Session 5pMU

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

Edgar J. Berdahl, Chair
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Invited Papers

1:00

5pMU1. Real-time physical models of musical instruments: Applications and findings. Florian Pfeifle and Rolf Bader (Inst. of Musicology, Univ. of Hamburg, Neue Rabenstrasse 13, Hamburg 20354, Germany, Florian.Pfeifle@uni-hamburg.de)

Real-time auralization of physical models has attracted vivid interest over the last years. This is mainly due to the rising computational capabilities of personal computers and the accessibility of specialized (external) accelerating hardware, like GPGPUs (general-purpose graphics processing units) or FPGAs (field programmable gate arrays). In this work, an extended framework of real-time physical models of musical instruments, calculated with symplectic and multi-symplectic finite difference algorithms, on a FPGA is presented. The former study, as presented in earlier publications by the authors, is extended in three aspects: (a) A methodology for coupling FPGA boards via a highspeed general purpose IO, to facilitate calculations of larger instrument geometries, such as piano sound-boards, is implemented. (b) A generalized design structure for all models is developed. (c) An enhanced external interface communication protocol is realized. These extensions resulted in several new possible applications for music and for musicological research.

1:20

5pMU2. Embedded physical modeling synthesis in three dimensional environments. Stefan Bilbao (Music, Univ. of Edinburgh, Rm. 7306B, JCMB, Kings Bldgs, Mayfield Rd., Edinburgh EH9 3JZ, United Kingdom, sbilbao@staffmail.ed.ac.uk)

3D audio rendering of virtual spaces, for purposes of artificial reverberation, or in concert hall auditioning has seen great advances in recent years. Of particular interest are wave based techniques, such as finite difference time domain methods. Such methods are computationally intensive, and parallel architectures, such as GPGPUs, can be of use in accelerating computation times. A further use of such methods is in synthesis—through the embedding of physical models in a three dimensional space, allowing the complete spatial rendering of the acoustic field. In this paper, a variety of membrane- and plate-based percussion instruments will be discussed, with special emphasis on implementation issues in parallel hardware. Sound examples will be presented.

1:40

5pMU3. Computation and simulation of frequency variations in musical instrument sounds. James W. Beauchamp (School of Music and Dept. of Elec. & Comput. Eng., Univ. of Illinois at Urbana-Champaign, 1002 Eliot Dr, Urbana, IL 61801-6824, jwbeauch@illinois.edu)

Frequency variations of musical instrument sounds were measured using phase-derivative and frequency-tracking methods based on the short-time Fourier transform. Frequency variations are important features of instrument sounds and are very useful for musical expression. Three categories of variation are: vibrato, portamento, and microvariation. Microvariations exist even when a tone is played at a constant pitch, and they can be approximated as small frequency-deviation low-frequency noise signals. Portamento is a purposeful pitch glide embellishment that can occur during attacks, between notes, or, less often, at the ends of notes. Vibrato can be characterized as an approximately sinusoidal frequency variation, and usually its amplitude is sufficient to interact with instrument resonances and cause significant harmonic amplitude modulations. Deviation amplitudes and frequencies of acoustic instrument vibratos are not perfectly steady, but rather vary over the durations of instrument tones. Measurements of vibrato characteristics of the harmonic frequencies and amplitudes as well as the frequency and amplitude microvariations of various instruments and voice indicate that a variety of parameters are required for effective instrument synthesis. The challenge in synthesis is to avoid a "mechanical sound."

Contributed Papers

2:00

5pMU4. Haptic interaction design using Synth-A-Modeler. Edgar J. Berdahl (Music, Louisiana State Univ., 102 New Music Bldg., Baton Rouge, LA 70803, eberdahl@ccrma.stanford.edu)

Synth-A-Modeler is an open-source and modular software environment for designing physical models using a mechanical analog approach. Notably, physical models provide the most reliable method for programming haptic force-feedback interactions that can be ported across a wide array of haptic devices and usage scenarios. In this presentation, we explain how Synth-A-Modeler facilitates teaching haptic interaction design, with an emphasis on audio-haptic interaction. A series of example models demonstrates how mass-interaction, modal synthesis, and digital waveguide elements, as well as combinations thereof, can be employed in

Synth-A-Modeler to simulate virtual audio-haptic environments. Although Synth-A-Modeler can hide the details of the model implementations, some equations are employed to calibrate the models. The models are tested with the FireFader open-source haptic device; however, the models should be compatible with a wide array of other haptic devices and DSP targets as well.

2:15

5pMU5. Physical modeling of musical instruments on handheld mobile devices. Gregory P. Scandalis, Julius O. Smith, and Nick Porcaro (moForte.com, 286 Carmelita Dr., Mountain View, CA 94040, gps@moforte.com)

Handheld mobile computing devices are now ubiquitous. These devices are powerful, connected and equipped with a variety of sensors. Their pervasiveness has created an opportunity to realize parametrically controlled, physically modeled, virtual musical instruments. We will present a brief history of physically modeled musical instruments and the platforms that those models have been run on. We will also give an overview of what is currently possible on handheld mobile devices including modeling done in the "moForte Guitar" mobile application. "moForte Guitar" is an application for mobile devices that models the physics of the guitar family of instruments. Modeling makes expressive interactive articulation possible, which cannot be directly achieved with sample playback techniques. Features that are modeled include: electric and acoustic instruments, strumming at various string positions, string scraping and damping, harmonics, glissando, automated modeling of strumming, statistical variation of physical parameters, feedback/distortion and classic processed electric guitar effects. We will show a number of real-time demonstrations on a handheld mobile device for what is possible with this model.

2:30

5pMU6. Spectrally accurate numerical solution of acoustic wave equations. John W. Amuedo (Signal Inference, 3267 Butler Ave., Los Angeles, CA 90066, jamu@siginf.com)

Finite difference models of wave propagation have presented challenging problems of stability and accuracy since initial experimentation with these models began on early digital computers. The advent of spectral methods in the late 1960s has led to the latter's increasing use for solving differential equations in a range of fluid dynamic, electromagnetic and thermal applications. Spectral methods transform a physical grid of state variables (such as acoustic velocity and pressure) into an alternative spectral space characterized by a particular set of basis functions. Spatial derivatives of physical state variables are computed in spectral space using exact differential operators expressed in terms of those functions. Fast numerical transforms are employed to exchange immediate state of a simulation between its spectral and physical representations. In problems equally suited to spectral and finite difference formulation, spectral methods often yield increased fidelity of physical results and improved stability. Spectral methods sometimes enable computational grid size requirements of a simulation to be substantially reduced, with concomitant computational savings. This paper reports on spectral implementations of the acoustic wave equation and Webster horn equation for simulating audio transducer cavities, musical instrument resonators, and the human vocal tract.

2:45

5pMU7. The mother tongue of organ pipes-Synchronization, experiments, numerical simulations, and model. Jost Fischer and Markus Abel (Dept. for Phys. and Astronomy, Univ. of Potsdam, Karl-Liebknecht-Str 24/25, Potsdam, Brandenburg 14476, Germany, jost.fischer@uni-potsdam.de)

We present recent results on the synchronization (Mitnahme Effect) of organ pipes. Previous work has focused on the detailed measurement and reconstruction of the driving of an organ pipe by a loudspeaker. As a result the full Arnold tongue was measured and reconstructed and a synchronization could be found down to a fraction of 1/500 of the sound pressure level of the organ pipe. In this contribution, we give detailed results on the experimental determination of the Arnold Tongue for two pipes. The results are accompanied by detailed numerical simulations of sound generation and sound radiation with the aim to clarify the interaction of the jets and the dependence of the synchronization region on coupling strength (realized by varying distance). Furthermore, we propose a model for the coupling function.

3:00

5pMU8. Towards a physical model of the berimbau: Obtaining the modal synthesis of the cabaza. Pablo Castellanos Macin and Julius O. Smith (Dept. of Music - Ctr. for Comput. Res. in Music and Acoust. (CCRMA), Stanford Univ., 660 Lomita Dr., Stanford, CA 94305, pablocm@ccrma.stanford.edu)

The worldwide presence of Brazilian culture grows every day. However, some of the musical instruments used in its principal cultural activities lack of a formal acoustic analysis which would make them more understandable for the rest of the world. One of them is the berimbau-de-barriga (berimbau), which consists of a string (wire) attached to an arched rod and a resonance box called cabaza. Modeling the berimbau will not only open up possibilities for its application to other musical genres, but will also allow the incorporation of its characteristics into new virtual instruments. The present work describes the modal synthesis of the cabaza, i.e., modeling this sounding box as a parallel bank of digital resonators. Impulse response measurements were obtained using a force hammer, and second-order resonator frequency-responses were fit to the data using MATLAB.

3:15

5pMU9. Aural ordinary differential equations: Methods for generating audio from mass-spring systems. Andrew S. Allen (UCSD, 4757 Clairemont Mesa Blvd., Apt. 306, San Diego, CA 92117, drewbitllama@gmail.com)

In this article, I focus on the harmonic oscillator as a model by which to compare several numerical methods for solving ordinary differential equations (ODEs). I first define the simple harmonic oscillator as an ODE and then extend its behavior by adding additional forces and physical properties to the equation. I next proceed to discuss computational methods for solving ODEs and use the oscillator model as a means of evaluating and comparing three methods in terms of their stability, drift, and computational costs when working at the audio-rate.

3:30

5pMU10. Modeling the free vibrations of an acoustic guitar top plate. Micah R. Shepherd, Stephen A. Hambric, and Dennis B. Wess (Appl. Res. Lab., Penn State Univ., PO Box 30, M.S. 3220B, State College, PA 16801, mrs30@psu.edu)

Using computer models to simulate the sound of an acoustic guitar can significantly decrease lead time for new designs. In order to create an accurate computer model of a Dreadnought-style acoustic guitar, a sequential modeling approach was used. A finite element model of a bare top plate with braces and a bridge plate was created. The top and plate and braces were modeled as plate elements with orthotropic material properties. The natural variation of the wood properties was also examined along with their dependence on moisture content. The modes of the model were then compared to experimentally obtained modes from top plate prototypes. The modeshapes of the model compared well to those measured. Uncertainty analysis was also performed and the statistical bound of natural error between wood samples was determined to be approximately 8%. The natural frequencies of the model fell within the error bound for lower-order modes but diverged slightly for several higher-order modes. These results indicate the importance of using accurate material properties in models of acoustic guitars.

Session 5pSC

Speech Communication: Crosslinguistic Analysis (Poster Session)

Molly E. Babel, Chair
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Contributed Papers

5pSC1. Range of variability in native and non-native spontaneous speech intervocalic stops. Miguel Simonet (Spanish and Portuguese, Univ. of Arizona, Tucson, AZ), Natasha L. Warner, Dan Brenner, Maureen Hoffmann, Andrea Morales, and Alejandra Baltazar Molina (Dept. of Linguist., Univ. of Arizona, Box 210028, Tucson, AZ 85721-0028, nwarner@u.arizona.edu)

Speakers produce sounds differently in spontaneous vs careful speech, and how they do this shows both similarities and differences across languages. The current project examines spontaneous conversational speech and read speech among monolingual English speakers, Dutch-English bilinguals, and Spanish-English bilinguals (for Dutch and Spanish, in both their L1 and English). The phonology of intervocalic stops differs in these languages: Dutch has final devoicing, Spanish has approximation of /bdg/, and English has flapping of /td/. In our recordings, Dutch speakers often devoiced final stops in both Dutch and English in spontaneous speech, while native English speakers produced voiced stops or approximants. Speakers of all the languages produced some approximant realizations and some deletions. Through measurements of consonant duration, amplitude dip during the consonant, and cessation of voicing, this work shows the range of acoustic variability produced by speakers of three languages in their L1 and their L2, in spontaneous and careful speech. This allows a comparison of how much of speech variability stems from the native language phonology, from language-specific phonetics, and from language-general spontaneous speech reduction.

5pSC2. Intelligibility of speaking styles elicited by various instructions. Rachael C. Gilbert, Nicholas Victor (Linguist, Univ. of Texas at Austin, 4812 Ave. H, Apt. B, Austin, TX 78751, rachaelgilbert@gmail.com), Bharath Chandrasekaran (Commun. Sci. & Disord., The Univ. of Texas at Austin, Austin, TX), and Rajka Smiljanic (Linguist, Univ. of Texas at Austin, Austin, TX)

The acoustic-phonetic modifications made by talkers are attuned to the specific communicative situations that listeners are experiencing (Lam and Tjaden, 2013; Hazan and Baker, 2011). The extent to which such modifications are under explicit control remains largely unknown. This study examined the extent to which native and non-native talkers can implement acoustic-articulatory enhancements following specific instructions and the extent to which these changes will improve intelligibility. Ten native and 10 Korean-accented talkers read sentences in various styles including in conversational and clear speech, while imitating a native speaker's conversational and clear speech, with exaggerated vowels, more slowly, and more loudly. Sentences were mixed with noise (−5 dB SNR) and presented to native listeners. Intelligibility results revealed that nonnative talkers were overall less successful in enhancing intelligibility following different instructions compared to native talkers. Instructions to speak clearly and imitating native clear speech sentences provided the largest intelligibility benefit while the instructions to slow down were least successful in improving intelligibility across talkers. Speaking loudly and exaggerating vowels increased intelligibility only for native talkers. Acoustic analyses will examine which acoustic-phonetic changes were implemented following each instruction. The results have important implications for enhancing intelligibility in difficult communicative situations (e.g., classrooms).

5pSC3. Normalization and matching routine for comparing first and second language tongue trajectories. Shusuke Moriya, Yuichi Yaguchi, Naoki Terunuma, Takahiro Sato, and Ian Wilson (Univ. of Aizu, Tsuruga Ikkimachi, Aizuwakamatsu, Hukushima 965-8580, Japan, s1190242@gmail.com)

The main purpose of this research is specifying the articulation difference between L1 and L2 speakers by digitizing tongue motions and analyzing their differences between utterances. Differences in tongue motion directly influence speakers' pronunciation, so it may be possible to determine a speaker's L1 from tongue motion data. By comparing L1 and L2 speakers' tongue motion, we can also guide L2 speakers to improve their L2 pronunciation. In this research, we use coronal cross sections of the tongue taken by an ultrasound scanner to carry out the following: first, record the ultrasound of a speaker's tongue motion using the story "The Boy Who Cried Wolf." Then, sample mobility information by using histogram of oriented gradients. Next, use Karhunen-Loeve expansion to reduce the vector dimensions. At this time, we get the average difference between the starting vector of tongue motion and the subsequent vectors, then normalize the direction of the two averages. Finally, we use dynamic time warping to compare each vector per frame. The experiment results allowed us to compare speakers' tongue mobility information in words which were recorded in different experiment environments or by different speakers.

5pSC4. Coarticulatory effects of lateral tongue bracing in first and second language English speakers. Sunao Kanada, Ian Wilson (CLR Phonet. Lab., Univ. of Aizu, Tsuruga, Ikki machi, Aizuwkamatsu, Fukushima 965-8580, Japan, s1180011@u-aizu.ac.jp), Bryan Gick (Dept. Linguist, Univ. of Br. Columbia, Vancouver, BC, Canada), and Donna Erickson (Showa Music Univ., Kawasaki, Japan)

This study uses electromagnetic articulometry (EMA) to examine the coarticulatory effects of tongue bracing in L1 and L2 English speakers. The tongue is hydrostatic, so we brace it against our teeth for added control, and this bracing is an important part of pronunciation. The amount of bracing may differ across languages (and may be part of one's articulatory setting), so understanding these differences could be a key to L2 pronunciation learning. Although lingual coarticulation has been examined using acoustics and midsagittal views of the vocal tract, not much focus has been placed on the coronal view. We collected EMA point-tracking data from two native speakers of North American English and looked at the movement of a lateral tongue marker. As stimuli, we choose the nursery rhyme "Mary had a Little Lamb" because of the variation in vowels, and also the /l/ and /r/ phonemes, which are absent in Japanese. Initial results show differences between vowels that occur next to /l/ and those that occur next to /r/ and stops. Results will also be presented for Japanese speakers of both their L1 (Japanese) and L2 English. If we find crosslinguistic differences in bracing, this fact will be important for pedagogical purposes.

5pSC5. Perceptual and phonotactic effects in loanword adaptation: English postvocalic stops in Taiwan Mandarin. Jui Ching Chang (National Chiao Tung Univ., 3/F, Humanities Bldg. 2, 1001 Ta-Hsueh Rd., Hsinchu 300, Taiwan, Hsinchu 300, Taiwan, showtheray@gmail.com)

When an English word with a postvocalic stop is borrowed into Taiwan Mandarin (TM), because TM allows only nasal coda consonants, an often-used strategy to repair the illegality is vowel-insertion (e.g., Wood → [wu.tɤ]). Based on a corpus study of 335 English borrowed names, this trend is confirmed (76%). Among the deleted cases, an asymmetry of different places of articulation was found: Coronal stops are deleted most often (15%, e.g., Hollywood → [hau.lai.wu]), and dorsals more often than labials (12%, e.g., Titanic → [t^{h}iɛ.ta.ni] vs 0%, e.g., Jeep → [tɕ. p^{h}**u**]). Following Kang's (2003) perceptual explanation, the tendency of coronal-deletion can be explained by the fact that postvocalic coronals are often unreleased and thus less perceptually salient to TM speakers. According to TIMIT corpus, the release rate of coronals, labials, and dorsals stops is 37%, 52%, and 83%, respectively (Kang, 2003). However, this cannot explain the reversed pattern of dorsals and labials. I propose that this is due to another factor: Labial coda is marked in TM since only [n] and [ŋ], but not [m], can occur in coda position. In other words, the deletion of postvocalic stops depends on the saliency that considers both perceptual and phonotactic factors.

5pSC6. Neural plasticity in phonetic training of the /i-I/ contrast for adult Chinese speakers. Bing Cheng (Xi'an Jiaotong Univ., 164 Pillsbury Dr. SE, 115 Shevlin Hall, Minneapolis, Minnesota 55455, chengbing72@gmail.com) and Yang Zhang (Univ. of Minnesota, Minneapolis, MN)

This study investigated neural plasticity associated with phonetic training using a software program developed after Zhang *et al*. [NeuroImage **46**, 226–240 (2009)]. The target sounds were /i/ and /I/ in English, a non-phonemic contrast in Mandarin Chinese. The training program integrated four levels of spectro-temporal exaggerations, multi-talker variability, audio-visual presentation, and adaptive listening in seven sessions, each lasting about 15 min. The participants were ten adult Chinese English-as-a-second-language learners. Identical pre- and post-tests were administered one week before and after training. Behavioral measures included discrimination and identification tasks as well as formant analysis of vowel production. Event Related Potential (ERP) measures examined training-induced changes in the mismatch negativity (MMN) responses. The behavioral results showed significant improvement in identification and discrimination scores and a clear continuous-to-categorical perceptual shift, which were also reflected in the MMN responses for detecting the across- vs within-category differences at the pre-attentive level. There was also strong evidence for transfer of learning from trained to untrained stimuli as well as from perception to production. The results demonstrate the existence of substantial neural plasticity for speech learning in adulthood and provide further testimony for the efficacy of the adaptive audiovisual training method for promoting second language phonetic learning.

5pSC7. The perception of Mandarin lexical tones by native Japanese and Thai listeners. Kimiko Tsukada (Int. Studies, Macquarie Univ., Sydney, NSW, Australia), Rungpat Roengpitya (Faculty of Liberal Arts, Mahidol Univ., Mahidol University, Bangkok, Thailand, rungpat@gmail.com), Hui Ling Xu (Int. Studies, Macquarie Univ., Sydney, NSW, Australia), and Nan Xu (Linguist, Macquarie Univ., Sydney, NSW, Australia)

Mandarin differentiates four tones (T1: high level (ā), T2: high rising (á), T3: dipping (ǎ), T4: high falling (à)). Learning these lexical tones is known to be difficult for those from non-tonal language background (e.g., English). What about listeners with no knowledge of Mandarin but have varying experience with tones or pitch variation? This study examined the discrimination of 6 Mandarin tone contrasts (T1-T2, T1-T3, T1-T4, T2-T3, T2-T4, and T3-T4) by native speakers of Japanese (pitch-accent language) and Thai (tonal language). The listeners' tone discrimination accuracy was assessed in a categorical discrimination test developed by Jim Flege and colleagues. Both non-native groups were less accurate than the native group, in particular, for the T1-T2, T1-T3, T1-T4, and T2-T3 contrasts. Despite using lexical tones in their first language (L1), Thai listeners did not have a distinct advantage over Japanese listeners and the two groups showed a similar pattern of results. Overall, discrimination accuracy of contrasts involving T1 was lower than other contrasts with the exception of T2-T3. Both Japanese and Thai listeners had greatest difficulty with T2-T3. Since previous knowledge of L1 tones may interfere with the perception of non-native tones, these results will be discussed with reference to a Thai tonal system.

5pSC8. The effect of language distance and language experience in third language acquisition. Seung-Eun Chang (East Asian Lang. and Cultures, Univ. of California Berkeley, 3413 Dwinelle, Berkeley, CA 94720-2230, sechang71@berkeley.edu)

This research aims to examine the role of second-language (L2) phonology in third-language (L3) acquisition. As a mean to assess the degree of influence of the L1 accent and L2 accent in L3 production, an experiment that involved the judgment of a foreign accent was developed. Two groups of native English speakers [(i) five who had not learned any language other than Korean, and (ii) five who had learned Japanese before learning Korean] produced Korean sentences, and 25 native Korean-speaking raters identified each production according to the speaker's dominant accent, either English or Japanese. The results revealed that native English speakers who had learned Japanese before learning Korean were more frequently identified as having a strong Japanese, rather than English, accent in their Korean production. In accounting for the results, several hypotheses were discussed, including language distance (typological proximity), inherently different mechanisms for foreign language acquisition as compared with the natural acquisition of the L1, psycho-affective factors, and stronger links between foreign languages in the speaker's mind. The findings of this study provide further evidence for the claim that L2 exerts an influence on L3 accent; however, this interference is reduced with an increase in L3 proficiency

5pSC9. The effects of acoustically enhanced speech on lexical tone perception in Mandarin as second language learners. Huei-Mei Liu (Special Education, National Taiwan Normal Univ., 162 Ho-Ping East Rd. SEC 1, Taipei 106, Taiwan, liumei@ntnu.edu.tw) and Feng-Ming Tsao (Psych., National Taiwan Univ., Taipei, Taiwan)

The tonal language learners who speak non-tone language have difficulty discriminating lexical tones of a tone language. This study aimed to examine the effects of acoustically enhanced speech on perceptual sensitivities and organizations of lexical tones in Mandarin as second language learners. Three groups of participants were recruited, native Mandarin speakers (n = 26), native English speakers (n = 28), and native Thai speakers (n = 26). Both groups of Mandarin learners have learnt Mandarin as second language (L2) for several years. Mandarin lexical tone discrimination and identification tasks with two sets of tone stimuli, with and without pitch contour exaggeration, were used in this study. The results showed that Mandarin L2 learners performed less well on the tone discrimination and identification tasks, relative to native Mandarin speakers. In addition, Mandarin L2 learners perceptually weight less to pitch direction than pitch height in their perceptual organization for tones, showing different perceptual weights from native Mandarin speakers. In the context of listening to acoustically enhanced stimuli, the group difference on tonal sensitivity and cue-weighting patterns of perceptual organization were greatly reduced. Results imply that the signal enhancement facilitates Mandarin L2 learners to process lexical tones.

5pSC10. Acoustic measurement of word-initial stop consonants in English-French interlingual homophones. Paula Castonguay and Jean E. Andruski (Commun. Sci. and Disord., Wayne State Univ., 60 Farnsworth St., 207 Rackham Bldg, Detroit, MI 48202, dx4720@wayne.edu)

The purpose of the present study is to examine word-initial stop consonants of Canadian English (CE) and Canadian French (CF) interlingual homophones in order to describe how they differ in their acoustic properties. Interlingual homophones (IH) are words across languages that are phonemically identical but phonetically and semantically different, for example, English two /tu/ and French tout <all> /tu/. Even though they are deemed phonemically identical, at the acoustical level they may be quite different. In the current study, Canadian bilingual English and French speakers were asked to produce interlingual homophones embedded in carrier phrases and in isolation. Voice onset time, relative burst intensity, and burst spectral

properties of the IH words were measured and compared within and across languages. The acoustic measurements obtained will be used (1) to make predictions about which acoustic features may provide cues to language identity, and (2) to create stop tokens for a Goodness Rating study. Results from this study will provide insight on the acoustic-phonetic representation of stop consonants in Canadian bilingual English and French speakers.

5pSC11. The use of durational variables to characterize the rhythmic patterns of non-fluent Japanese utterance by non-native speakers. Shigeaki Amano, Kimiko Yamakawa (Faculty of Human Informatics, Aichi Shukutoku Univ., 9 Katahira, Nagakute, Aichi 480-1197, Japan, psy@asu.aasa.ac.jp), and Mariko Kondo (School of Int. Liberal Studies, Waseda Univ., Shinjuku, Tokyo, Japan)

Twenty-nine durational variables were examined to clarify rhythmic characteristics in non-fluent Japanese utterances by non-native speakers. Discriminant analysis with these variables was performed on 343 Japanese words, each pronounced in a carrier sentence by six native Japanese speakers and 14 non-native Japanese speakers (7 Vietnamese with low Japanese proficiency and 7 Chinese with high Japanese proficiency). The results showed that a combination of two durational variables could discriminate Japanese speakers from Vietnamese speakers with a small error (8.7%, $n = 4458$), namely the percentage of vowel duration and the average of "Normalized Voice Onset Asynchrony," which is an interval time between the onset of two successive vowels divided by the first vowel's duration. However, these two variables made a large error (39.4%, $n = 4458$) in the discrimination of Japanese speakers from Chinese speakers who had higher Japanese proficiency than Vietnamese speakers. These results suggest that the two variables characterize the rhythmic pattern in a non-fluent Japanese utterance by non-native speakers with low Japanese proficiency. [This work was supported by JSPS KAKENHI Grant Numbers 22320081, 24652087, 25284080, and by Aichi Shukutoku University Cooperative Research Grant 2013-2014.]

5pSC12. Prosodic characteristics in Japanese speech by Taiwan Mandarin speakers and native Japanese speakers. Naomi Ogasawara (Ctr. for Lang. Res., Univ. of Aizu, 90 Tsuruga Ikkimachi, Aizuwakamatsu 965-8580, Japan, naomi-o@u-aizu.ac.jp), Timothy J. Vance (National Inst. for Japanese Lang. and Linguist, Tokyo, Japan), and Chia-Lin Shih (The Graduate Inst. of Linguist, National Taiwan Normal Univ., Taipei, Taiwan)

Previous studies (Ishihara *et al*., 2011; Sato 1995) show that prosody contributes more to native-like accents than segments do. It was also found that compared with errors in timing, errors in pitch accent in Japanese speech were more tolerable to native and non-native speakers. This suggests that non-native speakers pay less attention to pitch accent when speaking Japanese; as a result, their acquisition of correct pitch accent does not progress as their overall Japanese proficiency improves. In this study, Taiwan Mandarin speakers and native Japanese speakers produced Japanese words with different syllable structures, some containing all short syllables and others at least one long syllable. These words are 2 to 4 moras long and have nine pitch accent patterns. Each participant produced each word in isolation and in a carrier sentence. All speech data were acoustically analyzed to measure (1) the highest F0 point in accented syllables and (2) the difference in F0 between an accented syllable and adjacent unaccented syllables. The purpose of this study is to investigate common F0 patterns in pitch accents among native and non-native speakers of Japanese, and common pitch accent errors made by the non-native speakers.

5pSC13. Vowel identification in temporal modulated noise for native and non-native listeners: Effect of language experience. Jingjing Guan, Chang Liu (Dept. of Commun. Sci. and Disord., The Univ. of Texas at Austin, 1 University Station A1100, Austin, TX 78712, jane.guan@utexas.edu), Sha Tao, Lin Mi, Wenjing Wang, and Qi Dong (State Key Lab. of Cognit. Neurosci. and Learning, Beijing Normal Univ., Beijing, China)

Previous work in our laboratories found vowel identification in babble was significant different between Chinese-native listeners in China and United States. As a follow-up, the current study focused on whether the two groups of Chinese listeners had any difference in using temporal cues of noise for vowel identification. Temporal modulation transfer function and vowel identification in temporal modulated noise were measured for American English native (EN) listeners, Chinese-native listeners in United States (CNU), and Chinese-native listeners in China(CNC). Results revealed that TMTF is similar across three groups, indicating that psychophysical temporal processing is independent of listeners' language backgrounds. However, for vowel identification in noise, EN and CNU listeners showed significantly greater masking release from temporal modulation of the noise than CNC listeners, especially at low SNR conditions (e.g., −12 dB). Altogether, native English exposure may change the use of temporal cues on English vowel identification for Chinese-native listeners.

5pSC14. Influence of second language on the perception of third language contrasts. Hiromi Onishi (Univ. of Arizona, 503 Washington Ave. #4, Grinnell, Iowa 50112, honishi@email.arizona.edu)

The influence of L2 knowledge on the perception of L3 contrasts was examined in several experiments with two groups of Korean learners of Japanese. All participants have studied English as an L2 prior to beginning their study of Japanese as an L3. One group participated in a forced-choice identification experiment, and the other group participated in an AXB discrimination experiment with various Japanese contrasts. Additionally, both groups participated in a forced-choice English minimal pair identification experiment. Correlation between each group's performance in the Japanese experiment and the English experiment was examined in order to determine whether the perceptual level in English has any influence on the identification and discrimination of Japanese contrasts. The results of the correlation analysis suggested that the participants used increased knowledge in the L2 in a direct manner. That is, the better the participants performed on the L2 contrasts the better they also identified the L3 contrast, which is known to be difficult for them. During the L3 discrimination experiment, however, the participants seem to have used their increased L2 knowledge in a general manner. These results are considered an indication of L3 learners' general enhanced sensitivity as a result of the experience in L2 learning.

5pSC15. The acoustics of Mandarin tones in careful and conversational speech. Daniel Brenner (Univ. of Arizona, 814 E 9th St., Apt. 14, Tucson, AZ 85719-5322, dbrenner@email.arizona.edu)

A large proportion of the world's languages use phonological categories centering on vocal pitch to distinguish words. One of these, Mandarin, represents the largest native speaker population of any language in the world (SIL International, 2013). Although tones have long been foregrounded in phonetic/phonological work on Mandarin, and have been estimated to carry as much information in Mandarin phonology as vowels (Surendran and Levow, 2003), little is yet known about what happens to the tonal categories in conversation. This acoustic production study aims to detail the relationship between tones produced in casual conversation and those in the careful reading of a word list to determine the separability of tonal categories and the relative utility of acoustic cues in identifying those categories across speech styles. References: SIL International. (2013). "Statistical Summaries." In Lewis, M. Paul, Gary F. Simons, and Charles D. Fennig (eds.), *Ethnologue: Languages of the World*. Online resource: http://www.ethnologue.com/statistics/size. Surendran, Dinoj, and Gina-Anne Levow. (2003). "The Functional Load of Tone in Mandarin is as High as that of Vowels," in *Proceedings of the International Conference on Speech Prosody* 99–102.

5pSC16. Does first language prosodic transfer affect second language prosody? Charlotte F. Lomotey (Lit. and Lang., Texas A&M Univ., Commerce, 1818D Hunt St., Commerce, TX 75428, cefolatey@yahoo.com)

Learners of English have been found to transfer their L1 prosody into the prosody of L2 (Ramírez Verdugo, 2006). However, the effect of this transfer is not known or may not be universal. Besides, while English uses fundamental frequency in its intonation system, to indicate prominence in syllables and in phrases, and to signal differences in sentence intonation, Awutu uses it to signal lexical tone, a common phenomenon of tone languages. The present study investigates the effect of transfer of some prosodic features of Awutu, a language of Ghana, on English. To achieve this,

10 speakers of Awutu who are non-native speakers of English were asked to read narrow and broad focus statements and questions in both Awutu and English. The data were subjected to acoustic analysis for fundamental frequency using the Computerized Speech Laboratory. Preliminary findings show that Awutu speakers of English raise their fundamental frequency on focused words to show prominence. However, the pitch tracks of both statements and questions show that even though these speakers transfer some sentence prosody from Awutu, they do not show any consistency in the transfer. These findings suggest that the nature of L1 prosodic transfer into L2 may be language-specific.

5pSC17. The adaptation of tones in a language with registers: A case study of Thai loanwords in Mon. Alif Silpachai (Linguist., Univ. of California, Los Angles, 3170 Aintree Ln., Apt./Ste., Los Angeles, CA 90023, silpacha@usc.edu)

How do tones get adapted into languages with registers? This study examined loanword adaptation in which a language with registers borrows words from a language with lexical tones. In particular, this study presents an acoustic analysis of Thai loanwords in Mon, a language with two registers—one with tense voice and high f0 and the other with lax voice and low f0 accompanied by breathy voice. To investigate phonetic realizations, eight Mon speakers native to Thailand were recorded uttering 135 Thai loanwords in a carrier sentence. Results show that the tones in Thai loanwords get adapted as four level tones in Mon. In particular, loanwords with high tone have the highest f0, loanwords with mid tone have the second highest f0, loanwords with low tone and rising tone have the third highest f0, and loanwords with falling tone have the lowest f0. It is puzzling why Thai falling tone—not low tone—gets adapted as the lowest f0 in Mon. Results suggest that Mon spoken in Thailand may be developing lexical tones due to language contact.

5pSC18. Realization of Thai tone change in the Northern Thai dialect of Chiang Mai. Maureen Hoffmann (Dept. of Linguist., Univ. of Arizona, P.O. Box 210025, Tucson, AZ 85721, mhoffm@email.arizona.edu)

Recent studies have found evidence of tone change in progress among Thai speakers. In particular, changes in the high tone, traditionally considered a level tone, have caused some to suggest it should instead be considered a contour tone (Zsiga, 2008; Teeranon and Rungrojsuwan, 2009). However, the previous research has focused primarily on the Central Thai dialect found in Bangkok, the standard dialect of Thai. This study examines the current state of tones in the Northern Thai dialect of Chiang Mai, which has six contrastive tones, rather than the five found in Central Thai. This data allows for a comparison to both the Central Thai literature as well as previous studies of Northern Thai, to examine whether Northern Thai is undergoing tone change as well and whether it exhibits similar changes to those reported for Central Thai. Significant exposure to Central Thai via mass media as well as the education system, and widespread bi-dialectalism, may carry the influences of Central Thai tone changes into Northern Thai as well. This study aims to provide further insight into the ongoing changes in the Thai tonal space, in order to clarify the nature of Thai tones today.

5pSC19. The influence of lexical factors on word recognition by native English speakers and Japanese speakers acquiring English: An interim report. Kiyoko Yoneyama (English, Daito Bunka Univ., 1-9-1 Takashimadaira, Itabashi-ku, Tokyo, 175-8571, Japan, yoneyama@ic.diato.ac.jp) and Benjamin Munson (Speech-Language-Hearing Sci., Univ. of Minnesota, Minneapolis, MN)

In our earlier work [Yoneyama and Munson, J. Phonet. Soc. Jpn. 14-1 (2010)], we investigated whether neighborhood density and word frequency affect spoken word recognition in English by beginning and advanced Japanese L2 English speakers, and by native English speakers. Our study was modeled after the work of Imai *et al*. [J. Acoust. Soc. Am. (2005)]. The results indicated that there were strong effects of frequency and neighborhood density on the performance of all three groups of listeners. However, there was no clear evidence for an emerging "neighborhood competition" effect in the Japanese learners of English, contrary to Imai *et al*. Here we report two additional analyses of these data. The first uses log-linear modeling (i.e., the j-factors in Boothroyd and Nittrouer [J. Acoust. Soc.Am. (1998)]) to examine word recognition in the two groups. The second examines the influence of lexical variables on spoken word recognition response times in L1 and L2 speakers. Preliminary results suggest that the effect of word frequency and neighborhood density on these measures is similar for L1 and L2 speakers of English.

5pSC20. Effects of native language and speech rate on perceptual and decisional processing of voicing and syllable affiliation in stops. Noah H. Silbert (Commun. Sci. & Disord., Univ. of Cincinnati, 3202 Eden Ave., 344 French East Bldg., Cincinnati, OH 45267, noahsilbert@gmail.com), Kenneth de Jong (Linguist, Indiana Univ., Bloomington, IN), Byung-jin Lim (East Asian Lang. & Lit., Univ. of Wisconsin, Madison, WI), and Kyoko Nagao (Ctr. for Pediatric Auditory and Speech Sci., Nemours Biomedical Res., Wilmington, DE)

Previous work shows that variation in speech rate influences the perception of voicing distinctions (/b/-/p/) and syllable affiliation ("pea"-"eep"), and it is well-documented that native language influences how listeners perceive phonological distinctions. We analyze the influences of speech rate and native language in the perception of voicing and syllable affiliation by applying a model of perception and response selection to data from Japanese, English, and Korean listeners who identified the voicing and the syllable affiliation of (English) stops produced at slow, moderate, and fast rates. The fitted model indicates that for all three native language groups, perceptual salience decreases substantially as speech rate increases for both voicing and syllable affiliation. Even at slow rates, however, the salience of voicing is lower for coda than for onset stops. In addition, as rate increases, all three groups exhibit an increasing bias toward "onset" responses, with a bias toward "voiced" responses for coda stimuli and toward "voiceless" responses for onset stimuli. Despite broad similarities across all three groups, fine-grained patterns of perceptual salience and response bias vary with listeners' native language. These data and fitted models illustrate the utility of rate-varied speech in investigations of native language effects in speech perception.

5pSC21. Training effect on the second language learning for young learners using computer-assisted language learning system: Quantitative consideration on relationship among speech perception of the second language, learning experience and amounts of learning. Yuko Ikuma (English Education, Osaka Kyoiku Univ., 4-1-1-801, Bingo-cho, Nada-ward, Kobe, Hyogo 657-0037, Japan, yyikuma@mve.biglobe.ne.jp)

Longitudinal training experiment was conducted in order to examine the relation between the perceptual ability of English as a foreign language and amount of learning experiences beyond schools targeting Japanese elementary school students. Over four hundred students among the 3rd grade through 6th grade participated in this study. Three hundred and thirty-two students of them had learning experience beyond school, and the other, 134 students, did not. Students spent approximately 10 h of individualized computer-based training that focused on intensive auditory input. The result of t-test showed that the scores of the group of students who have previous learning experience exceeded the scores of the students in the other group at the beginning; however, at the end of the period, it revealed from the result of ANOVA that students without learning experience before starting learning English at school improved their sensitivity on perception of English syllable and some phonemes much more than the experienced. These results suggest that the appropriate perception training utilizing the auditory input is effective in cultivation of aural comprehension. Implications for foreign language education for young learners will be discussed. [Work supported by JSPS KAKENHI Grant-in-Aid for Young Scientists (B) 23730832, Japan.]

5pSC22. Intonational transfers in second language English speakers. Sergio Robles-Puente (Linguist., Univ. of Southern California, 3601 Watt Way; Grace Ford Salvatori 301, Los Angeles, CA 90089-1693, roblespu@usc.edu)

Previous research on Spanish imperatives has demonstrated that their phonetic characteristics may not differ from those of declaratives. However,

under the right conditions, imperatives can be produced with up-stepped patterns where nuclear pitch-accents show higher F0 values than pre-nuclear ones. These circumflex configurations are never attested in declaratives (Robles-Puente, 2011). The current study concentrates on the imperatives and declaratives produced by 31 Mexican Spanish/English bilinguals and reveals that this variety of Spanish, unlike Iberian Spanish and English, allows not only imperatives but also declaratives to be produced without the aforesaid intonational constraint. Additionally, the English productions of the same speakers show circumflex configurations indicating a clear prosodic transfer characteristic of their mother tongue. Robles-Puente, Sergio. 2011, "Looking for the Spanish imperative intonation," in *Selected Proceedings of the 5th Conference on Laboratory Approaches to Romance Phonology*, edited by S. Alvord, pp. 153–164. Somerville, MA: CPP.

5pSC23. The effects of dialectal differences on the identification of English vowels by native and nonnative listeners. Takeshi Nozawa (Lang. Education Ctr., Ritsumeikan Univ., 1-1-1 Nojihigashi, Kusatsu 525-8577, Japan, t-nozawa@ec.ritsumei.ac.jp)

This study attempts to investigate how dialectal differences of English affect the identification of English vowels by native and nonnative speakers of English. Served as listeners were native speakers of New Zealand English and Japanese. They heard and identified /i, ɪ, eɪ, ɛ, æ, ɑ̃, ʌ/ uttered by native speakers of New Zealand and American English. Repeated-measures ANOVAs were performed, respectively, for each listener group. The results revealed that there was no significant main effect of dialect ($p = 0.013$), but a main effects of vowels was found significant ($p < 0.001$). An interaction between dialect x vowels was also significant ($p < 0.001$). Pairwise comparisons revealed that NZ listeners identified NZ English /ɪ/, /ɑ̃/, /ʌ/ better than AM English counterparts ($p < 0.05$), but they identified AM English /æ/, /ɛ/ better than NZ English counterparts ($p < 0.05$). Native Japanese listeners, on the other hand, identified AM English vowels significantly better than NZ English vowels ($p < 0.001$). Particularly, they identified /i, ɪ, ɛ, æ/ uttered by AM English talkers than those uttered by NZ English talkers. However, native Japanese listeners identified NZ English /ɑ̃/ better than American English counterpart($p < 0.05$).

5pSC24. Perception of voicing of English word-final consonants: A comparative study of English listeners and Korean listeners. Ji Yea Kim (English Lang. and Lit., Seoul National Univ., 1 Gwanak-ro, Gwanak-gu, Seoul 151-745, South Korea, jiyeakim@snu.ac.kr)

This study aims to investigate the perception of word-final consonant voicing. Preceding vowel duration is of interest in comparing the perception of 7 English listeners (EL) and 7 Korean listeners (KL). Each listener was required to listen to 104 stimuli randomly composed of English voiceless and voiced consonants (e.g., "picks" and "pigs") and to choose from two options what they heard for each of the stimuli. There were 2 types of stimuli: original and manipulated. To manipulate vowel duration, for example, the vowel in the originally voiceless stimulus "picks" was lengthened, whereas the vowel in the voiced stimulus "pigs" was shortened by using PRAAT. The results show that, in the original stimuli, both groups tend to perceive voicing accurately, but ELs are better than KLs. It is assumed that the lower percentage of KLs' perception is due to the fact that there is no voicing contrast in Korean. In the manipulated stimuli, however, both groups generally fail to perceive voicing, and the number of stimuli whose voicing was never perceived was greater for ELs than that for KLs. This clearly indicates that ELs rely more on the voicing of following consonants than they do on the preceding vowel length.

5pSC25. Perception of epenthetic vowels in English /s/-initial clusters by Spanish-speaking second language learners of English. Maria Teresa Martinez-Garcia and Annie Tremblay (Linguist. Dept., Univ. of Kansas, 3700 Clinton Parkway, Apt. 212, Lawrence, KS 66047, maria.martinezgarcia@ku.edu)

Second language learners' (L2ers') perception and production of consonant clusters is influenced by the syllable structure of the native language (L1). This study investigates whether the perception of epenthetic vowels is partially responsible for why Spanish speakers have difficulty producing /s/ + Consonant ("sC") clusters in English, and whether it affects word recognition in continuous speech. Spanish, German L2ers of English, and native English speakers completed: (i) an AXB task with (/ə/)sC-initial nonce words (e.g., [əsman]-[sman]); (ii) a word monitoring task with (/ə/)sC-initial words in semantically ambiguous sentences (e.g., I have lived in that (e)state for a long time); and (iii) a production task with the same sentences as in (i). L2ers also took a word-familiarity rating task and a cloze test to assess their proficiency. For (i) and (ii), accuracy rates were recorded, and response times were measured from target onset. For (iii), acoustic analyses showed whether the L2ers' productions of sC-initial words contained an epenthetic vowel. Preliminary results suggest that perception difficulties may be partially responsible for Spanish speakers' production and word-recognition difficulties with sC-clusters in English, but production data suggest that articulatory problems may also play an important role. Proficiency does not seem to help overcome this difficulty.

5pSC26. The perception of English and Thai fricatives and affricates by Thai learners. Rungpat -. Roengpitya (Dept. of English, Faculty of Liberal Arts, Mahidol Univ., Thailand, 240 Soi 17, Rama IX Rd., Bangkok 10320, Thailand, rungpat@gmail.com)

English has eight voiceless-voiced fricatives /f, v, θ, ð, s, z, ʃ, and ʒ/ and two affricates /tʃ and dʒ/ in all positions. Thai, however, carries only two initial voiceless fricatives /f, s/ and one initial voiceless affricate /tʃ/. In the literature, the acoustic cues for fricatives include the frication noise, the amplitude, and the fundamental and formant frequencies on the adjacent vowels. This research explores how Thai listeners can perceive the English fricatives and affricates, as opposed to the Thai set. Thirty-one English and fifteen Thai words with fricatives and affricates were chosen. Two native-American male speakers read all English words, and a native-Thai female speaker read all Thai words. All the words were acoustically measured for the acoustic cues and digitally modified for all 312 tokens with different quality and quantity. Twenty native-Thai listeners (14 females and 6 males) listened and identified each token whether it contained which original fricative or affricate. The results revealed that the correct responses of the Thai learners were at a higher rate (90–100%) for the Thai original and modified tokens, and at a lower rate (30–100%) for the English set. It is hoped that this study will shed light on to future perceptual studies.

5pSC27. Effects of listener characteristics on foreign-accentedness rating of a non-standard English dialect. Andrea Morales and Natasha Warner (The Univ. of Arizona, 5242 S Hampton Roads Dr., Tucson, AZ 85756, andreamorales@email.arizona.edu)

This project analyzes what characteristics of listeners affect whether they perceive Chicano English as foreign-accented English. Many Americans assume Chicano English (CE) is non-native English spoken by native Spanish speakers, but CE is often spoken as a native dialect of English. CE is a very common dialect in Tucson, Arizona, and this project examines the correlation between listeners' ethnicity, familiarity with Hispanic people, and political stance on immigration, and their perception of CE as foreign-accented. Stimuli are sentences read by CE and other Tucson speakers that contain phonetic environments where CE has features that distinguish it from Standard American English (SAE). The listener population is Southern Arizonans of various ethnicities with varying degrees of exposure to CE and Spanish. The experiment uses a Foreign Accentedness Rating (FAR) task, as well as classification of stimuli as spoken by a Hispanic vs Anglo speaker and background questions on listeners' language background and political opinions. Highly accurate identification of ethnicity is predicted, as well as correlations between some measures of the listeners' background and strength of FAR rating of CE speakers. Conclusions involve the effect of long-term exposure to a local dialect and sociolinguistic status on perceived degree of foreign accent

5pSC28. Effect of native Mandarin dialects on English learners' use of prosodic cues to stress. Zhen Qin and Annie Tremblay (Dept. of Linguist, Univ. of Kansas, Blake Hall, Rm. 427, 1541 Lilac Ln., Lawrence, KS 66045, qinzhenquentin2@ku.edu)

Second-language learners (L2ers) weight phonetic cues to stress as a function of how these cues are used in the native language. This study investigates the effect of native dialects on the use of prosodic cues (F0 and duration) to English stress by native speakers (NSs) of Standard Mandarin (SM), Taiwanese Mandarin (TM), and English. Both TM and SM use F0 to realize lexical tones, but only SM uses duration to realize lexically contrastive stressed-unstressed vs stressed-stressed words. English NSs and intermediate-to-advanced TM-speaking or SM-speaking L2ers of English (at the same English proficiency) completed two sequence-recall tasks. In each trial, they heard four English non-words with trochaic and iambic stress, and pressed "1" and "2" to recall them in the correct order. In Experiment 1, participants heard natural stimuli (converging F0 and duration cues); in Experiment 2, the stress stimuli were resynthesized to contain only F0 cues, only duration cues, converging F0 and duration cues, or conflicting F0 and duration cues. In Experiment 1, all groups used naturally produced stress to recall English non-words. In Experiment 2, SM-speaking L2ers used duration more than TM-speaking L2ers to recall English non-words. Native dialect is suggested to be considered in L2 speech processing models.

5pSC29. Familiarity with a foreign accent aids perceptual accent adaptation. Cynthia P. Blanco (Linguist., Univ. of Texas at Austin, 113 East Hillside Dr., Greenville, South Carolina 29609, cindyblanco@utexas.edu), Emily Tagtow, and Rajka Smiljanic (Linguist, Univ. of Texas at Austin, Austin, TX)

A change in speaker accent is reported to temporarily slow speech processing (Bradlow and Bent, 2003; Clarke and Garrett. 2004). Recent work suggests that this delay may be an artifact of task expectations and reflects a surprise effect, not the time needed for accent adaptation (Floccia *et al*., 2009). The present study tested listeners with high and low exposure to Spanish- and Korean-accented English to determine if frequent exposure to these accents decreases the surprise effect in an experimental setting. Participants listened to four blocks of meaningful sentences and responded to probe words; they heard a native-accented speaker in the first block and either native-, Spanish- or Korean-accented speakers in blocks 2 and 3. Results thus far show that the change from native-accented to foreign-accented speaker (block 1 to block 2) elicited a processing delay for participants in the Korean-accented condition, but not in the Spanish-accented condition. This pattern remained, but was somewhat attenuated, in the change from block 2 to block 3, when voice but not accent changed. These results show that extensive experience with a particular foreign accent (Spanish) outside the lab results in a smaller processing cost when listening to accented speech in the lab.

5pSC30. Predicting code-switches from phonetic information: The discourse marker *like* in Spanish-English code-switching. Page E. Piccinini (Linguist., Univ. of California San Diego, 9500 Gilman Dr., La Jolla, CA 92093-0108, ppiccinini@ucsd.edu)

The present study investigated whether Spanish-English bilinguals (L1 Spanish, English dominant) use phonetic cues to anticipate code-switches. Listeners were presented with four sets of 10 utterances. In a given set all utterances began in English or Spanish. All utterances included the discourse marker *like*. In each set, half of the utterances continued in the same language after *like* and half switched languages after *like*. Listeners only heard up to and including *like*. Listeners evenly sorted the utterances into two columns, "continues in English" or "continues in Spanish," to indicate which five utterances involved code-switching. Half of listeners received instructions in English and half in Spanish. Both sets of listeners were significantly above chance for stimuli beginning in English [$p < 0.05$]. Listeners who received Spanish instructions were also trending above chance for stimuli beginning in Spanish [$p = 0.08$]. This suggests listeners can use phonetic cues to anticipate switches from their dominant to their non-dominant language. Additionally, when language mode is the non-dominant language, listeners can also anticipate switches from their non-dominant to their dominant language. These results support a theory where both languages are somewhat activated at all times, allowing bilinguals to use phonetic cues to anticipate language switches.

5pSC31. Perception of English narrow and broad focus by native speakers of Mandarin Chinese. Ratree Wayland and Chelsea Guerra (Linguist, Univ. of Florida, 2801 SW 81st St., Gainesville, FL 32608, ratree@ufl.edu)

The aim of this study is to examine the ability to accurately perceive and comprehend English intonation patterns among native Mandarin speakers. Intonation patterns are patterns of rising and falling in pitch over the course of a full utterance. Both English and Mandarin make use of intonation patterns. However, unlike English, Mandarin is a tonal language in which pitch changes served to distinguish word meaning. The tonal patterns of words thus cause additional pitch fluctuation in the overall intonation of a Mandarin sentence. Sixteen Mandarin and 12 English speakers participated in the study. In the first task, participants were asked to listen to English sentences with either a falling or a rising intonation, and to decide whether the sentence is complete or incomplete. Participants' comprehension of English sentences produced with an intonation pattern focused on the verb, the noun or the entire sentence was examined. The results obtained indicated that (a) native speakers of English outperformed native Mandarin speakers on both tasks, that (b) both groups performed better on the second task, and that (c) the difference between the two tasks was greater among Mandarin speakers than among English speakers.

5pSC32. Prosodic profile of American Aviation English. Julia Trippe and Eric Pederson (Dept. of Linguist., Univ. of Oregon, Eugene, OR 97403-1290, trippe@uoregon.edu)

Aviation English (AE) is under scrutiny due to miscommunication between international pilots and controllers. To enhance public safety, since 2011, aviation professionals must prove technical and practical English proficiency. Previous studies measure AE speech accuracy by task performance and repeated elements (Barshi and Healy, 2011), and speech comprehensibility using native speaker judgments (Farris *et al*., 2008). The current study develops a quantifiable index for evaluating AE production based on prosody. Reasonably fluent prosody is critical to language comprehensibility generally, but since AE has no predictable intonation due to signal limitations, lack of function words, standard phraseology and rapid speech rate, we are specifically developing a rhythm profile of Native Speaker AE (NSAE) to evaluate Non-native Speaker AE production and model training methods for different first language (L1) prosodic types. We are training a speech aligner on tapes of US controllers to calculate a baseline for American NSAE. Our index will be generated using known metrics such as delta-V/C, %V (Ramus, 2000), PVI (Low *et al*., 2000), and varcoV/C (Dellwo, 2006). Since AE is derived from "stress-timed" English to be standardized and predictable, we predict that AE will exhibit a rhythmic signature comparable not only to English but to "syllable-timed" languages.

5pSC33. White-matter microstructure differs in adult bilingual and monolingual brains. Patricia K. Kuhl, Todd L. Richards, Jeff Stevenson, Dilara D. Can, Liv Wroblewski, Melanie S. Fish, and Julia Mizrahi (Inst. for Learning & Brain Sci., Univ. of Washington, Box 357920, Seattle, WA 98195, pkkuhl@u.washington.edu)

Behavioral research indicates that bilingual children and adults outperform monolinguals at executive function tasks, especially those related to cognitive flexibility, suggesting that experience with two languages alters brain structure. We investigated white-matter microstructure using Tract-Based Spatial Statistics (TBSS) in monolingual ($n = 15$) and Spanish-English bilingual ($n = 16$) adults, quantifying fiber tract organization in measures of directionality (fractional anisotropy, FA) and diffusivity perpendicular to the main axonal direction (radial diffusivity, RD). FA was significantly higher for monolinguals ($p < 0.05$, corrected) in three brain regions: the right posterior limb of the internal capsule, the right sagittal stratum that includes inferior frontal occipital fasciculus, and the right thalamus. RD was greater for bilinguals ($p < 0.05$, corrected) in multiple brain areas, most prominently in the cerebellum, inferior frontal occipital fasciculus, and superior longitudinal fasciculus. We interpret these differences in

brain structure between monolinguals and bilinguals as consistent with the idea that bilingual language experience leads to a pattern of more diffuse connectivity in the brain, which may be related to increased cognitive flexibility skills.

5pSC34. Comparison of perceptual training and production training on tone identification. Shuang Lu, Ratree Wayland, and Edith Kaan (, Dept. of Linguist., Univ. of Florida, Turlington Hall 4131/P.O. Box 115454, Gainesville, FL 32611-5454, shuanglu@ufl.edu)

Previous studies have shown that short-term perceptual and production training can improve the comprehension and production of lexical tones by non-tone language speakers (e.g., Wang *et al*., 1999; Leather, 1990). The current study compared the effectiveness of an identification-only training and an identification-plus-imitation training on lexical tone perception. Stimuli consisted of 12 monosyllables associated with three linear tones that resemble the level, rising and falling tones in Mandarin Chinese. Twenty participants first did a baseline identification task, and then received either an identification-only or an identification-plus-imitation training. The trainings were exactly the same except that the identification-plus-imitation training required participants to imitate the stimuli, while the identification-only training had participants utter the tone types of the stimuli (i.e., level, rising or falling). Lastly, all participants did the same baseline identification task again. The tone identification accuracy improved in both the identification-only and the identification-plus-imitation groups after training. Moreover, the identification-plus-imitation group identified the tones more quickly in the post-training task than in the pre-training task while the identification-only group did not show any improvement. These results indicated that the identification-plus-imitation training was more effective to improve the tone identification than the identification-only training.

FRIDAY AFTERNOON, 6 DECEMBER 2013 CONTINENTAL 6, 1:00 P.M. TO 3:20 P.M.

Session 5pUW

Underwater Acoustics and Acoustical Oceanography: Sediment Acoustics: Modeling, Measurement, and Inversions III

Nicholas P. Chotiros, Chair
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Marcia J. Isakson, Chair
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David P. Knobles, Chair
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Chair's Introduction—1:00

Invited Papers

1:05

5pUW1. Acoustic scattering from ocean sediment layers with multiple rough interfaces using finite elements. Marcia J. Isakson and Nicholas P. Chotiros (Appl. Res. Labs., The Univ. of Texas at Austin, 10000 Burnet Rd., Austin, TX 78713, misakson@arlut.utexas.edu)

Acoustic scattering from the ocean bottom is a major component in shallow water reverberation and propagation as well as having a significant effect on the transmission of acoustic communication. However, boundary element models can only model scattering from a single rough interface. While some scattering models, such as the GeoAcoustic Bottom Interaction Model (GABIM), have considered scattering from layered sediments, these models are normally constrained to only one rough interface. Finite element models have been shown to accurately model scattering from both fluid and elastic boundaries, and, unlike conventional models based solely on the Helmholtz-Kirchhoff integral, are not limited to boundary interactions. In this study, a two-dimensional finite element model for scattering from two fluid layers and a fluid layer over an elastic layer is compared with perturbation theory and Kirchhoff approximation models to test the validity of considering the considering underlying interfaces flat. [Work sponsored by ONR, Ocean Acoustics.]

1:25

5pUW2. Adding thermal and granularity effects to the effective density fluid model. Kevin Williams (Appl. Phys. Lab. - Univ. of Washington, 1013 NE 40th St., Seattle, WA 98105, williams@apl.washington.edu)

Previously, an effective density fluid model (EDFM) was developed for unconsolidated granular sediments and applied to sand. The model is a simplification of the full Biot porous media model. Here two additional effects are added to the EDFM model: heat transfer between the liquid and solid at low frequencies and the granularity of the medium at high frequencies. The frequency range studied is 100 Hz–1 MHz. The analytical sound speed and attenuation expressions obtained have no free parameters. The resulting model is compared to ocean data.

1:45

5pUW3. Hybrid geoacoustic inversion scheme with an equivalent seabed model. Zhenglin Li and Renhe Zhang (State Key Lab. of Acoust., Inst. of Acoust., Chinese Acad. of Sci., No. 21 Beisihuan West Rd., Beijing 100190, China, lzhl@mail.ioa.ac.cn)

Acoustic propagation in shallow water is greatly influenced by the properties of the bottom. The purpose of geoacoustic inversion is estimation of ocean bottom acoustic parameters such as sediment sound speeds, densities, and attenuations from measured acoustic fields. Especially, geoacoustic inversion could give low frequency attenuation, which cannot be measured by coring the sediment. Therefore, it has been paid much attention in recent years. A hybrid geoacoustic inversion scheme, which combines several inversion methods together to invert for the bottom parameters, has been proposed based on the fact that the bottom acoustic parameters have different sensitivities to the different physical parameters of acoustic field. This inversion scheme could avoid the problem of the multiple solutions, which are often companied with some geoacoustic inversion methods. The validity of the inversion scheme is verified in a series of sea experiments at different sites. In the experiment, six different sediment types: Fine Sand, Silty Sand, Sand Silty, Sand-Silty-Clay, Silty Clay and Mud, are included in an area in the Yellow Sea. The inverted bottom parameters could distinguish the atlas marked bottom type quite well. [Work supported by the National Natural Science Foundation of China under Grant Nos. 11074269 and 10734100.]

Contributed Papers

2:05

5pUW4. *In situ* measurements of sediment sound speed in the frequency band of 2–10 kHz at target and reverberation experiment site. Jie Yang and Dajun Tang (Acoust. Dept., APL-UW, 1013 NE 40th St., Seattle, WA 98105, jieyang@apl.washington.edu)

As part of the environmental measurements for TREX13 (Target and Reverberation EXperiment 2013), in situ measurements of surfacial sediment sound speed were carried out off Panama City, Florida, using a system called Sediment Acoustic-speed Measurement System (SAMS). SAMS consists of ten fixed sources positioned just above the seafloor, and one receiver which is driven into the seabed to a known depth. During TREX13, 10 deployments were made along the main reverberation track which is about 7.5 km in length. All measurements were made at a penetration depth of 3 m between 2 to 50 kHz, focusing on 2–10 kHz. Preliminary sediment sound speed results show variation from low sound speeds (muddy sites) to high sound speeds (sandy sites). A 3–5% of dispersion was observed at coarse sandy sites between 2 and 10 kHz, whereas little dispersion was observed at muddy sites. [Work supported by ONR.]

2:20

5pUW5. Assessing grain size as a predictor of mid-frequency bottom backscattering strengths. Roger C. Gauss, Edward L. Kunz, and Altan Turgut (Acoust. Div., Naval Res. Lab., Code 7164, 4555 Overlook Ave., S.W., Washington, DC 20375-5350, roger.gauss@nrl.navy.mil)

Scattering from the seabed can be a complex mix of surface roughness and volume heterogeneity contributions. A series of mid-frequency (MF; 1.5–4.5 kHz) bottom backscattering strength data collected by the Naval Research Laboratory at a number of shallow-water locations (Stanton Banks, Malta Plateau, Heceta Bank) is first used to demonstrate the inadequacies of using Lambert's Law to model bottom backscattering strengths, and that more general empirical power laws, where not only the strength but the angular exponent can vary, are needed to match the data at a given frequency. The Stanton Banks data, where sediment types range from mud to gravel, are then used to explore the extent to which easy-to-access geophysical data (such as surficial grain size distributions from bottom grab samples) may be capable of providing suitable estimates of key model inputs (such as sediment sound speeds/attenuations, density and roughness/volume spectral strengths/exponents). These results show that both grain size and "bottom type" are in general unreliable predictors of the measured MF bottom backscattering strengths, and that a physics-based modeling approach coupled with in-situ environmental characterization is required. [Work supported by ONR.]

2:35

5pUW6. Estimates of sediment volume heterogeneity spectra from several distinct shallow water locations. Charles W. Holland (Appl. Res. Lab., The Penn State Univ., P.O. Box 30, State College, PA 16804, cwh10@psu.edu)

Theory indicates that sediment volume heterogeneities tend to dominate seabed scattering above the critical angle. However, recent evidence indicates that scattering from volume heterogeneities can also be the dominant mechanism below the critical angle. This raises questions about the nature and scales of volume heterogeneities in marine sediments. Direct measurements of sediment heterogeneities have been performed on cores using for example x-ray CT scans, however this and related methods only sample a very small volume. In this paper, a method is presented for estimating sediment heterogeneity spectra from acoustic reverberation data where the sediment volume probed is order 10^7 m^3. The large averaging volume permits measuring a wide range of spatial frequencies and tends to emphasize persistent scales. Resulting sediment volume spectra from several different shallow water regions will be presented. [Research sponsored by the ONR Ocean Acoustics.]

2:50

5pUW7. Laboratory measurements of sound speed and attenuation in sandy sediments. Yi-Wang Huang, Shi-e Yang, Qi Li, Sheng-Qi Yu, Fei Wang (Sci. and Technol. on Underwater Acoust. Lab., Harbin Eng. Univ., Harbin, China, huangyiwang@hrbeu.edu.cn), Dajun Tang, and Eric I. Thorsos (Appl. Phys. Lab., Univ. of Washington, Seattle, WA)

Marine sediments exist universally as the lower boundary for sound propagation in ocean waveguides, and knowledge of the properties of these sediments is important for accurate modeling of sound propagation and reverberation. In order to test theory predictions of the frequency dependence of sound speed and attenuation, it is necessary to have accurate information on the sediment properties, which is most easily done in a laboratory environment. Initial results reported here were done at high frequency in a small tank, as a preliminary step before making similar low frequency measurements in a much larger tank. A sandy sediment was used and the sound speed and attenuation were measured through different thicknesses of the sample. In the frequency range of 90–170 kHz, the measured sound speed was 1757–1767 m/s, and the attenuation was 22–30 dB/m. The sound speed dispersion was found to be very weak, as expected, and much smaller than the measurement uncertainty. The attenuation was found to increase approximately linearly with frequency. The measured sound speed agrees well with Biot theory predictions, while the measured attenuation is higher than Biot predictions, most likely because the measurement include effects such as volume scattering not taken into account in the theory.

3:05

5pUW8. Comparison of the finite element method with perturbation theory and the small-slope approximation for acoustic scattering from one-dimensional rough poroelastic surfaces. Anthony L. Bonomo, Marcia J. Isakson, and Nicholas P. Chotiros (Appl. Res. Labs., The Univ. of Texas at Austin, 10000 Burnet Rd., Austin, TX 78713, anthony.bonomo@gmail.com)

The finite element method is used to address the problem of acoustic scattering from one-dimensional rough poroelastic surfaces. The poroelastic sediment is modeled following the Biot-Stoll formulation. The rough surfaces are generated using a modified power law spectrum. Both backscattering strengths and bistatic scattering strengths are calculated. These results are compared with lowest order perturbation theory and the lowest order small-slope approximation, as extended to the case of scattering from poroelastic

surfaces. It is known that these approximate methods are sufficient for the study of rough surface scattering in the case of sediments modeled as fluids. This work seeks to assess whether or not these methods are accurate when applied to the case of poroelastic sediments. [Work supported by the Office of Naval Research, Ocean Acoustics Program.]