of Naval Research for much of the research discussed in this poster.]

3pIDb6. Music perception and the Hunt Fellowship. Ian M. Lindevald (Physics, Truman State Univ., 100 East Normal St., Kirksville, MO 63501, lindy@truman.edu)

I was the 1987–1988 Hunt Postdoctoral Research Fellow a lifetime ago. As a mathematics/physics nerd with a love of music, I consider it the greatest privilege of my life to have spent my formative years at the feet of Dr. Arthur Benade at Case Western Reserve University, where I earned my Ph.D. in physics. Art was my mentor and my friend, and I was his last Ph.D. student. I accompanied him to many ASA meetings in the early 1980's. Although Art's primary expertise was in the physics of wind instruments, he put me to work on issues of perception of musical sounds in the random sound fields of enclosed spaces. The focus on music perception paved the way for my post-doctoral research in Munich, supported by the Hunt Fellowship, where I worked with Professor Ernst Terhardt at the Technical University of Munich, testing his robust pitch algorithm with genuine musical sounds derived in a reverberant space. The results of that research mainly supported Terhardt's work. Since then, I have redirected my interests to physics education and undergraduate research and also serve in departmental leadership at Truman State University, a public liberal arts institution in rural northeast Missouri.

3pIDb7. Hunt Magic: A lifetime of fruitful collaboration. E. Carr Everbach (Eng., Swarthmore College, 500 College Ave., Swarthmore, PA 19081, ceverba1@swarthmore.edu)

The 1989–1990 F.V. Hunt Fellowship allowed me to spend one year at the University of Rochester in Edwin Carstensen's lab to investigate the physical mechanisms of shock wave lithotripsy (ref Boston). Coming from the lab of Bob Apfel at Yale, where I had worked on nonlinear propagation and measurement of B/A, at U. Rochester I applied these concepts to shock wave propagation and measurement in lithotripsy. I also investigated the role of inertial cavitation in both lithotripsy and blood clot dissolution, developing collaborations with Mort Miller's biophysics lab and clinicians at the Strong Memorial Hospital. The fruitful collaborations I developed at U. Rochester during my Hunt year continued for years thereafter, including several summers spent in Rochester until marriage and family intervened. I can credit the awarding of my NSF Presidential Faculty Fellowship and decades of ultrasound bioeffects work to my Hunt Fellowship year, and I relish ongoing collaborations that enrich my teaching and research at an all-undergraduate institution.

3pIDb8. From Berlin to Atlanta, with a sojurn in Oz. Kenneth Cunefare (Georgia Tech, Mech. Eng., Atlanta, GA 30332-0405, ken.cunefare@me.gatech.edu)

Having been lured away from Exxon to pursue a Ph.D. by Gary Koopmann, I had no idea during a 1989 visit to the TU in Berlin, with the Berlin Wall still a looming presence, that he was laying the ground work with Herr Dr. Prof. Manfred Heckl of the Institute of Technical Acoustics to host me should I receive the Hunt. When I arrived in July 1990, the wall had fallen, and great changes were underway. The year passed all too quickly, with Pink Floyd at "The Wall," technical visits to Dresden, Gottingen, and ISVR, and more. The work I did in that year remains some of my highest cited work. Having already accepted a faculty position at Georgia Tech made the year much less stressful. The connections and colleagues I made at the TU remained throughout my career. At GT I explored a number of areas triggered by my Hunt year, including structural acoustic optimization, acoustic mode representation for exterior fields, and active structural acoustic control which led to a sabbatical year, with results akin to my Hunt year, at the University of Adelaide in Australia. I am also a founding member of a successful acoustic consultancy (Arpeggio).

3pIDb9. An indispensable detour: From a Hunt Postdoctoral Research Fellowship to microelectronics packaging. Quan Qi (Apple SEG Packaging, 1 Infinity Loop, MS 34-4HWT, Cupertino, CA 95014, quan_qi@apple.com)

After receiving my Ph.D. degree in Theoretical and Applied Mechanics from University of Illinois at Urbana-Champaign, I faced a choice of taking an industrial job offer or pursuing research in nonlinear acoustics as the 1992-93 Hunt Postdoctoral Research Fellow. My argument at the time was rather simple: I can always choose to go back to industry at any time but there will not be another "shot" to be a Hunt Fellow! Having studied fluid mechanics, it was a natural extension to leverage that background to focus on nonlinear acoustics for the Hunt Fellowship, specifically to investigate feasibility of using high-frequency acoustical streaming to replace the cavitation based mechanism to clean micron-sized particle from the surface of silicon wafers. During the Hunt Fellowship, I became interested in electronics packaging: wafer cleaning led to silicon chips, which in turn led to microchip packaging. I have worked in this particular area, starting at Hewlett-Packard, with other companies and now with Apple. Occasionally, I wonder: what if I had taken that industry job instead of the Hunt Fellowship? I am thankful, though, for what I have and very grateful for the Hunt Fellowship opportunity that led to gratifying professional career in microelectronics packaging.

3pIDb10. Nucleation of a career in biomedical ultrasound. T. Douglas Mast (Biomedical Eng., Univ. of Cincinnati, 3938 Cardiovascular Res. Ctr., 231 Albert Sabin Way, Cincinnati, OH 45267-0586, doug.mast@uc.edu)

I was introduced to the Acoustical Society of America by Allan Pierce, who supervised my doctoral dissertation "Physical Theory of Narrow-Band Sounds Associated with Intracranial Aneurysms" in Penn State's Graduate Program in Acoustics. Professor Pierce also introduced me to Robert Waag, whose Diagnostic Ultrasound Research Laboratory I joined as a postdoctoral research associate at the University of Rochester. I received the 17th F. V. Hunt Postdoctoral Fellowship in 1994/1995 to investigate "Ultrasonic scattering: new techniques for measurement, analysis, and imaging." As a Hunt Fellow in Professor Waag's laboratory, I was immersed in the broad, interdisciplinary field of biomedical ultrasound, including tissue characterization from scattering measurements, breast imaging by diffraction tomography, and numerical modeling of propagation through realistic tissue models. My subsequent career has focused on biomedical applications of ultrasound, including positions at Penn State working with David Swanson, at Ethicon Endo-Surgery where Inder Makin recruited me to collaborate on a therapeutic ultrasound platform, and at University of Cincinnati where Christy Holland recruited me to join the Department of Biomedical Engineering. Through collaborations with these and many other acousticians, I have learned the value of applying physical acoustics principles to biomedical problems.

3pIDb11. Shock waves in the atmosphere, the body, and mercury. Robin Cleveland (Eng. Sci., Univ. of Oxford, Inst. of Biomedical Eng., Old Rd. Campus Res. Bldg., Oxford OX3 7DQ, United Kingdom, robin.cleveland@magd.ox.ac.uk)

As the 1995/96 F.V. Hunt Fellow, I transferred skills acquired during my Ph.D., at the University of Texas at Austin, in developing a numerical models of sonic boom propagation in the atmosphere, in order to investigate how shock waves propagate through the body, in order to better understand lithotripsy the medical procedure where shock waves are used to fragment kidney stones, at the Applied Physics Laboratory at the University of Washington in Seattle. After my fellowship, I joined the faculty at Boston University where a collaboration with Oak Ridge National Laboratory resulted in a project to understand shock wave generation and propagation in liquid mercury. This talk will focus on the underlying nonlinear acoustics associated with shock waves in fluids and by use of nondimensionalization demonstrate the strong similarity in these three apparently disparate propagation problems. It will be then shown that even with modern computers the memory and calculation requirements associated with fully three-dimensional high-fidelity models of these problems are substantial. Finally, the differences in the problems due to boundary conditions and medium properties will be discussed. The Hunt Fellowship was the vehicle by which my training in shock propagation could be used to further research in other areas.

3pIDb12. Distinctive Features. Mark A. Hasegawa-Johnson (Elec. and Comput. Eng., Univ. of Illinois, 405 N Mathews, Urbana, IL 61801, jhasegaw@illinois.edu)

I was the Hunt Post-Doctoral Fellow in 1996–1997; my Hunt fellowship led directly to a successful application for an NIH R01 post-doctoral fellowship with the same mentor, which led, in turn, to my current position as Professor at the University of Illinois. As part of my Hunt post-doc, I rented a very low frequency electromagnetic field meter, and demonstrated that the articulograph presents minimal risk to human subjects; this was published as my first article in JASA. As part of my NIH post-doc, I acquired MRI of static vowel configurations (http://isle.illinois.edu/sst/data/mri/), and demonstrated that a PARAFAC rank-3 factor analysis of the English vowels supports two speaker-independent factors matching the distinctive features. As part of my research in Urbana, I have developed automatic speech recognizers using distinctive feature models grounded in both speech production and speech perception. In 2015, Preethi Jyothi and I published the idea of mismatched crowdsourcing: an American listening to Uyghur is modeled as a machine who transcribes each distinctive feature shared by the two languages, with an error probability related to the similarity with which the two languages use the feature.

3pIDb13. An unexpected but fulfilling path: From a Hunt Postdoctoral Research Fellowship in Denmark to academia in Nebraska. Lily M. Wang (Durham School of Architectural Eng. and Construction, Univ. of Nebraska - Lincoln, PKI 100C, 1110 S. 67th St., Omaha, NE 68182-0816, lwang4@unl.edu)

As the 1998-99 Hunt Postdoctoral Research Fellowship recipient, I conducted postdoctoral research at the Technical University of Denmark under the supervision of Prof. Anders Christian Gade. My goal as a teenager was to become an acoustical engineer who designed concert halls, after reading about such a job from a high school physics textbook. After receiving my Bachelor's of Science degree in Civil Engineering, I had planned to get a Master's degree in Acoustics from the Pennsylvania State University and then become an acoustical consultant; I certainly had no intention of pursuing a Ph.D., a postdoc, or an academic position. I was fortunate, though, to have had mentors who guided me on an unexpected but fulfilling career path: first in getting my Ph.D. instead of Master's degree, then applying and receiving the Hunt Postdoctoral Research Fellowship to study abroad in Europe during which I made firm connections to other strong architectural acoustics groups, and finally becoming a faculty member at the University of Nebraska's Architectural Engineering program, focused on architectural acoustics teaching and research. This poster explores the career path I have followed and reflects on the influential role the Hunt Postdoctoral Research Fellowship had upon it.

3pIDb14. An appreciation of the benefits of a Hunt Fellowship. James C. Lacefield (Elec. & Comput. Eng., Western Univ., Thompson Eng. Bldg, Rm. 279, London, ON N6A 5B9, Canada, jlacefie@uwo.ca)

I was awarded the Hunt Fellowship in 2000-01 as a postdoctoral researcher at the University of Rochester working under the supervision of Robert Waag. My research during the Fellowship experimentally analyzed methods of compensating for focus aberration in medical ultrasound imaging using multirow and matrix transducer arrays. I was subsequently recruited to a faculty position at Western University in London, Ontario, at the time Western established its Biomedical Engineering program, which I currently direct while continuing to conduct research in biomedical ultrasound. One of the enduring benefits I acquired during my Fellowship was to develop my skill at and appreciation of precise scientific communication, which are characteristics Professor Waag instilled in all of his trainees. Another valuable benefit the Fellowship granted me was an opportunity to begin forming my own scientific network through the ASA and other organizations. Holding the Hunt Fellowship provided me both encouragement and financial resources to become more active in the biomedical ultrasonics research community, which was a key step toward launching my academic career.

3pIDb15. Expect the unexpected: A path enlightened by the Hunt Fellowship. Chao-Yang Lee (Commun. Sci. and Disord., Ohio Univ., Grover W225, Athens, OH 45701, leec1@ohio.edu)

My interest in language led to an interdisciplinary and international journey through psychology (B.S., National Chengchi University, Taiwan), linguistics (A.M., Brown), cognitive science (Ph.D., Brown), and speech communication (postdoc, MIT) before joining the faculty of Communication Sciences and Disorders at Ohio University. Being awarded the Fellowship in 2001 was a pleasant surprise. The generous support of the Fellowship allowed me to witness how great scientists think, act, and educate. Studying with Professor Ken Stevens and members of the MIT Speech Group further prepared me for research on crosslinguistic aspects of speech communication. The experience also inspired me to mentor my students as I was mentored: with respect and genuine interest. As Professor Hunt envisioned, this Fellowship allowed me to play a small but meaningful part in furthering the science of, and education in acoustics. I am deeply grateful to Professors Sheila Blumstein (Brown), Phil Lieberman (Brown), and Ken Stevens (MIT) for making the journey possible and for believing in me.

3pIDb16. Hunt-ing for new therapies: From red blood cells to acoustic nanobubbles. Constantin Coussios (Inst. of Biomedical Eng., Dept. of Eng. Sci., Univ. of Oxford, Old Rd. Campus Res. Bldg., Oxford OX3 7DQ, United Kingdom, constantin.coussios@eng.ox.ac.uk)

The Acoustical Society has undoubtedly nurtured me through all key stages of my career. I attended my first ASA meeting as the last doctoral student of noise acoustician Prof. Shôn Ffowcs Williams, working on acoustic scattering from red blood cells to detect hemolysis. At a time when I was questioning whether research in general and acoustics in particular were right for me, the unexpected award of the biomedical acoustics student prize (Atlanta, 2000) and a chance meeting with my future Hunt fellowship mentor, Prof. Ron Roy, radically changed my outlook. Until that point, my perception of biomedical acoustics had been confined to diagnostic applications, but discovering the emerging therapeutic potential of focused ultrasound and acoustic cavitation made me realize that it was possible for an acoustician to impact key aspects of human health, such as treating cancer or facilitating orthopedic surgery. Much of the training and inspiration of my Hunt fellowship year at Boston University (2002–2003) travelled back with me to Oxford when I set up the BUBBL research group, which over a decade and following further encouragement by an ASA R. Bruce Lindsay award (2012) enabled my team and me to translate novel acoustic therapeutic technologies into clinical practice.

3pIDb17. HUNTing for new biomedical ultrasound applications. Tyrone M. Porter (Boston Univ., 110 Cummington Mall, Boston, MA 02215, tmp@bu.edu)

The use of ultrasound in biomedical applications has evolved dramatically in the last few decades. Biomedical ultrasound first gained widespread use clinically as an imaging modality for monitoring pregnancy and diagnosing cardiovascular diseases. The introduction of encapsulated microbubbles as contrast agents enabled the development of contrast-enhanced diagnostic ultrasound initially and ultrasound-mediated drug delivery more recently. During my year as a Hunt Postdoctoral Fellow, I worked on the development of submicron vesicles that could serve as both ultrasound contrast agents and drug carriers. These vesicles could be leveraged for image-guided ultrasound-mediated drug delivery for various medical conditions. My tenure as a Hunt Postdoctoral Fellow paved the way for a faculty position at Boston University where I continue to work on vesicles and droplets in an emerging research field that combines therapy and diagnostics more commonly known as theranostics. This poster illustrates research and activities that were spawned by my tenure as a Hunt Postdoctoral Fellow.

3pIDb18. The Hunt Postdoctoral Fellowship: Opening doors to interdisciplinary research. Erica E. Ryherd (Durham School of Architectural Eng. & Construction, Univ. of Nebraska - Lincoln, 1110 S 67th St., Architectural Eng., Omaha, NE 68182-0816, eryherd@unl.edu)

I was honored to receive the 2006–2007 F.V. Hunt Postdoctoral Fellowship to conduct research at the Sahlgrenska Academy of Medicine at Gothenburg University in Sweden. I worked under the supervision of Dr. Kerstin Persson Waye, studying the impact of noise in hospitals on staff and patients. My background and training leading up to my postdoc was in engineering with a specialty in architectural acoustics and noise control. Through the Hunt Fellowship, I was able to deepen my skillset by pursuing interdisciplinary research in occupational and environmental health. I will never forget the excitement of working in an entirely different environment and learning how to navigate both medical terminology and another language simultaneously. The adaptability I gained by facing those challenges served me well on my path to tenure. One of the most fruitful parts of my postdoc from a research standpoint was identifying the many areas of hospital acoustics that needed more work. To this day, I continue to collaborate with students and colleagues in engineering, medicine, and other diverse disciplines to improve healthcare built environments. Ten years later, I can truly say that the F.V. Hunt Fellowship had a profound impact on my life and career path.

3pIDb19. The Hunt Fellowship: Inspiring acoustics professionals of the future. Alison K. Stimpert (Bioacoustics/Vertebrate Ecology, Moss Landing Marine Labs., 8272 Moss Landing Rd., Moss Landing, CA, alison.stimpert@gmail.com)

Students may exit a Ph.D. program feeling fatigued, and sometimes a bit directionless professionally. These feelings combined with the challenging academic job market could be part of the reason for this time period being one of the biggest "leaks in the pipeline," for women scientists in particular. The flexibility and generosity of the Hunt Fellowship can be inspiring at this crossroads of a young scientist's career. As the 2009–2010 Hunt Postdoctoral Research Fellowship recipient, I studied the acoustic behavior of humpback whales on their Antarctic feeding grounds, working under the mentorship of Dr. Whitlow Au (University of Hawaii) and Dr. Douglas Nowacek (Duke University). This project followed seamlessly from my dissertation, yet brought me to new ecosystems and reinvigorated my research questions with surprising data. The signal processing skills I gained in acoustic and animal movement analysis solidified my interest in quantitative acoustic behavior research and I made strong connections with several interdisciplinary research groups. This all fueled my career path toward my current Research Faculty position at Moss Landing Marine Laboratories, using similar sound and movement tags to study the effects of anthropogenic noise on cetaceans in general.

3pIDb20. The French connection: My experience as a Hunt Fellow. Michael Canney (CarThera, 1490 Delgany St., Apt. 603, Denver, CO 80202, michael.canney@gmail.com)

After finishing my Ph.D. degree in 2009 at the University of Washington, I was grateful to be the recipient of the Hunt Fellowship. During my year as a Hunt Fellow, I worked at an academic laboratory in Lyon, France, under the supervision of Dr. Cyril Lafon and Dr. Jean-Yves Chapelon. The laboratory specialized in the field of therapeutic ultrasound and had several translational projects to take new therapeutic ultrasound technologies into the clinic. Little did I realize that a one-year fellowship would turn into a 6-year hiatus living abroad in France and a working relationship with the French that continues to this day. After my Hunt fellowship, I continued as one of the first employees of a French startup company and helped lead the development of a novel therapeutic ultrasound device for brain drug delivery. During the six years that I worked in France, this device was successfully transitioned from animal experiments to clinical trials. This poster explores the work that I started in France on these technologies and which I continue to work on presently. In addition to the professional development it allowed, the Hunt Fellowship gave me the opportunity to pursue a lifelong dream to live and work in a foreign country and to become fluent in a second language.

3pIDb21. In pursuit of noninvasive microsurgery. James J. Choi (Dept. of BioEng., Imperial College London, Rm. 4.06, Royal School of Mines Bldg., South Kensington Campus, London SW7 2AZ, United Kingdom, j.choi@imperial.ac.uk)

I am committed to creating safe and high performance noninvasive surgical devices and the 2011 Hunt Fellowship supported me at a critical point on my path toward this goal. Noninvasive surgery refers to the local modulation of tissue deep in the body without surgical incisions. This technology has the potential to treat devastating diseases, such as Alzheimer's disease cancers, and stroke. I entered research in this field as an undergraduate at the University of Michigan building multi-element therapeutic arrays under Prof. Charles Cain. I then developed technologies that could deliver drugs to the brain at Columbia University during my doctoral research under Prof. Elisa Konofagou. At this stage, I noticed a severe gap in capability. Although we could spatially control where an ultrasound beam is placed, we had poor control of the safety and performance within it. The 2011 Hunt Fellowship supported me on the development of passive acoustic mapping technologies—a unique technology that allowed for the resolution of sub-beam interactions. This work was conducted at the University of Oxford under Prof. Constantin Coussios. I now lead a team at Imperial College London as a tenured Associate Professor and remain committed to continuing my pursuit of noninvasive microsurgical devices.

3pIDb22. The unexpected but fulfilling impact of the Hunt Postdoctoral Research Fellowship in my academia career. Likun Zhang (Dept. of Phys. and Astronomy, Univ. of Mississippi, 145 Hill Dr., University, MS 38677, zhang@olemiss.edu)

Soon after I graduated with my Ph.D. degree in Physics from Washington State University in 2012 under the supervision of Dr. Philip L. Marston, I applied to the 2013–2014 Hunt Postdoctoral Research Fellowship. I was honored to receive the fellowship that funded my proposed postdoctoral research on acoustic propagation through internal waves under the joint supervision of Dr. Harry L. Swinney at the University of Texas at Austin and Dr. James F. Lynch at Woods Hole Oceanographic Institution. I am very grateful to the Hunt Fellowship for providing me with the opportunity to shift from analytical work on physical acoustics and fluid dynamics in my Ph.D. study to numerical and laboratory work on underwater acoustics in postdoctoral research. This has broadened the range of tools that I have to address acoustic problems in my academia career. I am fortunate to have had mentors who guided me on an unexpected but fulfilling career path that led me to becoming a faculty member in Physics at the University of Mississippi with my research affiliated with the National Center for Physical Acoustics. This poster explores the influential role of the Hunt Fellowship in the career path that I have taken.

3pIDb23. I wonder how animals can do it so well: An ongoing detour to build better sonar, enabled by the Hunt fellowship. Wu-Jung Lee (Appl. Phys. Lab., Univ. of Washington, 1013 NE 40th St., Seattle, WA 98105, wjlee@apl.washington.edu)

The Hunt Postdoctoral Research Fellowship gave me the freedom and flexibility to take a detour to pursue research topics that are not on a linear path from my Ph.D. training. My graduate study in the MIT-WHOI Joint Program in Oceanography focused on modeling and measuring the acoustic scattering of marine organisms for improving sonar, or echosounder, performance. Knowing the current limitation of human-made sonar, I have always been curious about how echolocating bats and dolphins can perform acoustic-guided search, identification and tracking of prey so efficiently. As a Hunt fellow in Dr. Cynthia Moss' lab in Johns Hopkins University, I learned first-hand the sophisticated echolocation and flight behavior of bats, which helped me develop insights for computational modeling. Using the research funds provided by the Hunt fellowship, I was fortunate to work with Dr. Whitlow Au, who first introduced me to the field of acoustics before graduate school, again to investigate the dolphins' adaptive biosonar beam control during prey capture. These opportunities lay the foundation for me as an early career scientist to integrate the conventional physics-based approach with the study of biological sonar toward a goal of developing better acoustic tools to observe and understand the ocean.

3pIDb24. Physical Acoustics and Oxford: My experience as a researcher, a fellow, and beyond. Jason L. Raymond (Dept. of Eng. Sci., Univ. of Oxford, 17 Parks Rd., Oxford OX1 3PJ, United Kingdom, jason.raymond@eng.ox.ac.uk)

In May 2015, I arrived in London after completing my Ph.D. work under the direction of Prof. Christy Holland at the University of Cincinnati and moved shortly thereafter with a goal to help establish one of the principal physical acoustics laboratories in the UK at Oxford. At the outset, it was my hope and expectation that the F. V. Hunt Fellowship would help to define a unique trajectory for my career. During the fellowship and along with the support of my mentor, Prof. Ronald Roy, I have been able to develop a network of collaborators and conduct research which will help to define the next phase of my career and work in acoustics. A highlight of my term as a Hunt Fellow was the opportunity to travel to China, during which I visited four research laboratories relating to my work in therapeutic ultrasound and delivered two invited seminars. I am grateful to the Hunt family estate and the Acoustical Society of America for offering this fellowship, which has not only provided me with the opportunity to conduct research, but also the flexibility to develop as an independent scientist and to work with international collaborators.

3pIDb25. Impact of the F. V. Hunt postdoctoral fellowship on a trainee's research and career advancement. Himanshu Shekhar and Christy K. Holland (Dept. of Internal Medicine, Univ. of Cincinnati, 3933 Cardiovascular Ctr., 231 Albert Sabin Way, Cincinnati, OH 45267, himanshu.shekhar@uc.edu)

The F. V. Hunt Postdoctoral Research Fellowship in Acoustics gave Dr. Himanshu Shekhar an opportunity to pursue a new research direction in therapeutic ultrasound at University of Cincinnati with Prof. Christy Holland as a mentor. This research was performed at the Image-Guided Ultrasound Therapeutics Laboratories, which is composed of trainees, principal investigators, physician-scientists, and clinical collaborators. During his tenure as a Hunt fellow (June 2015–May 2016), Dr. Shekhar developed cavitation-mediated lytic and bioactive gas delivery to treat ischemic stroke. He also contributed to ongoing research on microfluidic manufacture of thrombolytic-loaded echogenic liposomes, thrombolysis using histotripsy, and comparative lytic activity of a lytic in human and porcine clots. His work led to two first author peer-reviewed manuscripts, three coauthored manuscripts, and two presentations at the meetings of the Acoustical Society of America (ASA). This fellowship also enabled Dr. Shekhar to enhance his engagement with the ASA as a full member of ASA, serving on the biomedical acoustics technical committee, and on subcommittees of the live-streaming initiative and the Hunt recognition campaign. The training, mentorship, and the exposure received during the Hunt Fellowship tenure has prepared Dr. Shekhar, who plans to pursue an academic research career in biomedical acoustics.

3pIDb26. The F.V. Hunt fellowship: A step toward research independence and leadership. Romain Fleury (EPFL, EPFL - STI - LWE, ELB 033 - Station 11, Lausanne 1015, Switzerland, romain.fleury@epfl.ch)

As the recipient of the 2016 F.V. Hunt postdoctoral fellowship, I had the immense privilege to experience postdoctoral research in one of the most active acoustic groups in France, in the Langevin Institute at ESPCI (School of Physics and Chemistry) under the supervision of Prof. Mathias Fink and Dr. Geoffroy Lerosey. This poster presents what I learned during this wonderful experience and the impact of the fellowship on my academic career and identity as a researcher.

3pIDb27. Frederick V. Hunt Postdoctoral Research Fellowship: My journey toward clinical research in audiology. Anna Diedesch (Dept. of Otolaryngology/Head & Neck Surgery, Oregon Health & Sci. Univ., 3710 SW US Veterans Hospital Rd., Portland, OR 97239, acdiedesch@gmail.com)

As the current Hunt Postdoctoral Research Fellow, I am evaluating binaural cue distortion in hearing aids at the VA RR&D National Center for Rehabilitative Auditory Research. Beginning early in life I always wanted to teach. Ironically, during my undergraduate education I felt that would require too much education. I instead found the field of Audiology and was fascinated by the science and technology in the field as well as rewarded by being able to treat and counsel patients regarding their hearing difficulties. While working on my Doctor of Audiology, I became aware of the difficulties in our field to train clinical researchers who would return to academia to train the next generation of audiologists. I was hesitant to pursue a Ph.D., so instead took a job as a Research Audiologist while I figured out my next step. With the guidance from Frederick J. Gallun and Marjorie Leek, I eventually began my Ph.D. with G. Christopher Stecker. This poster explores my journey toward becoming a clinical researcher and how the Hunt Fellowship is influencing my career trajectory.

Session 3pNS

Noise and ASA Committee on Standards: Urban Planning Using Soundscape I

David Woolworth, Cochair
Roland, Woolworth & Associates, 365 CR 102, Oxford, MS

Brigitte Schulte-Fortkamp, Cochair
Institute of Fluid Mechanics and Engineering Acoustics, TU Berlin, Einsteinufer 25, Berlin 101789, Germany

Contributed Papers

1:15

3pNS1. Acoustic planning of a music festival site. Adam Young (CSTI Acoust., 16155 Park Row, Ste. 150, Houston, TX 77084, adam@cstiacoustics.com)

CSTI acoustics worked with a community on the planning of a festival site that will host outdoor concerts. Our work involved measuring sound from an outdoor concert at a nearby venue, documenting ambient sound levels in communities surrounding the proposed festival site, modeling the sound propagation from optional stage locations and orientations, and proposing procedures and sound limits for future performances.

1:30

3pNS2. A big dilemma: Airport noise and property value. Yalcin Yildirim (Urban Planning and Public Policy, Univ. of Texas at Arlington, 601 W Nedderman Dr. #203, Apt. 933, Arlington, TX 76019, yalcin.yildirim@mavs.uta.edu) and Sriram Villupuram (Finance and Real Estate, Univ. of Texas at Arlington, Arlington, TX)

Even though many attributes to the airport creates value for properties, many other factors such as noise is considered to have wither neutral or negative effects residential property values. This research examines the relationship between airport noise and housing prices by using disaggregated transactions in Dallas-Fort Worth Airport which is the fourth busiest airport in the United States (FAA, 2015). The effects of airports on residential property values have been studied in several fields and contexts. Tomkins *et al.* (1998) examined the Manchester Airport by performing hedonic method. In addition, Nelson conducted a meta-analysis about noise and housing price near airport and these studies applied census tract aggregated data. This paper examined the implications of the airport noise on disaggregated residential property transactions in a rapid growing urban area—Dallas Fort Worth Metropolitan- by performing Multi-Level-Modeling. To do this, variables are defined for each level. Property level is considered with many characteristics such as number of bedrooms, bathrooms, floor, etc. Moreover, there are also neighborhood attributes such as demographics, income, and green space to evaluate. Based on results, total and marginal benefits of noise reduction were estimated that a 1 dB noise reduction may lead to increase 0.6% of house values.

1:45

3pNS3. Parking lot noise evaluation. Christopher L. Barnobi (Noise and Air Quality, Dudek, 1102 R St., Sacramento, CA 95816, cbarnobi@dudek.com), Connor Burke (Noise and Air Quality, Dudek, Encinitas, CA), and Jonathan Leech (Noise and Air Quality, Dudek, Santa Barbara, CA)

Parking Lot noise is regularly evaluated for CEQA noise assessments, but a standardized method has not been generally adopted. This paper presents sound level measurements of common parking lot activities. Other published sound level data for parking lot activities is provided to further solidify typical parking lot sound levels. A review of published methods for evaluating parking lot noise is summarized. The appropriateness of the methodology is evaluated and a simplified methodology is presented based on the similarities and differences applicable to California for CEQA analysis and the United States in general.

2:00

3pNS4. Electric vehicles and environmental noise: Assessing the noise impact of an electric fleet through strategic noise mapping. Eoin A. King (Mech. Eng., Univ. of Hartford, 200 Bloomfield Ave., West Hartford, CT 06117, eoking@hartford.edu)

Electric vehicles are fast becoming a reality and are being heralded as a real alternative to the highly polluting internal combustion engine fleet. Often electric vehicles are reported as being silent vehicles and may significantly reduce a population's exposure to environmental noise. This paper investigates what effect the widespread adoption of an electric fleet would have in a midsize city in the United States. The source level of an electric fleet is estimated by a combination of previous pass-by measurements, published data, and calculation. These estimations are used to develop a noise map of the city assuming an electric fleet. Results are then compared to noise levels assuming the current fleet. Results show that while an electric fleet will improve environmental noise levels within a city, the overall benefit is limited when expressed using a traditional strategic noise map, primarily due to the use of a time averaged L_{eq} indicator. In light of this, alternative metrics to better account for the changing acoustic characteristics of electric vehicles are discussed.

2:15

3pNS5. A preliminary look at the acquisition of acoustic field data using selected smartphone apps. Jennifer Lentz (Speech and Hearing Sci., Indiana Univ., 200 S. Jordan Ave., Bloomington, IN 47405, jjlentz@indiana.edu) and Roger M. Logan (Houston, TX)

Numerous smartphone applications exist that measure sound levels in the acoustic field. In some cases, these apps also provide additional acoustic data in the form of real-time spectral analysis. Yet, very few studies exist that have evaluated the validity of these apps for sound level measurement. Notably, these studies evaluated performance in the laboratory and only assessed the accuracy of the measurement of sound levels. Here, we present field-acquired data on the accuracy of dB level measurement and spectral analysis of a variety of smartphone apps for both Android and iOS platforms. We then discuss the feasibility of using these applications for field data acquisition.

Session 3pPA

Physical Acoustics: General Topics in Physical Acoustics II

Alexey S. Titovich, Chair
Naval Surface Warfare Center, Carderock Division, 9500 MacArthur Blvd., West Bethesda, MD 20817

Contributed Papers

1:00

3pPA1. Acoustic and seismic propagation between water and land—An experimental study. Michelle E. Swearingen (Construction Eng. Res. Lab., CERL, US Army ERDC, P.O. Box 9005, Champaign, IL 61826, michelle.e.swearingen@usace.army.mil), Donald G. Albert, and Jason R. Dorvee (CRREL, US Army ERDC, Hanover, NH)

Pressure waves can travel through coupled media, such as water and land. A field experiment was performed to characterize impulsive signal propagation between these media. Balloon pops underwater provided the in-water source, while sledgehammer blows provided the land-based source. Data were collected using a distributed sensor array that included locations on land and in the water, using a combination of microphones, hydrophones, and geophones. The array extended 75 m from the shore onto land and 75 m into the water perpendicular to the shoreline. Additional sensors were placed 25 m from the nominal shoreline and parallel to the shore. Source locations varied over the area to maximize capture of varying propagation paths. Data are analyzed for travel time, amplitude, and waveform shape. A description of the field experiment and results are presented. [Work funded by U.S. Army ERDC.]

1:15

3pPA2. Seismic wave propagation between ice-covered water and land—An experimental study. Jason R. Dorvee, Donald G. Albert (CRREL, US Army ERDC, US Army Corps of Engineers, ERDC, 72 Lyme Rd., Hanover, NH 03755, Jason.R.Dorvee@usace.army.mil), and Michelle E. Swearingen (CERL, US Army ERDC, Champaign, IL)

A field experiment was performed to characterize impulsive signal propagation between ice-covered water and land in both directions. Sledgehammer blows provided the source on both the surface of the ice and the ground. Underwater signals were generated with a balloon breaker source positioned 1 m below the surface of the ice. Sources on the ice and on land were located either in-line with the sensor array or oblique to array. Data were recorded using a combination of hydrophones in the water, geophones on the ice, geophones on the land, and hydrophones on land used as microphones. The different velocity structure in the two media produces different waveform characteristics. A hammer blow on ice produces a wave about three times larger on ice compared to one on the ground. In general, waves traveling in the ice have higher frequency content, lower attenuation, and travel faster than waves on land. In addition, the water layer below the ice produces reverse dispersion with higher frequencies arriving before lower frequencies, the opposite of the situation on land. As these waves transit the shoreline, complex waveform changes occur as a result of the different propagation characteristics. [Work funded by U.S. Army ERDC.]

1:30

3pPA3. Modeling particle-laden and poroacoustic flow phenomena via the generalized continua approach. Pedro M. Jordan (Acoust. Div., U.S. Naval Res. Lab., Stennis Space Ctr., MS 39529, pedro.jordan@nrlssc.navy.mil)

With a focus on acoustic phenomena, we investigate several dual-phase (i.e., fluid-solid) flows using the generalized continua (GC) modeling approach, where by "GC" we mean modern generalizations of the constitutive relations of classical continuum mechanics that seek to capture the impact of sub-scale structure/dynamics on the (macroscopic) field variables. Working under the finite-amplitude framework, we derive and analyze generalizations of the weakly nonlinear versions of the Euler and Navier–Stokes equations for the case of particle-laden and poroacoustic flows. Using both analytical and numerical methods, we examine the impact of the solid phase on the propagation and evolution of (1D) traveling and acceleration waves. Along the way, the advantages and disadvantages of this modeling approach will be discussed and applications to other fields noted. [Work supported by ONR funding.]

1:45

3pPA4. Introducing C/S: A companion nonlinearity indicator to the Morfey-Howell Q/S. Won-Suk Ohm, Taeyoung Park (Yonsei Univ., 50 Yonsei-ro, Seodaemun-gu, Seoul 120-749, South Korea, ohm@yonsei.ac.kr), Kent L. Gee, and Brent O. Reichman (Brigham Young Univ., Provo, UT)

The Morfey-Howell Q/S is a frequency-domain, single-point nonlinearity indicator, initially proposed for propagation of intense broadband noise [AIAA J. **19**, 986–992 (1981)]. It represents the extra change in level of a frequency component due to the nonlinearly generated absorption [*J. Acoust. Soc. Am.* **139**, 2505–2513 (2016)]. At the center of the definition of Q/S is the quadspectrum, which is the imaginary part of the cross-spectrum between the pressure and squared-pressure waveforms. The real part of the cross-spectrum (known as the cospectrum), however, has received little attention until recently Ohm *et al.* showed that its normalized version, hereby dubbed C/S, reflects the extra change in phase angle of the frequency component due to the nonlinearly generated dispersion [Proc. Mtgs. Acoust. **29**, 045003 (2016)]. In other words, Q/S and C/S signify two sides of the same coin in a nonlinear wave process under an arbitrary absorption/dispersion law: C/S is to dispersion as Q/S is to absorption. In this talk, we demonstrate the use of C/S in comparison with Q/S for the case of finite-amplitude waves in a thermoviscous fluid with multiple relaxation mechanisms.

2:00

3pPA5. Dynamics of quasi-empty rupture in the layer of cavitating liquid under SW-loading. Valeriy Kedrinskiy (Physical Hydrodynamics, Lavrentyev Inst. of Hydrodynamics, Russian Acad. of Sci., Lavrentyev Prospect 15, Novosibirsk 630090, Russian Federation, kedr@hydro.nsc.ru) and Ekaterina Bolshakova (Physical Dept., Novosibirsk State Univ., Novosibirsk, Russian Federation)

The problem of formation and collapse of a quasi-empty rupture in the layer of a cavitating liquid under shock wave (SW) loading is considered. The SW-pulse is generated in the layer by electro-magnetic hydrodynamic shock tube in a result of high-voltage discharge of capacitor bank on a flat helical coil. The latter is located right up to the bottom (conducting membrane) of container with the layer of two-phase distilled liquid. The analysis of the experimental data shows that the rupture is shaped as a spherical segment, which retains its topology during the entire process of its evolution and collapse. It was shown that potential energy of maximum volume of rupture at its collapse is practically transformed in acoustical losses (SW-radiation) and rupture disappears. Dynamics of main parameters and an existence time of rupture were determined. The analysis of cavitating nuclei state in the form of thin layer on an entire interface of rupture shows that in the field of rupture collapse the thin cavitating layer is transformed to a cavitating cluster. The latter takes the form of a ring-shaped bubbly vortex floating upward to the free surface of the liquid layer. A p-κ two-phase mathematical model was formulated, and calculations were performed to investigate the collapse of a quasi-empty spherical cavity (rupture model) in the unbounded cavitating liquid, generation of ultra-short shock wave and to discover the dynamic growth of micro-bubbles in a cluster by five orders of magnitude. [Work supported by RFBR Grant 15-05-03336.]

2:15

3pPA6. Enhancing the convergence of multipole expansions at intermediate frequency. Hui Zhou, Emily Mui, and Charles Thompson (Univ. of Massachusetts Lowell, 1 University Ave., Lowell, MA 01854, hui_zhou@student.uml.edu)

In this work, we examine near-field acoustic wave scattering from media having a spatial variation in compressibility contrast. Typically, the scattered acoustic pressure can be expressed as a convergent Neumann series when the compressibility contrast is relatively small. However as the magnitude of the compressibility contrast increases a resonant scattering condition ensues, yielding a divergent series. It has been shown that Padé Approximants method can be used in these cases, thereby extending the range of utility of the Neumann series solution. The proposed research explores hybrid methods that combine multipole-methods, and Padé Approximant approaches to calculate the near-field scattered pressure. As part of this work, we will examine the low-frequency breakdown in the plane wave, and monopole-monopole expansion approaches as it affects the numerical stability of spatial translation operations.

2:30

3pPA7. Application of particle-based computational acoustics to sound scattering by vortex and moving bodies. Yong Ou Zhang (Dept. of Naval Architecture, Ocean and Structural Eng., School of Transportation, Wuhan Univ. of Technol., Wuhan 430063, China, zhangyo1989@gmail.com)

The Lagrangian meshfree method with interacting particles is a powerful and natural approach for simulating physical systems with complicated domain topologies, moving boundaries, and multiphase media. Particle-based computational acoustics (PCA) is a noval branch of computational acoustics that aims to simulate acoustic phenomenon by Lagrangian meshfree particle methods. The ability of different particle methods to simulate flow-acoustic and flow-structure-acoustic interaction problems is evaluated, and problems include scattering of sound by a vortex or moving bodies. To separate the acoustic perturbation from the particle motion, Lagrangian acoustic perturbation equations (LAPE) including two sets of governing equations are used. Smoothed particle hydrodynamics (SPH), corrective smoothed particle method (CSPM), and finite difference particle method (FDPM) are selected for a comparison. Several checks on the accuracy and convergence of the Lagrangian meshfree PCA method are discussed. Numerical results are obtained for vortex scattering and sound wave scattering by moving rigid bodies. Various acoustic boundary conditions including moving boundaries and perfectly matched layers are examined.

Session 3pSC

Speech Communication: Clinical Populations (Poster Session)

Irina A. Shport, Chair
English, Louisiana State University, 260-G Allen Hall, Baton Rouge, LA 70803

All posters will be on display and all authors will be at their posters from 1:00 p.m. to 3:15 p.m.

Contributed Papers

3pSC1. Measuring progress during practice: Motion analysis throughout visual biofeedback treatment for residual speech sound errors. Rebecca Mental (Psychol. Sci., Case Western Reserve Univ., 11635 Euclid Ave., Cleveland, OH 44106, rlm142@case.edu), Holle Carey (Vulintus, Dallas, TX), Gregory S. Lee (Elec. Eng. and Comput. Sci., Case Western Reserve Univ., Cleveland, OH), Michael J. Hodge (Speech-Lang. Pathol., Cleveland Hearing and Speech Ctr., Cleveland, OH), and Jennell Vick (Psychol. Sci., Case Western Reserve Univ., Cleveland, OH)

The question of why some individuals make progress in speech therapy while others do not remains largely unanswered. Treatment delivery method could be a factor; individuals whose speech sounds have not improved through traditional therapy may be more responsive to alternative forms of treatment, such as visual biofeedback. The present study utilized visual biofeedback in the form of Opti-Speech, which uses real-time, three-dimensional streaming data from the Wave EMA system to create an avatar of a participant's tongue. Participants included two adult females with residual /r/ errors. One participant demonstrated marked improvement during and after treatment, while the other exhibited little perceptual change. It is possible that a more flexible motor system (i.e., one that shows more variability as a new skill is being learned) is more conducive to the acquisition of new speech sound movements than a more rigid system. Kinematic data were analyzed from each session, including duration, maximum displacement, distance traveled, and peak and average speeds. The coefficient of variation was calculated for each measure to assess variability. The length of the ballistic phase versus the corrective phase of movement was also calculated as treatment progressed. These measures were compared to perceptual outcomes.

3pSC2. Articulatory compensation strategies employed by an aglossic speaker. Asterios Toutios, Dani Byrd, Louis Goldstein, and Shrikanth S. Narayanan (Univ. of Southern California, 3740 McClintock Ave., EEB 400, Los Angeles, CA 90089, toutios@sipi.usc.edu)

We are employing real-time MRI to probe the speech production patterns of a speaker with congenital aglossia, a rare syndrome in which an individual is born without a tongue. The speaker being studied has only a small stump-like tongue rudiment in the region of the tongue root and a hypertrophied floor of the mouth (mylohyoid) and base of the tongue. Nevertheless, the speaker has acquired the ability to produce highly intelligible speech. One initial finding is that the speaker, in the absence of a tongue tip, produces plosive consonants that are perceptually similar to /t/ and /d/ by using a bilabial constriction with a significantly increased anteroposterior extent (relative to her /p/ or /b/ productions). Our aim is to provide an articulatory-acoustic account of this compensatory strategy via detailed analysis of her production strategies as evidenced in the real-time MRI data and via simulations using an articulatory synthesizer. We examine whether the increased anteroposterior extent of the bilabial constriction can by itself fully explain its coronal-like percept, or whether other factors contribute, such as the overall shaping of the back cavity or the dynamics of the "laminal" bilabial (pseudo-coronal) constriction formation and release. [Work supported by NIH.]

3pSC3. Subject-specific anatomical assessment of the human tongue in amyotrophic lateral sclerosis (ALS) by high-resolution MRI and diffusion tensor imaging. Euna Lee, Fangxu Xing, Sung Ahn, Timothy Reese, Ruopeng Wang (Radiology, MGH/Harvard, Boston, ME), Jordan Green (MGH Inst. of Health Professions, Boston, MA), Nazem Atassi (Neurology, MGH/Harvard, Boston, MA), Van Wedeen, Georges El Fakhri, and Jonghye Woo (Radiology, MGH/Harvard, 55 Fruit St., White 427, Boston, MA 02114, jwoo@mgh.harvard.edu)

Amyotrophic Lateral Sclerosis (ALS) is a progressive and irreversible neurological disorder, which affects upper and lower motor neurons in the motor cortex that control voluntary movements including speech and swallowing. High-resolution MRI (hMRI) and Diffusion Tensor Imaging (DTI) can provide non-invasive imaging of three-dimensional muscle anatomy and fiber myoarchitecture such as fiber orientation within the human tongue, respectively. In this work, we aim to assess anatomical differences of the tongue using both imaging methods by demonstrating the differences in quantities related to fiber connectivity for both normal and ALS subjects. We first manually delineate the genioglossus and superior longitudinal muscles on hMRI, which are aligned to each b0 image of DTI using deformable registration to provide regions of interest. We then compute fractional anisotropy and statistics about fibers connecting each pair of muscles. We apply our framework on five datasets including both normal and ALS subjects, revealing obvious quantitative degradation of muscle fibers in ALS patients compared to that in controls within and between muscles. Our framework has the potential to provide insight regarding the detrimental effects of ALS on speech and swallowing when combined with tongue motion data.

3pSC4. Acoustic speech analysis of patients with decompensated heart failure: A pilot study. Olivia Murton (Speech and Hearing BioSci. and Technol., Harvard Med. School, 24 Peabody Terrace, #1202, Cambridge, MA 02138, omurton@g.harvard.edu), Maureen Daher, Thomas Cunningham, Karla Verkouw, Sara Tabtabai, Johannes Steiner (Inst. for Heart, Vascular and Stroke Care, Massachusetts General Hospital, Boston, MA), Robert E. Hillman (Ctr. for Laryngeal Surgery and Voice Rehabilitation, Massachusetts General Hospital, Boston, MA), G. W. Dec, Dennis Ausiello (Inst. for Heart, Vascular and Stroke Care, Massachusetts General Hospital, Boston, MA), and Daryush Mehta (Ctr. for Laryngeal Surgery and Voice Rehabilitation, Massachusetts General Hospital, Boston, MA)

Heart failure (HF) is a chronic condition characterized by impaired cardiac function, increased intracardiac filling pressures, and peripheral edema. HF can escalate into decompensation, requiring hospitalization. Patients with HF are typically monitored to prevent decompensation, but current

methods are of only limited reliability (e.g., weight monitoring) or invasive and expensive (e.g., surgically implanted devices). This study investigated the ability of acoustic speech analysis to monitor patients with HF, since HF-related edema in the vocal folds and lungs was hypothesized to affect phonation and speech respiration. Ten patients with HF (8 male/2 female, mean age 70 years) undergoing inpatient treatment for decompensation performed a daily recording protocol of sustained vowels, read text, and spontaneous speech. Mean length of stay was 7 days, and average weight loss was 8.5 kg. Acoustic features extracted included fundamental frequency, cepstral peak prominence, automatically identified creaky voice segments, and breath group durations. After treatment, patients displayed increased fundamental frequency (mean change 3.7 Hz), decreased cepstral peak prominence variation (mean change -0.41 dB), and a higher proportion of creaky voice in read passages (mean change 6.9 percentage points) and sentences (mean change 5.5 percentage points), suggesting that phonatory biomarkers may be early indicators of HF-related edema.

3pSC5. Not all /r/s and /l/s are the same: Classification of errors in children with cochlear implants versus normal hearing. Laura Conover and Ruth Bahr (Commun. Sci. and Disord., Univ. of South Florida, 4202 E Fowler Ave., PCD 1017, Tampa, FL 33612, lconover1@mail.usf.edu)

Purpose: As children acquire speech sounds, they progress from clear substitutions, to "intermediate forms" (covert contrasts), to adult-like productions. However, there is evidence that this progression may be different in CI users as compared to NH children. Identification of intermediate forms is dependent upon rating scales that are sensitive to fine phonetic detail, such as visual analogue scales (VAS). This study uses both traditional VAS and a new 3-dimensional rating scale to explore differences in the /r,l/ productions of young children with and without hearing loss. **Methods**: Correct and error productions of /r,l/ were extracted from a standardized articulation test for nine congenitally deafened children who received cochlear implants (CIs) prior to age 3 and their speech age-matched controls. Stimuli were shortened to nonsense syllables to prevent real-word bias. Listeners rated these productions on both a VAS and a triangular scale, which allowed listeners to rate phone quality as a multi-dimensional function of /r/, /l/, and /w/. **Results & Conclusions:** Both rating scales were sensitive to subtle acoustic differences in speech sounds. Listener responses suggested more variability in sound production within the group of CI users. Listeners preferred the triangular scale because it provided greater response sensitivity.

3pSC6. Articulatory kinematics of bilateral stops in speakers with Parkinson's disease: Preliminary data. Sarah E. Worrell and Yunjung Kim (Louisiana State Univ., 85 Hatcher Hall, Louisiana State University, Baton Rouge, LA 70803, sworre2@lsu.edu)

The current study presents data on articulatory kinematics of bilateral stop production in speakers with Parkinson's disease (PD) for the long term purpose of developing a segment-specific articulatory profile of people with PD. As an initial step, we examined bilateral stops because of their relatively high frequency of occurrence and involvement of articulatory motions associated with surrounding vowels (Kim, Berry, and Kuo, 2017; Mines, Hanson, and Shoup, 1978). A total of 10 speakers (5 speakers with PD and 5 speakers without PD) were asked to read *The Caterpillar* passage in a conversational voice. An electromagnetic articulatography system (Wave, NDI) was used to track the motion of the tongue (tongue front and back) and lip (upper lip and lower lip) during bilabial stop productions (from the onset of stop closure interval to the onset of the following vocalic nuclei). The results will be presented regarding the (1) range (e.g., 2D distance) and (2) timing (e.g., the timing of minimum lip aperture) of articulatory movements focusing on group comparisons between the two speaker groups, people with and without PD.

3pSC7. Acoustic properties of vowel production in Mandarin-speaking patients with post-stroke spastic dysarthria. Zhiwei Mou (Jinan Univ., 613 West HuangPu Ave., Rehabilitation Department, HuaQiao Hospital, GuangZhou 510630, China, 405038856@qq.com), Jing Yang (Univ. of Central Arkansas, Conway, AR), Zhuoming Chen, Hong Wang, Yinhui Jiang, Jiamin Li, Wen Deng (Jinan Univ., Guangzhou, China), and Li Xu (Ohio Univ., Athens, OH)

This study investigated the acoustic features of vowel production in Mandarin-speaking patients with post-stroke spastic dysarthria. The subjects included 31 native Mandarin-speaking patients with post-stroke spastic dysarthria (age: 33–73 years old) and 40 normal adults in a similar age range (age: 22–68 years old). Each subject were recorded producing a list of 28 Mandarin monosyllables that composed of six monophthong vowels (i.e., /a, o, ɤ, i, u, y/) embedded in the /CV/ context. The patients' speech samples were evaluated by two native Mandarin speakers. The evaluation scores were then used to classify each patient into one of the two categories: mild or moderate-to-severe severity. Midpoint F1 and F2 of each vowel token were extracted and normalized. Results showed no significant differences between the patients and normal speakers on vowel duration. However, the vowel categories in the patients were more scattered and greatly overlapped than in the normal speakers. The magnitude of the vowel dispersion and overlap increased as a function of the severity of the disorder. The deviations of the vowel acoustic features in the patients from the normal speakers may provide guidance for clinical rehabilitation to improve the speech intelligibility of this type of patients.

3pSC8. Articulatory kinematics during stop closure in speakers with Parkinson's Disease. Austin R. Thompson, Amanda Kuylen, and Yunjung Kim (Louisiana State Univ., 56 Hatcher Hall, Field House Dr., Baton Rouge, LA 70803, atho184@lsu.edu)

Numerous studies have identified the perceptual characteristics of speakers with Parkinson's disease (PD), *imprecise consonants* (e.g., Darley, Aronson, and Brown, 1969). Acoustic studies have supported these findings with the observations such as spirantization, or the incomplete closure and fricative-like production of aperiodic noise during the closuresilent interval of stop consonants (Weismer, Yunusova, and Bunton, 2012). The current presentation explores the articulatory kinematics in speakers with PD during the closure interval duration of stop consonants with respect to distance, displacement, and timing of inter-articulators motion. In addition, the changes in articulatory movements during this brief time interval are examined as the speakers voluntarily vary the degree of speech intelligibility. Participants with PD and neurologically healthy controls were asked to read sentences containing stop consonants (e.g.,*"Buy Bobby a puppy"*). Movement data were collected using the WAVE (NDI, Canada). The results from the five articulatory measurement points (tongue front, tongue back, upper lip, lower lip, and jaw) will be presented with emphasis on segment-specific movement characteristics of individuals with Parkinson's disease, PD.

3pSC9. Tongue- and jaw-specific contributions to increased vowel acoustic contrast in response to slow, loud, and clear speech in talkers with dysarthria. Antje Mefferd (Hearing and Speech Sci., Vanderbilt Univ. Medical Ctr., 8310 Medical Ctr. East, Nashville, TN 37232, antje.mefferd@vanderbilt.edu)

Slow, loud, and clear speech can elicit increased acoustic vowel contrast in talkers with dysarthria. However, articulator-specific changes in response to these speech modifications and their relative contribution to vowel acoustic changes remain poorly understood despite the fact that these three speech modulations are commonly used as speech treatments to increase intelligibility in dysarthria. This preliminary study examined tongue and jaw movements in talkers with Parkinson's disease (PD) and amyotrophic lateral sclerosis (ALS) using electromagnetic articulography. Participants repeated the phrase "See a kite again" five times under four speech conditions: typical, slow, loud, and clear speech. Tongue movements were decoupled from the jaw to determine the relative contribution of the jaw and tongue to the overall tongue composite movement during the diphthong /ai/ in "kite". In the acoustic signal, the F2 minimum during /a/ and the F2 maximum during /i/ and their corresponding F1 values were extracted to calculate acoustic vowel contrast in F1-F2 vowel space. Linear regression analyses were used

to determine tongue- and jaw-specific contributions to acoustic vowel contrast changes in response to these speech modifications. Data analysis is currently underway. We hypothesized that talkers with PD and ALS demonstrate different response patterns to these speech modifications.

3pSC10. Tic word duration and speaking rate in Tourette's. Mairym Llorens (Linguist, Univ. of Southern California, 3601 Watt Way, Grace Ford Salvatori 301, Los Angeles, CA 90089-1693, llorensm@usc.edu)

Tourette's syndrome is a neurological condition characterized by the presence of an inventory of involuntary movements and vocalizations called tics that is unique to each individual. Tics occur on a background of typical, ongoing voluntary behavior, including speech. The voluntary speech of persons with Tourette's, like the speech of neurotypicals, shows expected signatures of underlying prosodic structure, e.g., emphatic word lengthening, utterance-final word lengthening and changes in speaking rate across an utterance. Many vocal tics resemble words or phrases uttered out of context but studies investigating the acoustic properties of tics in relation to the surrounding speech context do not exist. This state of affairs precludes understanding the relationship between linguistic vocal behavior, speech disfluencies, vocal ticking and other vocal behaviors like coughing. The current case study represents a linguistically informed analysis of vocal tic production during rehearsed, voluntary speech that investigated the impact of proximity to a prosodic boundary on tic word duration and speaking rate in an effort to determine whether vocal tics are produced via the typical speech planning and production pipeline.

3pSC11. The influence of vocal disorder on the perception of charisma in political speech. Rosario Signorello and Didier Demolin (Laboratoire de Phonétique et Phonologie, Université Sorbonne Nouvelle, Laboratoire de Phonétique et Phonologie, 19 Rue des Bernardins, Paris 75005, France, rosario.signorello@gmail.com)

Voice conveys leaders' charisma traits and triggers emotional states in listeners. A speaker with disordered voice quality is often perceived as a different individual in terms of intrinsic (personality traits and emotional states) and extrinsic characteristics (age, sex, and ethnicity) (Kreiman et Sidtis, 2011). In case of significant alteration, voice can convey significantly different charisma traits and trigger emotional states in listeners that diverge from the leaders' goals. Voice disorder can thus affect effective persuasion in the communication process. The present study reports investigations on the influence of vocal disorder on the perception of charisma traits and emotional triggering in political speech. Audio stimuli from non-disordered and disordered voice conditions of two politicians (Luiz Inácio Lula da Silva, former president of Brazil and Umberto Bossi, former leader of the Italian Lega Nord party) were collected. First, voice profiles reporting specific acoustic patterns during the two conditions were created. Secondly, cross-cultural perceptual tests of both conditions were conducted with French listeners to determine if the disordered voice condition (a) still conveys charisma and leadership traits, (b) what type of emotional states it triggers in listeners, and (c) how it influences listeners' voting behavior. [Work supported by grant DS0707-2015 ArtSpeech.]

3pSC12. Developing a remotely deliverable digit triplet in noise test for detecting high frequency hearing loss. Lina Motlagh Zadeh, Noah H. Silbert (Univ. of Cincinnati, 3239 Bishop St. Apt. #4, Cincinnati, OH 45220, motlagla@mail.uc.edu), Katherine Sternasty (Speech-Lang. Pathol. and Audiol., Miami Univ., Cincinnati, OH), and David R. Moore (Commun. Sci. Res. Ctr., Cincinnati Children's Hospital, Cincinnati, OH)

The prevalence of late-diagnosed or often unrecognized hearing loss (HL) is higher in developing countries due to the lack of access to hearing health care services. Due to the importance of hearing screening tests in early diagnosis of HL, development of remotely deliverable screening tests that can detect HL reliably, quickly, and easily provides significant benefits, specifically for underserved population. The purpose of this research is to refine the established English digit triplet test (DTT) to improve detection of high-frequency HL. The sensitivity and specificity of the DTT for detecting high frequency HL will be analyzed for low-pass filtered speech-shaped noise with three different cut-off frequencies (2 kHz, 4 kHz, and 8 kHz). The current study will also replicate previous work showing that speech reception thresholds estimated from the DTT correlate highly with listeners' pure tone average audiometry. This research should improve the accuracy of convenient, efficient tools for diagnosing HL for millions of people who have limited access to hearing health care.

3pSC13. Dysprosodie in preschool children with autism spectrum disorders. Daphne Hartzheim, Yunjung Kim, and Ariel Johnson (Commun. Sci. and Disord., Louisiana State Univ., 86 Hatcher Hall, COMD, Baton Rouge, LA 70803, dhartz4@lsu.edu)

One of the core language characteristics of children with autism spectrum disorders (ASD) have been described as monotone speech (i.e., reduced range of pitch and loudness). In this study, we investigated acoustic properties of primary prosodic cues, loudness, pitch, and speech rate. For this purpose, we analyzed speech samples from children ages 8-15 years with and without ASD while they were answering questions about social scenes. The child was asked to describe what he or she was supposed to do in a certain situation while provided a visual stimulus. The responses were video and audio recorded for later analysis. All children with ASD had verbal skills (i.e., ability to answer questions with sufficient length for acoustic analysis), even if receptive and expressive language skills was decreased for some children according to the Clinical Evaluation of Language Fundamentals-5 (CELF-5). Each child with ASD was paired with two children that were typically developing to account for natural variability in development. At the conclusion of data collection, the audio recording was analyzed for f0 variation, intensity variation, and the number of syllables produces per second using a computer software, PRAAT.

3pSC14. Daylong acoustic amplitude from the perspective of young children with and without hearing loss. Mark VanDam, Haille Heid, Stephen James (Elson S. Floyd College of Medicine, Speech & Hearing Sci., Washington State Univ., PO BOX 1495, Spokane, WA 99202, mark.vandam@wsu.edu), Samantha Schraven, Danette Driscoll, Amy Hardie, Stacy Cahill (Hearing Oral Program of Excellence (HOPE) of Spokane, Spokane, WA), and Daniel Olds (Elson S. Floyd College of Medicine, Speech & Hearing Sci., Washington State Univ., Spokane, WA)

Very little is known about the acoustic characteristics of the daylong auditory environment of children, especially for those children who belong to an at-risk population such as those with hearing loss. This work looks at the daylong acoustic amplitude from the auditory perspective of young children. Naturalistic audio was collected from a wearable audio recorder. Amplitude values were collected from 814 daylong recordings from children aged 1–90 months, with 318 from children who are typically developing and 496 from children with mild- to moderate hearing loss. We compared for difference by sex, hearing status, and age. Results suggest that boys' recordings had higher amplitude than girls', and that recordings of children with mild- to moderate hearing loss had higher amplitude than children who were typically developing. There were no observed sex by hearing status or sex by age interactions. For the recordings from children with hearing loss amplitude was negatively correlated with age, but for typically developing children amplitude was positively correlated with age. Results may be important for better understanding of children with hearing loss, language and speech development, automatic processing routines (such as automatic speech recognition), and intervention or therapeutic techniques for at risk populations.

3pSC15. Using real time magnetic resonance imaging to measure changes in articulatory behavior due to partial glossectomy. Maury Lander-Portnoy, Louis Goldstein (Linguist, Univ. of Southern California, 3601 Watt Way, Grace Ford Salvatori 301, Los Angeles, CA 90089-1693, landerpo@usc.edu), and Shrikanth S. Narayanan (Elec. Eng., Univ. of Southern California, Los Angeles, CA)

Real time MRI presents an exciting new method for studying speech articulation, providing the ability to capture articulatory kinematics and coordination. The current study utilizes real time MRI to document the speech of a patient who has undergone partial glossectomy at both preoperative and postoperative time points. While previous work has studied and evaluated postoperative outcomes, the comparison of individual speakers

preoperatively and postoperatively is lacking. The possibility of compensation for the pathological articulator by other articulators necessitates the ability to image multiple articulators simultaneously to observe changes in articulatory coordination. In this paper, we present a method for quantifying changes in articulatory behavior, such as compensation for pathology, between two points in time. We find no significant changes in the patient's articulatory coordination that would indicate compensation for pathology. We attribute this to the relatively high degree of speech intelligibility preserved postoperatively for this particular patient. We do observe differences in vocal tract morphology as well as changes in the variability and principle axes of movement for the tongue. The methods we present here provide a means not only for measuring individual morphological changes, but also for observing the relationship between changes in morphology and changes in articulatory behavior.

3pSC16. Vowel space in children with residual speech sound disorders. Caroline E. Spencer, Jade Clark, Sarah M. Hamilton, and Suzanne Boyce (Commun. Sci. and Disord., Univ. of Cincinnati, 3202 Eden Ave., PO Box 670379, Cincinnati, OH 45267, spenceco@mail.uc.edu)

Children with Residual Speech Sound Disorders (RSSD) are considered to have typical speech except for a few misarticulated sounds. During the course of ultrasound biofeedback therapy, parents frequently remark that their children have improved intelligibility, even if the misarticulated sound is not yet successfully remediated. One possible explanation is that therapy improves articulatory precision and expands their articulatory action space. In this study, we collected vowel space measures for 10 RSSD children pre and post 10 sessions of ultrasound therapy. In addition, we collected vowel space measures for 10 typically developing children. Preliminary results suggest a difference between populations. Across RSSD speakers pre-therapy, formant values were variable within phonemic categories; in contrast, formant values were consistent within phonemic categories in typical speakers. Further results of the comparisons between RSSD and typical children as well as for RSSD children's performance pre and post therapy will be discussed.

3pSC17. Measuring the source waveform of esophageal speakers using a two-port transfer matrix method. Andressa Beckert Otto, Andrey R. da Silva (Mech. Eng., Federal Univ. of Santa Catarina, Campus Universitário da Trindade, Florianópolis, Santa Catarina 88020-000, Brazil, andressa.beckert@hotmail.com), and Ana C. Ghirardi (Health Sci. Ctr., Federal Univ. of Santa Catarina, Florianópolis, Brazil)

The glottal waveform is an important parameter from which relevant information related to the phonation process can be extracted. A few non-invasive techniques are available on the literature in order to obtain the glottal waveform from the external measurements of a subject's voice. These techniques normally obtain the source waveform by inverse filtering the influence of the subject's vocal tract and the mouth radiation impedance based on linear prediction algorithms. Nevertheless, such techniques are not entirely adequate for subjects with esophageal and tracheoesophageal phonation, mainly due to the aperiodic behavior of these types of waves. The present work proposes a new technique, in which the transfer matrix of a subject's vocal tract is obtained by the layer-peeling algorithm. Thereafter, the source waveform is obtained by resolving a two-port transfer matrix equation, where the source waveform and the measured voice are the input and output ports, respectively. Preliminary results using the new technique are compared with those obtained by the traditional methods involving inverse filtering and the Sondhi tube.

3pSC18. Recovering prosody of a case of foreign accent syndrome (FAS). Grace Kuo (Dept. of Classics, Modern Lang. and Linguist, Concordia Univ., 3125 Campbell Hall, Los Angeles, CA 90095, grace.kuo@concordia.ca)

Foreign Accent Syndrome (FAS) is a rare disorder characterized by the emergence of a perceived foreign accent following brain damage. In this case study, acoustic analyses were performed on the speech of a Mandarin-speaking female FAS patient at her four doctor visits. The reading materials included news in newspaper and a tongue twister. The acoustic analyses include sentence-level intonation and rhythm measures such as %V and PVIs. Results reveal a gradual recovery trajectory from a disfluent stressed-timed pattern to a fluent syllable-timed pattern. A heritage Mandarin speaker and an advanced nonnative speaker recorded the same reading materials and the same acoustic analyses were performed on their speech for comparison.

3pSC19. Phoneme production by Hispanic hearing-impaired children. Tanya Flores (World Lang. and Cultures, Univ. of Utah, 255 S Central Campus Dr., LNCO 1400, Salt Lake City, UT 84109, Tanya.Flores@utah.edu)

This study examines the speech productions of Hispanic deaf and hearing impaired (DHI) children from 3 to 7 years of age who have had delayed medical intervention. The data presented here is from the initial data collection session and will focus on the segmental phonemic productions of the target group as compared to the productions of the control groups (Hispanic peers with normal hearing and non-Hispanic DHI peers) from the same local community. The goal of the study is to create a speech corpus of Hispanic DHI children that will be used to study various aspects of their language development. Findings will contribute to the currently limited acoustic research on minority DHI children whose home language differs from their specialized language program (in this case, English Listening and Spoken Language Program).

Session 3pSP

Signal Processing in Acoustics and Underwater Acoustics: Detection, Classification, Localization, and Tracking (DCLT) Using Acoustics (and Perhaps Other Sensing Modalities) IV

Ballard J. Blair, Cochair
Electronic Systems and Technology Division, MITRE Corporation, 202 Burlington Rd., Bedford, MA 01730

R. Lee Culver, Cochair
ARL, Penn State University, PO Box 30, State College, PA 16804

Invited Papers

1:00

3pSP1. The Virtual Ocean—A high-fidelity, physics-based testbed for distributed, autonomous undersea acoustic sensing networks. Henrik Schmidt (Mech. Eng., Massachusetts Inst. of Technol., 77 Massachusetts Ave., Rm. 5-204, Cambridge, MA 02139, henrik@mit.edu)

Behavior-based autonomy enables unmanned vehicles to adapt to the current environmental and tactical situation, with behaviors individually optimized for the detection, classification, localization, and tracking phases of the sensing mission. However, the adaptation has limited predictability with platform actions potentially becoming suboptimal or risky, in turn requiring extensive experimentation and testing. For obvious cost reasons, simulations are critical to this process. However, to be reliable, it is critical to the robustness evaluation that the processing chain and autonomy system is identical to the one operated on the physical platforms, with only the sensor stimulation and the platform dynamics being simulated. The Virtual Ocean is a physics-based ocean environment testbed, developed for carrying out virtual experiments with MOOS-ivP platform autonomy systems for environmentally and tactically adaptive acoustic sensing and communication networks. Coupled to ocean modeling frameworks such as MSEAS and HYCOM, and legacy acoustic models, it supports virtual experiments involving multiple fixed or mobile nodes with arbitrary volumetric or towed arrays, operating in realistic 3D ocean environments. Examples and experimental validations will be discussed. [Work supported by ONR and DARPA.]

1:20

3pSP2. Multitouch ultrasonic touchscreen. Kamyar Firouzi and Butrus T. Khuri-Yakub (Ginzton Lab, Stanford Univ., 348 Via Puebla Mall, Rm. 102, Stanford, CA 94305, KFIROUZI@STANFORD.EDU)

Touchscreen sensors are widely used in many devices such as smart phones, tablets, laptops, etc. We present the design, analysis, and implementation of an ultrasonic touchscreen system that utilizes interaction of transient Lamb waves with objects in contact with the screen. The governing principle revolves around the propagation and reverberation of guided elastic waves in a bounded space, in which the localization of touch points can be challenging. Reverberant fields in enclosures can potentially carry useful information, however, in an incoherent way. Incoherency comes from consecutive reflections of the wave energy several times in the domain, ultimately leading to mixing of the wave energy in a seemingly random way. However, spreading of the wave energy can lead to multiple interrogations of each point in the enclosure. Hence, temporal information buries information about substructural changes making it feasible to conduct only a few spatial measurements. We present a learning localization algorithm capable of localizing multiple simultaneous touch points (up to 12 touches on a tablet) and with a very limited number of measurements (one or two). This in turn can significantly reduce the manufacturing cost. We also present an algorithm to improve on robustness to environmental and thermal noise.

Contributed Papers

1:40

3pSP3. Dispersion correction for acoustic borehole logging data. Said Assous and Peter Elkington (GeoSci., Weatherford, East Leake, Loughborough LE126JX, United Kingdom, said.assous@eu.weatherford.com)

Compressional and shear formation velocities are key to the prediction of petrophysical properties from seismic attributes. In fast formations shear velocity may be obtained from monopole source, but in slow formations, it is commonly determined from the flexural mode associated with dipole excitation, which is a dispersive borehole-guided mode who's low frequency and high frequency asymptote to the formation S-velocity, and to the Scholte-velocity, respectively. The shear slowness is commonly computed from well log dipole flexural mode data using Semblance Time Coherence (STC) processing. Dispersion is handled by restricting the waveforms spectral content to the low frequencies that travel close to the formation's shear velocity. This restricting may not eliminate the need for a residual dispersion correction. Inversion addresses this difficulty by computing shear slowness directly from observed dispersion characteristics. In order to make the inversion efficient the iterative steps which compare observed and forward modeled dispersion curves are replaced with a neural net trained on a large number of pre-modeled curves generated with known formation and borehole properties. Automated mode frequency detection constrains the bandwidth over which dispersion curves are matched. Results from 127,000 modelled and field data points show improved accuracy and precision relative to STC processing.

1:55

3pSP4. Damage localization based on the reconstructed Green's function from a diffuse noise field on a thin rectangular aluminum plate. Sun Ah Jung (Seoul National Univ., Bldg. 36 212, 1 Gwanak-ro, Gwanak-gu, Seoul 151-742, South Korea, sunj@snu.ac.kr), Keunhwa Lee (Sejong Univ., Seoul, South Korea), and Woojae Seong (Seoul National Univ., Seoul, South Korea)

The extracted Green's function from ambient noise cross-correlation is applied to localize a damage on an aluminum plate using a passive sensor array. Damage was investigated by drilling holes at various locations with different sizes. The localization process uses a subtracted Green's function of an undamaged plate from that of a damaged plate, which can reveal the scattered wave from the damage boundary. Localization algorithms used in active structural health monitoring, including the time of arrival, the time difference of arrival, the energy arrival and the Rayleigh maximum likelihood estimation [Flynn *et al*., Proc. R. Soc. Lond. A. Math. Phys. Sci. (2011)] methods are applied to the subtracted signal according to the number of sensors and that of noise sources. The subtracted signals are band pass filtered with various center frequency resulting in multiple images which are used in image fusion to increase the accuracy of localization [Michaels *et al*., Wave motion. (2007)]. The performance of the algorithms demonstrates the efficacy of the passive sensing-based localization method even when using small number of sensors and sources.

2:10

3pSP5. Parameter estimation of acoustic scattering echoes of underwater targets using sparse representation approach. Xiangxia Meng, Xiukun Li (College of Underwater Acoust. Eng., Harbin Eng. Univ., No. 145, Nantong St., Harbin, Heilongjiang 150001, China, mengxiangxia@hrbeu.edu.cn), and Andreas Jakobsson (Dept. of Mathematical Statistics, Lund Univ., Lund, Sweden)

The acoustic scattering echo of an underwater target usually consists of multiple overlapped components. The time delay of each reflection is of great importance to estimate the size of the target. Herein, a sparse approach is presented to obtain the estimation of time delays with high resolution and accuracy. The parameters are determined using a dictionary with many more elements than expected reflections, with each dictionary element being found as the convolution of the transmitted signal and a potential impulse. The estimation problem is then converted into a convex optimization problem, which is then solved efficiently using the alternating direction method of multipliers (ADMM) framework. The estimation accuracy depends on the grid of the dictionary. To obtain high resolution, a dictionary refinement technique is employed. To model the time-varying nature of the signal amplitudes, we further estimate the temporal envelope of the signal using a weighted combination of splines. Using this technique, the algorithm can estimate both the time-delay and amplitude of a reflection simultaneously, without the need of prior information about the number of components. The method can be applied for the separation of overlapped components and high-resolution estimation of multi-angle echoes.

2:25

3pSP6. Scattered signal distributions, parametric uncertainties, and Bayesian sequential updating. D. K. Wilson, Carl R. Hart (Cold Regions Res. and Eng. Lab., U.S. Army Engineer Res. and Development Ctr., 72 Lyme Rd., Hanover, NH 03755-1290, D.Keith.Wilson@usace.army.mil), Chris L. Pettit (Aerosp. Eng. Dept., U.S. Naval Acad., Annapolis, MD), Daniel J. Breton (Cold Regions Res. and Eng. Lab., U.S. Army Engineer Res. and Development Ctr., Hanover, NH), Edward T. Nykaza (Construction Engineering Res. Laboratory, U.S. Army Engineer Res. and Development Ctr., Champaign, IL), and Vladimir E. Ostashev (Cold Regions Res. and Eng. Lab., U.S. Army Engineer Res. and Development Ctr., Hanover, NH)

A variety of probability density functions (pdfs) have been proposed for scattered signals, which have varying analytical advantages and ranges of physical applicability. We discuss here situations modeled by a compound pdf, in which a basic pdf, attributable to the underlying scattering process, has uncertain parameters or is modulated by variability in the environment. The parameters of the modulating pdf are termed *hyperparameters*. Some previous examples of compound formulations include the K-distribution, for which strong scattering (exponential pdf) is modulated by a gamma pdf for the mean signal power, and scattering by intermittent turbulence, for which strong scattering is modulated by a log-normal pdf for the structure-function parameter. We describe some alternative formulations, including strong scattering modulated by a gamma pdf for the *inverse* mean power, and Rytov (log-normal) scattering modulated by a normal pdf for the log-mean of the signal. These lead to relatively simple marginalized signal power distributions (Lomax and log-normal, respectively). Furthermore, the conditional scattered signal pdf may be viewed as a likelihood function in which the modulating pdf is the Bayesian conjugate prior. Hence the hyperparameters of the modulating process can be refined by simple sequential Bayesian updating as additional transmission data become available.

2:40

3pSP7. Implications of the evolving sound speed field on detection and classification of targets in shallow water. David R. Dall'Osto (Acoust., Appl. Phys. Lab. at Univ. of Washington, 1013 N 40th St., Seattle, WA 98105, dallosto@apl.washington.edu), Alan Blumberg (Stevens Inst. of Technol., Hoboken, NJ), Peter J. Stein (Sci. Solutions Inc., Nashua, NH), Eric I. Thorsos (Acoust., Appl. Phys. Lab. at Univ. of Washington, Seattle, WA), and Amy Gruhl (Sci. Solutions Inc., San Diego, CA)

Acoustic refraction caused by gradients in the sound speed field within a region covered by an active sonar system affects its performance and quality of information. From the perspective of target strength, refraction can focus sound and enhance target returns, or it can redirect sound and create shadow zones where targets will drop out. These effects depend on the evolving sound speed field, as well as the placement of the transmitters and receivers. In addition, focused sound at the water-sediment interface can produce a small region of enhanced backscatter, which can rise above the nominal reverb level by 6 dB or more. Continuous evolution of the time-dependent sound speed field can cause these relatively compact returns to appear as moving targets, increasing false-alarm detections. Advances in fine scale oceanographic models facilitate studying these propagation effects, both the enhanced/degraded target returns and the target-like bottom backscattered features. A combined acoustic and oceanographic model is presented for discussion on what conditions cause these effects, the possibility of identifying their occurrence within data, and what the consequences are on a practical sonar system operating in shallow water.

2:55

3pSP8. Environmental calibration curves. Gerald L. D'Spain, Dennis Rimington, Shih-Hsuan (Shane) Yuan (Marine Physical Lab, Scripps Inst. of Oceanogr., 291 Rosecrans St., San Diego, CA 92106, gdspain@ucsd.edu), and Tyler A. Helble (SPAWAR Systems Ctr. Pacific, San Diego, CA)

Sound propagation through the ocean causes distortion of the received waveform, characterized by the impulse response of the channel (which often assumes a fixed medium since ocean Mach numbers are so small and the temporal scales of oceanographic variability typically are much larger than signal travel times). In addition, noise, both its level and temporal character, impact signal detection and processing. The purpose of this presentation is to describe a physics-based approach to developing environmental calibration curves to account for environmental effects in the received field. The methods are first applied to passive acoustic recordings by fixed, single-hydrophone packages deployed in the Southern California Bight. Five types of baleen whale calls from blue, fin, and humpback whales are the signals of interest. Results show that these environmental calibration curves, determined by the probability of detection, are most sensitive to sediment thickness over the blue and fin whale frequency band, whereas they are most sensitive to sediment type for humpback calls. The statistical framework for estimating the mean, bias, and variance of these environmental calibration curves also is discussed. [Research supported by the Living Marine Resources Program, the Office of Naval Research, and the Joint Industry Programme.]

3:10

3pSP9. Estimation and equalization for shallow water communication channel using geometric encoding of channel multipath. Ananya Sen Gupta (Elec. and Comput. Eng., Univ. of Iowa, 4016 Seamans Ctr. for the Eng. Arts and Sci., Iowa City, IA 52242, ananya-sengupta@uiowa.edu)

The shallow water acoustic channel is well-known to exhibit rapid fluctuations in its impulse response, which is challenging to estimate and compensate for in real time. In particular, the moving ocean surface and static sea bottom reflect the acoustic signal in unpredictable ways to create rapidly time-varying multipath arrivals. The talk will focus on the nexus of shallow water acoustic propagation paths and how multipath can be discovered and exploited to improve shallow water acoustic communications. In particular, the talk will review sampling strategies for the time-varying shallow water acoustic channel and propose novel geometric encoding techniques that exploit non-uniform channel sampling strategies. We will also demonstrate how geometric encoding can be harnessed for real-time channel estimation as well as semi-blind channel equalization. Results based on experimental field data in recent work as well simulation results will be presented.

Plenary Session and Awards Ceremony

Marcia J. Isakson,
President, Acoustical Society of America

Annual Membership Meeting

Presentation of Certificates to New ASA Fellows

John S. Allen, III – For contributions to the understanding of ultrasound contrast agents

Kelly Benoit-Bird – For contributions to marine ecological acoustics

John J. Loverde – For contributions to quantification and understanding of building response to sound and impact

Alexander Ya Supin – For contributions to the understanding of auditory systems of humans and marine mammals

Introduction of Scholarship and Award Recipients

Curtis Wiederhold, recipient of the 2017 Frank and Virginia Winker Memorial Scholarship
for Graduate Study in Acoustics

Matthew Neal, recipient of the 2017
Leo and Gabriella Beranek Scholarship in Architectural Acoustics and Noise Control

Introduction of Andone C. Lavery, recipient of the 2017 Walter Munk Award
for Distinguished Research in Oceanography Related to Sound and the Sea
a joint award of The Oceanography Society, the Office of Naval Research, and
the Office of the Oceanographer of the Navy

Presentation of Awards

Ryan Kellman, recipient of the Science Writing Award in Acoustics for Journalists for his video
Singing Ice: A Star Wars Story (NPR.org, 2016)

Tyler Adams, recipient of the Science Writing Award for Professionals in Acoustics for
Sound Materials: A Compendium of Sound Absorbing Materials for Architecture and Design
(Frame Publishers, Amsterdam, 2016)

David T. Bradley, Erica E. Ryherd, and Lauren M. Ronsse, *recipient of the Science Writing Award for Professionals in Acoustics* for their book

Worship Space Acoustics: 3 Decades of Design (Springer Science+Business Media, New York (ASA Press), 2016)

Robert D. Celmer, recipient of the 2015 Rossing Prize in Acoustics Education

Michael J Buckingham, Pioneers of Underwater Acoustics Medal

Evgenia Zabolotskaya, Silver Medal in Physical Acoustics

David Griesinger, Wallace Clement Sabine Medal

Session 3eED

Education in Acoustics and Women in Acoustics: Listen Up and Get Involved

Keeta Jones, Cochair
Acoustical Society of America, 1305 Walt Whitman Rd., Suite 300, Melville, NY 11787

Tracianne B. Neilsen, Cochair
Brigham Young University, N311 ESC, Provo, UT 84602

This workshop for New Orleans area Girl Scouts (age 12–17) consists of hands-on tutorials, interactive demonstrations, and discussion about careers in acoustics. The primary goals of this workshop are to expose girls to opportunities in science and engineering and to interact with professionals in many areas of acoustics. A large number of volunteers are needed to make this a success. Please e-mail Keeta Jones (kjones@acousticalsociety.org) if you have time to help with either guiding the girls to the event and helping them get started (5:00 p.m. to 6:00 p.m.) or exploring principles and applications of acoustics with small groups of girls (5:00 p.m. to 7:30 p.m.). We will provide many demonstrations, but feel free to contact us if you would like to bring your own.

WEDNESDAY EVENING, 6 DECEMBER 2017 BALCONY I/J/K, 5:00 P.M. TO 8:00 P.M.

OPEN MEETINGS OF TECHNICAL COMMITTEES

The Technical Committees of the Acoustical Society of America will hold open meetings on Tuesday, Wednesday, and Thursday. See the list below for the exact schedule.

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 Tuesday, 5 December

Committee	**Start Time**	**Room**
Engineering Acoustics	4:30 p.m.	Studio 7
Acoustical Oceanography	7:30 p.m.	Salon A/B/C
Animal Bioacoustics	7:30 p.m.	Salon F/G/H
Architectural Acoustics	7:30 p.m.	Studio 9
Musical Acoustics	7:30 p.m.	Studio 4
Physical Acoustics	7:30 p.m.	Balcony L
Psychological and Physiological Acoustics	7:30 p.m.	Balcony M
Structural Acoustics and Vibration	8:00 p.m.	Studio 7

Committees meeting on Wednesday, 6 December

Committee	**Start Time**	**Room**
Biomedical Acoustics	7:30 p.m.	Balcony M
Signal Processing in Acoustics	7:30 p.m.	Salon D

Committees meeting on Thursday, 7 December

Committee	**Start Time**	**Room**
Noise	7:30 p.m.	Studio 2
Speech Communication	7:30 p.m.	Salon A/B/C
Underwater Acoustics	7:30 p.m.	Salon F/G/H

3p WED. PM

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ACOUSTICAL SOCIETY OF AMERICA
PIONEERS OF UNDERWATER ACOUSTICS MEDAL

Michael J. Buckingham
2017

The Pioneers of Underwater Acoustics Medal is presented to an individual irrespective of nationality, age, or society affiliation, who has made an outstanding contribution to the science of underwater acoustics, as evidenced by publication of research in professional journals or by other accomplishments in the field. The award was named in honor of five pioneers in the field: H. J. W. Fay, R. A. Fessenden. H. C. Hayes, G. W. Pierce, and P. Langevin.

PREVIOUS RECIPIENTS

Harvey C. Hayes	1959	Ivan Tolstoy	1990
Albert B. Wood	1961	Homer P. Bucker	1993
J. Warren Horton	1963	William A. Kuperman	1995
Frederick V. Hunt	1965	Darrell R. Jackson	2000
Harold L. Saxton	1970	Frederick D. Tappert	2002
Carl Eckart	1973	Henrik Schmidt	2005
Claude W. Horton, Sr.	1980	William M. Carey	2007
Arthur O. Williams	1982	George V. Frisk	2010
Fred N. Spiess	1985	Michael B. Porter	2014
Robert J. Urick	1988		

CITATION FOR MICHAEL J. BUCKINGHAM

". . . for contributions to the understanding of ocean ambient noise and marine sediment acoustics."

NEW ORLEANS, LOUISIANA • 6 DECEMBER 2017

After a few words in conversation with Mike, it isn't difficult to figure out where his roots are, the accent gives it away. Mike Buckingham grew up in the suburban North London district of Edgware, about 20 km northwest of Big Ben. Very early on as a young student, Mike developed a consuming interest in math and physics, so it followed naturally that he enrolled in graduate school in science at the nearby University of Reading in 1967. Like many others of that era, Mike's route into underwater acoustics was not direct, but through another field of research, in his case, solid state physics. It's not clear if he had any idea as a graduate student that his research career would be focused on sound in the ocean, but there was one aspect of his PhD studies that translated smoothly into his future work. His thesis research involved the study of noise, electronic noise in silicon p-n junctions, work that subsequently became the basis of a book, "Noise in Electronic Devices and Systems," published a few years after his graduation in 1971. While working on the book, Mike had already moved on to defense research in the Royal Aerospace Establishment, where he spent a lot of time flying in Royal Air Force BAC 1-111 twin-engine jet aircraft flown by Royal Air Force test pilots on missions to deploy hydrophones in the Arctic Ocean. He quickly realized that the ocean is a very noisy environment, probably a lot noisier than a p-n junction. His first papers on ocean noise and sound propagation earned early recognition of the A.B. Wood Medal of the Institute of Acoustics in 1982, and attracted considerable attention on this side of the Atlantic. Mike was soon in high demand as a visiting scientist in the United States. After a number of research appointments that kept a foot on each side of the Atlantic, he and his charming wife, Penny, settled in San Diego in 1990 where he is currently Distinguished Professor in the Marine Physical Laboratory at the Scripps Institute of Oceanography.

The central theme of Mike Buckingham's research is ambient noise in the ocean. His research into the physical nature of ambient noise, both experimentally and in theoretical model development, has created and stimulated the active and highly productive research field of ambient noise oceanography. Before Mike's pioneering insight that was published in 1987, ambient noise in the ocean was viewed as a problem, at the very least a nuisance that corrupted or masked the signals we were trying to detect. Now acousticians the world over use ambient noise as a valuable signal in its own right. Present day research using ambient noise as natural sound sources for applications such as geoacoustic inversion and imaging of objects in the ocean owes its existence to Mike's work. The timeliness of this approach cannot be overstated given the general concern about impacts of anthropogenic generated sound on marine life.

Perhaps the most publicized of Mike's work in underwater acoustics was his research on acoustic daylight, the use of ambient noise for imaging objects in the ocean. This work was a showpiece for underwater acoustics that captured widespread attention scientifically (a publication in *Nature* in 1992) and in the popular journals (an article in *Scientific American* in 1996).

His experience with ambient noise for geoacoustic inversion introduced him to a challenging research problem in marine sediment acoustics: dispersion of sound in sediments. Mike questioned the conventional ideas about sound propagation in porous marine sediments, and announced a new approach, the grain-shearing theory, published in 1997. It challenged the accepted approach for sound propagation in porous sediment media developed by Maurice Biot over 60 years ago, and made an immediate impact in geoacoustic research, stimulating new experimental and theoretical research, for example, the Office of Naval Research Sediment Acoustics Experiments in 1999 and 2004, SAX'99 and SAX'04. Mike's continued development of his viscous grain-shearing theory consolidates his place as a central figure in marine sediment acoustics.

Mike is an experienced aircraft pilot and is passionate about flying, to the extent that it eclipses his interest in and commitment to most other events, including plenary sessions of the Acoustical Society of America. I have to confess being corrupted by Mike to skip out for a Wednesday afternoon aerial tour of San Diego while the rest of the society was in plenary session during the meeting held in that city a few years ago. But flying is not all fun and games for Mike, he turned it into serious business, proposing that aircraft noise could be a useful sound source for characterizing geoacoustic properties of the ocean bottom. He worked out the theory for coupling the aircraft sound into the ocean bottom, and then demonstrated the concept by flying his aircraft as the sound source in a simple but sensational experiment along the San Diego coastline within full view of the Director's office at Scripps. Fortunately, the flight time was not charged against annual leave.

Most recently Mike has focused his attention on another extreme, measurement of ambient noise in the deep ocean, that is, at the deepest known depths. Mike, along with his graduate students, designed, built and successfully used a unique instrument to record ambient noise as it descended to the deepest depths in the Mariana Trench. The deployment of the instrument established a record for depth of noise measurement when it dropped into the Challenger Deep.

Throughout his research career, Mike has challenged conventional ideas in underwater acoustics and provided fresh insight that has led us in new directions that are recognized as paradigm shifts in our research. His trademark approach is characterized by pulling together ingenious and bold theoretical advances with clever and simple experiments, all carried out with flair and elegance at the same time. He has published over 40 papers in the *Journal of the Acoustical Society of America*, each one of which serves as an excellent example for young researchers in clarity and logic in scientific writing. His leadership as a founding member and inaugural Chair of the Technical Committee on Acoustical Oceanography and his unselfish service in many other roles has enriched the Acoustical Society. It is a great pleasure to introduce Mike Buckingham, avid pilot, renowned acoustical oceanographer and truly, Pioneer in Underwater Acoustics.

N. ROSS CHAPMAN

ACOUSTICAL SOCIETY OF AMERICA

Silver Medal in

Physical Acoustics

Evgenia Zabolotskaya

2017

The Silver Medal is presented to individuals, without age limitation, for contributions to the advancement of science, engineering, or human welfare through the application of acoustic principles, or through research accomplishment in acoustics.

PREVIOUS RECIPIENTS

Isadore Rudnick	1975	Robert E. Apfel	1997
Martin Greenspan	1977	Gregory W. Swift	2000
Herbert J. McSkimin	1979	Philip L. Marston	2003
David T. Blackstock	1985	Henry E. Bass	2006
Mack A. Breazeale	1988	Peter J. Westervelt	2008
Allan D. Pierce	1991	Andrea Prosperetti	2012
Julian D. Maynard	1994		

CITATION FOR EVGENIA ANDREEVNA ZABOLOTSKAYA

". . . for contributions to nonlinear acoustics and bubble dynamics"

NEW ORLEANS, LOUISIANA • 6 DECEMBER 2017

Evgenia (Zhenia) Andreevna Zabolotskaya was born and raised in Moscow. Her grandfather worked as a janitor in the Kremlin and lived there with his family before and after the Russian Revolution, and during the 1930s the Soviet secret police took her mother away from their home for several days because she was active in her church. Zhenia demonstrated a proclivity for math and physics at a young age, so it was no surprise that she was admitted to the prestigious Physics Department at Moscow State University (MSU), where some of her classes were taught by none other than Lev Landau, who received the Nobel Prize in Physics in 1962. She still recalls Landau's intimidating challenge on the first day his electrodynamics class, "If you do not understand quantum mechanics, you should think about whether you have chosen the right path in life."

While at MSU, Zhenia met Yurii (Yura) Ilinskii, a remarkable young theoretical physicist. After Zhenia and Yura graduated, she with her bachelor's degree and he with his PhD, both were employed at the Electro-Mechanics Institute in Moscow, where they started dating, and in 1963 they married. That same year Zhenia returned to MSU to pursue a PhD in the Wave Processes Chair under Rem Khokhlov in the Physics Department. By the 1970s, the work conducted in Khokhlov's chair made MSU a leading international center for theoretical nonlinear acoustics and, even more influentially, for nonlinear optics.

Zhenia was among the first graduate students in Khokhlov's nonlinear acoustics group. Other members of the group at that time included Stepan Soluyan, Oleg Rudenko, Vyacheslav Kuznetsov, and Nellie Pushkina. One of Zhenia's four papers that culminated in her PhD in 1968 contained nothing less than a model equation for nonlinear bubble dynamics that became widely used in the former Soviet Union instead of the Rayleigh-Plesset equation that was used extensively in the West [Sov. Phys. Acoust. 13, 254 (1967)]. The same paper also contained the first effective medium theory for nonlinear propagation of sound in bubbly liquid.

In 1966, while still a doctoral student, Zhenia joined the Acoustics Institute in Moscow, sharing an office with other Khokhlov protégés Anna Polyakova and Konstantin Naugolnykh. After receiving her PhD, her continued collaboration with Khokhlov produced one of the most famous advances in twentieth-century nonlinear acoustics: the Khokhlov-Zabolotskaya equation for nonlinear sound beams [Sov. Phys. Acoust. 15, 35 (1969)]. The KZ equation became known as the KZK equation after Kuznetsov added a term accounting for losses in 1970.

The impact of the KZK equation on practical applications of nonlinear acoustics, whether biomedical, industrial, or sonar related, cannot be overstated. Originally important for describing nonlinear effects in sonar (1970s and 80s), for the past two decades the KZK equation has provided the main theoretical basis for modeling HIFU (High Intensity Focused Ultrasound), a therapeutic procedure for treating cancer. Reports of modeling HIFU using the KZK equation are now presented routinely at ASA meetings. Subsequent work by Zhenia with mathematicians Nikolai Bakhvalov and Yakov Zhileikin was published in 1982 in their book *Nonlinear Theory of Sound Beams*, which was deemed so groundbreaking that it was translated into English by Robert Beyer for the American Institute of Physics.

Zhenia returned to MSU in 1971 where she was appointed not in the Physics Department but, interestingly, in the Biology Department, and in 1982 she joined the General Physics Institute of the USSR Academy of Sciences. In 1985 she was awarded the USSR State Prize for her overall contributions to nonlinear acoustics, a level of recognition that today is bestowed in the Kremlin and accompanied by personal congratulations from the Russian president.

Zhenia's path to the United States began unwittingly in 1982 in Tallinn, Estonia, where she encountered David Blackstock from the University of Texas at Austin (UT), basically

Khokhlov's American counterpart in nonlinear acoustics, at a symposium on nonlinear deformation waves. Blackstock maintained contact with Zhenia following that symposium, and in 1987 he encouraged her to meet his UT faculty colleague and former graduate student Mark Hamilton at the International Symposium on Nonlinear Acoustics to be held that August in Novosibirsk, in the heart of Siberia. Zhenia and Mark hit it off, because his research at the time was based largely on the KZK equation, and in 1988 he returned to the USSR specifically to visit her.

Zhenia then visited Hamilton in the Mechanical Engineering Department at UT for several months in both 1989 and 1990, and in 1991 she moved to Austin with Yura and their two daughters. She immediately published a theoretical model for nonlinear Rayleigh waves [J. Acoust. Soc. Am. 91, 2569 (1992)], a type of interface wave in solids, initiating a line of research that continued for over a decade. In collaboration with UT students, her fundamental theory was extended to include Scholte and Stoneley waves, and also surface waves in anisotropic and piezoelectric materials. Nonlinear interface waves are generated on very large scales by earthquakes and on very small scales by piezoelectric actuators in microfluidic and SAW (Surface Acoustic Wave) devices.

In 1997 Zhenia and Yura took a position at a startup company in Virginia at which two former UT doctoral students hired them to develop theoretical models for nonlinear sound fields in resonators. Zhenia and Yura returned to UT's Mechanical Engineering Department in 2000 to work on nonlinear phenomena in thermoacoustic engines. Then in 2003 UT's Applied Research Laboratories hired Zhenia and Yura to initiate a research program in biomedical acoustics. This appointment enabled Zhenia to return to one of her original research interests, nonlinear bubble dynamics, but this time for medical applications such as shock-wave lithotripsy.

Zhenia and Yura retired from their research staff positions at UT in February 2015. They continue to live in Austin where they remain engaged in acoustics research at UT, as well as consult for a startup company in Massachusetts for which they model particle manipulation with acoustic radiation force.

Zhenia's contributions to theoretical nonlinear acoustics are prolific and foundational. Her publications are not only exclusively on nonlinear acoustics but equally divided between *Soviet Physics-Acoustics* in the first half of her career and the *Journal of the Acoustical Society of America* in the second half. The name Zabolotskaya is justifiably iconic in the history of nonlinear acoustics.

MARK F. HAMILTON
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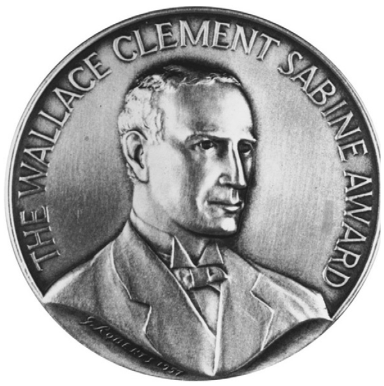
WALLACE CLEMENT SABINE AWARD OF THE ACOUSTICAL SOCIETY OF AMERICA



David Griesinger

2017

The Wallace Clement Sabine Award is presented to an individual of any nationality who has furthered the knowledge of architectural acoustics, as evidenced by contributions to professional journals and periodicals or by other accomplishments in the field of architectural acoustics.

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Vern O. Knudsen	1957	Richard V. Waterhouse	1990
Floyd R. Watson	1959	A. Harold Marshall	1995
Leo L. Beranek	1961	Russell Johnson	1997
Erwin Meyer	1964	Alfred C. C. Warnock	2002
Hale J. Sabine	1968	William J. Cavanaugh	2006
Lothar W. Cremer	1974	John S. Bradley	2008
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SILVER MEDAL IN ARCHITECTURAL ACOUSTICS

The Silver Medal is presented to individuals, without age limitation, for contributions to the advancement of science, engineering, or human welfare through the application of acoustic principles, or through research accomplishment in acoustics.

PREVIOUS RECIPIENT

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CITATION FOR DAVID GRIESINGER

". . . for contributions to the understanding of electroacoustics and human perception of sound"

NEW ORLEANS, LOUISIANA • 6 DECEMBER 2017

David Griesinger was born in Cleveland Ohio. He attended Harvard University, earning a B.A. degree in 1966, M.A. degree in 1968 and a PhD in physics in 1976. He is the recipient of the Gold Medal of the Verband Deutscher Tonmeister, Silver Medal of the Audio Engineering Society, and the Peter Barnett Award from the Institute of Acoustics. While attending graduate school, he met his wife Harriet who is also a physicist. Together, they have one son Ben, and one grandchild.

David's father was a versatile musician. He had one of the first FM radios, as well as a large collection of 78 rpm records. He would often organize chamber music evenings at their home with a trio, quartet, or quintet. In the early 1950's David's father purchased the first consumer magnetic tape recorder made in America, and David soon learned to use it. Several years later David convinced his mother to purchase "Magnetic Tape Recording" by Marvin Cameras in lieu of a book from the children's section of the bookstore. In less than two years he had built his own tape machine "out of old motors, ball bearings, rubber belts, vacuum tubes, and wood." He was also singing in the church choir, the school glee club and learning to play French horn.

While attending Harvard, David recorded every concert that he could, working with many notable conductors and musicians. He modified tape recorders, and built his own electronics to improve sonic quality, including an 8-channel mixer with independent VU meters, which was a novelty in its day. He even machined and built his own condenser microphones which he states "were a vast improvement" over the dynamic microphones he was using previously. A source of frustration was the inability to correct balance between instruments while also optimizing their balance in the reverberation. Making this correction was time consuming, tedious, and subject to interruption.

By this time David had built his own microcomputer, and the price of memory had dropped sufficiently to contemplate building a digital reverb. After constructing several prototypes, he had a system that produced the desired results, which became the basis for the Lexicon 224 digital reverb. The 224 and its successors (224X and 224XL) created a paradigm shift in the audio recording industry. It delivered unprecedented acoustic flexibility in a chassis that was smaller than a bread box. Its portability made it accessible to any studio, producer, or engineer as a rent in for specific sessions, or live recordings. In addition, it enabled artists to specify the system for touring productions.

The 224 was quickly recognized as the gold standard of its day. However, the audio community was about to undergo another paradigm shift in the form of digital media. This spawned the development of the next generation of the 224–the Lexicon 480L. The 480L was the platform that allowed David to create both a new digital reverb as well as audio tools in the digital domain. This included one of the first digital mixers, digital compression, and digital EQ. Many other tools followed. David built a Dolby compatible 4:2:4 surround decoder that automatically corrected azimuth errors in VHS recordings. The resulting product, the Lexicon CP-1, started Lexicon's consumer products division. Subsequent work led to a patent for the Logic 7 surround sound process. Throughout this time, David remained active with recording and acoustics research, publishing numerous papers on subjects ranging from microphone technique to binaural recording surround sound and acoustics.

In the late 1980's, Neil Muncy asked if David had any experience using digital reverberation to alter physical spaces. Neil had been hired by the Ontario Heritage Foundation to oversee the acoustics of the Elgin Theatre, one of the last remaining Lowes double decker venues (theatre built on top of a theatre) in the world. Past attempts at electronic acoustic augmentation had produced systems with great complexity, limited flexibility, and less than optimum sonic quality. David decided to investigate what was necessary to create a system that was both practical, and capable of making a substantial improvement in acoustic quality. This research led to the development of LARES (Lexicon Acoustic Reinforcement and Enhancement System) and a patent for the system. The first system was installed in the Elgin Theatre, and since that time hundreds of similar systems have been installed throughout the world to high critical acclaim.

Working with LARES afforded David exposure to both a wide range of venues as well as many practitioners working in architectural acoustics. It also provided the opportunity to work with numerous conductors and musicians. His focus began to shift to the physics involved in the perception of reverberation and the neural processing of human hearing. This research has led to a series of discoveries conveyed in papers starting in 2004 ("Pitch Coherence as a Measure of Apparent Distance and Sound Quality in Performance Spaces" IOA 2006; "Phase Coherence as a Measure of Acoustic Quality, Part One: The Neural Network." ICA 2010). By 2010, David had described the neural mechanisms that invoke the sensations of acoustic distance and acoustic intimacy or "engagement," and had developed the means to reliably measure it, which he dubbed LOC (The measure LOC predicts the threshold for localizing speech in a diffuse reverberant field, based on the strength of the direct sound relative to the build-up of reflections in a 100 ms window.). These mechanisms also explain many other aspects of aural perception including the cocktail party effect, the ability to tune instruments to high precision, the reasons we hear pitch in octaves, why fifths and fourths sound so harmonious, why we are so good at hearing signals buried in noise, why mechanical speech to text systems are >10 dB worse than human hearing in the presence of noise, why we can separate two simultaneous talkers into two independent neural streams, if they are different in pitch by just over ¼ semitone, and why children can't remember what teachers say in most classrooms. This research also resulted in new algorithms for electronic acoustic enhancement that provide a substantial improvement in perceived clarity.

The implications of this research for acoustic design of spaces built for music and speech is substantial. It represents an equivalent paradigm shift in the field of architectural acoustics to similar paradigm shifts that David has instigated throughout his career. His enduring interest in the human perception of sound is manifested by the ongoing research, continued writing and publishing of technical papers, and true inventions in the field to which he has contributed so much.

STEPHEN BARBAR