Session 1aAA

Architectural Acoustics: Acoustics of Small, Multipurpose Performance Spaces

Michael R. Yantis, Cochair
Sparling, 720 Olive Way, Ste. 1400, Seattle, WA 98101-1833

Bill Dohn, Cochair
630 Quintana Rd., Morro Bay, CA 93442

Chair's Introduction—8:30

Invited Papers

8:35

1aAA1. Translating acoustical concepts from large to small multipurpose performance spaces. Richard Silva and William Chu (McKay Conant Hoover, Inc., 5655 Lindero Canyon Rd., Ste. 25, Westlake Village, CA 91362, rsilva@mchinc.com)

The design of small or large multipurpose performance spaces involves similar subjective listening parameters when considering the same types of acoustical programs. Such design includes sound absorptive material selection for reverberation control, and wall and reflector shaping for sound reflection or diffusion. However, simply scaling the same physical features does not necessarily achieve the same acoustical design goals. Drawing from a few case studies, this paper explores several design principles for small performance spaces and compares their acoustical effectiveness to their larger performance space counterparts.

8:55

1aAA2. Balancing reflection strength and loudness in small concert halls. Tim Gulsrud (Kirkegaard Assoc., 954 Pearl St., Boulder, CO 80302, tgulsrud@kirkegaard.com)

Small concert halls, such as those encountered at many music education institutions, are frequently called upon to support a wide range of musical ensembles, including full symphony orchestra, within a volume significantly smaller than in traditional concert halls. On one hand, a degree of early reflection strength and reverberation is needed to support unamplified instruments and musician hearing on stage. On the other hand, constrained cubic volumes, limited audience seating, and sound-reflective finishes can lead to overloudness in these small halls. This paper will discuss recent listening and measurement experiences in small concert halls as they relate to achieving a suitable balance between reflection strength and loudness control.

9:15

1aAA3. Granoff Music Center: A multipurpose facility. K. Anthony Hoover (McKay Conant Hoover Inc., 5655 Lindero Canyon Rd., Westlake Village, CA 91362) and Matthew Moore (Cavanaugh Tocci Assoc. Inc., 327 F Boston Post Rd., Sudbury, MA 01776)

The Granoff Music Center at Tufts University is distinguished by its emphasis on classical, traditional, and world music. Completed in February 2007, it finally collects the entire Music Department under one roof after a century of inadequate office, rehearsal, and performance spaces that were scattered throughout the campus. Its intent was to house rehearsal and performance spaces whose acoustical environments are each distinctive so that the entire complex becomes multipurpose. Furthermore, the design essentially dismissed electroacoustic reinforcement or enhancement in favor of ''natural'' acoustics. This paper reviews the history, design, value engineering, and results of the facility, and the emergence and rapid escalation during construction of a multimedia program including multichannel recording, sound system, and A/V system features.

9:35

1aAA4. Acoustic design in small performance venues: "Unplugged" amplification, spatial presentation of dance, unamplified loudness control. Scott Pfeiffer (53 West Jackson Blvd. Ste. 1734, Chicago, IL 60604, spfeiffer@thresholdacoustics.com)

Facilities for the 150-seat S.N. Shure Theatre and 400-seat MUNTU Dance Theatre and for a small family of 500-seat high school auditoria all employ techniques particular to the venue size. At Shure, an emphasis on an "unplugged" sound led to a room design that is intimate and controlled. Architectural features that would be cost prohibitive on a larger scale are implemented gracefully here. The MUNTU Dance Theatre is small enough to allow for the audience to be convincingly provided with directional realism. Area microphones on stage directly feed left, center, and right clusters to allow the acoustic sounds made by the dancers to be naturally "panned" to their actual location on stage, allowing for a seamless placement of the performer. Lastly, "one-room" design approaches for schools at Nazareth Academy, Marengo High School, and Benet Academy allowed for a basic theatrical function while at the same time linking the stage volume to the house. Absorption on the tops of the ceiling system and in the materials selected for basic finishes controls loudness for circumstances where ensembles are large when compared to the audience size. Variations in approach to these similar-sized venues are discussed.

9:55—10:10 Break

10:10

1aAA5. Case studies of variable acoustic design: A repertory theater and performing arts chapel. David Conant (McKay Conant Hoover Inc., 5655 Lindero Canyon Rd., Ste. 325, Westlake Village, CA 91362)

Two multipurpose halls required variable acoustic design with minimal alteration of their appearance. The 400-seat Performing Arts Chapel at Fuller Theological Seminary (awaiting construction) will accommodate everything from pipe organ concerts to lectures-in-the-round by employing multiple variable acoustics methods with adjustable treatments deployed above the visual ceiling and along sidewalls and the performance platform. The 550-seat Virginia Piper Theater at the Mesa Arts Center (recently opened) successfully hosts everything from drama to choral works via novel, inexpensive, and wonderfully simple means, entirely beyond audience view.

10:30

1aAA6. Who cares if small high school auditoria sound any "good" for music? Bill Dohn (630 Quintana Rd., 312, Morro Bay, CA 93442, bill.dohn@gte.net)

High school music instructors, high school music students, and acoustical consultants certainly care if their auditoria sound good for music, but not all high school districts or architects appear to be all that interested. Examples of some recently completed small high school (multipurpose) auditoria are presented. Some of these have not proven particularly satisfactory for music, and (thankfully) some have. Basic programming and design criteria to achieve satisfactory music performance and listening environments in small mulitpurpose auditoria are suggested.

10:50

1aAA7. Two new terms for the comparison between acoustical measurements, calculations (ray or image models), and subjective impressions. Jason R. Duty, Hari V. Savitala, and David R. Schwind (Charles M. Salter Assoc., Inc., 130 Sutter St., Ste. 500, San Francisco, CA 94104)

The sound energy growth (SEG) curve is a new parameter depicting the growth in sound energy during the first 200–300 ms. An instantaneous sound envelope (ISE) is a new parameter yielding the sound amplitude and arrival time of individual reflections. ISE is especially useful for comparison with calculated reflectograms generated in computer models. ISE shows the contribution of individual reflections to the SEG. The two new terms provide a better comparison between measurements (ISE), calculations (from ray or image computer models), and subjective impressions (SEG) based on energy parameters.

Contributed Papers

11:10

1aAA8. Case study of measurement results for medium-sized multipurpose halls. Hari V. Savitala and Jason R. Duty (Charles M. Salter Assoc., Inc., 130 Sutter St., Ste. 500, San Francisco, CA 94104)

This case study focuses on presenting measurement results for medium-sized multipurpose halls (400–600 seats). Objective acoustical parameters, such as Reverberation Time (T20) and Clarity (C80), were correlated to subjective impressions of the spaces by the end users. The results are presented to better understand how to design medium-sized multipurpose halls.

11:25

1aAA9. Audibility of absorption, diffusion, or a specular reflector on the first lateral reflection. Benjamin Bridgewater (7383 Stagecoach Trail Rd., Manhattan, MT 59741, benbridgewater@gmail.com)

To better understand the importance of treatment on the first reflection in a small room, a study of the audibility of the treatment of the first lateral reflections in a small room was conducted. Subjects completed the ABX tests comparing the different treatments of the first lateral reflection to determine if there was a noticeable difference between the treatments of the first lateral reflection.

Session 1aMU

Musical Acoustics: Dynamical Approaches in the Study of Music Perception and Performance I

Edward W. Large, Chair
Florida Atlantic Univ., Ctr. for Complex Systems, 777 Glades Rd., Boca Raton, FL 33431

Chair's Introduction—8:30

Invited Papers

8:35

1aMU1. A dynamic approach to attending: New issues. Mari Riess Jones (Dept. of Psych., Univ. of California, Santa Barbara, 5388 Traci Dr., Santa Barbara, CA 93111, jones.80@osu.edu)

Musical events entail crafted serial changes in frequency, intensity, and time that are explicitly patterned to engage attending activities over relatively long periods of time (i.e., versus brief time periods required for single tones). Serial changes vary in salience, with some functioning as accents outlining higher-order time spans between nonadjacent tones. Accordingly, attending to music must be dynamic and sustained, capable of anticipatory behaviors while continuously reacting and adapting to various serial changes, accented and unaccented. Issues of meter perception and melodic phrasing also mean that attending must be responsive to different time levels marked by accents. Approaches to attending that ground attentional tracking in biological entrainment have potential for describing these aspects of musical listening. They also raise new issues, as illustrated in experiments inspired by entrainment theories; as reviewed here, these address effects of rhythm on time discrimination, time judgments, and responses to melodic changes. Also considered are general issues relating to development of new paradigms, age-specific preferred rate (i.e., preferred intrinsic periods), and synchronization limits.

9:05

1aMU2. Perspectives on perceptual timing. J. Devin McAuley (Dept. of Psych., Bowling Green State Univ., Bowling Green, OH 43403, mcauley@bgsu.edu)

There has been a notable increase in research on the neural bases of timing in recent years. A focus of much of this work has been on identifying the locus and functional characteristics of a putative central clock mechanism under the assumptions that (1) both human and nonhuman animal timings involve similar pacemaker-accumulator mechanisms and (2) the functional characteristics of the internal clock are the same whether timing an isolated duration, such as a stoplight, or dancing to music, even though the latter requires perceiving a periodic beat, while the former does not. This talk presents research from an alternative dynamic perspective that emphasizes the importance of assessing (1) the timing of extended temporal sequences characteristic of music rather than isolated durations and (2) individual differences. [Work supported by the GRAMMY Foundation.]

9:35

1aMU3. Neural dynamics of beat perception and production. John Iversen (The Neurosci. Inst., 10640 John J Hopkins Dr., San Diego, CA 92121)

The perceptual experience of a rhythm depends on its metrical interpretation. Prior work using magnetoencephalography has shown that brain activity reflects a listener's metrical interpretation of simple ambiguous rhythms: neural response to a note coinciding with the listener's internal sense of the beat is enhanced in the beta frequency range (20–30 Hz). An unanswered question raised by this result is where in the brain the transient periodic enhancement of evoked response to the beat might arise. Ongoing research on brain responses to syncopated rhythmic patterns is presented. In these syncopated patterns, some beats are never marked by physical tones. It is asked if the increase in transient beta activity observed in prior experiments can also indicate internal beat placement even in the predictable absence of a physical input. If so, it may reveal the nature of the internal modulation of cortical responses to sound and enable localization of its source. The presentation will conclude with a discussion of what brain architectures may be able to support beat perception and synchronization, with reference to nonhuman animals. [Work supported by Neurosciences Research Foundation.]

10:05—10:30 Break

10:30

1aMU4. Time courses of cortical beta and gamma-band activity during listening to metronome sounds in different tempi. Takako Fujioka (Rotman Res. Inst., Baycrest, Univ. of Toronto, 3560 Bathurst St., Toronto, ON M6A 2E1 Canada, tfujioka@rotman-baycrest.on.ca), Edward Large (Florida Atlantic Univ., Boca Raton, FL 33486), Laurel Trainor (McMaster Univ., Hamilton, ON L8S 4K1, Canada), and Bernhard Ross (Univ. of Toronto, Toronto, ON M6A 2E1, Canada)

Oscillatory cortical activities in beta-band (13–20 Hz) are related to a somatomotor system, and gamma-bands (20 Hz) are involved with feature binding in perception. Previously gamma-band activity in electroencephalography was found to modulate with musical pulse with a two-beat metric accent. The present study examined beta- and gamma-band activities in auditory cortices recorded via magnetoencephalography (MEG) when subjects listened to musical pulse in various tempi. Tones were presented with intervals of (1) 390 ms, (2) 585 ms, and (3) 780 ms, and (4) with irregular intervals between 390 and 780 ms. In addition, the same tones were presented with a 390-ms interval using a two-beat accent, while occasionally either (5) an accented tone or (6) an unaccented tone was omitted. Beta-band activity decreased immediately after the stimulus and returned to the previous level just before the next stimulus, regardless of the tempo, except in the irregular condition. The tone omission resulted in an extra beta rebound. Gamma-band activity increased right after the pulse or the omission. We propose that beta oscillations may encode the timing of the next sound in a regular pulse sequence, whereas gamma oscillations likely reflect processing of the current auditory events including omissions.

11:00

1aMU5. Tempo fluctuation and predictive synchrony in music. Summer Rankin, Edward Large, and Philip Fink (Ctr. for Complex Systems and Brain Sci., Florida Atlantic Univ., Boca Raton, FL 33431, rankin@ccs.fau.edu)

The goal of this study was to understand the ability of musicians and nonmusicians to entrain to musical performances with naturally fluctuating tempo. In experiment 1, we investigated the nature of tempo fluctuations produced by a musician. We collected four music performances from a skilled pianist who was instructed to play with natural expression. We extrapolated the beat times by comparing the performances with the musical scores and performed a spectral analysis and a rescaled range analysis on the interbeat intervals. The results indicate fractal scaling of the performance tempo in each case. Thus, musical tempo fluctuations exhibit long-range correlations characterized by a $1/f$ type long memory process. The stimuli in experiment 2 included two performances from experiment 1 and mechanical versions of the same pieces. Participants were asked to synchronize at slower (quarter note) and faster (eighth note) metrical levels. Musicians and nonmusicians synchronized successfully and were able to accommodate large tempo fluctuations. Entrainment was superior at the slower metrical level. Participants were less variable for the mechanical versions. Most importantly, participants predicted the tempo fluctuations observed in experiment 1, suggesting a possible relationship between fractal tempo scaling, pulse synchronization, and neural oscillation in the perception of rhythm. [Work supported by NSF grant BCS-0094229.]

11:30

1aMU6. Dynamics of emotional communication in performed music. Heather Chapin, Edward Large (Ctr. for Complex Systems, Florida Atlantic Univ., 777 Glades Rd., Boca Raton, FL 33431, chapin@ccs.fau.edu), Kelly Jantzen (Western Washington Univ., Bellingham, WA 98225), J. A. S. Kelso (Florida Atlantic Univ., Boca Raton, FL 33431), and Fred Steinberg (Univ. MRI of Boca Raton, Boca Raton, FL 33431)

Musicians vary performance parameters, such as tempo and sound intensity, to express emotion dynamically. Our goals were to link specific parameters of performance expression with listeners' emotional responses and neural activity. Ten musically trained and ten untrained participants listened to two versions of a romantic piano composition. The expressive performance included variations in timing and sound intensity. The mechanical performance maintained constant tempo and sound intensity throughout. Participants reported emotional responses in a two-dimensional response space (emotional intensity and valence) before and after fMRI scanning. In the fMRI scanner, participants listened to both versions without reporting emotional responses. Ratings of emotional intensity were positively correlated with tempo. The fMRI analysis revealed a main effect of performance, showing increased BOLD responses for the expressive performance in an emotion-related network. A main effect of training showed increased BOLD responses for trained participants in areas associated with emotion processing and reward. We also observed BOLD responses that were temporally correlated with tempo fluctuations. In summary, performance expression predicted listeners' dynamic ratings of emotional intensity. Moreover, limbic areas responded to expressive versus mechanical performances, and dynamic BOLD changes tracked performance expression and reported emotional intensity over time. [Work supported by NSF BCS-0094229.]

Session 1aNS

Noise and Animal Bioacoustics: Advances in Measurement and Noise and Noise Effects on Humans and Non-Human Animals in the Environment I

Anne E. Bowles, Cochair
Hubbs Sea World Research Inst., 2595 Ingraham St., San Diego, CA 92109

Brigitte Schulte-Fortkamp, Cochair
Technical Univ. Berlin, Inst. of Fluid Mechanics and Engineering, Einsteinufer 25, 10587 Berlin, Germany

Chair's Introduction—8:30

Invited Papers

8:35

1aNS1. New approaches in soundscapes: About the triangulation of measurements. Brigitte Schulte-Fortkamp (Inst. of Fluid Mech. and Eng. Acoust., TU-Berlin, Einsteinufer 25, D-10587 Berlin, Germany)

A procedure is developed following the soundscape approach, which will provide acoustical indicators and parameters describing urban and other outdoor living areas with respect to physical conditions and their relevance for life. In particular, the contribution of important sources like traffic noise to the overall sound exposure and its influence on the evaluations by humans has to be determined. Moreover, the question is to which degree does a single source determine the soundscape of the environment with respect to the perception and evaluation? Qualitative evaluations have been conducted introducing the concept of new experts with respect to data triangulation.

8:55

1aNS2. Spatial variation in marine mammal habitat soundscapes within one coastal region. Jennifer L. Miksis-Olds (Appl. Res. Lab., The Penn. State Univ., P.O. Box 30, State College, PA 16803, jlm91@psu.edu) and Jeffrey A. Nystuen (Univ. of Washington, Seattle, WA 98105)

Manatees and dolphins inhabit coastal waterways in which they are constantly exposed to sound produced by physical processes, biological activity, and human activities. Ambient sound levels can change rapidly on the scale of minutes to hours, but variability in sound level is the only one component of the acoustic environment that has the potential to impact marine mammals. Soundscapes, or acoustic footprints, of a region provide a visual snapshot of the acoustic components contributing to the ambient sound level. Acoustic footprints provide information on the identity of sound sources as well as sound levels. A passive aquatic listening instrument was deployed in 24 sites around Sarasota Bay, FL. Recordings were made in 24 sites frequented by manatees and dolphins. Generation of acoustic footprints from each site illustrates the temporal and spatial variabilities of source components within and between the habitat types. Vessel noise is a more dominant sound source in sites used less frequently by manatees compared to more frequently used sites. Sites used most heavily by manatees tended to be dominated by biological activity or wind.

9:15

1aNS3. Underwater acoustic scene analysis: Exploration of appropriate metrics. William T. Ellison, Adam S. Frankel, David Zeddies, Kathleen J. Vigness Raposa, and Cheryl Schroeder (Marine Acoustics, Inc., 809 Aquidneck Ave., Middletown, RI 02842)

A recent review of published accounts of acoustic noise exposure and behavioral response found that the reported results were often limited by the lack of supporting information on basic acoustical metrics as well as potentially important contextual variables. [Southall *et al.*, Aquat. Mamm. **33**, 411–521(2007)]. Human studies have also shown that simple measures such as sound level are insufficient to represent complex acoustic scenes [Dubois, J. Acoust. Soc. Am. **122**, 3011–(2007)]. While source and received levels are frequently reported for underwater studies, other characteristics of the resultant acoustic field are rarely described. Understanding the full spatial, temporal, and spectral nature of the sound field can provide additional quantitative measures useful in elucidating the animals' response to the incident sound field exposure. The animals' perception of received acoustic field may also be influenced by the biological meaningfulness of the signal and the experience of the receiver with signals of a given type. Here we provide guidelines for future studies corresponding to three phases: preplanning, field measurements, and postmeasurement analysis, addressing acoustic field metrics as well as the seasonal distribution and baseline behavior of the animals of interest. Examples from selected field measurements will be used to illustrate the salient features.

9:35

1aNS4. Is it time to seriously consider the effects of acoustic particle motion on hearing and behavior in fish? Mardi Hastings (Penn State Univ., Appl. Res. Lab, P.O. Box 30, State College, PA 16804, mch26@psu.edu)

Although sound exposure level (SEL) and sound pressure level (SPL) are the metrics being applied to assess effects of underwater sound on fish, no correlation exists between SEL or SPL and temporary threshold shift (TTS) or behavior. Certainly particle motion plays a major role in the auditory scene of fishes because their inner ears are literally accelerometers that detect signals via relative motion between sensory epithelia and solid otoliths in the auditory endorgans. Most all hearing data, however, continue to be measured with respect to SPL, and TTS with respect to SEL or SPL. Neither metric accounts for effects of particle motion. An analysis of findings from several recent acoustic impact studies on various species using different types of sources indicates that differences in observed effects are most likely due to differences in received levels of acoustic particle motion. Field studies with real sources in open water predict an onset of TTS at higher SEL than do studies conducted in confined spaces or with specimens located in the source near a field where acoustic particle motion is higher than estimated by simple pressure–particle velocity relationships. Thus monitoring only sound pressure may not be sufficient to protect fish from adverse impacts.

9:55—10:15 Break

10:15

1aNS5. Results of giving a bottlenose dolphin control over exposure to a net alarm: Implications for the measurement of aversion and detection thresholds. Ann Bowles (Hubbs-Sea World Res. Inst., 2595 Ingraham St., San Diego, CA 92109, abowles@hswri.com) and Rindy Anderson (Duke Univ., Durham, NC 27708-0338)

When exposed to pings from a Dukane Netcom 1000 net alarm, bottlenose dolphins responded with avoidance and aggression. These species-typical behaviors were tested as a tool for measuring the threshold for aversion. Two bottlenose dolphins were exposed to pings with varying signal-to-noise ratios (SNRs of 5–70 dB) in randomized order. Trials were terminated when the dolphins exhibited any agonistic behavior. Sixty-nine animal trials were terminated by the avoidance or aggressive approach. Seventy-seven trials were terminated by fluke-slapping, for which latency could be measured precisely. At SNR of 10 dB or below, the dolphin did not fluke-slap. Above 10 dB SNR, the probability of response increased and latency to slap decreased rapidly. The shape of the latency-SNR curve was similar to equal latency curves measured in audiometric studies using operant conditioning, suggesting that control over pings was intrinsically rewarding. Cessation of pings may have been the reward, but because the dolphin chose to terminate stimuli at levels just above the limit of detection, another possibility should be considered: control over the stimulus could reinforce itself. If so, conditioning experiments could be designed for audiometric research on wild cetaceans [Work supported by NMML and SeaWorld San Diego; NMFS Permit 1016.]

10:35

1aNS6. The impacts of energy development noise playback on lek attendance and behavior in greater sagegrouse. Jessica Blickley (Dept. of Evolution and Ecology, Univ. of California, Davis, One Shields Ave., Davis, CA 95616, jlblickley@ucdavis.edu), Diane Blackwood (Baywing Assoc., Williamston, MI 48895), and Gail Patricelli (Univ. of California, Davis, Davis, CA 95616)

The spread of human development has caused a dramatic increase in noise across the landscape. Recent studies suggest that noise may negatively impact wildlife, yet little is known about the causes and consequences of this impact. Furthermore, most previous studies have not been designed to isolate noise impacts from other confounding factors. This study is investigating the impacts of energy development noise on greater sage grouse (*Centrocercus urophasianus*), a species of management concern across western North America. Sage grouse are declining in areas of energy development and circumstantial evidence suggests that noise is a cause of this decline. To test this hypothesis, control leks and leks with experimentally-introduced energy development noise were monitored. Results from three seasons of experimental noise playback will be presented, comparing lek attendance, territory selection, and display behavior between noise and control leks. This is the first long-term playback experiment investigating the chronic impacts of noise on any wild population, offering a unique opportunity to experimentally address noise impacts on avian behavior and breeding site selection while informing conservation efforts for this species.

10:55

1aNS7. The effects of gas well compressor noise on nesting birds in pinyon-juniper woodlands. Clinton D. Francis (Dept. of Ecology and Evolutionary Biology, Univ. of Colorado, UCB 334, Boulder, CO 80026, clinton.francis@colorado.edu) and Catherine P. Ortega (Fort Lewis College, Durango, CO 81301)

Anthropogenic noise has been implicated as a cause of declines in avian species diversity and densities; however, these patterns are not conclusive because noise has not been uncoupled from potential confounding variables that accompany noisy human activities. During the summers of 2005–2007, noise was isolated through the use of natural gas wells with and without noisy compressors (treatment and control sites, respectively). No difference in overall nest density on plots with and without compressors was found; however, noise significantly reduced nesting species richness. Individual species also demonstrated responses to noise: Mourning Dove nests were more abundant on control sites, whereas Black-chinned Hummingbird and House Finch nests were more abundant on treatment sites. Several species were also found to nest significantly farther from well pads on treatment sites than on control sites. Nest success was higher on treatment sites than on control sites, due to lower levels of predation. In areas influenced by anthropogenic noise, predators may be present, but unable to locate nests, or they are in lower densities or absent. Anthropogenic noise appears not only to influence avian nesting patterns, thereby altering the avian community, but also to influence nest success through changes to predation patterns.

Contributed Paper

11:15

1aNS8. Effects of varying levels of noise and vibration on behavioral and physiological stress responses in two species of freshwater aquarium fish: Fathead minnows (*Pimephales promelas*) and bluegill sunfish (*Lepomis macrochirus*). Alexandra Rose, Jeanette Thomas (Biological Sci. Dept., Western Illinois Univ.-Quad Cities, Moline, IL 61265), and Allen LaPointe (John G. Shedd Aquarium, Chicago, IL 60614)

Aquariums provide beautiful underwater environments for an array of fish species, but to maintain optimum water quality and aesthetically pleasing displays, a variety of mechanical systems that unintentionally produce noise, including pumps, filters, skimmers, bubblers, etc., are necessary. The objectives of this study are to measure the acoustic properties of noise in an aquarium and examine the effects of different noise levels on the stress experienced by two species of freshwater fishes: fathead minnows (*Pimephales promelas*), hearing specialists, and bluegill sunfish (*Lepomis macrochirus*), hearing generalists. We conducted a noise mapping of several fish galleries at the Shedd Aquarium using a BK 2560 SPL meter; Leq, SEL, and minimum & maximum decibel levels were measured up to 2 kHz using a DolphinEar hydrophone. We then tested the effects of four noise levels on the stress experienced by these two fish species by measuring oxygen consumption/respiration rates with Loligo respirometry chambers and cortisol release rate with a noninvasive radioimmunoassay that measures free cortisol in water samples [Ellis *et al.* 2004]. These measurements will help to evaluate the effects of noise in standard aquarium settings on fish welfare and may aid in the determination and regulation of acceptable anthropogenic noise levels in aquariums.

11:30—1:00
Session Luncheon and Moderated Discussion

MONDAY MORNING, 10 NOVEMBER 2008 LEGENDS 7, 9:00 A.M. TO 12:00 NOON

Session 1aSC

Speech Communication: Perception of Consonants and Vowels (Poster Session)

Catherine L. Rogers, Chair
Univ. of South Florida, Comm. Sci. and Disorders, 4202 E. Fowler Ave., Tampa, FL 33620-8150

Contributed Papers

All posters will be on display from 9:00 a.m. to 12:00 noon. To allow contributors an opportunity to see other posters, contributors of odd-numbered papers will be at their posters from 9:00 a.m. to 10:30 a.m. and contributors of even-numbered papers will be at their posters from 10:30 a.m. to 12:00 noon.

1aSC1. Duration and spectral shape as cues to vowel identity. Webster Tilton, IV and James R. Sawusch (Psych. Dept., State Univ. of New York at Buffalo, 206 Park Hall, Buffalo, NY 14260)

Theories of vowel recognition based on the vowel formant frequencies (or spectral peaks) are less accurate in identifying vowels than human listeners. This has been true even if the model uses dynamic spectral information such as the changes in the spectral peaks over time [H. Houde (2002)]. Studies with synthetic speech and edited natural speech have implicated duration and fundamental frequency as additional perceptual cues. The present work focused on duration, fundamental frequency, and spectral shape using synthetic vowels modeled on the speech of a male and a female talker. Series from /i/ to /I/, /E/ to /ae/, /uh/ to /a/, and /U/ to /u/ were created in which only duration, fundamental frequency, or the shape of the short-term spectrum were varied. Subsequent studies manipulated the formant frequencies and the duration or spectral shape orthogonally. Results indicated that the duration and spectral shape of a steady state vowel exert a potent influence on vowel identification, while varying the fundamental frequency appeared to have little effect.

1aSC2. Identification of transition-only and steady-state vowels by young and older normal-hearing listeners. Elizabeth Talmage, Gail Donaldson, and Catherine Rogers (Dept. of Comm. Sci. and Disord., Univ. of South Florida, PCD 1017, 4202 E. Fowler Ave., Tampa, FL, gdonalds @cas.usf.edu)

Normal-hearing listeners can identify vowels on the basis of either dynamic or steady-state (SS) cues. To determine which cues are more effective, vowel identification was measured for full, transition-only (TN) and SS versions of naturally produced exemplars of the syllables "beeb, bib, babe, beb, bab, and bob." TN stimuli retained 10, 20, 30, 40, 60, or 80 ms of the consonant-vowel and vowel-consonant transitions and were neutralized in overall duration. SS stimuli retained 10, 20, 30, 40, 60, or 80 ms of the vowel center but eliminated transitions. Young normal-hearing (YNH) and older normal-hearing (ONH) listeners were assessed. Performance declined as the duration of acoustic information decreased. On average, decrements were similar for TN and SS stimuli except at the shortest duration (TN10 and SS20), where average performance was poorer for the TN stimulus. However, relative performance for short-duration TN and SS stimuli varied substantially across vowels. TN and SS stimuli produced similar performance for some vowels, but TN stimuli produced much poorer performance than SS stimuli for other vowels. Preliminary findings indicate a trend for slightly lower performance among ONH listeners relative to YNH listeners but suggest similar patterns of performance across groups. [Work supported by NIH-NIDCD 5R03DC005561.]

1aSC3. Perceptual accommodation to sinewave speech. James M. Hillenbrand (Dept. of Speech Pathol. Audiol., Western Michigan Univ., Kalamazoo, MI 49008, james.hillenbrand@wmich.edu), Michael J. Clark (Western Michigan Univ., Kalamazoo, MI 49008), Robert A. Houde (Ctr. for Commu Res., Rochester, NY 14623), Michael W. Hillenbrand (Western Michigan Univ., Kalamazoo, MI 49008), and Kathryn S. Hillenbrand (Vicksburg High School, Vicksburg MI 49097)

Many studies have reported good intelligibility for sine wave replicas of sentences (e.g., R. Remez *et al.*, Science **212**, 947–950 (1981)]. Recent work, however, has shown poor intelligibility (~55%) for vowels in isolated syllables [J. Hillenbrand and M. Clark, J. Acoust. Soc. Am. **123**, 3326 (2008)]. While enhanced intelligibility for sentences undoubtedly reveals the importance of top-down mechanisms, it is also possible that sentence-length utterances allow listeners to make (as yet unknown) perceptual accommodations to the unfamiliar acoustic properties of sine wave speech (SWS). In this study, the intelligibility of SWS replicas of 16 vowels/diphthongs in isolated syllables ("heed," "hid," and "hide") was compared to that of the same syllables when preceded by a seven-word SWS carrier phrase (CP) spoken

by the same talker. Intelligibility was ~24 percentage points higher when the SWS syllables were preceded by the SWS CP than when the same utterances were presented in isolation. Furthermore, the effect was observed even when the CP and test-syllable talkers did not match, showing that the effect involves more than just talker normalization. Finally, a same-talker natural speech CP preceding the SWS syllable produced a decrement rather than an improvement in intelligibility.

1aSC4. The role of speech-specific signal characteristics in vowel normalization. Matthias J. Sjerps, James M. McQueen, and Holger Mitterer (Max Planck Inst. for Psycholinguistics, Wundtlaan 1, 6525 XD Nijmegen, matthias.sjerps@mpi.nl)

Listeners adjust their vowel perception to the characteristics of a particular speaker. Six experiments investigated whether speech-specific signal characteristics influence the occurrence and amount of such normalization. Previous findings were replicated with first formant ($F1$) manipulations of naturally recorded speech; target sounds on a /pIt/ (low $F1$) to /pt/ (high $F1$) continuum were more often labeled as /pIt/ after a precursor sentence with a high $F1$, and more often labeled as /pt/ after one with a low $F1$ (Experiment 1). Normalization was also observed, though to a lesser extent, when these materials were spectrally rotated, and hence sounded unlike speech (Experiment 2). No normalization occurred when, in addition to spectral rotation, the silent intervals and pitch movement were removed and the syllables were temporally reversed (Experiment 3), despite spectral similarity of these precursors to those in Experiment 2. Reintroducing only pitch movement (Experiment 4), or silent intervals (Experiment 5), or spectrally rotating the stimuli back (Experiment 6) did not result in normalization, so none of these factors alone accounts for the effect's disappearance in Experiment 3. These results show that normalization is not specific to speech but still depends on more than the overall spectral properties of the preceding acoustic context.

1aSC5. Measuring the impact of native inventory and native contrast on vowel perception. Marc Ettlinger and Keith Johnson (Dept. of Linguist., Univ. of California, Berkeley, 1203 Dwinelle Hall, Berkeley, CA 94720)

Theories of speech perception differ as to whether experience with sounds or with sound contrasts is more important when discriminating novel sounds. To explore this question, 21 American English, 16 Turkish, and 16 French speakers were tested on their ability to discriminate high front vowels in German (/i/,/y/,/Y/,/I/). The crucial difference between the languages is that English only uses the tense-lax contrast (/i/-/I/), while Turkish and French only use the rounding contrast (/i/-/y/). If contrast is crucial, then English speakers should be better at discriminating /y/-/Y/, whereas if the inventory is crucial, then they should be better at discriminating /I/-/Y/. The results of a fixed discrimination task show that there is no significant effect of language and that the tense-lax contrast (/i/-/I/; /y/-/Y/) is universally more easily discriminated than the rounding contrast (/i/-/y/; /I/-/Y/). The results of a rating task do reflect an influence of language, however, with English-listeners rating /I/-/Y/ as more distinct and French and Turkish speakers rating /y/-/Y/ as more distinct. So, because English has /I/, but no rounding contrast, what matters in the perception of new sounds is not experience with contrasts, but rather experience with particular sounds.

1aSC6. Perceptual compensation for /u/-fronting in American English. Reiko Kataoka (Dept. of Linguist., Univ. of California at Berkeley, 1203 Dwinelle Hall, Berkeley, CA 94720-2650, kataoka@berkeley.edu)

Listener's identification of speech sounds are influenced by both perceived and expected characteristics of surrounding sounds. For example, Ohala and Feder (1994) demonstrated that American listeners judge a vowel stimulus which is ambiguous between /i/ and /u/ more frequently as /u/ in alveolar context than in bilabial context, and do so both in cognitively "restored" contexts as well as acoustic contexts. This paper reports the results of three-part perception experiments with 31 native speakers of American English, aiming to confirm and extend these results. Experiment 1 replicated the findings of Ohala and Feder. Furthermore, it shows that reaction time (RT) for /u/ judgment is shorter in alveolar than in bilabial context. Experiment 2 showed that perceptual compensation became greater as the speech rate of the precursor sentence increased. The results from experiments 1 and 2 might indicate that listeners use both cognitively based categorical compensation and mechanically based gradient compensation. Experiment 3 investigated the role of speech production in perceptual compensation. Moderate correlation between the degree of /u/-fronting in production and the perceptual boundary of /i/-/u/ categories was obtained, suggesting a link between speech production and speech perception.

1aSC7. Dialectal differences in dynamic formant patterns in vowels. Robert Allen Fox and Ewa Jacewicz (Speech Percept. and Acoust. Labs, Ohio State Univ., 1070 Carmack Rd., Columbus, OH 43210, fox.2@osu.edu)

This study examines basic acoustic variation in the dynamic patterns of vowel formants among three regional variants of American English spoken in southeastern Wisconsin (affected by the Northern Cities Shift), western North Carolina (Appalachian English affected by the Southern Vowel Shift), and central Ohio (not considered to be affected currently by any vowel shift). Three groups of speakers (including men and women) produced vowels in citation form (in a /hVd/ context) and in sentences. The sentence material elicited two degrees of vowel emphasis (high and low) in the /bVd/ and /bVt/ contexts. The frequencies and amplitudes of the first three formants were extracted at points corresponding to 20%-35%-50%-65%-80% of the vowel's duration. A set of dynamic measures was then calculated using these values that included overall signed/unsigned change in formant frequencies, vector and trajectory lengths, direction/angle of vowel movement in the $F1$ by $F2$ plane, and rate of frequency change. The results show significant cross-dialectal differences in formant patterns in monophthongs, phonemic diphthongs, and nonphonemic diphthongs. The nature and extent of these formant changes varied as a function of speaker dialect in a manner apart from expected variation resulting from phonetic and prosodic context and speaking style. [Work supported by NIH.]

1aSC8. Production and perception of two vowels in Northeast Ohio. Anna Schmidt and Lois Powell (School of Speech Path Aud., Kent State Univ., Kent, OH 44242, aschmidt@kent.edu)

In Northeast Ohio, three dialect regions converge: the Inland North, North Midland, and Pittsburg regions (Labov *et al.* 2005). It is believed that the vowel in "bat" is raising and fronting while the vowel in "bet" is lowering and backing as part of the Northern cities vowel shift in the Inland North region. Earlier data from 50 talkers (aged 18–25) from these regions suggest vowel movement in each region with a full merger or reversal of the two vowels only for Inland North talkers. Talkers from all regions produced longer bat vowels than bet vowels. The current study examined perception as well as production of the vowels by talkers from these regions. Participants heard two synthetic vowel continua and identified the vowels: a duration continuum, in which the formant pattern was constant but the vowel duration varied, and a formant continuum, in which the duration was constant but the formant pattern varied from a low backed vowel to a high fronted vowel. Perception patterns were compared to production patterns in order to determine if (a) longer vowels were identified as bat vowels and (b) vowel identification followed vowel production.

1aSC9. Comparison of vowels in maternal speech to adults and to children with hearing loss. Laura Dilley (Dept. of Commun. Disord. and Dept. of Psych., Bowling Green State Univ., 247 Health Ctr., Bowling Green, OH 43403, dilley@bgsu.edu) and Tonya Bergeson (Indiana Univ. School of Medicine, Indianapolis, IN 46202)

Previous research has indicated that when speaking to normal-hearing children, maternal caregivers' speech is characterized by a vowel space which is expanded relative to that produced when speaking to other adults. The present study investigated the characteristics of the vowel spaces produced by mothers interacting with hearing-impaired children who had recently received a cochlear implant (CI), relative to those produced when interacting with another adult. Mothers were recorded interacting with their hearing-impaired children with CIs in quiet play sessions at 3- or 6-month interval postimplantation as well as in semistructured interviews with another adult. Measurements of $F1$ and $F2$ for the vowels /i/, /ɑ/, and /u/ in stressed syllables were taken, and the areas of the resulting vowel triangles for the two production conditions were compared. Preliminary results show that when speaking to their hearing-impaired children with CIs, vowel spaces of mothers were not expanded relative to when speaking to another adult. The results will be compared with vowel spaces produced to normal-hearing children and hearing-impaired children with hearing aids. These

findings have implications for developing intervention strategies aimed at caregivers for improving speech and language skills in children with CIs. [Work supported by NIH-NIDCD R01DC008581.]

1aSC10. The impact of caregivers' speech on infants' discrimination of a speech sound contrast. Alejandrina Cristià (Linguist., Purdue Univ., 500 Oval Dr., West Lafayette, IN 47907, acristia@purdue.edu)

The acquisition of speech perception has aimed primarily to detect variation across linguistic populations, assuming that the linguistic input to infants within a given linguistic community is essentially the same. In this presentation, individual differences due to variability within a linguistic community are investigated using a contrast that is phonemic in the language, but which is produced with a great deal of variation across speakers. English-learning 5-month-old and 13-month-old infants were tested for their ability to discriminate English sibilants, and the variance in their performance was correlated with the acoustic characteristics of the speech of their caregivers in order to investigate some of the possible sources of individual differences in speech perception.

1aSC11. Infants' perception of non-native sibilants following different distributions of frication and vocalic cues. Alejandrina Cristià (Linguist., Purdue Univ., 500 Oval Dr., West Lafayette, IN 47907, acristia@purdue.edu), Grant McGuire (Univ. of California at Santa Cruz, Santa Cruz, CA 95064), Amanda Seidl, and Alexander Francis (Purdue Univ., West Lafayette, IN 47907)

Previous work suggests that learning to perceive speech categories in infancy may be influenced by the distributions of acoustic cues that underlie them. However, studies on this topic have focused on distributions of single cues, especially voice onset time (VOT), whereas natural phonetic categories are typically defined according to multiple cues and, moreover, VOT may constitute a special case as nonhuman animals are known to exhibit categorical perception of this cue. In order to explore the role of cue distributions in a more natural context, and to extend this research beyond the domain of VOT, in this study we exposed infants to different distributions of cues to a non-native contrast of place of articulation in fricatives. Results suggest that young infants are indeed able to track multiple acoustic cue distributions at once, and that these distributions shape infants' perception after a brief exposure, possibly by enhancing the perceptual similarities between acoustically similar tokens.

1aSC12. Transmission and reception of visual speech signals produced by cued speech transliterators. Katherine Pelley and Jean C. Krause (Dept. of Comm. Sci. and Dis., Univ. of South Florida, 4202 E. Fowler Ave., PCD 1017, Tampa, FL 33620, jkrause@cas.usf.edu)

Although it is common practice for deaf individuals to use interpreters as a means of accessing spoken information, few investigations of interpreter skills have been reported and virtually none have focused on interpreter intelligibility [Kluwin and Stewart, Odyssey **2**, 15–17 (2001)]. In order to begin quantifying the contribution of factors affecting interpreter (transliterator) intelligibility for one English-based communication mode (cued speech), two experiments were conducted. In the first experiment, 12 cued speech transliterators were asked to transliterate materials at three different speeds (slow, normal, fast). Two characteristics of the visual speech signal produced by these transliterators were then examined: (1) accuracy, measured as a percent-correct score based on the target cue sequence, and (2) lag time, reported as the average delay between the spoken and transliterated messages. In the second experiment, eight to ten expert receivers of cued speech were presented with visual stimuli excised from the transliterated messages and asked to transcribe the stimuli. Intelligibility of the visual speech signals was measured as the percentage of words correctly received. Results show that accuracy is inversely related to lag time and accounts for roughly 25% (on average) or more (when transliterator experience is controlled) of the variance in intelligibility. [Work supported by NIH /NIDCD Grant 5-R03-DC007355.]

1aSC13. Online processing of acoustic cues used in speech perception: Comparing statistical and neural network models. Joseph Toscano (Dept. of Psych., Univ. of Iowa, Iowa City, IA 52242, joseph-toscano@uiowa.edu) and Bob McMurray (Univ. of Iowa, Iowa City, IA 52242)

Most phonological contrasts are signaled by multiple acoustic cues, yet it is unclear how these cues are combined during speech perception. Formal computational modeling offers a useful tool for studying this process. Two computational approaches are presented here. The first is a mixture of Gaussians (MOG) model that forms categories and combines cues based on their statistical distributions [Toscano and McMurray, Proceedings of the Cognitive Science Society (2008)]. The second is a neural network model that combines statistical learning and dynamic online processing [McMurray and Spivey, Proceedings of the Chicago Linguistic Society (1999)]. Both the MOG and the network use the statistical distributions of speech sounds to form categories. The MOG offers transparency in that its categories correspond directly to distributional statistics measured from phonetic data. However, it does not capture the online processing observed in behavioral experiments that suggest that the speech system makes preliminary commitments before all cues are available [McMurray, Clayards, Tanenhaus, and Aslin (submitted)]. The network offers an approach that may allow us to observe this processing. Thus, while the MOG may better clarify the relationship between acoustics and phonological categories, the network may better model the process of speech perception. [Work supported by NIH.]

1aSC14. Categorization and generalization of multiple dimensions in nonspeech stimuli. Grant McGuire (Dept. of Linguist., Univ. of California at Santa Cruz, 1156 High St., Santa Cruz, CA 95064-1077)

Nonspeech (NS) stimuli have seen considerable use for exploring linguistic perception questions. One problem with such studies is extrapolating results found using abstract sounds to specific linguistic phenomena. This paper reports a series of experiments using noise-tone pairs, which have all the advantages of NS sounds but also have sufficient similarity to speech sounds to make connections with linguistic data. These sounds were used in several perceptual learning experiments exploring categorization and generalization. Subjects were trained to categorize using a single dimension or two integrated dimensions and then asked to label different sets of novel stimuli to assess generalization and dimensional reliability. Preliminary results demonstrate that learned dimensions were preferred for categorizing novel sounds and that generalization of integrated dimensions depends strongly on the relationship between the two dimensions. These results are discussed in terms of linguistic categories and theories of perceptual learning.

1aSC15. From production to acoustics to perception: The case of fricatives. Bob McMurray (Dept. of Psych., E11 SSH, Univ. of Iowa, Iowa City, IA 52240, bob-mcmurray@uiowa.edu) and Allard Jongman (Univ. of Kansas, Lawrence, KS 66044, jongman@ku.edu)

Although the acoustics of speech mediate production and perception, few studies have examined the entire chain. English fricatives present an interesting case because they are realized by multiple cues. Previously, 20 speakers were recorded producing the eight English fricatives with six vowels. Twenty-one cues were measured [Jongman *et al.*, J. Acoust. Soc. Am. **108**, (2000)]. Fricatives were presented (with and without the vowel) to 20 listeners for identification. Listeners were better at identifying fricatives in context (M=91%) than isolation (M=75%), and sibilants (M=94%) than nonsibilants (M=72%). Acoustic measurements were analyzed with a regression model of cue-parsing [McMurray *et al.* (unpublished)]. The model approximated listeners' performance in context (M=87%). However, this was only true when speaker-specific variance could be parsed out; significant speaker variation was observed in every cue. Thus, vowel context may aid perception by helping listeners identify the speaker. While parsing speaker and vowel from the cues was helpful, this was not true for voicing. Voicing and place cues overlapped, but knowing the voicing did not improve identification of place (and vice versa). Finally, when cue weightings based

on perception and articulation were computed independently, subtle differences emerged, suggesting that perception is similar, but not isomorphic, to production

1aSC16. Perceptual sensitivity to within-category acoustic variation by language impaired and typically developing adolescents. Cheyenne Munson, W. Dan McEchron, Bob McMurray (Dept. of Psych., Univ. of Iowa, E11 SSH, Iowa City, IA 52242, cheyenne-munson@uiowa.edu), and J. Bruce Tomblin (Univ. of Iowa, Iowa City, IA 52242)

Perceptual deficits have been suggested as an underlying cause of language impairment, and language impaired (LI) listeners sometimes show less categorical perception than normal listeners (Tallal & Piercy, 1974, Neuropsychologia, 12; Sussman, 1993, J. Speech Language Hearing Research, 36). This suggests that LI listeners might be extrasensitive to acoustic details. This issue was addressed using the visual world paradigm. Participants (32 TD, 37 LI, 14–20 years old) saw pictures on a computer screen, including a minimal pair differing in VOT (e.g., *beach/peach*). Auditory stimuli were six 9-step VOT continua constructed from natural speech. Participants heard a stimulus and clicked the referent. Eye movements were monitored to measure lexical activation. Both groups showed identical categorization functions (mouse clicks). Looks to competitor objects (peach when they clicked beach) increased as a function of VOT for both groups with no group interaction on either side of the boundary (B: $p<.001$; P: $p<.001$). Results were identical when the step closest to the boundary was removed, indicating sensitivity to *within-category* acoustic details. However, the LI group showed a heightened competitor activation overall (P: $p<.01$; B: $p=.06$). Thus, problems inhibiting lexical competitors, not perceptual differences, may be an underlying cause of language impairment.

1aSC17. Retuning speech sound categories: An eyetracking study. Kaori Idemaru and Lori Holt (Dept. of Psych., Carnegie Mellon Univ., 5000 Forbes Ave., Pittsburgh, PA 15213)

Speech categories are defined by multiple probabilistic acoustic cues. Fundamental frequency (*F*0) and voice onset time (VOT) are correlated in the English stop voicing contrast, for example. However, such correlations are often imperfect—especially in cases of non-native or disordered speech. The present experiments investigate listeners' ability to adjust perceptual cue weighting in online perception in response to changes in the cue correlations experienced across time. Native-English listeners heard minimal-pair words beginning with stop consonants varying along a VOT series. The *F*0 of the words was gradually shifted over the course of the experiment from the canonical English correlation (higher *F*0 for voiceless stops) to the opposite pattern (lower *F*0 for voiceless stops). Categorization was assessed via explicit responses while eye gaze data were simultaneously recorded using the visual world paradigm. Both data types revealed that the influence of *F*0 on voicing categorization changed in response to changes in *F*0/VOT correlation. Some listeners use of *F*0 reversed such that higher *F*0 led to more voiced responses; other listeners discontinued use of *F*0 in voicing categorization. These patterns suggest that listeners are continually monitoring the input for regularity and retuning acoustic cue use in an online manner to accommodate these regularities.

1aSC18. Characteristics of listener sensitivity to talker-specific phonetic detail. Rachel M. Theodore and Joanne L. Miller (Dept. of Psych., 125 NI, 360 Huntington Ave., Boston, MA 02115-5000)

Listeners are sensitive to talker differences in phonetic properties of speech, including voice-onset-time (VOT) in word-initial stop consonants. Earlier findings from our laboratory [R. M. Theodore and J. L. Miller, J. Acoust. Soc. Am. **123**, 3934 (2008)] indicate that learning how a talker produces one voiceless stop (e.g., /p/ in *pain*) transfers to another voiceless stop (e.g., /k/ in *cane*), providing support for feature-based processing of VOT at the level of individual talkers. Here we examined possible constraints on such processing by asking whether transfer would also occur when the learning and transfer words were not minimal pairs. In familiarization phases, listeners heard two talkers produce *pain*. Critically, word-initial VOTs were manipulated such that one talker produced *pain* with relatively short VOTs and the other talker produced *pain* with relatively long VOTs. In test phases, listeners were presented with a short-VOT and a long-VOT variant of *coal* produced by each talker, and were asked to select which variant was most representative of the talker. Results showed that the listeners selected the VOT variant of *coal* in line with their previous exposure to *pain*, indicating that feature-based processing of talker-specific VOT is robust.

1aSC19. Categorization, category goodness, and psychophysical difference in perceptual assimilation. Jenna Silver (Dept. of Commun. Sci. and Disord., Univ. of Florida, Gainesville, FL 32611), Ratree Wayland (Univ. of Florida, Gainesville, FL 32611), and James D. Harnsberger (Univ. of Florida, Gainesville, FL 32611)

Two experiments were conducted to investigate the relative importance of three factors that influence the perceptual assimilation (i.e., identification and discrimination) of non-native speech contrasts: the categorization of non-native speech sounds with native speech sounds, the goodness of fit in such categorization judgments (or category goodness), and the phonetic differences between non-native stimuli. These factors were examined in a series of categorial *AXB* discrimination and forced-choice identification tests (which included goodness ratings) involving the perception by 80 native speakers of American English of 2 Hindi voicing contrasts, /tS/-/dZ/ and /k/-/g/, produced by three talkers in initial position in three different vowel contexts. The discrimination scores were correlated with (1) categorization scores based on the proportions of different responses in identification, (2) mean difference in goodness ratings, and (3) the results of an analysis of multiple acoustic cues for the Hindi stimuli (representing phonetic difference). Overall, the categorization factor showed the strongest correlation with discrimination scores ($r=0.87^{**}$), relative to phonetic difference ($r=0.57^{*}$), which was accounted for exclusively by measures of voice onset time. For non-native contrasts that were identified with single native categories, category-goodness difference was a more important factor in discrimination ($r=0.61^{**}$) relative to phonetic difference ($r=0.50^{*}$).

1aSC20. Perception of Japanese mora nasal /N/ and mora obstruent /Q/ by native Japanese, English, and Thai speakers. Takeshi Nozawa (Program in Lang. Education, College of Economics, Ritsumeikan Univ., 1-1-1 Nojihigashi, Kusatu, Shiga 525-8577, Japan, t-nozawa@ec.ritsumei.ac.jp) and Yuriko Furukawa (Osaka Univ., Mino, Osaka 562-8558, Japan)

Japanese mora nasal /N/ and more obstruent /Q/ are produced at different places of articulation, being homorganic with the following consonant. Four native speakers of Japanese produced /N/ and /Q/ in /CVNCV/ and /CVQCV/ contexts, where the consonant after /N/ and /Q/ is always a stop. Their utterances were recorded and digitized. The word final /CV/ was edited out, and the stimuli with the structure of /CVN/ and /CVQ/ were created. Twelve native speakers of Japanese, American English, and Thai were recruited as listeners. The listeners were told to identify the syllable-final nasal (/m/, /n/ or /ŋ/, and the missing stop (/p/, /t/, /k/, /b/, /d/, or /g/). Generally, the Thai listeners outperformed the other two groups of listeners, and the Japanese listeners performed most poorly. The Thai listeners good performance may be partly explained by the fact that in Thai postvocalic stops are normally unreleased, and the Thai listeners were less dependent on the release burst to identify the place of articulation of a postvocalic stop. The Thai listeners tended to identify voiced stops as voiceless stops of the same place of articulation. This may be because voiced stops cannot occur postvocalically in Thai.

1aSC21. Phonetic discrimination is affected by native language phonology. Jessica Maye (Dept. of Commun. Sci. and Disord., Northwestern Univ., 2240 Campus Dr., Evanston, IL 60208, j-maye@northwestern.edu)

English and Japanese speakers were tested on discrimination of phonetic contrasts that vary in their phonemic status according to phonological context. The presence versus absence of /u/ in English stimulus pair *ebzo-ebuzo* is nonphonemic in Japanese due to phonological syllable structure constraints, but in word-initial position (stimulus pair *zobe-uzobe* the same contrast is phonemic. Similarly, the contrast between Japanese /d/ versus /r/ is nonphonemic in the foot-medial position in American English due to an allophonic flapping process, but in word-initial position the two sounds are perceived as the English phonemic contrast /d/ versus /l/ (Japanese stimulus pairs *gudo-guro* and *dogu-rogu*. Participants were tested in a four-token oddball task on all four stimulus sets in a blocked design. Each participant group (Japanese and English) showed significantly poorer discrimination of the non-native contrast when it appeared in the phonological context in

which it is nonphonemic in their native language (p's < 0.001). This result was equally robust even for stimuli in which the contrastive portion of the stimulus (*zo-uzo*, *do-ro*) was spliced from the nonphonemic context and pasted into the phonemic context. These data indicate that phonological context plays an integral role in the perception of phonetic signals.

1aSC22. Articulatory gestures influence the perception of speech. Henny Yeung (Dept. of Psych., Univ. of British Columbia, 2136 West Mall, Vancouver, BC V6T 1Z4, Canada, hhyeung@psych.ubc.ca), Mark Scott, Bryan Gick, and Janet Werker (Univ. of Birtish Columbia, Vancouver, BC V6T 1Z4, Canada)

A central claim of the motor theory of speech perception [Liberman *et al.* (1967)] is that speech perception involves motor representations. We report evidence that articulatory movements influence perception. Subjects made forced-choice identifications of naturally recorded /aba/ and /ava/ tokens, while silently making articulatory gestures in time with presentation of the auditory tokens. These articulatory gestures either agreed with the auditory token (e.g., articulating "aba" while hearing /aba/) or disagreed (e.g., articulating "ava" while hearing /aba/). Subjects more frequently misidentified auditory /aba/ as /ava/ when articulated gestures disagreed, as compared to a base line condition (i.e., simply listening). Two further conditions suggest that simple priming of /ava/-percepts is unlikely. First, subjects articulated "afa" instead of ava while hearing /aba/. If error rates are specifically related to articulatory gestures, then the similarity in gestural movements between /f/ and /v/ should result in similar error rates. A priming account would not make such a prediction. In line with the motor explanation, subjects did have an equivalent error rate in afa and ava conditions. Second, minimal interference was observed when subjects only imagined themselves saying /ava/. These results support the notion that activation of motor movements can influence the perception of speech.

1aSC23. Investigating the consonant-vowel boundary. II. Perceptual contributions of glimpse windows. Daniel Fogerty and Diane Kewley-Port (Dept. of Speech and Hearing Sci., Indiana Univ., 200 S. Jordan Ave., Bloomington, IN 47405, dfogerty@indiana.edu)

Discrete segmental units do not occur in fluent speech because of coarticulation. However, separation of the meaningful sounds in language into the categories of consonants and vowels is one of the most fundamental principles of how sound is structured. Our previous research has shown that for sentence presentations, vowels have a distinct perceptual advantage over consonants in determining sentence intelligibility. TIMIT sentences were used to investigate perceptual contributions of consonants and vowels across the consonant-vowel (CV) boundary, by shifting the CV boundary by specific proportions of the vowel, such that consonant duration increased while vowel duration decreased. Glimpse windows are defined as the speech signal preserved between noise replacements. The perceptual effect of windows either locked to specific segmental information or placed randomly was examined. Results from glimpse windows locked to segmental information confirmed a 2-to-1 vowel advantage for intelligibility at the traditional CV boundary and suggest that vowel contributions remain robust against deletions of the signal. When glimpses were presented randomly, summed duration of glimpses predicted performance. However, performance remained lower than when glimpse windows of equivalent duration were locked to vowels. Specific segmental information appears to differentiate performance between consonant and vowel conditions. [Work supported by the NIH.]

MONDAY AFTERNOON, 10 NOVEMBER 2008 LEGENDS 9, 1:00 TO 3:10 P.M.

Session 1pAAa

Architectural Acoustics: Acoustics of Single Family Residences

Richard D. Godfrey, Cochair
448 N. Pearl St., Granville, OH 43023

Nancy S. Timmerman, Cochair
25 Upton St., Boston, MA 02118-1609

Chair's Introduction—1:00

Invited Papers

1:05

1pAAa1. New home buyer noise reduction listening study. Harry A. Alter (19 Beechtree Ln., Granville, OH 43023)

In 2007 Owens Corning Science Technology in Granville, Ohio built a comparative wall assembly listening facility called the Acoustic Research Experience Laboratory (AREL) Annex. Within this listening facility, approximately 100 perspective new home buyers were selected to listen and evaluate various sound clips when played through wall assemblies at varying levels of noise reduction. Jurors responded to perceptual and lifestyle questioning. The building of the AREL Annex and listening study results will be discussed.

1:25

1pAAa2. Effects of residential audible distractions on the performance and perception of home office workers. Alicia J. Wagner and Lily M. Wang (Architectural Engr. Prog., Peter Kiewit Inst., Univ. of Nebraska-Lincoln, 1110 S. 67th St., Omaha, NE 68182-0681, aliciajean01@gmail.com)

This research examines the effects that typical residential audible distractions have on task performance and subjective perception of home office workers when transmitted across various residential wall constructions. Previous studies have investigated how speech, music, and office equipment noises may deteriorate one's performance, but few have presented these distractions in such a way as to imitate the home office environment or used audible distractions that are characteristic of a residential setting. In this study, subjects performed math, verbal, and typing tasks over 1 h while exposed to four types of audible distractions: (1) pop music, (2) television, (3)