Effects of stimulus-heterogeneity upon distance estimates

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This study evaluated the result of a reduction in the number of types of stimuli (heterogeneity) in the visual field upon distance estimates. Heterogeneity reduction led to significantly shorter distance estimates when a standard consisted of unequal numbers of stimulus-types, but not when they were equally represented.

The heterogeneity (number of stimulus-types) in the visual field may be altered as a person approaches or recedes from a stationary point, the amount of reduction depending upon the nature of the environment. This psychophysical experiment was designed to investigate one aspect of this phenomenon; the effects of heterogeneity reduction upon estimates of distance. Two standard conditions were tried in which the number of three stimulus-types differed. One standard consisted of an *equal* number of three types of stimuli (triangles, circles, and squares); the second standard had an *unequal* distribution of these same three figures. In both situations, if it is assumed that factors defining a stimulus-type are constant, decreases in heterogeneity from the standard levels should be accompanied by shorter distance estimates.

Method

The apparatus and mode of stimulus construction were the same as described previously (Baird, 1966). The stimuli were viewed monocularly (right eye) through a reduction tube which eliminated extraneous visual cues; and the relevant patterns were presented before a lighted screen located 4 ft. from the cornea. The stimuli were divided into two sets, each containing a standard and three comparisons. Standard 1 consisted of 34 equilateral triangles (5.5 mm on a side), 34 circles (4.5 mm diameter), and 34 squares (4 mm on a side) drawn in black ink on white paper. The figures were placed so half of each type appeared in the top and bottom halves of the pattern. In addition, an attempt was made to place a particular type of figure at the greatest possible distance from its likeness, given the constraint of pattern-size (4 x 4 in.) and mean inter-figure distances (approximately 11 mm). When the pattern appeared before the lighted screen, the triangles and squares were oriented with one side parallel to the floor. The comparisons of Set 1 each contained three figures. One pattern consisted of three triangles (*low* heterogeneity); the second, two triangles, and one circle (*medium* heterogeneity); and the third, one triangle, one circle, and one square (*high* heterogeneity). The three figures in each comparison were identical in size with the figures in standard 1 and maintained the

same relative positions within all three patterns. The comparisons differed only in their stimulus-types.

Standard 2 contained 72 triangles, 24 circles, and six squares of dimensions equal to those in standard 1. Identical figures were located as far apart as possible, and the pattern-size and approximate mean inter-figure distances were the same as in standard 1. The three comparisons each represented a subset of the positions of the same six figures in standard 2. However, the types of figures differed among the comparisons. One contained six triangles (*low* heterogeneity), the second consisted of three triangles and three circles (*medium* heterogeneity), and the third contained two triangles, two circles, and two squares (*high* heterogeneity). When a standard was positioned before the lighted screen, its luminance was 58.3 ft.-L, while each comparison was 61.2 ft.-L as measured with the Macbeth illuminometer.

Twenty-four undergraduate men served as Os, and each was naive concerning the purpose of the experiment. All Os stated they had normal vision (corrected if necessary). The O was told to pretend he was in a capsule moving through space and that he must estimate the distance he had traveled toward a group of planetary objects by noting changes in the pattern appearing on the screen before him. The standard stimuli were stated as being 10 million miles away and O was told to use all the information he could in estimating the distances of the successively presented comparisons relative to their particular standards. Each O made two estimates of each comparison. Twelve Os first estimated the distances of the comparisons of Set 1 relative to standard 1, shown first for 10 sec.; and then they estimated the comparisons of Set 2. Twelve different Os were given the reverse order. Each of the six possible presentation orders within a set were run twice, and an O continued on the same order throughout both sets of patterns.

After distance estimates were obtained, estimates were made of the number of triangles, circles, and squares in each of the two standards. The stimuli were exposed individually for a 4 sec. interval, and order of presentation was the same as O experienced for his distance estimates.

Results

There were no important order effects. The mean distance values (in millions of miles) for the initial estimates of the comparison stimuli of Set 1 were: *low* heterogeneity, 5.6; *medium*, 5.6; and *high*, 5.4 with standard deviations of 2.8, 3.3, and 3.2 respectively.

The mean values for the second estimates of Set 1 were: *low*, 5.4; *medium*, 5.4; and *high*, 5.6 with a standard deviation of 2.9 for each pattern. Because of large individual differences, ranks were assigned independently to each O's mean estimate of each comparison, and a Friedman Test (Siegel, 1956) was conducted to test for differences among heterogeneity levels. The sum of ranks for the three comparisons were: *low*, 43.5; *medium*, 48.5; and *high*, 52.0. The obtained X^2_T was 1.5 which is not significant ($p > .05$, $df = 2$). The three patterns did not differ greatly in the proportion of time they received each of the three ranks though the trends are in the order hypothesized.

The means of the initial estimates of the comparisons of Set 2 in millions of miles were: *low* heterogeneity, 5.6, *medium*, 5.8 and *high* 6.6 with standard deviations of 2.7, 2.8, and 2.7 respectively. Comparable mean values for the second estimates of Set 2 were: *low*, 6.0; *medium*, 5.7; and *high*, 6.6 with standard deviations of 2.8, 2.8, and 2.4 respectively. A Friedman Test revealed significant differences between the sum of ranks for the means of the three comparisons of Set 2 ($X^2_T = 10.8$, $df = 2$, $p < .05$). The sum of ranks for the comparisons were: *low*, 40.0; *medium*, 43.0; and *high*, 61.0. The direction of these ranks are as hypothesized; namely, the less the heterogeneity, the smaller the ranked distance. Also, the *low* pattern was represented most frequently on Rank 1 (closest distance), the *medium* pattern on Rank 2 (medium distance), and the *high* pattern on Rank 3 (greatest distance).

The mean estimates of numerosity for the figures of standard 1 in which there was an equal number of each stimulus-type (34) were: 29.8 triangles, 25.5 circles, and 24.6 squares. These differences are not significant as tested by analysis of variance ($F = 1.17$, $df = 2/46$). The mean numerosity values obtained for standard 2 in which there were 72 triangles, 24 circles, and six squares were as follows: triangles, 47.0; circles, 23.0; and squares, 19.0. Through analysis of variance these differences were found to be significant beyond the .05 level of confidence, $F = 26.6$,

$df = 2/46$. Observers also was a significant source of variance ($F = 4.2$, $df = 23/46$, $p < .05$). Further analysis of individual means revealed that the mean estimate of triangles differed significantly from the mean estimate of circles ($p < .05$), but the difference between circles and squares was not significant.

Discussion

One of the more plausible explanations of these results can be constructed around the distinctions between the standard stimuli. Standard 1 had an equal number of triangles, circles, and squares, while standard 2 contained an unequal distribution of these figures. Observer movement toward these patterns would establish different probabilities that particular figures would be seen at different distances. For instance, in an environment represented by standard 1, approach might not produce heterogeneity reduction due to the equal occurrence of stimulus-types. On the other hand, movement through a standard 2 environment increases the probability that certain types are eliminated from the visual field at different distances. Because of their initial scarcity, squares would leave first followed later by circles; and at close distances, only triangles would be likely to remain. Therefore, the number of stimuli of a given shape class determines on a *probabilistic* basis the distance at which all its members disappear from view. Drawing upon these assumptions, a working statement for future research is: Heterogeneity reduction alone may affect changes in estimated distance but its strength depends upon the degree to which the frequency distribution of objects in the visual field renders such reduction possible.

References

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Note

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