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MECHANISMS MEDIATING THE PERCEPTION OF COMPLEX ACOUSTIC  
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R H WARREN 31 AUG 87 AFOSR-TR-87-1430 AFOSR-85-8260

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MECHANISMS MEDIATING THE PERCEPTION OF COMPLEX ACOUSTIC PATTERNS

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SUMMARY

Three studies dealing with perception of acoustic repetition for long-duration complex sounds have been completed.

1. Repetition of "frozen" Gaussian noise can be detected for infratonal repetition frequencies from 1 Hz through 20 Hz (repetition frequencies above 20 Hz are tonal). Infratonal repetition might be perceived either through the detection of the reoccurrence of singularities within the acoustic pattern, or through a holistic recognition of the entire pattern. The investigation just completed has indicated that a holistic recognition of the complex sound is normally responsible for detection of periodicity.

2. Illusory continuity of interrupted tones (pulsation thresholds) have been used to study peripheral auditory mechanisms. The investigators have found that illusory continuity also occurs in the infratonal range, requiring revision of the theories of basilar membrane mechanics based on the pulsation threshold paradigm.

3. The investigators demonstrated that "frozen" noises repeated at infratonal frequencies at one ear (silence at the other ear) are detected by some listeners with much greater clarity than when the other ear receives the signal. Ear advantages of this nature have not been observed with other types of complex sounds, and this finding has some interesting implications for auditory theory.

STATEMENT OF WORK

The goal of this research program supported by AFOSR is to further our knowledge of mechanisms and principles governing the perception of complex sounds. During the second year of the current grant, the investigators have concentrated upon the recognition of the repetition of complex acoustic patterns having periods from 50 ms through 1 s. The patterns employed were "frozen" Gaussian noise segments, which when repeated without pauses are heard as "whooshing" from 1-4 Hz and "motorboating" from 4-20 Hz (frequencies above 20 Hz are complex tones producing sensations of pitch).

The first study dealt with the mechanisms employed for the detection of infratonal repetition. Is detection of repetition of these complex waveforms based upon the recognition of reoccurrence of unique features or singularities, or upon a more holistic recognition of the pattern formed by these events? To answer this question, "frozen" noise segments were divided into three sections of equal duration (A, B, C) which were

reassembled and then repeated to form periodic sounds  $(ABC)_n$  and  $(ACB)_n$ . This manipulation changed the temporal arrangement between sections but preserved singularities and repetition rate. Untrained listeners heard a series of sequence bursts consisting of either one arrangement  $[(ABC)_n, (ABC)_n, (ABC)_n, \dots]$  or two alternating arrangements  $[(ACB)_n, (ABC)_n, (ACB)_n, \dots]$  and judged whether successive bursts were the same or different. Discrimination was possible when the duration of the entire iterated pattern  $(A+B+C)$  was 900 ms or less, indicating that a holistic recognition of patterns operates up to the limit of echoic storage.

The second study dealt with a comparison of tonal and infratonal auditory induction. Auditory induction can produce illusory continuity of a tone alternated with a brief louder sound if the louder sound is capable of masking the tonal signal. This perceptual synthesis of obliterated tonal segments has been widely studied ("pulsation threshold" experiments), and the limiting conditions for this illusory continuity have been used to define characteristics of neural spectral (place) analysis of tones. The present study extends investigation of the apparent continuity of interrupted complex periodic sounds to infratonal frequencies, exploring the range of repetition frequencies from 2000 Hz down to 10 Hz. Evidence is presented indicating that reconstruction of obliterated segments of periodic sounds need not be based upon the neural place mechanisms associated with perception of tones. Illusory continuity of periodicity can involve a perceptual synthesis based upon neural temporal information, and this suggests that theories which consider the results of pulsation threshold experiments solely in terms of a frequency domain analysis of neural place information may be incomplete and misleading.

The third study dealt with ear advantages for monaural periodicity detection. The investigators found that some listeners showed a striking ear difference in the clarity of infratonal repetition perceived in both the "whooshing" and "motorboating" ranges. In Experiment 1, an overall left ear advantage was found for repeated noise delivered monaurally and opposed by contralateral silence. In Experiment 2, lateralization of the monaural signal was abolished by simultaneous presentation of a louder on-line noise to the opposite ear (contralateral induction caused the monaural signal to be perceived as centered on the medial plane). Although this manipulation eliminated the possible influence of attentional biases favoring one of the sides, ear advantages were still obtained. These results suggest the possibility of asymmetry in active subcortical processing of periodicity information.

#### PUBLICATIONS

1. Warren, R. M. "Acoustic sequences: Explaining a perceptual paradox." Journal of the Audio Engineering Society, 1986, 34, 1021 (Abstract).

2. Warren, R. M., & Meyers, M. D. "Effects of listening to repeated syllables: Category boundary shifts versus verbal transformations." Journal of Phonetics, 1987, 15, 169-181.
3. Bashford, J. A., Jr., & Warren, R. M. "Multiple phonemic restorations follow the rules for auditory induction." Perception & Psychophysics, 1987, 42, 114-121.

#### ARTICLES IN PREPARATION

1. Warren, R. M., & Bashford, J. A., Jr. "Resolution of conflicting pitch cues: Implications for theory."
2. Warren, R. M., & Bashford, J. A., Jr. "Complex tones mistuned from unison."
3. Warren, R. M., Wrightson, J. M., & Poretz, J. "A comparison of tonal and infratonal auditory induction."
4. Bashford, J. A., Jr., & Warren, R. M. "Ear advantages for monaural periodicity detection."
5. Brubaker, B. S., & Warren, R. M. "Detection of infratonal repetition of frozen noise: Singularity recognition or pattern recognition?"

#### PROFESSIONAL PERSONNEL

In addition to R. M. Warren (Principal Investigator), James A. Bashford, Jr., Ph.D., is participating in the project in the capacity of Associate Researcher. Dr. Bashford's Ph.D. in Psychology was awarded in 1984 and his dissertation was entitled "The Illusory Continuity and Enhanced Intelligibility Produced by Adding Noise to Periodic Silent Gaps in Speech: A Study in Multiple Phonemic Restoration." Graduate Students Brad S. Brubaker and Daniel Zuck have also been working on the research project.

#### PROFESSIONAL INTERACTIONS

1. Invited speaker at a special perception session of the Audio Engineering Society, Los Angeles, November, 1986. Paper topic "Acoustic Sequences: Explaining a Perceptual Paradox." (Other invited speakers at session: Edward C. Carterette, John R. Pierce, W. Dixon Ward, Floyd E. Toole, and Diana Deutsch).

2. Member of panel preparing report on "Classification of Complex Sounds for the Committee on Hearing, Bioacoustics and Biomechanics (CHABA) of the National Research Council.
3. Members of my research group and I will be presenting three papers based on AFOSR work at the November meeting of the Acoustical Society of America.

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