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EFFECT OF WIDTH OF MOVEMENT OF A MASKING STIMULUS AT CONSTANT TARGET SEPARATION

by

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SUMMARY PAGE

THE PROBLEM

To determine the effects of varying amounts of movement of a line on light on a stationary target lying in its path when the separation of line and target is kept constant.

FINDINGS

Contrary to expectation, target detection improved at small separations of target and moving line as the amount of movement was increased.

APPLICATION

These results show that the detectability of small, stationary targets, such as radar blips, is not degraded by increasing the width of movement of the line of light around the target.

ADMINISTRATIVE INFORMATION

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Effect of Width of Movement of a Masking Stimulus at Constant Target Separation*

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THERE have been many studies of visual masking, the rise of the detection threshold of a target which occurs when a second stimulus is presented within certain spatiotemporal limits. Using a variety of stimulus configurations, investigators have studied such variables as the luminances of the two stimuli, their duration, temporal and spatial separation, retinal location, preadaptation level, and interocular effects.[1]

A number of recent studies have been concerned with contour effects.[2] Using concentrically overlapping stimuli, it has been shown that the threshold of a test stimulus increases as the size of the masking stimulus decreases and the edges of the two stimuli become more nearly congruent. This is interpreted as the result of neural processes occurring at the borders of the stimuli.

This study investigated the effects of varying the size of the masking stimulus, by extending its width of movement while, however, the separation between the masking and test stimuli was kept constant.

In the first part of this study, the effects of three widths of movement of the masking stimulus on the threshold of the test stimulus were measured. The mask was a vertical line of light 4.29° high and 0.36° wide. Its luminance, measured when it was stationary, was about 0.5 ft-L. It moved from left to right, at a speed of 17°/sec, toward both the test stimulus and the fovea, through a traverse of 0.36°, 1.15°, or 3.43° visual angle; the durations of these three movements were about 20, 67, and 200 msec. The movement terminated at one of four separations from the test stimulus, 0°, 0.3°, 0.6°, or 0.9° visual angle. The mask never moved past the test stimulus. The latter was a strip of light 1.15° high and 0.58° wide situated 4.3° to the left of a fixation point; its duration was 50 msec; its presentation was so timed that it and the mask disappeared simultaneously.

The apparatus and general procedure have been described in detail elsewhere.[3] Basically, the moving mask was produced by light through a slit in the bob of a pendulum. Both endpoints of its traverse could be varied independently by movable baffles, so the position of the onset of movement could be varied while the point at which it ended remained unchanged. Thus the separation of the mask and test stimulus remained constant as the width of movement varied.

In each session, two determinations were made under all conditions. The separations between the stimuli and the widths of movement at each separation were varied randomly. There were ten sessions for both observers. Observations were made with the right eye.

The results are given in Table I as ratios of the threshold of the test stimulus in the presence of the mask to its threshold by itself. The values are the averages for the ten sessions. A ratio of unity indicates no masking effect, and larger ratios indicate increased masking. The purpose of computing such ratios is to eliminate the effects of day-to-day variability of absolute sensitivity. There was, nevertheless, appreciable variability of the ratios for a given condition, between sessions. The significance of the results was tested, therefore, by the nonparametric sign test.[4] For each separation of test and masking stimuli, the test-stimulus threshold in the presence of the smallest width of movement was compared with the threshold in the presence of the two greater movements; comparisons were also made between the thresholds in the presence of the two greater movements.

The results are, in the main, similar for both observers despite differences of absolute sensitivity and of the amount of interaction for any given condition. As expected, the ratios increased as the separation between the stimuli decreased. But more important, for any given separation, the average threshold ratios were lower in the presence of the greatest movement than in the presence of the middle movement in every case except one. For the two smaller separations, the ratios in the presence of the greatest movement were smaller than in the presence of the smallest movement as well. There was usually a small but statistically insignificant rise of the ratio with the middle movement compared with the smallest movement.

Under these conditions, then, the threshold of the test stimulus does not continue to rise with increasing movement of the mask; on the contrary, there is a decrease of the amount of masking with the greatest movement despite the fact that the additional movement results in a greater total of luminous flux in the mask, a greater total duration of its visibility and more stray light—all of which might presumably be expected to increase the amount of masking.

These results are open to the criticism, however, that the duration of the greatest movement, 200 msec, may be long enough to permit eye movement, which would influence the results.[5] The slow speed used was adopted on the basis of the assumption that eye movements would more likely be toward the stimuli. This should result in the dim test stimulus being presented more foveally than planned and should produce higher thresholds rather than the lower ones which were obtained. If, on the other hand, the test stimulus were presented during the eye movement, there should also be an impairment of vision either during the movement,[6] or just before it,[7] whether the movement is voluntary or not.[8]

Nevertheless, it is possible that eye movements away from the stimuli occurred; therefore, a second experiment was done using

TABLE I. Ratios of the luminance threshold of the target in the presence of the mask to its threshold in isolation for both observers in the various conditions.

Separation of *T* and *M*	AR Width of movement 0.36°	AR 1.15°	AR 3.43°	SL Width of movement 0.36°	SL 1.15°	SL 3.43°
0°	34.22	25.77[a]	28.89[a]	14.35	14.65	10.62[a,c]
0.3°	12.87	12.49	10.81[b]	6.07	6.66	5.26
0.6°	4.20	7.38	5.26[c]	2.48	2.80	2.65
0.9°	2.59	3.18	2.68[d]	1.76	1.92	1.71

[a] Significantly different from short movement ($p < 0.01$).
[b] Significantly different from short movement ($p < 0.05$).
[c] Significantly different from middle movement ($p < 0.01$).
[d] Significantly different from middle movement ($p < 0.05$).

a nigher speed of the masking line, 85°/sec. Four widths of movement were used, 0.6, 1.7, 2.9, and 4.0° visual angle; the greatest exposure time now was less than 50 msec, and, owing to the design of the apparatus, the duration of the test stimulus was now 10 msec. Five separations of the test and masking stimuli were studied, those in the first experiment plus 2.0° visual angle.

Only one separation of target and masking stimuli was presented in each session and eight measurements of the target threshold were randomly obtained for each of the four widths of movement. There were three sessions for each separation of the stimuli, presented in different random orders for each observer.

The results are presented in Fig. 1 as the log of the target threshold. They are quite similar to those in the first experiment; the widest movement again resulted in a sharp decrease of target threshold at the first two separations for AR and at the zero separation for SL. The additional points, however, show that the functions are more complex than were indicated by Experiment 1; at the intermediate separations of the stimuli, they are U-shaped rather than flat. This appears clearly for SL at the three middle separations, although there is little more than a suggestion of it for AR at a separation of 0.6°. Both the U-shaped and the flat curves for AR at 0.9° again become falling curves at the largest separation.

It is clear that with both speeds of the moving line the thresholds of the test stimulus do not simply increase with increasing movements. On the contrary, at the smaller separations of the two stimuli, there is a sharp decrease of the amount of masking as the size of the mask is reduced. The only difference between the two sets of data is that in Experiment 1 the thresholds were somewhat greater, in most cases, for the 1.15° movement than for the other two movements. Under no condition, however, do the greatest movements result in an appreciable increase of masking compared to the least movements.

These results appear to be related to findings recently reported by Westheimer.[9] He has shown that the increment threshold of a test stimulus increases as the size of the surround (within certain limits of luminance) increases up to a certain point and then decreases with further increases of the size of the surround. These changes are ascribed to an increase of excitation in the region of the test stimulus when the surround close to it is illuminated and a decrease of excitation when more remote areas of the surround are also stimulated. An increase of excitation, for example, results in an increase of threshold.

We, also, are dealing with increment thresholds, since the screen on which the stimuli are projected is dimly illuminated. It seems reasonable, then, that the greater threshold for the 1.15° movement than for the 0.36° movement results from the same process as causes the increase of Westheimer's thresholds with increasing size of surround. The decrease of AR's data may indicate that her functions would peak at a somewhat different movement. The continued increase for the 1.15° movement, even when the separation between the two stimuli is increased, suggests that, within limits, the width of the surround, as well as the distance from the test stimulus, is important.

In Fig. 1, where the smallest movement was 0.6°, there is almost invariably an initial decrease of threshold rather than an increase. This presumably indicates that at this retinal location, the 0.6° movement is on the falling part of Westheimer's curve. But where there is an appropriate separation between the mask and the test stimulus, the thresholds do not continue to decrease with continued increases of movement but rather increase again.

These data indicate that when there is a very small or no separation between the mask and test stimulus, increasing the movement beyond 0.6° produces continually greater decreases of excitation in the test area. When there is enough separation, however, the lateral interactions may be so attenuated that the depressive effect may be more than nullified by the effect of stray light so that the thresholds begin to increase again. Or it

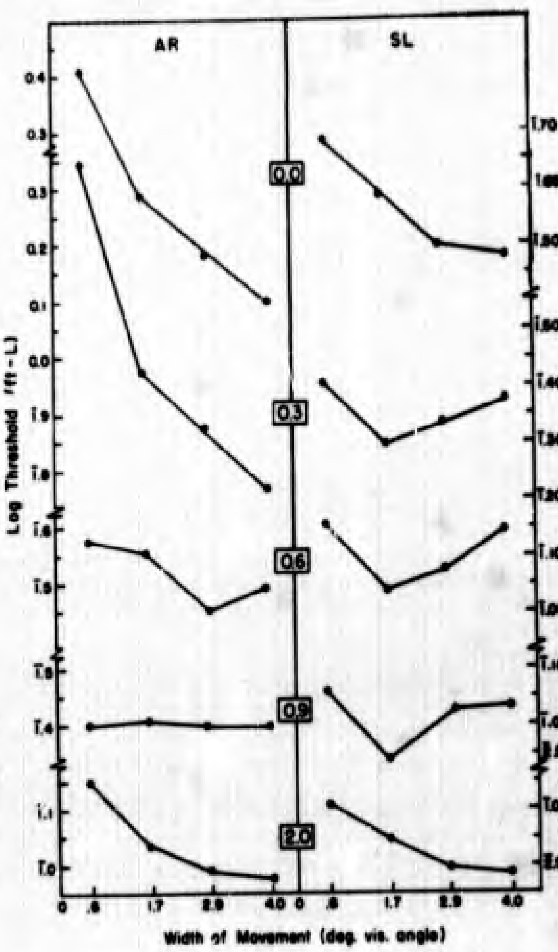

FIG. 1. Thresholds of the test stimulus as a function of the width of movement at the various separations of mask and test stimulus. Threshold for the test stimulus alone was about −2.5 log ft-L for SL and about −2.8 for AR

may be that the mask is now affecting the excitation only in the area between the stimuli. Only a small mask is required to increase the threshold of the test stimulus by a given amount. When the width of the mask is slightly increased, the activity in the gap would at first be increased; this would result in a reduction of activity in the area of the test stimulus and hence a lower threshold. As the width of the mask is further increased however, the excitation in the gap would begin to decrease, resulting in increased excitation in the stimulus area and an increase of threshold. For further study of this problem, the use of stationary stimuli should be considered. The present results would probably be confirmed, since in the second experiment the speed was too great for the perception of movement.

* From Bureau of Medicine and Surgery, Navy Department, Research Work Unit MFO22.03.03-9011. The opinions or assertions contained herein are the private ones of the author and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

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[9] G. Westheimer, J. Physiol. (London) 181, 881 (1965).

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13. ABSTRACT

In certain pieces of equipment, such as radar screens, operators are required to detect small target blips in the path of a moving line of light. Since the moving line presumably reduces the amount of contrast and, hence, the detectability of the blip, it might be supposed that the detectability of the target is more and more degraded as the amount of visible movement increases prior to the appearance of the target.

In this study, target threshold was measured when a moving line was visible for varying distances beside the target, at several final separations of target and line. Contrary to expectation, it was found that an increase in the width of movement significantly improved the detectability of the stationary target in its path. Unless the moving line can be completely eliminated, it should not be restricted to narrow widths of movement near the target.

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