

XIX. SIGNAL DETECTION BY HUMAN OBSERVERS*

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RESEARCH OBJECTIVES

About five years ago, it was shown that the behavior of the human observer — in detecting and identifying simple auditory and visual signals — may be described in terms of a theory of signal detectability modeled after statistical-decision theory. A primary concern of this group is to extend the range of the psychophysical application of the theory through further development of the theory, and through experimental study of detection and identification situations that are less restricted than the simple situations investigated previously. Thus we are interested in problems involving sequential observations of a signal, complex signals (including speech), large ensembles of signals, large signal-to-noise ratios, and so forth.

Our second concern stems from the fact that the application of decision theory has identified new independent and dependent variables in psychophysical testing, with the consequence that methods have been refined and conceptions of sensory processes have been revised. For example, the theory specifies the mode of control exerted by an observer over his criterion for signal existence, and it has guided the design of methods of data collection and analysis which permit experimental separation of the effects of variation in the criterion from variation in sensitivity. This result, in addition to illuminating the detection process and providing more reliable indices of detectability, makes possible the unification of data collected under a variety of psychophysical procedures. Given these new tools and conceptions, we are interested in re-examining some of the classical problems in sensory psychology, and in examining other substantive problems in vision and audition that show promise as a result of these developments.

During the past year we have conducted experiments on pitch perception, color perception, signal uncertainty, intensity discrimination, and sequential-observation procedures.

J. A. Swets

A. THE DETECTION OF A PULSED SINUSOID OF UNCERTAIN FREQUENCY

Detection experiments were conducted under two conditions. Under one condition, the observer knew that a particular signal frequency would be used on all the trials of a sequence. In the other condition, the observer knew only that the signal would always be some frequency in a given range. In the second instance the particular signal frequency used on any trial of the sequence was determined by a random process. The observer was therefore uncertain as to the signal frequency on any one trial, but he did know the range of possible signal frequencies. Under both conditions the signals were adjusted in amplitude so that their detectability would be the same at all frequencies.

The effect of frequency uncertainty was very small. In the most extreme condition, in which the signal ranged from 500 to 4000 cps, the decrement in detectability was approximately 3 db, as compared with the condition in which the signal frequency was fixed.

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This result is inconsistent with several models that have been proposed to explain the effects of signal uncertainty. It is also very puzzling when compared with the critical-band hypothesis of Fletcher. In Fletcher's experiments, the masking noise was progressively filtered to determine which frequency components of the noise were actually effective in masking the sinusoidal signal. The result, which has since been verified by several investigators, was that only the noise components in a small band around the signal frequency were important in masking the signal. This result has usually been interpreted to imply that in a detection situation the first stage of the auditory mechanism must be likened to some type of narrow-band filter. It was supposed that there are many of these filters in parallel, and that the one having the center frequency of the signal is the only one used to detect a sinusoidal signal in noise. Clearly, the result of the experiment employing frequency uncertainty calls for a re-evaluation of the simple critical-band hypothesis.

D. M. Green