4-1972

Orderly versus Random Stimulus Organization as a Parameter of Problem-Solving Difficulty in a Visual Discrimination Task

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ORDERLY VERSUS RANDOM STIMULUS ORGANIZATION AS A PARAMETER OF PROBLEM-SOLVING DIFFICULTY IN A VISUAL DISCRIMINATION TASK

by

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A Thesis
Submitted to the
Faculty of the Graduate College
in partial fulfillment
of the
Degree of Master of Arts

Western Michigan University
Kalamazoo, Michigan
April 1972

ACKNOWLEDGEMENTS

I wish to express my appreciation to Dr. Fred Gault for his advice and enduring patience both of which were essential to this study. I would also like to thank Dr. Neil D. Kent and Dr. David O. Lyon for their critical assistance and advice on this manuscript. In addition, I would like to recognize the assistance of Dr. Marvin Levine of the State University of New York at Stony Brook in whose tutelage the theoretical background of this paper was developed and in whose laboratory the pilot work for this study was done. Finally, I would like to express my appreciation to my wife, Marti, for her assistance, advice and above all, patience, throughout this project in all its various stages.

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MASTERS THESIS M-3430

ITKIN, Edward S.
ORDERLY VERSUS RANDOM STIMULUS ORGANIZATION AS A PARAMETER OF PROBLEM-SOLVING DIFFICULTY IN A VISUAL DISCRIMINATION TASK.

Western Michigan University, M.A., 1971
Psychology, experimental

University Microfilms, A XEROX Company, Ann Arbor, Michigan

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INTRODUCTION

In the relatively short history of the work in concept formation--the selection or identification of one of several possible solutions to a discrimination problem consisting of a finite set of possibilities--several major trends of investigation have enjoyed widespread popularity. The most inclusive of these trends is that of mediation--the various ways data are selected, encoded and processed from the onset of an initial stimulus to the solution of the concept formation or concept identification problem.

In an early study, Bloom and Broder (1950) investigated the problem solving process of college students by having them use an extended form of what they called, "thinking aloud". Another step in this line of investigation, though not much less imprecise, is a study by Bruner et al (1956). They reported a concept identification study in which the discriminitive stimuli were pictures of family units which varied along various dimensions of clothing and expression. Bruner attempted to quantify the subjects' ease and/or difficulty in solving the problems using an interpretation of the thematic value of the pictures. He believed that the emotional value of the various "themes" of the stimuli affected the ease of solving the problem.

For a time major emphasis was upon the ability to perceive information from a visual field and process it. Sperling (1960) provided data on the ability to perceive information in a complex stimulus field by a stimulus field sampling technique. Following tachistoscopic presentation of a complex stimulus field containing a large number of stimuli arranged in a grid-like pattern, Ss were asked to report the content of a small section of the stimulus field. By repeated and extensive sampling Ss could perceive and recall almost all points in the complex stimulus field when tested with this post hoc method. The field sampling technique allowed Sperling to study memory decrement as a function of time and to refute Miller's earlier assertion (1956) that perception of the elements in this complex field was more limited.

In addition to the question of how much information an observer could process, the question of how feedback from early trials affected concept identification was the topic of several investigations (Hovland and Weiss, 1953; Levine, 1966). Both these investigators found that on outcome trials (where S is informed on a trial-to-trial basis of the correctness of his responses) that information of a negative type, i.e. wrong hypotheses, was less helpful in eliminating hypotheses from a set or pool of hypotheses (Restle, 1962; Levine, 1966) than were correct responses, even though both types of information provided equal amounts of feedback.

During the past decade there has been a growing interest in mediation and the encoding of stimulus input. One of the most durable statements in this area is the verbal-loop hypothesis of Glanzer and Clark (1963; 1963b; 1964; Glanzer, Taub and Murphy, 1968). As stated by these researchers the verbal-loop hypothesis predicts that "a subject carrying out a perceptual task translates the input information into words and then uses them as the basis for his final task. The hypothesis implies that the extent of the Ss covert verbalization (or translation) for a given stimulus object is critical in determining the efficiency of his performance." (Glanzer and Clark, 1964). In other words, the S must first describe the stimulus input to himself ("covert verbalization") and the greater the number or the complexity of the words required to make the description the harder it will be to solve the problem based on this stimulus input. In their study, Glanzer and Clark discovered that stimuli which had previously been found to be difficult to learn when used in a discrimination experiment (Fehrer, 1935) correlated highly with being difficult to describe. They found that twenty-six stimuli from a list based on Fehrer's study which were hardest to process in a discrimination problem, were also the hardest ones (i.e. took the most words) to describe.

Other workers have been investigating different levels of encoding complexity as a parameter of concept identification (Hovland and Weiss, 1953; Hunt and Hovland, 1960; Hunt, 1962; Conant and Trabasso, 1964; Wells, 1967). Conant and Trabasso found in their study using combinations of colors and shapes, that the more complex the labeling method, the harder it was to solve a set of concept identification problems.

The purpose of the present study is to investigate further the role of perceptual and encoding complexity as a function of problem solving difficulty. The goal is to design a task to test the hypothesis that the more difficult the encoding task the more difficult it will be to solve problems based on these hard-to-encode stimuli. One group will see the stimuli arranged in a familiar pattern--a face. The other group will see the stimuli arranged in a random pattern. The hypothesis being tested assumes that the stimuli in the random arrangement will be more difficult to encode ("covertly verbalize") and therefore it should be harder to learn problems based upon them. If this is the case then the data will conform to the predictions of the verbal-loop hypothesis.

METHOD

Subjects

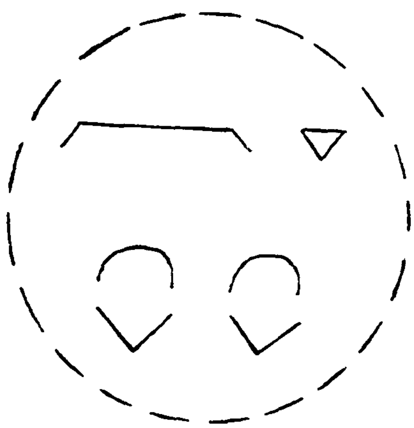
Twenty-eight introductory psychology students served as subjects. The data from one other S was discarded due to a temporary equipment failure.

Stimuli and Apparatus

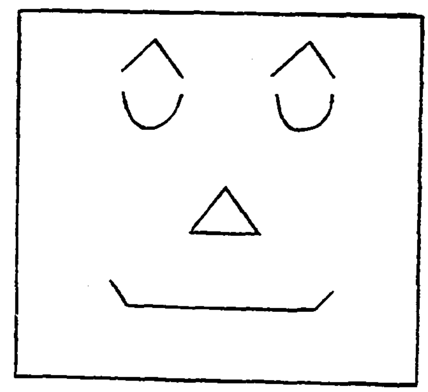
Two sets of stimulus slides were constructed, each slide consisting of six binary dimensions (two-level variables). Each set contained sixty-four slides divided into sixteen four-slide problems. The only difference between the two sets of slides was the topographical arrangement of the stimuli. In the Random set, the stimuli were arranged in a non-orderly fashion; in the Orderly set, the stimuli were arranged to approximate the topographical arrangement of a human face. The slides and binary dimensions are shown in Fig. 1.

The problems consisted of four slides on which all six dimensions could vary between levels from slide to slide. A level is one of the two possible modes of a stimulus in a binary dimension. In each set of four slides comprising a problem, both levels of each dimension appeared at least once, except one. Therefore, in each problem one level of one dimension remained constant (and its opposite level never appeared). The solution to

Figure 1. Sample slides from the Random set (a) and the Orderly set (b) with a list of the binary dimentions (c). The levels of the dimensions correspond to the stimuli in the sample slides.



(a)



(b)

<u>Stimulus Dimensions</u>

Dimension	level (a)	level (b)
Border	broken	solid
Small angles	down	up
Curves	up	down
Double angle	down	up
Shape	circle	square
Triangle	down	up

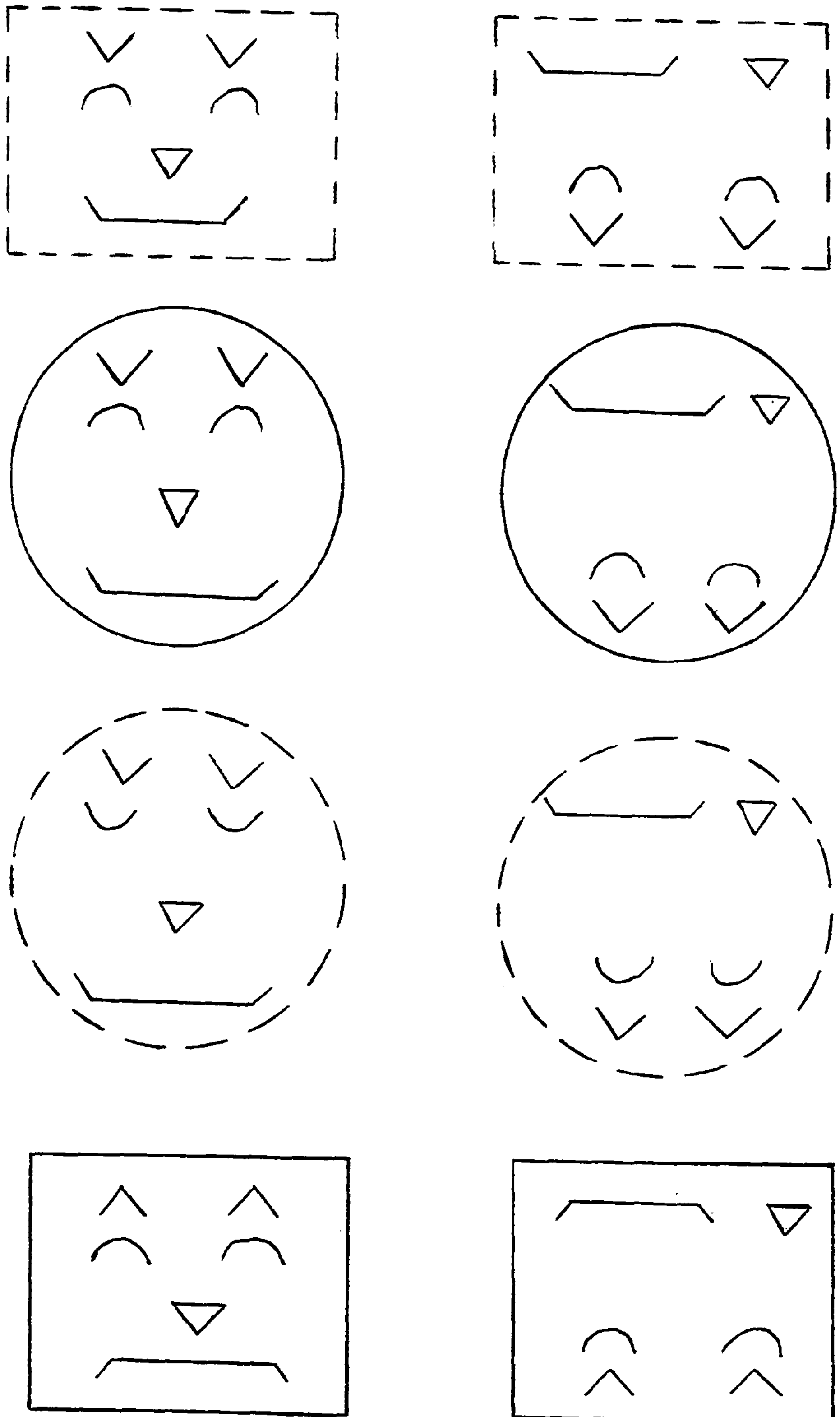
a given problem was the specification of the constant level, i.e. the level of one dimension that appeared in all four slides. The problems were constructed such that each problem had only one correct solution and it was not possible to eliminate all incorrect solutions until all four slides had been presented. At least two levels of various dimensions remained constant until the third slide in a set of four and only after presentation of the fourth slide was it evident which level of which dimension was the solution. A typical problem for both the Random set and the Orderly set is shown in Fig. 2. Note that both sets have the same stimuli and the same solution, they differ only in arrangement.

A Kodak Ektographic slide projector was used. The slides were black and white 35mm negative (not color-reversed) slides. By projecting non-reversed slides, the projected image on the screen consisted of white stimuli on a dark background (produced by photographing black stimuli on a white background.

Procedure

Ss were alternatively assigned to the Random Group or the Orderly Group as they arrived for the experimental session. They were initially seated at a desk, opposite the experimenter, where the necessary subject identification data was solicited. The Ss were then read the

Figure 2. A typical problem, shown for both the Orderly (a) and the Random (b) patterns. Both levels of each dimension vary in the set of slides, except the triangle, which is pointed down in all slides, and is the solution to the problem.



(a) (b)

following instructions:

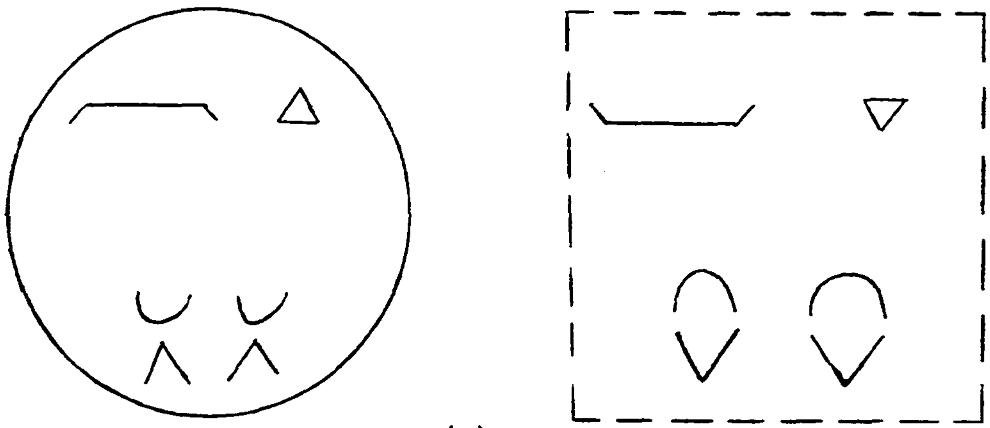
> You are about to be shown a series of slides, consisting of various geometric figures. The slides are arranged in such a manner that they form a series of problems. You will see the slides one at a time. These two slides, however, are samples of the kind of slides you will see. Once the task begins, you will see only one slide at a time.

At this point Ss were shown a stimulus sample containing two sample stimulus configurations which demonstrated the binary nature of the six stimulus dimensions. (see Fig. 3). The Random Group saw stimulus samples with the stimuli arranged in the Random pattern. Orderly Group subjects saw stimulus samples with the stimuli arranged in the Orderly (face) pattern.

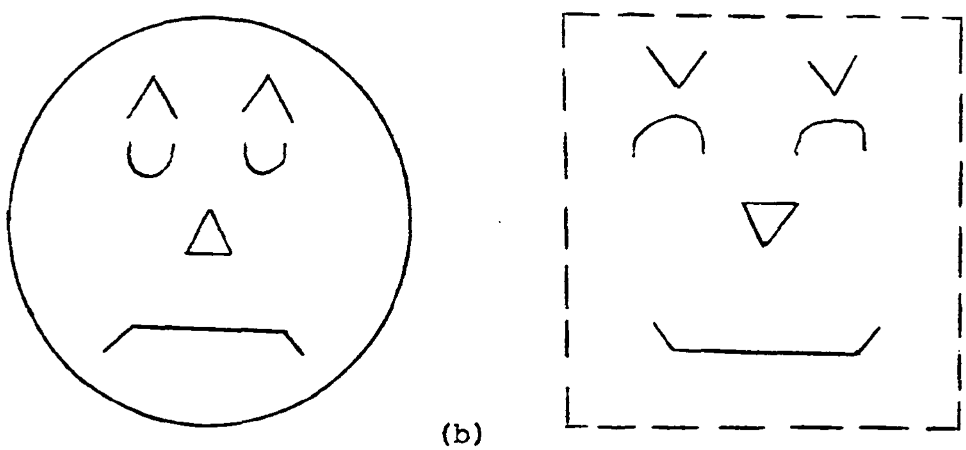
The following instructions were then read:

> Note that the slides can vary in several ways. The shape can either be a circle or a square. The texture can either be broken or solid. This figure can be pointed either this way or this way. (The experimenter pointed out, with a pencil, all the relevent dimensions.) This figure can be oriented either this way or this way. These two figures can be this way or this way and these two figures can be oriented this way or this way.
>
> Are there any questions so far?
>
> Every problem will consist of a set of four slides. The figures will vary from one orientation to the other within the set of four slides. However, one aspect will always remain constant. For example, in the set of four slides comprising a problem, all four slides may have a solid border or all four will have this figure pointed this way (indicating the triangle). Remember, in each problem all of the aspects will vary except one, which will remain constant. In all four slides, all other aspects will be changing on one or more slides. A constant aspect is called a 'VEG'. Your task is to find the aspect which remains constant or 'VEG' in all four slides.

Figure 3. The stimulus samples shown to the subjects in the Random Group (a) and the Orderly Group (b).



(a)



(b)

> The solution will always be unitary--that is it will be either one of the two possible forms of a given aspect like circle or square, or broken or solid. It will never be complex, never a combination of figures, like triangle in a circle, etc.
>
> After the fourth slide of a problem, you are to tell me what was the 'VEG' or constant aspect in the preceding problem.
>
> I might mention that what we are doing is investigating the human problem solving process. Our goals and your task are totally unrelated to intelligence or aptitude testing. So relax and try to do your best on each problem.
>
> Remember, your task is to discover which single aspect of the series of slides remains constant: that is, to find the 'VEG'.

The term "VEG", a non-sense syllable, was used merely to give the S a label for the concept considered to be the solution to the problem.

Following the instructions the S was seated in front of the screen and the first set of problems was shown. Each slide was projected for five seconds, timed by the projector's internal timer. After the fourth slide of a given problem, the S was asked for his solution to the problem. S's responses were recorded by E on an individual answer sheet. Following S's report of his solution, the warning "ready" was given and the next problem was begun. No outcomes (report as to the correctness of S's response) were given.

Each Group received all sixty-four problems in each problem set. The Random Group was shown the Random set of problems first, followed by the Orderly set of problems. The Orderly Group was shown the Orderly (face) set of problems first, followed by the Random set.

After the first set of problems all subjects were asked:

a) "Did the stimulus arrangement remind you of anything?"

b) "Did you use any special trick or method to solve the problems?"

Following the second set of problems all subjects were asked:

a) "Was this set of problems harder, easier or the same as the first set?"

b) "Did the stimulus arrangement remind you of anything?"

c) "Did you use the same method to solve these problems or did you modify your method?"

Finally, S was instructed not to discuss the stimuli or the experiment with anyone until the conclusion of the entire experiment to prevent contamination of the subject pool.

RESULTS

The main comparison is between the performance of the subjects in the Random Group who saw the Random set of problems first and the subjects in the Orderly (face) Group who saw the Orderly set first. The mean number of problems solved correctly (out of the sixteen problems present in each condition) for the Random First (R1) condition is 8.64. The mean number of problems solved correctly for the Orderly First (01) condition is 10.93. A "t"-test for differences between these two means is significant at the .05 level.

A comparison was made between the means of the Random Second (R2) condition (the group that saw the Orderly problems first and the Random problems second) and the Orderly Second (02) condition. ($\overline{R2}$ = 10.43; $\overline{02}$ = 12.07) which demonstrated a significant difference between these two groups ("t" = 1.8196, .05).

A test between the Random First condition and the Orderly Second condition showed a significant difference at the .05 level ("t" = 2.9362).

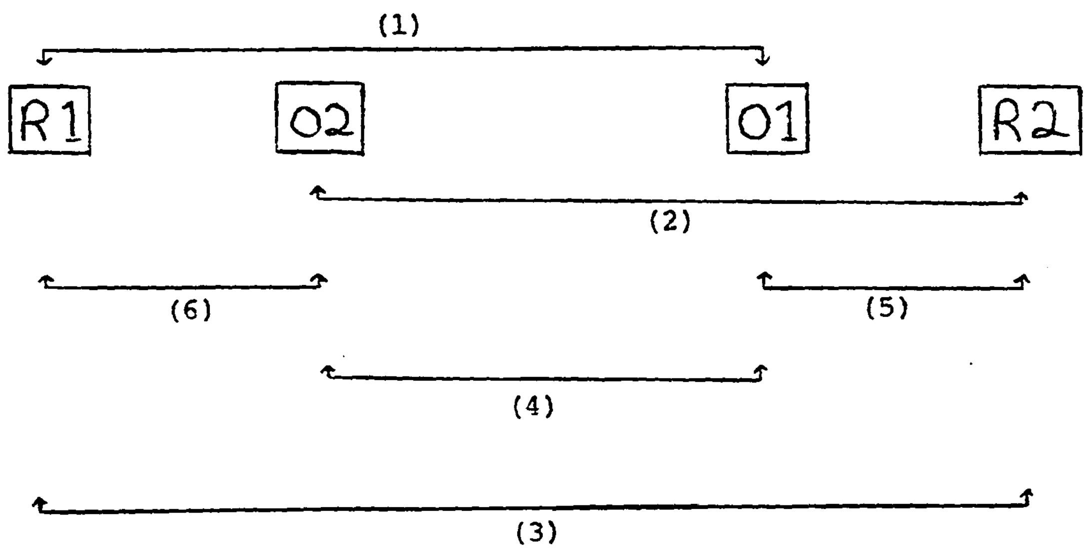
The results of all other binary combinations of $\overline{R1}$, $\overline{R2}$, $\overline{01}$, and $\overline{02}$ yielded insignificant differences as shown in Table 1. Figure 4 schematically shows the various comparisons by test number.

Table 1. Means for all conditions and t-test values for all comparisons.

Means	Comparisons (test #)	"t" value*
R1 = 8.64	R1 vs 01 (1)	1.7180
R2 = 10.43	R2 vs 02 (2)	1.8196
01 = 10.93	R2 vs R1 (3)	1.6292
02 = 12.07	02 vs 01 (4)	0.9715
	R2 vs 01 (5)	0.4523
	02 vs R1 (6)	2.9362

*"t" $_{.05}$ (df = 26) = 1.706

Figure 4. Schematic representation of the various t-tests by test number.


(1)
R1
O2
O1
R2
(2)
(6)
(5)
(4)
(3)

In response to the question: "Does the stimulus arrangement remind you of anything?", after the first set of problems; in the R1 condition ten Ss responded, "no", one responded "Yes, a face," and three responded, "Yes, maybe a face." In the 02 condition, twelve responded that it looked like a face and two responded that it reminded them of nothing. After the second set of problems, in the 02 condition all fourteen Ss responded that the stimulus arrangement looked like a face. In the R2 condition, thirteen responded that the stimulus arrangement reminded them of nothing and one responded that it looked like a face.

In response to the question, "Was this set of problems harder, easier or the same as the first set?", in the Random Group (which saw the Orderly set second) nine reported that the Orderly set was easier, two reported that they were of equal difficulty and two reported that the Orderly set was harder to solve than the Random set. In the Orderly Group (which saw the Random set second) eleven reported that the second set, the Random problems were harder, two found them of equal difficulty and one reported that the Random problems were easier to solve.

The responses to the questions concerning method or trick used to solve the problems were generally anecdotal and difficult to quantify. In general, the Ss used some form of mental catalogue of the various stimuli, updating the catalogue at the onset of each new slide in the current problem.

DISCUSSION

The data from this experiment support the general statement that in a visual discrimination problem of multiple stimulus dimensions that it is easier to solve a problem when the stimulus arrangement has some perceptual meaningfulness than when it is a random pattern. The data indicate that a group (Orderly) which saw a stimulus field of geometric figures arranged in a meaningful pattern (a face) did significantly better, i.e. produced more correct responses, than a group (Random) which solved the same problems constructed of the same geometric figures but arranged in a random pattern. This perceptual meaningfulness might also be called "label-ability". These data and this general statement conform to the predictions of the verbal-loop hypothesis (Glanzer and Clark, 1963; 1963b; 1964; Glanzer, Taub and Murphy, 1968). As reported above, this theory states that the harder it is to describe a visual field, the harder it will be to solve a discrimination problem based upon this stimulus field. Intuitively then, it would seem that it would be easier to learn a discrimination when the stimuli are the familiar parts of an orderly arranged face than it would be to learn the same discrimination when the parts are randomly arranged, thus perceptually less meaningful.

thus harder to describe. The fact that the Orderly problems were solved significantly more frequently than the Random problems bears this out. Glanzer and Clark called this encoding of the visual stimuli "covert verbalization" (Glanzer and Clark, 1964) while Miller (1956) originally described essentially the same process as "linguistic recoding".

Additional support is given to this interpretation by the fact that the Orderly Second condition (subjects who solved the sixteen Orderly arranged problems after previously solving the Random problems) produced significantly more correct solutions than did the Random Second condition. In other words, not only did the subjects do better when they saw the Orderly condition first, but the subjects who were switched from the Random condition to the Orderly condition did significantly better than those who solved the Orderly problems first and then were switched to the Random problems.

Another very convincing datum in support of the hypothesis that the perceptually meaningful stimuli are easier to learn than the random stimuli is the fact that the Orderly Second condition did significantly better than the Random First condition but the Random Second condition did not do signficantly better than the Orderly First condition (see Table 1) thus disallowing any possible practice effect.

The responses to the subjective questions, to the extent that they are interpretable, support the assumption that S perceived the Orderly stimulus arrangement as a familiar pattern (twenty-six of the twenty-eight reported that it look like a face). In addition, the Ss subjectively felt that the Random arrangement was harder than the Orderly arrangement (twenty subjects reported that the Random was harder or that the Orderly was easier; while three subjects reported the converse of one of these two statements; five subjects reported that the Random and the Orderly problems were of equal difficulty).

This experiment demonstrates that, at least with geometric figures, it is easier to solve a visual discrimination problem when the stimulus is perceptually meaningful than when it is a random pattern. These data are compatible with the verbal-loop hypothesis of Glanzer and Clark (1963; 1963b; 1964; Glanzer, Taub and Murphy, 1968).

Whether the implications of these results are limited to the particular stimuli used in this study or have general application to many multiple stimulus dimension discrimination problems remains to be ascertained by further research.

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