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Estimation and Detection: A Unified Approach I FREE

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active suppression originating in the contralateral hemisphere. In the course of these experiments, it was observed that the rate of clicks that alternate from side to side was underestimated when compared to a train of clicks presented monaurally. A subsequent experiment by Axelrod with college students as subjects showed precisely the degree of underestimation. [Work supported by Grant from N. I. M. H.]

N4. Binaural Effects in Psychoacoustic Research. DAVID M. GREEN, *University of California at San Diego, La Jolla, California 92038.*—A review of the psychoacoustic research on sound localization and the role of phase and amplitude differences between the two ears is presented. The precedence effect and the steady-state cues for localization are related. A survey of the work on masking level differences (MLD's) as well as two prominent theoretical accounts of this phenomena are discussed. [Research supported in part by the National Institutes of Health, Public Health Service, U. S. Department of Health, Education and Welfare.]

N5. On Listening to Competing Stimuli and Functional Differentiation of the Cerebral Hemispheres. DONALD SHANKWEILER, *Haskins Laboratories, New York, New York.*—A number of experiments have indicated a reliable right-ear advantage in recognition of speech materials presented dichotically to the two ears. If the stimuli are melodic patterns, however, listeners recognize more accurately those presented to the left ear. Since each ear has greater representation in the opposite cerebral hemisphere, these lateral differences in perception must reflect functional differences between the hemispheres in processing speech and nonspeech stimuli. The special relation of the left cerebral hemisphere to language processes has long been recognized, but the details of this relationship have remained obscure, partly because the evidence could only be obtained through study of patients who had incurred brain damage. The technique of dichotic listening offers an approach to the further specification of the functions of the two cerebral hemispheres in persons with intact nervous systems. Experiments with speech materials are described that bear on the problem of the units of perception and the procedures by which the perceptual apparatus arrives at phonemic decisions.

WEDNESDAY, 15 NOVEMBER — MEDALLION EAST, 9:00 A.M.

Session O. Underwater Acoustics III: Symposium on Adaptive Signal Processing

F. V. HUNT, *Chairman*

Invited Papers (30 minutes)

O1. Estimation and Detection: A Unified Approach I. HENRY COX, *Naval Ship System Command, Washington, D. C. 20360.*—The thesis of this paper is that a variety of results in optimum detection and estimation can be most easily comprehended if one first examines in detail some very simple but general problems and fully understands the assumptions, solutions, and interrelationships for these simple problems. The relationships among a variety of seemingly diverse, complicated problems may then be clearly seen since the first step in obtaining a solution is usually to transform the problem by some technique into one of the simple problems. The transformation step is frequently of such mathematical complexity that the basic strategy is effectively camouflaged. After examining the simple general problems, various applications, including optimum arrays, are discussed.

O2. Null Steering as a Realizable Process and Its Relationship to Optimum Beamforming. VICTOR C. ANDERSON, *University of California, San Diego, Marine Physical Laboratory of the Scripps Institution of Oceanography, San Diego, California 92152.*—A real-time digital processor is described that is designed to reject plane-wave interference from an operator-controlled direction, prior to normal beamforming. Both hardware and an analysis are discussed. The process is compared with the corresponding optimum process, indicating the similarities and differences that occur.

O3. Adaptive Antenna Systems. B. WIDROW, P. MANTEY, L. GRIFFITHS, B. GOODE, *Electrical Engineering Department, Stanford University, Stanford, California.*—A system consisting of an antenna array and an adaptive processor can perform filtering in both the space and frequency domains, thus reducing the sensitivity of the signal-receiving system to interfering directional noise sources. Variable weights of a signal processor can be automatically adjusted by a simple adaptive technique based on the least-mean-squares (LMS) algorithm. During the adaptive process an injected pilot signal simulates a received signal from a desired "look" direction. This allows the array to be "trained" so that its directivity pattern has a main lobe in the previously specified look direction. At the same time, the array processing system can reject any incident noises, whose directions of propagation are different from the desired look direction, by forming appropriate nulls in the antenna directivity pattern. The array adapts itself to form a main lobe, with its direction and bandwidth determined by the pilot signal, and to reject signals or noises occurring outside the main lobe as well as possible in the minimum mean-square error sense. Several examples illustrate the convergence of the LMS adaptation procedure to the corresponding Wiener-optimum solutions. Rates of adaptation and misadjust-