tions agree well with the main features seen in the measurements. [Work supported by DFG (Ho 1627/1-1) and by NIDCD (Grant DC00100).]

1:45

5pPP3. The index of interaural envelope correlation: Normalized cross-covariance or normalized cross correlation? Leslie R. Bernstein and Constantine Trahiotis (Ctr. for Neurological Sci. and Surgical Res. Ctr., Dept. of Surgery, Univ. of Connecticut Health Ctr., Farmington, CT 06030)

This study principally evaluated whether the normalized cross covariance (Pearson product-moment correlation) or the normalized cross correlation describes discriminability of changes in interaural disparities conveyed by the stimulus enveloped. In a four-interval, two alternative task, listeners detected which interval contained a 4-kHz tone added antiphasically to diotic, 200-Hz-wide, noise (NoSπ). The "nonsignal" intervals contained the tone added homophasically (NoSo). Discriminability (d') was measured as a function of S/N for values between -30 and $+30$ dB (really!). For all S/N's, overall level was 70 dB SPL. Listeners' performance was very well accounted for by the normalized cross correlation but not the normalized cross covariance. Additionally, listeners were tested in a "direct" discrimination task where changes in envelope correlations ($\Delta\rho$) were produced by "mixing" two independent Gaussian noises. Although $\Delta\rho$'s at threshold ($d'=1.0$) obtained from the two tasks were similar, the psychometric functions obtained with the direct discrimination task were more steep. Discussion will include how the normalized cross correlation of the envelope accounts for classic data concerning discriminability of interaural time differences at high frequencies as a function of depth of modulation. [Work supported by NIH DC02103.]

2:00

5pPP4. Precedence and plausibility. William A. Yost and Sandra J. Guzman (Parmly Hear. Inst., Loyola Univ. Chicago, 6525 N. Sheridan Rd., Chicago, IL 60626)

The "Clifton effect" [R. K. Clifton, J. Acoust. Soc. Am. **82**, 1834–1835 (1987)] was studied in a sound-deadened room with seven loudspeakers. One loud speaker produced a source click while other loudspeakers produced delayed copies simulating echoes (delays: 2–30 ms). Each combination of source and echoes is one click event and was presented as a train of click events (1–20 click events). A train was presented to listeners who made two judgments for the LAST click event presented: (1) The number of loudspeakers which produced sounds for the last click event, and (2) the loudspeaker location for each perceived source. "Catch trials" were introduced to make sure listeners used all possible responses and were able to locate the loudspeaker sources. When more than 10 click events were presented, a switch in conditions was introduced between the 10th and 11th click event. If the switch was plausible for a natural source and its echoes, responses indicated that listeners processed delayed clicks as echoes. If the change was implausible, then responses after the switch changed indicating listeners processed all clicks as if they were sources rather than echoes. [Work supported by NIH and AFOSR.]

2:15

5pPP5. Lateralization of high-frequency FM tones and frequency sweeps. Kourosh Saberi (Psychoacoust. Lab., Dept. of Psychol., Univ. of Florida, Gainesville, FL 32611)

Lateralization thresholds were measured in three experiments. In experiment I, thresholds measured for sinusoidal FM with carriers of 3 or 4 kHz and modulation rates from 50 to 800 Hz were comparable to those measured for sinusoidal AM stimuli. Lowest thresholds (at 71% correct) were about 100 μs, obtained at modulation rates of 300–350 Hz. In experiment II, a 300-ms tone was linearly swept in frequency from 2 to 5 kHz. The slope and intercept of the time-frequency function were randomized by 10% on each observation. Lateralization thresholds were about 50 μs. Unequal time-frequency slopes at the two ears produced a sense of motion. In experiment III, a sinusoidal FM was presented to one ear and a sinusoidal AM to the other ear. When the FM and AM had the same modulation rate (250 Hz), a single image was perceived. Observers were sensitive to the interaural modulation phase with near perfect discrimination of homophasic from antiphasic conditions. Results are discussed in terms of an FM-to-AM transduction mechanism. [Work supported by NIH and AFOSR.]

2:30

5pPP6. The segregation of SAM 4-kHz targets from SAM 2-kHz distractors on the basis of interaural envelope delay. R. H. Dye (Parmly Hear. Inst., Loyola Univ., 6525 N. Sheridan Rd., Chicago, IL 60626)

A stimulus-classification paradigm was used to examine the extent to which judgments of the laterality of 4-kHz targets, sinusoidally amplitude modulated at 200 Hz, were influenced by 2-kHz distractors that were modulated at rates ranging from 50 to 400 Hz. On each trial, the target was presented with one of ten envelope delays (ranging from -250 to $+250$ μs in 50-μs steps), as was the distractor. Each test interval was preceded by a diotic presentation of the target alone. The duration of the signals was 200 ms. During a block of 100 trials, each combination of target-distractor delay was presented once. The relative salience of the envelope delays carried by the target and the distractor was assessed by the slope of the best linear boundary between left and right responses. Two listeners gave increasing weight to the target as the difference between the target and distractor modulation frequencies increased, but weighed that target and distractor equally when both were modulated at 200 Hz. Two other listeners gave increasing weight to the 2-kHz distractor as modulation frequency increased, as though its relative salience increased with "number of looks." These data will be compared to measures of binaural interference that have been obtained for similar stimuli. [Work supported by NIH.]

2:45

5pPP7. Precision of sound localization measured by a reaching task. Daniel H. Ashmead, Xuefeng Yang, Robert Wall, and Kiara Ebinger (Dept. of Hear. & Speech Sci., Vanderbilt Univ. Med. Ctr., Nashville, TN 37232-8700)

This study validates a reaching measure of sound localization for subsequent application to children. Seven adults reached for broadband sound sources while hand position was measured to within 2 mm. Sounds came from 18 regions in frontal reaching space, with the loudspeaker moved away just after stimulus offset. In the "visual" condition subjects watched until the sound ended, then closed their eyes and reached. In the "auditory" condition subjects were blindfolded. Precision of sound localization was estimated by comparing variability in the visual and auditory conditions: $s = \sqrt{s_A^2 - s_V^2}$. Estimates were computed for horizontal angle, vertical angle, and distance for each target location. Results agreed reasonably well with conventional measures. For targets straight ahead at ear level, horizontal $s=2.6°$, vertical $s=5.0°$, and distance $s=9.5\%$. Systematic variations occurred across target locations. This reaching task is a rapid, naturalistic way of measuring three-dimensional sound localization. [Work supported by DOE and NIH.]

3:00

5pPP8. Virtual auditory reality reduced to the bare essentials. William Morris Hartmann and Andrew Wittenberg (Michigan State Univ., Dept. of Phys., East Lansing, MI 48824)

Successful imaging of real sound sources by headphones can be done by measuring free-field head-related transfer functions (HRTF) using small microphones in the ear canals and then inverse filtering by the headphone response. A simpler alternative to this standard procedure is described where a listener, with small microphones in the ear canals, wears open-air headphones throughout the experiment. A synthesized vowel is played, first from a loudspeaker and then from the headphones. The headphone signal is adjusted so that the amplitudes and phases of the harmonics measured with the small microphones are the same as those found when the loudspeaker is sounding. The technique is successful in that listeners cannot distinguish between real and virtual sources. It lacks the flexibility

of the HRTF technique, but it allows an experimenter to study the most interesting psychoacoustical questions about sound localization and externalization using an experimental technique that is simpler and probably more reliable. [Work supported by the NIDCD and by the NSF Research Participation for Undergraduates Program.]

3:15–3:30 Break

3:30

5pPP9. Cochlear acoustic reflectance and traveling wave delay. Barry P. Kimberley (Dept. of Surgery, Univ. of Calgary, 3330 Hospital Dr. N. W., Calgary, Alberta T2N 4N1, Canada), Greg Shaw (Univ. of Calgary), Christopher Shera (Eaton Peabody Labs.), and Jont B. Allen (Bell Labs.)

Inner ear acoustic impedance and reflectance, SFOAEs, DPEs, and PTTs were measured with a calibrated probe situated in the ear canal of normal-hearing subjects. The use of a calibrated probe allowed for the conversion of the SFOAE recordings into reflectance. In a number of subjects, low stimulus levels results in rippling of the reflectance. The phase slope of the acoustic reflectance was found to be a linear over a narrow range of frequencies. This slope is taken as equivalent to the traveling wave delay to the corresponding frequency(ies). Traveling wave delay estimates (reflectance phase slope) however did not change as stimulus level ranged from 50 to 10 dB SPL. This is in contrast to previous traveling wave delay estimates using DPEs where delay increased with a decrease in stimulus level [Kimberley *et al.*, J. Acoust. Soc. Am. **94**, 1343–1350 (1993)]. The discrepancy between DPE-based and SFOAE-based estimates of traveling wave delay is discussed.

3:45

5pPP10. Modeling distortion product otoacoustic emission fine structure in humans. Carrick L. Talmadge, Arnold Tubis, Pawal Piskorski (Dept. of Phys., Purdue Univ., West Lafayette, IN 47907), and Glenis R. Long (Purdue Univ., West Lafayette, IN 47907)

The presence of fine structure in distortion product otoacoustic emissions (DPOAEs) in humans and other species provides important clues concerning the underlying mechanisms which give rise to this structure. Recent experimental findings of our group indicate that (i) synchronous evoked emissions, hearing threshold microstructure, and the fine structure of DPOAES in each ear appear to correspond, (ii) the fine structure of higher-order DPOAEs, i.e., $f1-n(F2-f1)$, $n>2$ depends on the DPOAE frequency, and (iii) DPOAEs with $n<-1$ do not have well-formed fine structure. These data will be used to contrast and compare two distinct models of DPOAE generation, one in which the fine structure arises from the interactions in the strong overlap region of the $f1$ and $f2$ activity patterns (near the $f2$ tonotopic place), and one in which the fine structure arises from reflections of the distortion product near its tonotopic location. The data strongly favor the later model.

4:00

5pPP11. Fine structure of $2f_1-f_2$ acoustic distortion product: Effect of $L1/L2$ ratio. Ning-ji He and Richard A. Schmiedt (Dept. of Otolaryngol. and Commun. Sci., Medical Univ. of South Carolina, 171 Ashley Ave., Charleston, SC 29425-2242)

The fine structure of the $2f_1-f_2$ acoustic distortion product (ADP) was measured in a group of normal-hearing subjects with different combinations of primary levels ($L1$ and $L2$). The frequency ratio ($f_2/f_1, f_2>f_1$) was 1.2, and the f_2 frequency was swept from 1781 to 2300 Hz in $\frac{1}{32}$ octave steps. In condition 1, $L1$ was fixed at 50 dB SPL while $L2$ varied from 30 to 75 dB SPL in 5-dB steps. In condition 2, $L2$ was fixed at 50 dB SPL and $L1$ was varied as in condition 1. For a fixed $L1$, an upward frequency shift was evident in the ADP fine structure as the $L2$ level increased, whereas for fixed $L2$, a downward frequency shift in the ADP pattern was observable with an increasing $L1$. These results support a vector sum computer model for the ADP fine structure [Sun *et al.*, J. Acoust. Soc. Am. **96**, 2166–2174, 2175–2183 (1994)], suggesting that ADP fine structure is largely generated in the overlap area of the traveling waves for the primary tones, and the effects of reemissions from the $2f1-f2$ area are minimal. A large variance was observed in the best $L1/L2$ ratio, ranging from -7.5 to 20 dB both across and within subjects. [Work supported by NIDCD.]

4:15

5pPP12. Pure-tone thresholds and cubic distortion product otoacoustic emissions in the chinchilla following carboplatin treatment. Brenda M. Jock, Kristen-Lyn Petriello, Lori G. Aldrich, Ann R. Johnson, Roger P. Hamernik, and William A. Ahroon (Auditory Res. Lab., State Univ. of New York, Plattsburgh, NY 12901)

In the chinchilla, carboplatin has an unusual ototoxic effect on the sensory epithelium of the cochlea [Takono *et al.*, Hear. Res. **75**, 93–102 (1994)]. Twelve chinchillas were treated with a single IP or IV injection (50 or 75 mg/kg) of carboplatin. Baseline auditory evoked potential audiograms and cubic distortion product otoacoustic emissions (3DPE) were obtained on each animal. Threshold and 3DPE functions were also acquired at regular intervals between one hour and 30 days post-injection. The sensory epithelium of the cochlea was evaluated using the surface preparation method. Anatomical analysis indicated that the carboplatin caused relatively severe but scattered losses of inner hair cells (IHC) throughout most of the cochlea. The outer sensory cell population was intact and the cells appeared normal at the level of the light microscope. Despite the IHC pathology, which also included vacuolization in the area of the IHCs, evoked potential thresholds, measured at the level of the inferior colliculus were very near normal and 3DPE functions showed very little change. [Work supported by Bristol-Myers Oncology Division and SUNY-Plattsburgh.]

4:30

5pPP13. Spontaneous and click-evoked otoacoustic emissions of the frog inner ear: Spectral characteristics and temperature dependence. Bert Maat, Pim van Dijk, and Hero P. Wit (Inst. of Audiol., ENT Dept. Univ. Hospital Groningen, P.O. Box 30.001, 9700 RB Groningen, The Netherlands)

Spontaneous otoacoustic emission (SOAE) and click-evoked otoacoustic emission (CEOAE) measurements were performed in frogs (*Rana esculenta*). The SOAE and CEOAE measurements followed each other repeatedly, while the frog's body temperature was changed at a rate of approximately 0.1 °C/min. In some sessions, only SOAE measurements were performed. The SOAE and CEOAE spectra were closely related: The spectra of CEOAE contained the same peaks as those observed in the related SOAE spectrum. It seems that click evoked emissions in the frog are synchronized spontaneous emissions. The click-evoked responses show a nonlinear compressive amplitude growth with the stimulus intensity. As function of temperature, various emission modes, and complex amplitude patterns were observed for both types of emissions.

4:45

5pPP14. Enhanced cochlear responses after sound exposure. Yvonne M. Szymko and Jozef J. Zwislocki (Inst. for Sensory Res., Syracuse Univ., Syracuse, NY 13244)

Hensen's cell alternating potentials were recorded in the gerbil cochlea by means of the approach developed previously in this laboratory. An intensity series of magnitude and phase transfer functions (TFs) and cochlear microphonic (CM) TFs from 125 Hz to 16 kHz were obtained at 40–90 dB sound pressure level (SPL) by means of frequency sweeps. Subsequently, the same frequency sweeps at either 80, 90, or 100 dB SPL were delivered to the ear for 10–40 min. CM, Hensen's cell TFs, and EP were monitored periodically post-exposure. Hensen's cell responses showed enhancement within 40–50 min post-exposure and a phase lead. There was no correlation between changes in peak response and changes in receptor potential or EP. The response enhancement and its associated phase lead is explained with the help of Zwislocki's cochlear model [*Mechanics and Biophysics of Hearing*, edited by P. Dallos (Springer-Verlag,