Reaction time to visual targets as a function of the proximity of a contour

by Stephen Charles Murphy

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Psychology
Montana State University

Abstract:
Recent investigations have found that the larger the display diameter, the faster the subjects' reaction times to targets presented in that display. Three alternative explanations have been proposed for these results. The first, which, involved the Gestalt principle of internal cohesion, does not provide a viable explanation. The second explanation involved contour interference effects. The third was based on simultaneous contrast effects. It has been impossible to determine which of the latter two explanations is superior, due to confounding in earlier research. In order to obtain a clean test of the contour interference explanation, all potential simultaneous contrast effects have been eliminated from the display used in the present study. The subjects' reaction times to targets presented within a simple contour ring were recorded. The four angles of separation between the contour and the targets were 1° , 3°, 6°, and 8&deg,. Contrary to what would be predicted by the contour interference explanation, no significant difference in reaction times was found as the separation between the target stimuli and the contour increased. Thus, contour interference effects can be rejected as an explanation for the earlier findings. The simultaneous contrast explanation, therefore, remains the only viable alternative of those considered.

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Abstract

Recent investigations have found that the larger the display diameter, the faster the subjects' reaction times to targets presented in that display. Three alternative explanations have been proposed for these results. The first, which involved the Gestalt principle of internal cohesion, does not provide a viable explanation. The second explanation involved contour interference effects. The third was based on simultaneous contrast effects. It has been impossible to determine which of the latter two explanations is superior, due to confounding in earlier research. In order to obtain a clean test of the contour interference explanation, all potential simultaneous contrast effects have been eliminated from the display used in the present study. The subjects' reaction times to targets presented within a simple contour ring were recorded. The four angles of separation between the contour and the targets were 1°, 3°, 6°, and 8°. Contrary to what would be predicted by the contour interference explanation, no significant difference in reaction times was found as the separation between the target stimuli and the contour increased. Thus, contour interference effects can be rejected as an explanation for the earlier findings. The simultaneous contrast explanation, therefore, remains the only viable alternative of those considered.

Introduction

Bell, Symington, and Bevan (1974) have investigated the effect of the size of a display on the reaction time to targets presented in the display. In this study, a square stimulus array, consisting of four small, brightly illuminated disks, was presented for .1 seconds in a circular display area. Two display area diameters were used; one diameter was 20 inches and the other diameter was 30 inches. The two display diameters were used in both a near and a far viewing condition. This combination of display diameter and viewing distance resulted in four display sizes, each subtending a different visual angle. In the far viewing condition, the 20-inch display subtended a visual angle of 9°, while the 30-inch display subtended an angle of 14°. In the near viewing condition, the 20-inch display subtended an angle of 28°, while the 30-inch display subtended a 38° visual angle. The display area, in all conditions, was surrounded by a black field. Figure 1 is an example of the display used by Bell et al. The subject's task was to report, as quickly as possible, whether or not a cross (target) had been presented in place of one of the disks (nontargets) in the array. The subject responded either positively (cross presented) or negatively (cross not presented) by depressing one of two keys. The time which elapsed between the onset of the stimulus array and the

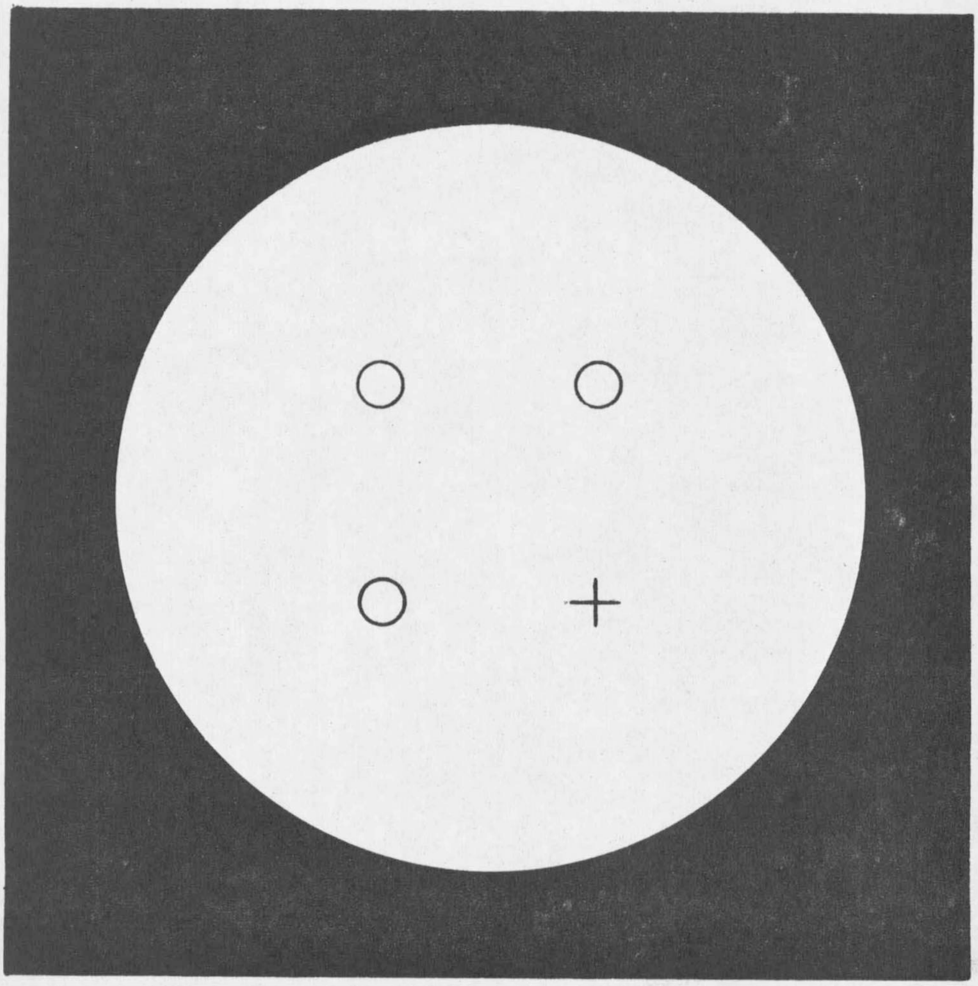

Figure 1. Display used by Bell, Symington, and Bevan (1974). The black surround measured 35 x 35 inches. The light display area had a diameter of either 20 or 30 inches. The stimuli (crosses and disks) were lighter than the display area.

depression of one of the response keys was recorded as the subject's reaction time.

Bell et al. found that the reaction times to targets presented in the 30-inch display conditions were significantly shorter than the reaction times to targets in the 20-inch display conditions, regardless of viewing distance. Since the stimulus array subtended a visual angle of 6° in all display conditions, dispersion was not considered to have influenced the results.

One explanation offered for the results was based on the Gestalt principle of internal cohesion. According to Koffka (1935), when a contour line is closed (such as a circle) the area inside the contour becomes a unified entity, completely separate from the area outside the contour. The enclosed area is said to be internally cohesive because it tends to resist the formation of any other figure within its boundaries. The enclosed figure is most easily viewed as being homogeneous (Wertheimer, 1955). Bell et al. suggest that the border between the display area and the black surround constituted an enclosing contour. Thus, the internal cohesion of the display area interfered with the detection of the targets. Bell et al. implied, but never directly stated, that the larger display diameter had less internal cohesion than the smaller display diameter. Less internal cohesion would mean less interference with the detection of the target and, therefore, faster reaction times in the larger display.

Internal cohesion, however, is a uniform property of the figure and is lost only when the figure is no longer perceived as being a figure (Koffka, 1935). It is not a function of the size of the figure or the distance from the enclosing contour. In the Bell et al. study, internal cohesion was a constant in both display diameters and, therefore, should have had no effect on the reaction times.

Furthermore, Craik and Zangwill (1939) have empirically tested the internal cohesion assumption. In the first experiment reported by these authors, the threshold for a test spot was higher when the test spot appeared inside a figure than when the test spot appeared outside the figure. In the second, and more important, experiment, the threshold at which the test spot was just detectable rose as black lines were added to the field around the test spot. The rise in the threshold was the same, regardless of whether the lines were arranged to form a good figure (a square) or merely to form a set of parallel lines on either side of the test spot (see Figure 2). Craik and Zangwill considered the second finding incompatible with the principle of internal cohesion. While the authors offered no firm expla-

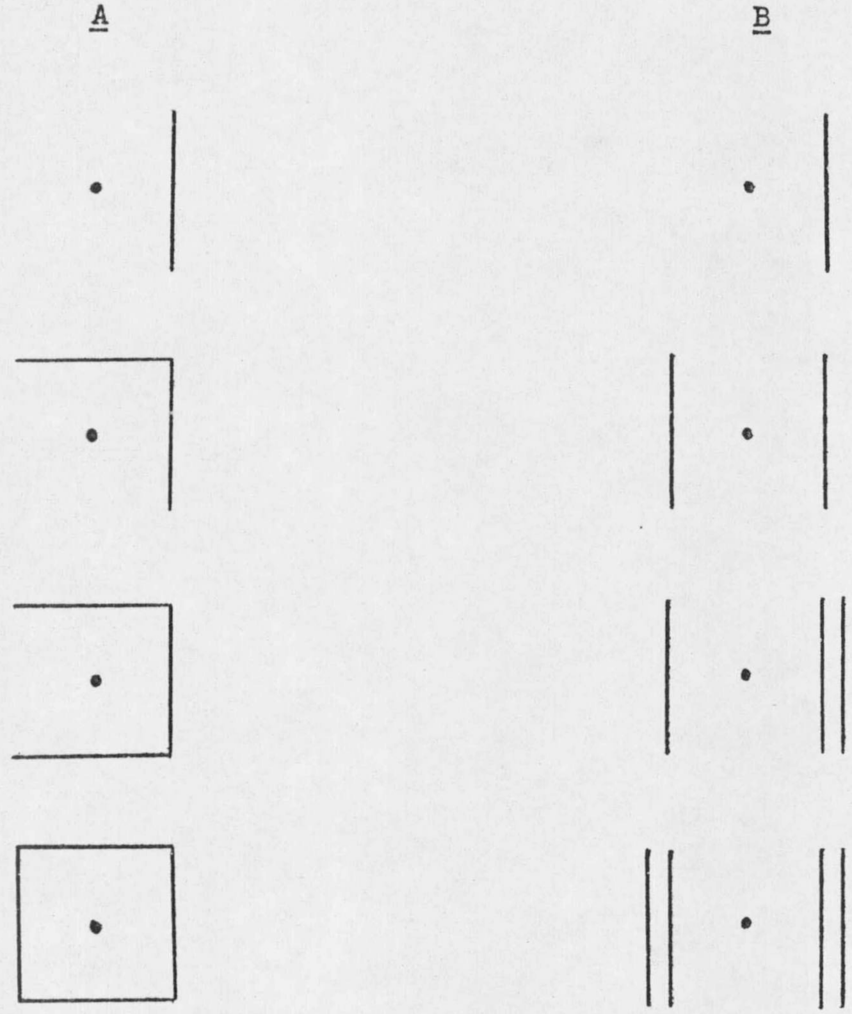

Figure 2. Stimuli used by Craik and Zangwill (1939). The stimuli in column A were arranged so that as more lines were added they formed an enclosing contour. The stimuli in column B were arranged so that as more lines were added they formed sets of parallel lines to the right and left of the test spot (dot). While the threshold of the test spot rose as the number of lines increased, the arrangement of the lines had no effect.

nation for their findings, they did mention the possibility that the change in the amount of light stimulating the retina, which was a result of the addition of the black lines to the field, may have influenced the threshold for the test spot. Youniss and Calvin (1961) have confirmed the basic findings of Craik and Zangwill.

A second explanation offered by Bell et al. involves contour interference effects. They suggested that the strong contour created at the point where the light display area met the black surround interfered with the subject's ability to distinguish the targets from the nontargets. The closer the contour to the target stimuli, the stronger should be the interference effect. Thus, in the 30-inch display conditions, where the contour was separated from the targets by a greater distance than in the 20-inch displays, there would be less interference with the differentiation between targets and nontargets. Easier differentiation of the targets would result in faster reaction times for the subjects. It should be noted, however, that Bell et al. reported their results in terms of display diameter, rather than angle of contour-target separation.

The support for the contour interference explanation cited by Bell et al. is based on an experiment reported by

Fry and Bartley (1935). Using the display shown in Figure 3, they found that when the distance between the test spot A and the contour line B was varied, the contrast threshold at which A was detactable also varied. As the separation between A and B increased, the threshold at which A was detectable decreased. The explanation offered was that the edge of contour B interfered with the differentiation of a boundary between A and the background. The further B was from A, the less the boundary was affected by this interference. This effect, however, was not found when the separation between A and B exceeded 4^{o} of visual angle (see Figure 4).

In a related study, Flom, Weymouth, and Kahneman (1963) found that a nearby contour line can adversely affect visual resolution. Flom et al. used Landolt C's, surrounded by four tangentially arranged black contour lines, as stimulus patterns (see Figure 5). The separation between the Landolt C and the black contour lines varied between 0^{o} and $2^{o}38'$ of visual angle. Each subject viewed the stimulus pattern from a distance at which he could, 80% of the time, correctly identify the position of the gap in an unsurrounded C. When the contours were within 1/3 of a degree of the Landolt C, the probability of the subject correctly identifying the position of the gap was reduced by as much as 0.80. When the contours