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Detection and recognition of alphabetic characters: Simultaneous and contiguous

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The present experiment was designed to examine the temporal ordering of detection performance and recognition performance in the perception of alphabetic characters, employing a visual backward-masking by noise paradigm. The results suggest that the encoding processes that lead to a correct "detection" response are completed earlier than the encoding processes that lead to a correct "recognition" response.

In recent years, several theoretical models of information processing have adopted "stages-of-processing" conceptions that suggest that the analysis of an input stimulus is the result of a series of sequential encoding processes. Each of these processes is responsible for the extraction of some aspect of the incoming signal. An empirical example of the approach can be constructed by considering a series of investigations that examined the detection performance and recognition performance (or discrimination performance) of observers who were required to make simultaneous but independent judgments at the termination of an observation interval as to whether a signal was presented and which signal was presented. Earlier research was designed to examine the concept of a high sensory threshold, a limen that had to be exceeded before a stimulus was analyzed by the sensory system. It was hypothesized that the existence of a high sensory threshold would preclude performance above chance on a recognition task in response to a signal that had been presented, but the observer had failed to "detect" (i.e., the observer responded "no" on the detection task). In the first of a series of related studies on this topic, Shipley (1965) surmised that the concept of a high sensory threshold was supported: Observers could not make correct recognition responses to signals that they reported as not having occurred. Lindner (1965), however, argued that the initial data reported by Shipley were less than conclusive, since a psychophysical procedure had been employed that confounded sensory effects with criterial or response-bias effects. In an interesting experiment that controlled and manipulated criterial effects, Lindner showed that observers could often perform significantly above chance on a recognition task in response to signals that had been presented but to which the observers replied negatively on the detection task. In both the Lindner and the Shipley studies, the signals employed were tonal pulses presented in a background of acoustic masking noise. The observers were required to indicate independently whether the tone was present or not and whether the tone (detected or not) was a high-frequency tone or a low-frequency tone. In a later paper, Munsinger and Gummerman (1968) showed that observers also could perform above chance on a recognition task in response to signals that were not "detected," when visual stimuli were employed and a hue-discrimination task was used.

In a more recent set of experiments on both the auditory and the visual systems, Blakeslee and Robinson (1973), Egan and Benson (1966), Henning (1967), and Rollman and Nachmias (1972) have shown that the psychometric function[1] that describes the ability of an observer to detect a signal may have a different slope and intercept than the psychometric function that describes the observer's ability to recognize or discriminate some aspect of the signal. In each of these experiments, the observer's ability to perform on the detection task and on the recognition task was measured in a forced-choice psychophysical setting as a function of signal-to-noise ratio. The results, in terms of percent correct, were plotted in the form of a psychometric function relating percent correct to signal-to-noise ratio. In the group of experiments, it was shown that the psychometric function for detection may often be steeper and have a lower intercept than the psycho-

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metric function for recognition when the observer has to both detect a signal and make a recognition response along a lateralization dimension (Egan & Benson, 1973), a frequency dimension (Henning, 1967), a duration dimension (Blakeslee & Robinson, 1973), or a hue dimension (Rollman & Nachmias, 1972). In the above research, then, the differentiation of the psychometric functions for detection and recognition indicated that the underlying encoding processes that lead to correct detection responses may not be identical to those encoding processes that lead to correct recognition responses.

The present research was designed to further distinguish detection processes from recognition processes by attempting to differentiate the two processes in the temporal domain, employing a visual backward-masking by noise paradigm. Specifically, do the processes underlying detection occur previous to or simultaneous with the processes underlying recognition in the perception of a visual stimulus with a fixed signal-to-noise-ratio?

METHOD

Subjects

Three experienced observers were employed.

Experimental Procedures

A variation of an experimental paradigm employed to study the perception of a briefly presented alphabetic character and described earlier (Mayzner, 1972, 1975) was utilized. The specific procedure involved the visual presentation of an uppercase letter (signal) on either the left or right half of a 10 x 18 mm area on a CRT display. The letter, which was 10 x 9 mm, was generated by the appropriate subset of a dot matrix and was viewed by an observer from a fixed position, 735 mm from the display. The duration of the letter was randomly varied, from trial to trial, from 2 to 18 msec in 2-msec intervals. The position of the letter (left or right half) also was randomly varied. Immediately following the presentation of the letter, a visual mask was presented on the entire 10 x 18 mm display area. The mask consisted of all points of the dot matrix and was presented for 500 msec. The luminance of the letter and the mask was the same on each trial, approximately 1 mL.

The task of the observer was twofold. First, the observer was required to indicate whether the signal was presented on the left or right half of the visual field (detection). Second, the observer was required to indicate which of two possible letters had appeared on the visual field (recognition). (Prior to each set of 100 trials, the observer was informed as to what pair of letters comprised the signal set, and the signal set was then used on each of the subsequent 100 trials.) The performance of the observer was measured in terms of percent correct for detection, P(D), and percent correct for recognition, P(R). The psychometric functions that were obtained on each observer, then, described the relationship between P(D) or P(R) and signal duration.

One further parameter was manipulated in the experiment. It was hypothesized that if different information-encoding processes were utilized by observers in making "detection" and "recognition" responses, these processes should be reflected in discriminably different psychometric functions (i.e., it was expected that correct recognition performance would require longer signal durations than correct detection performance). Further, it was hypothesized that the degree of disparity between the psychometric functions for detection and those for recognition could be manipulated by varying the complexity of the recognition task (Henning, 1967).[2] That is, the degree of confusability between the two letters comprising the signal set would not alter the psychometric function for detection, but would affect the psychometric function for recognition.

To manipulate the complexity of the recognition task, three sets of signals (letter pairs) were examined. Each pair was composed of letters that were equally detectable, but the degree of confusability (Mayzner, 1972, 1975) between the two letters varied. The three letter pairs, in increasing degree of confusability, were : L-T, P-R, and D-O (Mayzner, 1975).[3]

RESULTS

The results of the experiment are illustrated in Figure 1. The unfilled symbols represent the P(D) for the three letter pairs averaged across three observers. Each data point represents 600 observations, and the averaged data are representative of the data exhibited by each observer. The open squares depict data obtained for the letter pair L-T, the open triangles for the letter pair P-R, and the open circles for the letter pair D-O. The data from the recognition task, P(R), for the three letter pairs are illustrated with the filled-in symbols: the filled squares for the letter pair L-T, the filled triangles for the letter pair P-R, and the filled circles for the letter pair D-O. Again, each data point represents averaged data obtained on three observers and is representative of each individual's performance.

The detection functions for each of the three letter pairs were nearly identical. In all cases, P(D) increased from a level near chance performance to a level near perfect detection as signal duration was increased from 2 to 12 msec. The recognition functions, however, were different for the three letter pairs. The recognition function for the letter pair L-T closely resembled the pattern of the detection functions. Recognition functions for the letter pairs P-R and D-O, however, were displaced to the right of the detection functions and had much lower slopes. Recognition performance for the letter pair D-O was only 72% when the signal duration equaled 18 msec, and the detection of these letters was perfect. Additional observations on the letter

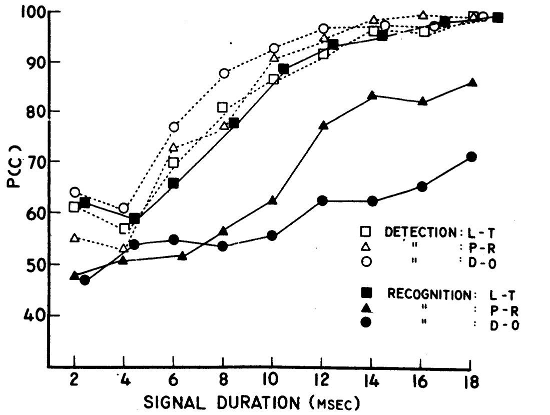

Figure 1. Probability of correct detection or recognition as a function of signal duration.

pair D-O that are not included in Figure 1 indicated that signal duration had to be increased to over 40 msec before recognition performance reached 100%.

DISCUSSION

The major conclusion of the investigation is that detection processes and recognition processes can be differentiated in the temporal domain. The encoding processes that led to correct detection responses clearly did not require the same signal duration as did encoding processes that led to correct recognition responses. This result strongly implies that, although detection and recognition processes may be initiated simultaneously, detection processes are completed prior to the completion of recognition processes. Further, since the position of the recognition functions were dependent upon task complexity, it can also be concluded that recognition processes for complex discrimination tasks require more time than do recognition processes for simpler discrimination tasks.

REFERENCES

Blakeslee, E. A., & Robinson, D. E. Comparison of detectability and discriminability of tones of different duration under homophasic and antiphasic conditions. *Journal of the Acoustical Society of America*, 1973, **54**, 309.

Egan, J. P., & Benson, W. Lateralization of a weak signal presented with correlated and with uncorrelated noise. *Journal of the Acoustical Society of America*, 1966, **40**, 20-27.

Henning, G. B. Frequency discrimination in noise. *Journal of the Acoustical Society of America*, 1967, **4**, 774-777.

Lindner, W. A. Recognition performance as a function of detection criterion in a simultaneous detection-recognition task. *Journal of the Acoustical Society of America*, 1968, **44**, 204-211.

Mayzner, M. S. Visual information processing of alphabetic inputs. *Psychonomic Monograph Supplements*, 1972, **4**(13, Whole No. 61), 239-243.

Mayzner, M. S. Studies of visual information processing in man. In R. L. Solso (Ed.), *Information processing and cognition: The Loyola symposium*. Hillsdale, N.J: Erlbaum, 1975.

Munsinger, H., & Gummerman, K. Simultaneous visual detection and recognition. *Perception & Psychophysics*, 1968, **3**, 383-386.

Rollman, G. B., & Nachmias, J. Simultaneous detection and recognition of chromatic flashes. *Perception & Psychophysics*, 1972, **12**, 309-314.

Shipley, E. F. Detection and recognition: Experiments and choice models. *Journal of Mathematical Psychology*, 1965, **2**, 277-311.

NOTES

1. Psychometric function is defined here as the function relating performance exhibited by observers, usually in terms of percent correct on a forced-choice psychophysical task, as a parameter of the input stimulus being manipulated. In a detection paradigm, for example, the psychometric function would describe the observer's percent correct in detection performance as a function of signal-to-noise ratio.

2. In the study by Henning (1967) on the auditory system, the position of the psychometric functions for recognition were dependent upon the difficulty of the frequency-discrimination task.

3. In earlier studies (Mayzner, 1972, 1975) that examined the entire alphabet, recognition functions and interletter confusability coefficients were determined.

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