Tactual form discrimination with varying size and duration of exposure¹

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Experimental manipulation of the size of random heptagons did not effect tactual discrimination of shape, unless size was varied within subjects. However, duration of exposure was an important condition, which was interpreted as determining the amount of repetition in scanning around vertices during the process of learning angular differences.

Contour perception by active touch (cf., Gibson, 1962), or tactual scanning, involves traversal of the object's periphery in successive segments. In this case, size of the object is negatively correlated with the average amount of repetition that is possible per unit time. Consequently, rate of form learning should also be negatively correlated with size. Further, if memory of contour derived from tactual scanning is organized into an overall "schema" (see, e.g., Pick, 1965), the difficulty of constructing correct schemata should increase with perimeter, as early traces deteriorate during the more prolonged scanning required to cover the form. Although any reduction in amount of practice due to perimeter enlargement could be offset by increase in exposure duration, such additional time would not prevent deterioration of traces and formation of faulty schemata. To investigate the implications of these possibilities, a factorial experiment was conducted, in which both size of object and exposure time were independent variables during memory training for a successive discrimination task.

Method

Stimulus Objects. Randomly-shaped heptagons were generated in sets of four, a primary form and three transformations, and transposed to 1/16-in. "Formica." Transformations were obtained by moving each of the primary vertices 1/4 in. in a random direction, yielding a difficult successive discrimination task for active touch (see Lobb, 1965). Ten different sets of small (S) objects were used, with mean perimeter of 13.5 in. (SD 1.7). Each form was replicated in larger (L) size by tripling the length of all sides, keeping angles constant.

Procedure. S's eyes were covered with opaque goggles before entering the test room. The stimulus objects were attached to posts on a rotatable wheel, and were always presented successively in the same location and orientation, convenient for the seated S to feel. Both hands were used freely to explore the contours of the object after being positioned by E on the first presentation. Every trial contained two phases: (1) S felt the primary form of a set, after being instructed to learn its shape; and (2) immediately afterwards performed the discrimina-

tion task, in which the primary and its three transformations were given in random order, S indicating for each that it was the same shape as the primary or not ("Yes" or "No"). Because their dimensions varied independently, the two phases will be identified separately as "Reinforcement" (R) and "Test" (T), respectively, according to Estes' (1960) usage. R conditions varied orthogonally with respect to size (S or L) and exposure time (4 or 12 sec.). In the T phase, either the four S objects were available for 2 sec. each (S2), or the L objects for 6 sec. each (L6), at interstimulus intervals of about 2 sec. A 2 by 2 by 2 factorial arrangement of these variables, symbolized as "R size," "R time," and "T condition," defined treatments for eight groups of nine college students. S was told that the size of the primary form might change for the recognition test, but that he was to "ignore the size and concentrate on the shape." Five trials per set were given at 5-sec. intertrial intervals, omitting any knowledge of results. The order of sets differed randomly for every S. The interval between sets was about 30 sec., while stimuli were exchanged.

Results

Two performance measures were analyzed: primary errors (incorrect "No") and transformation errors (incorrect "Yes"). An appropriate 2 by 2 by 2 by 5 analysis of variance was computed for each measure, using S's total errors across sets as individual scores.

The major result for primary errors was an interaction, R size by T condition ($p < .01$). Figure 1a graphically displays the interaction, suppressing non-

Fig. 1. Mean total errors across sets per trial according to relevant conditions.

Fig. 2. Mean total transformation errors across trials per set as a function of angular-variation index. See description in text.

significant R time. The interaction merely reflected a stable increment in primary errors, if size was switched between R and T phases. The difficulty of shifting from L to S was about equal to the reverse. Moreover, L primaries were identified as readily after R_4 as S primaries were after R_{12} , which serves to emphasize the lack of both time and size effects. Apparently, identification of most primaries was so easy that even brief exposures were sufficient.

On the other hand, in the analysis of transformation errors both R time and T condition were significant ($p < .05$ and $< .01$, respectively), whereas R size was not. Concerning the T effect, most likely the superiority of L6 over S2, illustrated in Fig. 1b, resulted from the time component, because elsewhere L size did not facilitate performance. Comparison of Figs. 1a and b reveals generally slower rate and lower levels of improvement in identifying transformations than primaries. Thus, in the more difficult task of learning difference cues, the relevance of exposure duration emerged for both R and T phases.

Large variation in difficulty of sets, as is visible in Fig. 2, prompted analysis of set dimensions. One such dimension concerned the change in angles from primary to transformation figures. An index of this angular variation was obtained for each set by selecting the largest single difference (limited to 45°) between corresponding angles of each transformation and its primary, and procuring the mean of the three values. The 10 coordinates plotted in Fig. 2 suggest that, within the present sample, this index is linearly related to mean total transformation errors. Indeed, the product-moment $r = -.91$. Secondly, mean perimeter of S sets was found to be correlated with the transformation-error means ($r = .66$, $p < .05$), but not with the angular-variation index. The multiple-correlation coefficient was then calculated ($r = .98$) which accounts for most of the variance in set difficulty.

Discussion

Whatever the properties of memory that mediated

correct discrimination, they were not attenuated by enlargement of primary forms for the R phase. No empirical support was found for the supposition of faulty schema construction. Nevertheless, size of whole sets was negatively correlated with proficiency in discriminating the transformations, when L and S conditions were pooled and exposure durations balanced. The obvious interpretation of this relationship is that set size was negatively correlated with the proportion scanned, or with number of scanning repetitions.

The importance of repetition in active touch is well demonstrated by some effects of R time on transformation errors. Since 4 sec. sufficed for the hands to cover all of any perimeter, the superiority of $R_{12} \cdot TS_2$ over $R_4 \cdot TS_2$, clearly shown in the Fig. 1b curves, is entirely attributable to repetition in scanning at least part of the primary form during the R phase. Even on Trial 3, $R_4 \cdot TS_2$ Ss committed reliably more transformation errors than Group $R_{12} \cdot TS_2$ did on Trial 1. In this case, "massed scanning" was more efficient than "spaced scanning." Possibly, perception of transformations interfered with memory of the primary form more effectively after R_4 than after R_{12} , much like visual perception has been noted (Lobb, 1965) to interfere with weak tactual memory.

Figure 2 suggests the general proposition that level of difficulty in discriminating complex, angular forms by active touch depends largely on differences between corresponding angles of the primary and transformation. This hypothesis is consistent with our casual observation that repeated scanning concentrated around vertices. It is also compatible with the assumption that the Ss were learning mainly angular differences, as "distinctive features" (Gibson & Gibson, 1955). For the future, formulation of the psychophysical laws of angle discrimination by active touch would be a helpful step towards scaling the difficulty of tactually discriminating polygonal forms.

References

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Notes

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2. The second author is now at the University of Toronto.