Dichopic summation of information in the recognition of briefly presented forms

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Visual form identification was studied under conditions where the forms to be identified were presented briefly to the right and left eyes alone, to the right and left eye simultaneously on corresponding areas, and to the right and left eye sequentially on corresponding areas. The results suggest the following conclusions: (1) successive stimulation of the two eyes is better than either eye alone if the stimulation falls on corresponding areas; (2) successive stimulation of corresponding areas is about identical to simultaneously stimulated corresponding areas; and (3) the amount of gain in identification accuracy resulting from stimulation to the two eyes was not greater than can be attributed to two independent opportunities to perceive.

While binocular brightness interaction has been extensively studied (see Levelt, 1965, for a recent summary) little work has been carried out on binocular contributions to form perception. The present experiment was concerned with form identification under conditions where (a) the form was presented to the right eye or to the left eye alone, (b) to corresponding retinal areas in both eyes simultaneously, and (c) to corresponding areas in the two eyes successively. By comparison of form identification accuracy under these conditions of presentation, the contribution of binocular viewing not only can be assessed but also whether the contribution depends upon simultaneity and further whether the gain from binocular viewing is greater than that to be attributed from two independent chances to perceive the form.

Method

The Ss were five patients at the Veterans Administration Hospital, Danville, and two staff members, screened for visual acuity. They had been further selected as being able to achieve the recognition criterion for forms presented to either eye alone at durations of 40 msec. or less.

The apparatus consisted of a dichopic tachistoscope containing three fields. One field provided for an adapting luminance to both eyes and the right and the left eye viewing fields could be aligned by the use of front surface mirrors so as to produce a fused stimulus image when viewed by the two eyes. Field durations and sequencing were carried out by a Scientific Prototype Model GB tachistoscopic timer. The stimuli consisted of three five-sided nonsense forms constructed according to the method described by Attneave (1957). Both the right and left viewing fields contained a black-lighted fixation cross subtending .22 min. of angle which when viewed binocularly fused into a single image. Single forms were presented .5° below the fixation point and all stimulation was foveal. The forms were black, subtending .22° of angle on a maximum dimension, and were mounted on white matte finish plastic cards. The adapting field had a luminance of .68 mL and remained on continuously. Stimulation from either of the two viewing fields was superimposed upon the adapting luminance and the viewing fields themselves had a luminance of .29 mL.

Stimulation was activated by a trigger controlled by S. He was instructed to fixate the cross and when the image was clear and fused, to press the trigger which would initiate the stimulation sequence. Following a form presentation S was required to make a forced choice response among the three form alternatives which were displayed to one side of the tachistoscope in front of the S. Prior to beginning the experimental trials all Ss were run for two practice sessions in order to become familiar with the forms and become adept at form recognition at brief durations. These practice sessions also served to establish an individual duration value (T) for the S which would yield above chance but less than 100% recognition for the forms presented to either eye alone. In the following four experimental sessions each S made 54 judgments for forms presented for duration T to the left eye alone, to the right eye alone, to the left eye for duration T followed immediately by stimulation to the right eye for duration T, to the right eye for duration T followed immediately by stimulation to the left eye for duration T, to both eyes simultaneously for duration T, and to both eyes simultaneously for duration 2T. On those presentations where both eyes were stimulated the stimulation fell on corresponding retinal points.

Results

Table 1 shows the mean percent recognition accuracy for the six different methods of form presentation. Statistical tests show that stimulation of either eye alone is significantly poorer ($p < .01$) than any of the other four methods of presentation. Stimulation sequentially of the right eye and then the left eye or vice versa is

Table 1. Percent Correct Form Identifications as a Function of Conditions of Monocular and Binocular Viewing

Monocular		Dichopic			
		Successive		Simultaneous	
Right eye	Left eye	Right to left eye	Left to right eye	Duration T	Duration 2T
47.1	48.4	61.7	57.7	57.7	66.6

not significantly different from stimulation of both eyes simultaneously. Stimulation of both eyes simultaneously for duration 2T was included as a control to insure that recognition accuracy on this task would improve by a measurable amount when time increased. As can be seen from the table, this requirement has been met. Recognition accuracy for stimulation simultaneously of both eyes at duration 2T is significantly ($p < .01$) higher than recognition accuracy under any of the other five conditions.

Discussion

The results seem clear in showing that you get equal accuracy in form identification with equal energy entering the visual system. Forty msec. of energy presented to each eye simultaneously yields essentially the same form identification accuracy as occurs when one eye is stimulated for 40 msec. followed immediately by 40 msec. of stimulation to the second eye. At first this would appear to be nothing more than another manifestation of time-intensity reciprocity but an interpretation in terms of the Bunsen-Roscoe effect would seem to rule out explanations of the latter as being localized in photo-chemical processes in the retina (Hartline, 1934). A central summation or integration of energy would seem to be required and would also be consistent with findings reported by Kahnneman & Norman (1964).

In the present experiment there was no delay between the successive presentations to the two eyes. The finding of essentially the same identification performance with successive as opposed to simultaneous stimulation suggests a systematic exploration of the effects of introducing measured delays between the successive stimulations. However, with increasing delays summation effects may be obscured by a possible contralateral suppression. Bouman (1955) has reported that monocular stimulation results in raised thresholds in the other eye with latencies at least beyond 400 msec.

It is also possible that the present results do not reflect a true summation of information or energy. Instead, the gain in identification obtained from dichopic viewing, either simultaneous or successive, in the present experiment may be the result of two independent opportunities to perceive. An approximation of the level of performance to be expected on the basis of independence can be obtained in the following manner. An estimate of the number of times Ss failed to perceive the stimulus and guessed can be obtained from the percent of wrong responses (52%) which with an a priori probability of 1/3 correct guessing would be 2/3 of the total number of times he had to guess. Thus the S would have guessed a total of 78% of the trials. The probability that he failed to perceive the stimulus with either eye is then $.78^2$ or .61. Assuming 1/3 of these correct by chance and added to the 39% of trials in which he perceived the stimulus with either eye or both, the resulting hit rate for two independent chances is found to be 59%. This is not appreciably different than the values of 57% and 58% obtained for simultaneous and successive dichopic presentations.

It has been shown (Eriksen, 1966) that this method of computing independence will tend to overestimate the expected level. However, as an approximation it is quite close to the obtained values, so close that the possibility cannot be discarded that the gain from the dichopic viewing in the present experiment can be attributable to two independent chances to perceive rather than to a summation or integration of information in the visual system. Pirenne (1943) has previously reported that the dichopic detection of brief flashes fits a probability model of independence.

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