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The Relative Discriminability of Twelve Random Shapes

L. E. Carver

Marilyn E. Marshall

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L. E. CARVER AND MARILYN E. MARSHALL

Abstract. From twelve randomly derived visual shapes, six were to be chosen, if possible, which were mutually equally discriminable. The chosen six were subsequently to be used as stimuli in a verbal-motor transfer task. The two members of all possible pairs of the twelve shapes, including "same" pairs, were presented in succession by means of an automatic slide projector, the exposure time for each member being .25 sec. "Same" or "different" judgments made by 12 subjects after the presentation of each pair, were 98% correct, making useful differentiation among the 12 shapes impossible. Difficulty of discrimination was increased by presenting the pairs tachistoscopically with an exposure time of .01 sec per member. Seventy-two subjects made same or different judgments, as before. The total number of errors in judgment, each shape compared with every other, was taken as an index of discriminability. Six shapes were then chosen which approximated the goal of mutually equal discriminability.

Studies of positive and negative transfer in the acquisition and retention of skill in the performance of discriminative motor tasks have led to an increased interest in the role of verbal pretraining in the facilitation and retardation of learning. Presumably, the learning of verbal responses to discrete stimuli which are more or less similar, increases the distinctiveness of the stimuli and reduces generalization among them. In any event, the subsequent mastery of motor tasks involving the same stimuli is usually facilitated.

The several stimuli used in discriminating tasks have typically been different colors, different sizes of a fixed geometric form, different intensities, and the like. A difficulty arises whenever more than two stimuli are employed which lie at different points along a single dimension. Equal discriminability among three or more stimuli cannot prevail if they are taken from any graded series.

For example, if three different colors are needed for a paired-associates study, red, green, and orange might be chosen. Green is much more distinct from both red and orange than is red from orange or orange from red. The consequence of such inequalities of difference is that when subjects are required to learn different responses to the three stimuli, the response to the more distinctive green will be learned more rapidly than

[1] This work was done under the general supervision of Dr. Don Lewis, Department of Psychology, State University of Iowa, Iowa City. During the period of its accomplishment, in the summer of 1960, Miss Marshall was a National Science Foundation Cooperative Fellow and Mr. Carver was an Undergraduate Research Participant in the program sponsored by the National Science Foundation.

comparable responses to red and orange. In other words, the amount of stimulus generalization differs from one stimulus to another from the outset.

The resolution of this problem is critical to the area of verbal pretraining where the investigator's empirical and theoretical interests center about experimentally induced increases or decreases in stimulus generalization. Before the effects of such changes in generalization by means of verbal pretraining can be assessed, equal initial distinctiveness of the stimuli should be sought. At the very least, the extent to which each stimulus is discriminable from each other member should be determined.

Several verbal pretraining studies conducted in the Iowa Laboratory have used the Star Discrimeter. This apparatus, described in detail by Cantor (1955), has a response unit with six slots spaced 60 degrees apart, radiating from a central opening in a horizontal steel plate. Out of this opening portrudes a wobble stick which can be moved into any one of the six slots. The stimulus panel contains a circular piece of opal glass onto which six different stimuli can be projected. For a particular task, each stimulus is associated with one of the response slots. *S* moves the stick into the appropriate slot as each stimulus appears, in random order. The stimuli have ordinarily been six colors of light; and these have not been equally discriminable.

The aim of the present study was to find, if possible, six mutually equally discriminable stimuli for use in the Star Discrimeter. A promising kind of stimulus seemed to be random shapes such as those generated by Attneave and Arnoult (1956) or Vanderplas and Garvin (1959). These shapes are constructed by taking different sets of randomly chosen points (fixed in number) located within a prescribed two-coordinate system, and then connecting the points according to principles previously established.

The specific aim of this study was to select from the 24-point shapes already constructed by Vanderplas and Garvin, six which came closest to being mutually equally discriminable.

METHOD

After a careful inspection of the thirty 24-point random shapes developed by Vanderplas and Garvin (1959), twelve were chosen for subsequent study by paired-comparisons procedures. The aim was to start with a set of the thirty shapes which seemed maximally homogeneous with respect to height, width, mass, and general configuration. The chosen twelve are shown in Figure 1.

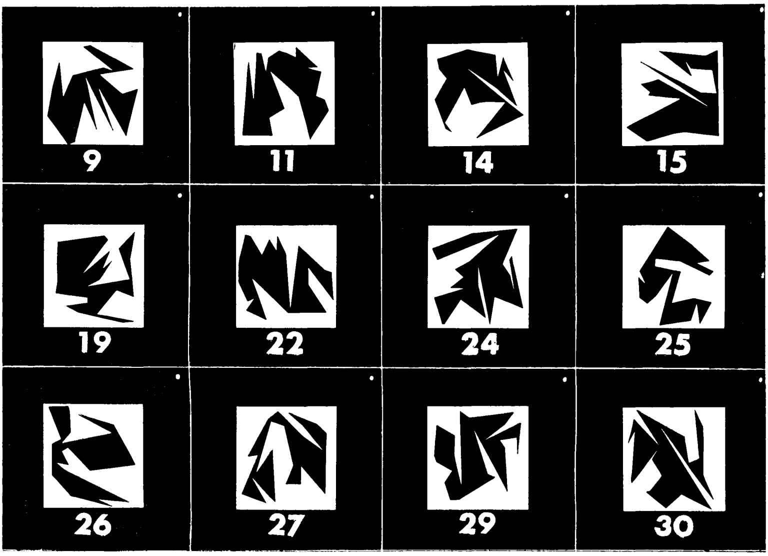

Figure 1. Twelve random shapes taken from a group of thirty 24-point shapes generated by Vanderplas and Garvin (1958). The numbers are those given by Vanderplas and Garvin.

The decision was made to present in succession the two members of all possible pairs of shapes and to ask the Ss to judge whether the second shape they saw was the same as, or different from the first. The use of same or different judgments required that the two members of half of the presented pairs of stimuli be identical. To control for possible order effects, each "different" pair was presented twice: once in a particular order and once in the opposite order. Consequently, 132 "different" and 132 "identical" pairs, 264 in all, were presented. The index of discriminability was the number of times that each stimulus was correctly judged to differ from every other stimulus.

Six positive prints of each of the twelve shapes shown in Figure 1 were made on 35 mm film, and these were mounted in 2 x 2 slides. The six copies of each shape were necessary to expedite the presentation of pairs.

The shapes were projected in 12 blocks of eighteen pairs each, in addition to two blocks of 12 and two blocks of 13 pairs. Within each block, the sequence of pairs was randomized except for the restrictions (a) that no one shape was to appear in the same block more than three times, either as the first or second number of a pair, and (b) that half of the pairs within each block consist of identical shapes, half of different shapes. Each pair of 'different" shapes, in the two orders, was presented

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only once. To facilitate the reverse-order presentation of the "different" pairs, the orders for blocks 3 and 4 were the reverse of those for blocks 1 and 2, respectively. Two *E*s were always necessary, one to operate the slide projector and one to rearrange slides in going from one block to the next.

Preliminary Experiment

Apparatus

The apparatus consisted of a LaBelle '33' automatic slide projector, a six-foot screen, and six Hunter decade-interval timers of the kind described by Hunter and Brown (1949) to provide for uniform exposure and judgment periods. As projected, the size of each shape with its square white surround was 12 x 12 inches.

Subjects sat in ordinary classroom chairs and wrote responses in spaces provided on a dittoed response sheet.

The experimental room was made maximally dark, with only enough light to enable Ss to write down their responses.

Subjects

Twelve men and women students taking a course in elementary psychology served as Ss. Each S received the equivalent of two examination points for participation in the experiment.

Procedures and Results

Subjects wrote "same" or "different" (S or D) responses to the 16 blocks of pair presentations. Each pair member was presented for .25 sec with .75 sec between members, and response intervals of 3.5 sec.

The judgments of the twelve subjects were 98% correct. From this information, the experimenters' observations, and the general comments of Ss, it was apparent that the shapes were very easy to discriminate. Subjects reported that the rapid sequential presentations of the shapes in a pair created after-image effects that were used as aids in judgment. The second of a pair of shapes was directly superimposed on the after-image of the first, making a correct judgment almost inevitable.

With the available stimulus materials, the most promising next move seemed to be to reduce the exposure time, reduce the figure-ground contrast, and thus increase the difficulty of discrimination.

Main Experiment

Apparatus

The same 2 x 2 slides were projected by means of a Keystone tachistoscope mounted on a Keystone Overhead Projector. A cardboard jig was constructed to hold the paired shapes in proper position and to block extraneous light from the projected image. A metal stop on the projector insured that the image was presented in the same location on the screen for each pair. The size of shape with its white surround was increased to 18 x 18 inches. During the experiment the room in which Ss sat was illuminated at a medium level.

Subjects

Seventy-two men and women students from the course in elementary psychology served as subjects. As before, each S received the equivalent of two examination points for participation in the experiment.

Procedure

In an effort to minimize the fatigue and boredom that had been evident in the preliminary experiment, the Ss were divided into two groups of 36 each. One group made responses to trial blocks 1 through 8, the other to blocks 9 through 16. These groups were divided further into smaller subgroups in order to keep differences in distance and angular displacement from the screen minimal. Subgroups were tested on different days.

Three *E*s operated the tachistoscope. One checked and snapped the shutter, one positioned the slides, and one rearranged the slides for the next block. It was necessary to use the reverse order of each block of pairs immediately after it was completed. Thus, the even-numbered blocks consisted of the pairs, in reversed order, of shapes appearing in their respective preceding odd-numbered blocks.

Each shape was presented for an interval lasting .01 sec with .75 sec between members of a pair, and about 3.5 sec for the response period. The operation of the tachistoscope did not allow automatic timing of interstimulus and judgment intervals, though with practice, fairly consistent timing was achieved.

The response required of subjects was identical with that of the preliminary experiment.

Results

When members of a pair consisting of different shapes were judged as being the same, an error was counted for both of the shapes involved. The total number of errors for each shape was counted and used as an index of discriminability. The shapes were rank ordered on the basis of these indices as shown in Table 1.

In addition, a matrix of error judgments was constructed, indicating the number of errors made in relation to each unique pair. Those six shapes were chosen which showed maximally homogeneous error counts in the matrix of errors when each of the six shapes was paired with each of the other five. Asterisks beside shape numbers in Table 1 indicate the shapes which were chosen.

Table 1. Rank Order of Discriminability Values of Random Shapes

Shape No.	Discriminability Value
30	160
24*	158
27*	153
11*	149
15*	147
9*	137
14*	136
22*	136
29	125
25	124
26	111
19	98

* Indicates those chosen for use in the Star Discrimeter.

Discussion

It is evident upon examination of Table 1 that the pair comparisons procedure does provide a means for differentiating stimuli with regard to discriminability when that concept is defined as above. In addition, it was possible to choose from the twelve stimuli six which showed greater homogeneity of error counts than any other set of six.

Although those six shapes were chosen which showed maximally homogeneous error counts on the fifteen pairings possible within the set, these error counts were far from equivalent. The failure of the present experiment to yield such equivalence may be a result of subjecting so few shapes to the judgmental procedure. Each of the twelve shapes contains quite distinctive features, and it is possible that in fact no such equivalence exists among any six of them.

The conclusion that the six chosen stimuli were indeed not mutually equally discriminable has been supported by a subsequent paired-associates learning study in which the six shapes were used as stimuli. Regardless of the type of verbal response learned to them—meaningful or nonsense, similar or distinctive—there appeared a consistent tendency for responses to some stimuli to be learned much more rapidly than to others.

Although the modified tachistoscopic presentation of shapes yielded useful data, the procedure was not without fault. By increasing the general level of illumination, difficulty of discrimination increased; but with figure-ground contrast reduced so markedly, the problem for Ss was no longer one of discriminating one shape from another but more often whether or not they saw anything at all.

The superimposition of the second shape upon the afterimage of the first occurred, even with the greatly reduced exposure interval.

Several changes in both stimulus material and procedure are suggested by the present study.

First, random shapes might be generated which are initially equally different, at least geometrically. A technique developed by Attneave and Arnoult (1956) utilizing variations on a prototype figure seems promising in this regard.

Second, a larger number of such shapes subjected to any judgmental procedure should increase the probability of obtraining six mutually equally discriminable ones.

Third, a change in procedure that eliminates afterimage cues will be a necessary feature in any future study of this kind. Some modification of the so-called ABX method used frequently in auditory discrimination suggests itself as a possible solution to this problem.

Finally, whatever the procedure ultimately used, it is evident that viewing conditions for Ss must be created such that their task involves genuine visual discrimination and not merely visual detection.

A study is presently in progress in the Iowa Laboratory along the lines of these suggestions. Its aim is to derive sets of mutually equally discriminable shapes at various levels of difficulty.

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