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ABSTRACT

Though previous studies had suggested a link between the rate of concept learning and instructional formats in which instances of concepts were held constant or grouped together, a 1964 study by Richard Anderson questioned the conclusion, suggesting that previous studies had been confounded by other irrelevant attributes that changed from trial to trial. The study was replicated to test certain anomalies. Via video screen, 50 undergraduate volunteers were delivered stimuli consisting of seven attributes: number, color, form, shading, vertical or horizontal bar, border, and field orientation. Subjects were given five tasks involving the learning of one pair of concepts. Five treatments differed in terms of the sequence of stimuli used to present the training. Results showed that: (1) when adjacent trials contained the same relevant cue, learning was maximized; and (2) the effects of alternate and constant series are conditional upon the number of stimulus attributes that change from trial to trial. (EMH)

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STIMULUS SEQUENCE AND CONCEPT LEARNING, EXPERIMENT II

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STIMULUS SEQUENCE AND CONCEPT LEARNING.
EXPERIMENT II

Richard C. Anderson and John T. Guthrie

Two studies (Kurtz & Hovland, 1956; Peterson, 1962) have seemed to indicate that rate of learning of a concept is accelerated when the instances of the concept are grouped together, that is to say, when the stimuli containing the same relevant cue are presented on adjacent trials. Anderson (1964) questioned the conclusion that grouped or constant series are superior to mixed series on the grounds that the method of composing series in these studies may have confounded type of series with the number of irrelevant attributes that changed from trial to trial, another variable that may effect rate of learning.

Detambel and Stolurow (1956, p. 40) have proposed that to maximize rate of learning: "(a) When the same relevant cue is presented on adjacent trials, as many as possible of the irrelevant stimulus components should have different values on the two trials, (b) When two different relevant cues are presented on adjacent trials, as many as possible of the irrelevant stimulus components should be kept constant." Detambel and Stolurow conducted a study in which a sequence composed according to the two rules mentioned in the quotation was contrasted with a sequence composed according to the inverse of these rules; namely, a sequence in which as many as possible of the irrelevant attributes were held constant when successive stimuli contained the same relevant cue and in which as many as possible of the irrelevant attributes were changed when successive stimuli contained different relevant cues. The result was a striking superiority for the sequence constructed according to the rules on both the training series and a test series in which the training stimuli were presented randomly.

It appears the mixed series in the Peterson study and, probably, the mixed series in the Kurtz & Hovland study as well, approximated rather closely the "bad" series in the Detambel & Stolurow study. In these studies, the probability was high that a large proportion of the irrelevant attributes would change from one trial to the next in both the mixed series and the grouped series, a condition that appears to retard learning in the former kind of series but promote it in the latter.

The first experiment (Anderson, 1964) endeavored to disentangle type of series from number of stimulus attributes changing from trial to trial. There were five experimental groups administered treatments that differed solely in terms of the sequence of stimuli presented during six training trials. Subjects were trained and tested individually, each subject learning one pair of concepts involving a single relevant attribute and four irrelevant attributes. Subjects in two of the groups received <u>alternating</u> series for six trials; that is a series in which one relevant cue appeared on trials 1, 3 and 5 while a different relevant cue appeared on trials 2, 4 and 6. Subjects in two other groups received <u>constant</u> training series; that is, series in which the same relevant cue appeared in the stimulus configuration presented on each of the six trials. The remaining group was a control, receiving six randomly-selected stimulus configurations on the six training trials.

Within one of the groups receiving alternating series (Group A1) and one of the groups receiving constant series (Group C1) exactly one stimulus attribute changed between any pair of adjacent training trials. For one group presented an alternating series (Group A3) and one group receiving constant series (Group C3) exactly three attributes changed from one trial to the next. Though the number of attributes changing was fixed, which attributes changed was determined at random (with a couple of constraints) for each trial, independently of the other trials. Immediately following the six training trials, S received test trials consisting of stimuli selected at random until he made 10 consecutive correct responses or completed 80 trials.

The main result of the first experiment was the significant interaction for both training trials ($F = 14.73$, $df = 1/100$, $P < .01$) and test trials ($F = 7.35$, $df = 1/100$, $P < .01$), between type of series and number of attributes changing from trial to trial. As predicted, in alternating series the condition in which just one stimulus attribute (the relevant attribute) changed was more efficient than the condition in which three attributes changed from trial to trial. In constant series, the condition in which three attributes changed was more efficient than the condition in which just one attribute changed.

The purpose of the experiment described in this report was to replicate the first study, with a few changes to investigate a couple of anomalies.

Method

Apparatus. -- The apparatus was a computer-based system called SOCRATES (System for Organizing Content to Review And Teach Educational Subjects) that consists of an IBM 1620 computer, an IBM 1710 control unit, and modified U. S. Industries AutoTutors as subject stations. The S sat in a cubicle with the AutoTutor in front of him with the center of the main AutoTutor screen approximately at eye level 20 inches away. The stimuli and instructions were presented on the main AutoTutor screen which was 7 x 9 inches. To the right of the main screen were three buttons labeled 'X', 'Y', and three inches below a button labeled 'Proceed'. Immediately above the X and Y button there was a small screen (1-1/2 x 2 in.) upon which the words Right and Wrong could be flahsed.

Stimulus Materials. -- The stimuli were drawn originally from templates on 3 x 5 in. file cards and then, along with the instructions, placed on 35 mm. color film. As they appeared on the AutoTutor screen, each of the stimuli was centered and was contained within a 2-1/2 x 3-1/2 in. rectangle. There were seven stimulus attributes, each of which had two values as follows: (1) number -- one or two figures; (2) color -- red or green; (3) form -- rectangle or diamond; (4) shading -- solid, outline; (5) centered black bar -- vertical, horizontal; (6) border -- continuous, broken; (7) position of figures -- horizontal, vertical.

Procedure. -- The S was presented with five tasks, one each under four treatment conditions and under a control condition. Prior to each problem, the S read the instructions. He then pressed the Proceed button and the first stimulus appeared. All Ss received the same instructions under all conditions. Within each task, stimulus figures appeared one at a time. The S responded to each stimulus by pressing one of the two buttons. Immediately following the button-press, the feedback message (Right or Wrong) appeared for 2 sec. A 12 sec. intertrial interval was maintained. Each treatment was administered to the S until he made 10 consecutive correct responses or completed 80 trials. Upon completion of training, test trials followed without interruption. The S continued to a criterion of 10 consecutive correct responses or 80 trials. The test trials under each treatment consisted of stimuli selected at random from the complete set of training stimuli and involved the same concepts as the training trials under that treatment. The entire experiment was controlled by the computer.

Treatments. -- All problems required the learning of one pair of concepts (e.g., rectangle -- Button Y and diamond -- Button X) involving one relevant attribute and six irrelevant attributes. There were five treatments that differed in terms of the sequence of stimuli presented during training. Two treatments (Condition A1 and Condition A6) involved alternating series in which one relevant cue appeared on odd numbered training trials and another relevant cue appeared on even numbered trials. Two other treatments (Condition C1 and C6) involved constant series in which the same relevant cue appeared on all training trials. Under Condition A1 and Condition C1, exactly one stimulus attribute changed between any two adjacent trials, the relevant attribute in the case of A1 and an attribute selected at random at each trial in the case of C1. Six stimulus attributes changed between any two adjacent training trials under Conditions A6 and C6, the relevant attribute and five randomly selected irrelevant attributes in A6 and all six irrelevant attributes for C6. The control treatment consisted of a sequence of randomly-selected stimuli. The experiment was executed according to a 5 x 5 x 5 repeated measurement design. The five treatments, five relevant stimulus attributes and five orders of presentation were presented according to a set of orthogonal Greco-Latin squares. The configuration was a replicated version of a design that Winer (1962, pp. 566-571) calls Plan 11. The buttons associated with a particular relevant cue were also counterbalanced.

Subjects. -- The Ss were 50 undergraduate volunteers, paid $2.00 for participating. Several times, a machine failure disrupted the experiment. Subjects with whom there was a failure were discarded and replaced by others. The time required for each S was about 1-1/2 hrs.

Results and Discussion

Table 1 displays the means and standard deviations of training errors and test errors. The raw score distributions of both training and test errors were skewed in a positive direction. A square root transformation normalized the distribution of training errors and tended to normalize the distributions of test errors.

[Insert Table 1 about here]

The results of the analysis of variance are outlined in Table 2 and Table 3 summarizes tests of significance among pairs of treatment means. The result of primary interest is the significant interaction between type of series and number of attributes changing from trial to trial for both the square root of training errors ($\underline{F} = 28.56$, df = 1/49, $\underline{P} < .01$) and the square root of test errors ($\underline{F} = 6.20$, df = 1/49, $\underline{P} < .05$). As predicted, for alternating series the condition in which one attribute changed was superior to the condition in which six attributes changed whereas for constant series, at least on training trials, the condition in which six attributes changed was superior to the condition in which one attribute changed.

[Insert Table 2 about here]

These results confirm Anderson's (1964) findings and lend support to the two rules proposed by Detambel & Stolurow (1956), which can be restated as follows:

Rule S. -- When the stimulus configurations presented on any pair of adjacent trials $\underline{j}$ and $\underline{j} + 1$ contain the same relevant cue, the rate (probability) of learning is maximized when the values of each of the irrelevant stimulus attributes change from trial $\underline{j}$ to trial $\underline{j} + 1$.

Rule D. -- When the stimulus configurations presented on any pair of adjacent trials $\underline{j}$ and $\underline{j} + 1$ contain different relevant cues, the rate (probability) of learning is maximized when the values of each of the irrelevant stimulus attributes is constant from trial $\underline{j}$ to trial $\underline{j} + 1$.

This experiment and the previous one (Anderson, 1964) seem to indicate some independent validity for each of the two rules. The Detambel & Stolurow study showed only that a training series constructed according to both rules was superior to a control series. There was no way of telling whether the superiority of the training condition was a function of both rules or only one or the other.

[Insert Table 3 about here]

The results that have been obtained are consistent with the rules that have been proposed, but could have occurred because of the special, constrained nature of the alternating and constant series. An S-transition is defined as the case when the <u>same</u> relevant cue appears on adjacent trials (e.g., green, green). A D-transition is defined as the case when <u>different</u> relevant cues appear on adjacent trials (e.g., green, red). An alternating series consists entirely of D-transitions whereas a constant series is made up of S-transitions only. It remains to be seen whether performance would be facilitated by the application of the two rules to S- and D-transitions embedded in mixed series in which the stimuli sometimes contain one relevant cue and sometimes another in an irregular pattern.

There was one unexpected result which is, perhaps, best interpreted in terms of the peculiar nature of the constant series. On the test trials, there were fewer errors ($\underline{F} = 24.96$, df = 1/49, $\underline{P} < .01$) under the conditions in which one attribute had changed from trial to trial during training than under conditions in which six attributes had changed. The reason is to be found in the surprisingly poor performance under the C6 condition. On the basis of the first experiment, one would have expected the C6 condition to show as few test errors as the A1 condition. Why were the results different? The belief is that the behavior of many Ss did not come under the control of the relevant cues in the present experiment. They learned only to press a certain button. The appropriate stimulus control was not established, it is conjectured, because under the C6 condition Ss saw only two stimuli (both of which contained the same relevant cue) which they learned to ignore or to which they adapted. Under the related condition in the first experiment, Condition C3, just three of the four irrelevant attributes changed from trial to trial. It may be that since there was more variety, Ss tended to pay attention to the stimulus under this condition and behavior came under the control of the relevant cues. These effects may have been exaggerated by the fact that there were only six training trials in the first experiment, whereas there was a training criterion in the present study.

A subsidiary analysis of variance that took the form of a replicated version of Winer's (1962, pp. 566-571) Plan 11 showed significant differences in the square root of training errors ($F = 2.16$, df = 8/104, $P < .05$) and the square root of test errors ($F = 6.52$, df = 8/104, $P < .01$) as a function of which attribute was relevant. An *a posteriori* test indicated that the differences were largely due to the difficulty of the attribute "position of figure". Of interest, since this was a repeated measurements design, is the fact that the main effect of order of presentation of the treatments was nonsignificant for both training trials ($F = 1.08$, df = 8/104) and test trials ($F = .35$, df = 8/104). Apparent interactions between treatment and order, and treatment and attribute did appear. Inspection of the data indicated that these interactions were spurious, introduced when the separate sums of squares for the two replications were combined. For these interaction sums of squares, the assumption of additivity was violated.

This experiment lends little support to the notion that grouping together presentations of the same relevant cue facilitates performance. It is true that significantly fewer errors ($F = 4.65$, df = 1/49, $P < .05$) were made under constant series conditions, but this result should be discounted since it seems likely that under the C6 condition many Ss failed to learn to respond under discriminative stimulus control. In any event, there was no difference between constant and alternating series on the test trials ($F = 1.33$, df = 1/49). Considering the results of this experiment and the previous one (Anderson, 1964), in which the alternating series actually outperformed the constant series during training, the belief that grouping together instances of each concept promotes learning is open to serious question. What these studies show is that the effects of alternating and constant series are conditional upon the number of stimulus attributes that change from trial to trial.

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Table 1

Means and SDs of Training Errors and Test Errors

	Measure			
	Training errors[a]		Test errors[a]	
Condition	M	SD	M	SD
A1	1.28	.60	.74	1.18
A6	2.27	1.50	2.75	2.25
C1	1.77	.83	1.75	1.98
C6	1.28	.44	2.45	2.36
Control	3.10	1.80	----	----

[a]Square root of errors.

Table 2

Analysis of Variance of Training Errors and Test Errors[a]

		Training errors[b]		Test errors[b]	
Source	df	MS	F	MS	F
Type of series (T)	1	3.21	4.65*	6.09	1.33
Number of attributes changing (N)	1	3.02	4.07*	91.98	24.96**
Subjects (S)	49	1.09		4.25	
T X N	1	27.58	28.56**	21.28	6.20*
T X S	49	.69		4.58	
N X S	49	.74		3.69	
T X N X S	49	.97		3.43	
Total	199				

*$p < .05$

**$p < .01$

[a]The control condition was not included in these analyses.

[b]Square root of errors.

Table 3

Summary of Tukey Gap Tests Among Pairs of Treatment Means

Rank order of treatment mean[a]	Training errors[b]	Test errors[b]
1	A1	A1
2	C6	C1
3	C1	C6
4	A6	A6
5	Control	Control[c]

Note: -- The means of treatments connected by a common line do not differ significantly. All other means are significantly different at the .01 level.

[a]The treatment with the lowest mean is listed first.

[b]Square root of errors.

[c]Test trials were not included in the control condition. This is the same data as was analysed under training errors.