THE EFFECT OF MEMORY REQUIREMENT

ON SCHEMA LEARNING

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A number of previous investigations have suggested that schema learning would be more readily facilitated by a recognition task than a reproduction task due to the increased memory requirement of the reproduction task. Differential memory requirements of 0, 4, 8, 16 and 32 seconds were imposed on 50 Ss in a recognition task to determine if increased memory requirements improved schema learning in the same mode as the reproduction task. The results indicated no significant improvement in schema learning with increased memory requirement. The data does suggest negative transfer from reproduction to recognition task. Recommendations for design and procedural improvements are included.

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THE EFFECT OF MEMORY REQUIREMENT

ON SCHEMA LEARNING

A schema is a property or rule underlying a class of objects. The schema is that regularly recurring property of the objects which is the basis for classing them together. When a recurring property is present in a set of objects, it is called a redundant property or simply redundancy. Redundancy then is a indication of the extent to which a class of objects adheres to its schema.

The process of schema learning is thought to be one of abstracting the redundant features from the objects for ease of storage and utilization. Oldfield (1954) and Attneave (1957) each proposed how this might occur. Oldfield proposed a mechanism by which the redundant property may be encoded into a simplified form and thus increase the ease of storage. Attneave proposed a mechanism in which the schema underlying a set of objects is stored and members of the schema family may then be remembered by noting those distinctive features which deviate from the schema.

Once a schema has been learned by some abstracting process, it is thought to exist in relatively permanent storage and to be usable in subsequent categorization of objects encountered. Evans (1964) demonstrated that human subjects could learn a statistical schema and achieve consistent categorization when they were shown objects that were and were not in a schema family. Significantly this consistent categorization was achieved without knowledge of results or external reinforcement.

Performance in tasks involving schema learning is to some extent a function of the nature of the perceptual task and the level of schematic redundancy. Pretraining with a schema in a reproduction task facilitated subsequent performance in a paired-associates task as compared to performance of groups given irrelevant pretraining experience, (Attneave, 1957). However, Fitts, Weinstein, Rappaport, Anderson and Leonard (1956) found that the redundancy of their stimuli hindered performance in a speed-of-recognition task. Evans (1967c) clarified this apparent discrepency by showing that the redundant properties in each case were the result of different operations. He also pointed out that increased schematic redundancy is associated with increased similarity and less discriminability of the objects. Thus, in a recognition task, schematic redundancy interferes with performance since patterns differ less from each other and from the schema, whereas schematic redundancy facilitates performance in a reproduction task since the number of distinctive features that must be remembered decreases as the schema is learned.

To investigate schema learning experimentally, a class of objects would be needed which permit the experimenter to know the schema and redundancy which permit independent manipulation of both. Such objects should preferably have the statistical properties mentioned above. VARGUS 7 has these properties, (Evans, 1967b).

The stimuli generated by VARGUS 7 look like histograms and provide a schema and redundancy which are independently manipulable. The columns of these patterns are generated using a seven-element Markov process. The columns of the matrix correspond to a column of a particular height and the transitional probabilities are selected to favor a particular sequence of column heights. The most probable sequence may be conceptualized as the schema. Selection of transitional probability value sets the redundancy level of the patterns.

Pick (1965) presented results which may further resolve the disparate finding of the Attneave and Fitts studies. In a series of three experiments in visual and tactual discrimination, she investigated the effect on the discrimination process of learning the schema and distinctive features of a set of stimuli.

In the first experiment all subjects were trained on the same task. She found that those whose task was structured to permit schema learning, performed better than the control group. She also found that the group whose task was structured to encourage discriminations based on distinctive features, performed better than either of the other groups.

A second analogous experiment used tactual stimuli to attempt to generalize the results. Successive comparisons of schemata and comparisons of stimuli were made by the Ss. Since both the destinctive feature and schema learning groups performed equally well and both performed better than the control group, it was concluded that memory requirement imposed by the successive tactual comparison may have been more conductive to schema learning.

The third experiment was to test this hypothesis. Ss now made simultaneous comparisons with both hands. (This removed memory requirement imposed by previous task.) As hypothesized, the schema learning group performed more poorly than the destinctive feature group and no better than the control group. For schema learning to occur the task must impose a memory requirement on the Ss. The differing memory requirement imposed by a reproduction and recognition task may account for the finding of Fitts et. al. (1956) and Attneave (1957).

Evans and Mueller (1967) investigated the effect of redundancy in a recognition task, a transfer task, and a reproduction task. Their study investigated the effect of four levels of redundancy (0, 30, 50 and 70 per cent) on performance in tasks involving a strong and minimum memory requirement. The recognition task subjects were presented with a single pattern and subsequently were shown eight confusion patterns from which they were to choose the pattern just previously seen. The results of this task, which was considered to have a minimum memory requirement, indicated that redundancy had a detrimental effect on performance, a result which agreed with the hypothesis.

Groups trained on higher redundancy patterns would perform better on the first trial of the task was the second hypothesis. In the reproduction task the 70 per cent group showed significant improvement, as did a comparison of the 70 and 0 per cent groups, though the hypothesis was not confirmed. This connoted, however, that in a task with higher memory requirement, increased learning may have occurred.

The results of Pick (1965) and Evans and Mueller (1967) taken together suggest that schema learning is a function of both redundancy and memory requirement. Evans and Mueller suggested further that varying the memory requirement in the recognition task itself might differentially encourage schema learning. If the time interval between the stimulus pattern and the response patterns were varied, this variable might serve to vary the memory requirement in the recognition task. If so, the longer delay before responding might encourage schema learning more than shorter delays.

The significance of the findings of such a study that does show improvement in the recognition task by increasing the memory requirement would serve to separate the influence of the memory requirement factor from the task factor and would establish whether memory requirement is truly a relevant factor in schema learning. Accordingly the problem is, "Does additional memory requirement within the recognition task facilitate schema learning in the mode of additional memory requirement in the reproduction task?"

Memory requirement was varied following Evans and Mueller's (1967) suggestions concerning differing time delays imposed between the single stimulus patterns and the response patterns of the recognition task. The advice of Abbomonte (1967) facilitated manipulation of Ss and delay groups, in association with the most closely related topic, memory.

Broadbent (1958) and Sperling (1973) have proposed models for the recall task. The first stage, short-term memory, might be called a buffer because of its large capacity and rapid decay. The second stage, long-term memory, has a limited capacity and a slow rate of decay. At this stage much initial information is lost in favor of the abstracting of stimulus qualities for long storage.

The abstracted redundant properties (schema) are thought to exist in long-term storage. It is desired that the storage times chosen should allow ample time for abstraction to happen. They should also show differential effects of the differing memory requirements if such a phenomenon exists. Storage times on the order of minutes could conceivably permit responses in the long-term memory mode but might not show performance differences due to differing memory requirement. Since the stimuli are unfamiliar, it seems sufficient decay would occur within less than a minute to allow responses based on abstracted stimulus qualities. To encourage the appearance of the differential varied on a multiplicative rather than equal-interval scale storage times of 0, 4, 8, 16, and 32 seconds seem appropriate. The following hypotheses were proposed.

In the test phase:

1. The greater the delay before responding, the better performance will be on the first three blocks of trials.

2. Initial differences between delay groups will diminish with practice.

3. The performance of all delay groups will improve with practice.

In the pretraining phase:

1. Groups with shorter delays will perform better than groups with longer delays.

2. The performance of all delay groups will improve with practice.

Method

Subjects

The subjects were 50 introductory psychology and education volunteers at Southwest Missouri State University. There were 5 males and 5 females assigned at random to each of 5 groups.

Apparatus

All patterns used a pretrain and test were 70 per cent redundant VARGUS 7 patterns. Each of these patterns was chosen at random from the most probable sequences (MPS) or schemas generated sequentially, using a seven-element Markov process.

Six booklets were prepared, with the format of all booklets alike. The first page was a blank sheet. The second page of each trial contained a single stimulus pattern, termed the priming stimulus, the third a blank separator page where Ss were delayed; the fourth contained three response patterns, and the final page was another separator page. There were 3 booklets used to pretrain the groups and 3 booklets to test all groups.

The 3 booklets used to pretrain the groups contained VARGUS 7 70 per cent redundant patterns with 20 trials each. For each trial in these booklets, the priming stimulus was chosen at random from one of the VARGUS 7 schema families. Two response patterns on each trial were chosen at random from the same family, plus one pattern identical to the priming stimulus.

Procedure

The procedure was to conduct nine sessions per day for two days to complete the testing of Ss. Testing was extended to 5 days in a

3-week space, as 40 per cent of Ss were absent or tardy.

In both pretraining and test phases, the general format for a trial was the same for all groups. A typical trial for all groups: (1) Ss have 8 seconds to scan the priming stimulus, (2) E will instruct Ss to turn the page, (3) E will instruct Ss to turn to the next page containing 3 response patterns and Ss will have 15 seconds to answer, (4) E will instruct Ss to turn the page, and (5) E will delay all groups 4 seconds.

The pretraining of the group was the pattern recognition task, in which Ss indicate which of three response patterns is identical to the priming stimulus just previously seen.

The test phase included the schema recognition task. In this task the Ss were instructed to choose which of three response patterns was most similar to the priming stimulus.

Results

The hypothesis of the test phase were tested with a 5 x 6 analysis of variance with repeated measures. The summary of the analysis of variance of the test is shown in Table 1.

The findings indicate that delay and delay-x-trials analysis produced less than significant results. Thus there was no support for test hypotheses 1 and 2.

TABLE I

ANALYSIS OF VARIANCE OF
THE TEST DATA

Source of Variation	Sums of Squares	df	MS	F
Between Ss	41.3285	49		
Delay	1.85	4	.4625	.5272
Ss within groups	39.4785	45	.8773	
Within Ss	140.17	250		
Trials	15.63	5	3.1260	6.4280*
Delay x Trials	13.79	20	.6895	1.4178
Trials x Ss within groups	109.4175	225	.4863	

$*p < .01$

A significant main effect for blocks of trials was the only significant finding in this phase. The results are plotted in Figure 1; the blocks of trials on the abscissa, the means of correct responses on the ordinate. However, it is clearly indicated that the trend does not support the hypothesis, but, in fact, is inversly related.

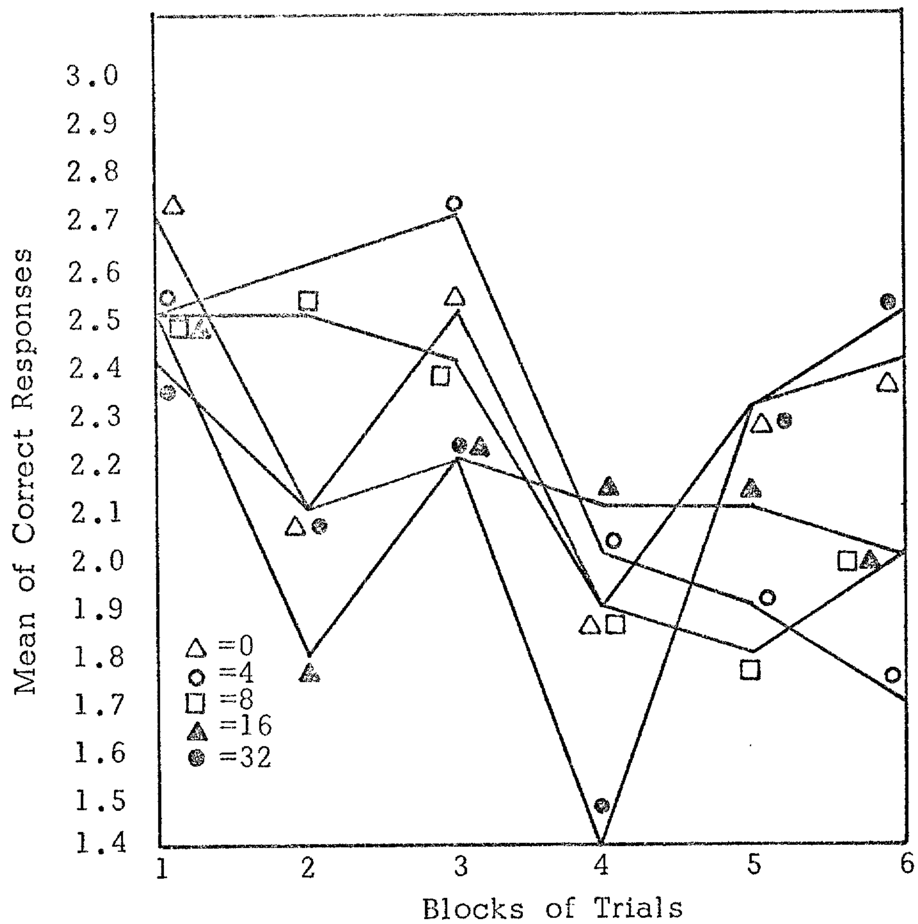

Fig. 1--Mean scores by trial block for test

The hypotheses of the pretraining phase were tested with a 6 x 6 analysis of variance with repeated measures. The summary of the analysis of variance of the pretraining data is shown in Table 2.

TABLE II

ANALYSIS OF VARIANCE OF THE PRETRAINING DATA

Source of Variation	Sums of Squares	df	MS	F
Between Ss	52.38	49		
Delay	1.90	4	.4750	.4235
Ss within groups	50.48	45	1.1216	
Within Ss	101.51			
Trials	8.23	4	1.6450	4.1518*
Delay x Trials	4.13	16	.2063	.5205
Trials x Ss within groups	89.15	180	.3962	

*p $<$ .01

Analysis indicates delay-x-trials produced less than significant results. Consequently, there is no support for the first pretraining hypothesis.

A significant main effect for blocks of trials indicates the only supported hypothesis in this study. The blocks of trials on the abscissa and the number of correct responses (means) on the ordinate in Figure 2 are plotted for comparison with results of test hypothesis 3.

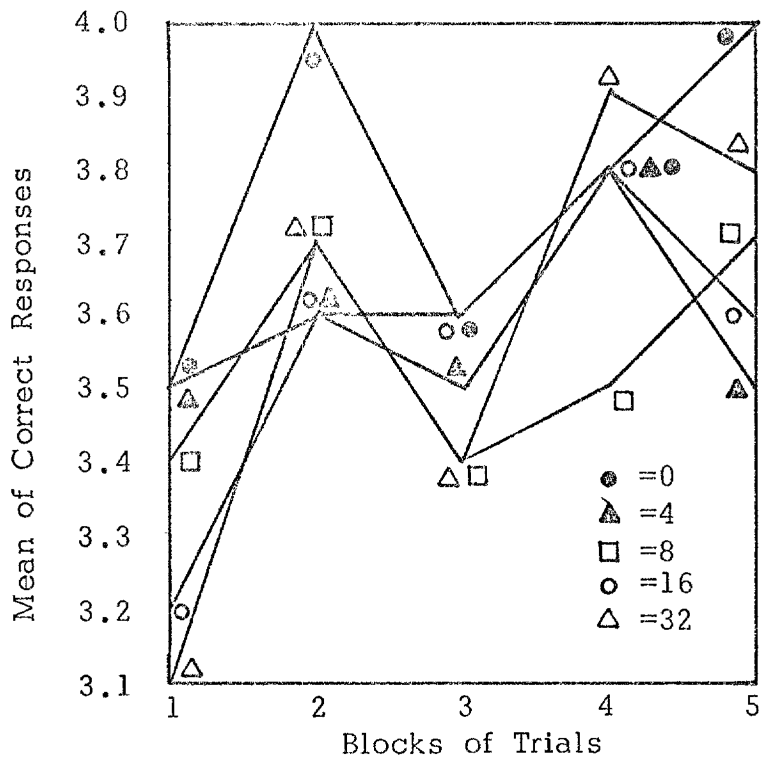

Fig. 2--Mean scores by trial block for pretrain test

Discussion

The hypotheses in the test phase were not confirmed. Thus, the indication here might be that memory requirement in schema learning is void. Subsequently, the assumption that differences between groups will diminish and that performance will improve with practice would be null. However, only one previous study proposed that differential memory requirement would affect schema learning (Abbamonte, 1967). Other prior studies by Pick (1965) and Evans and Mueller (1961) presumed that performance change after a change in task resulted from differing memory requirement. Due to the limitations of subjects, apparatus and scope of time delays, support cannot be allowed, but these limitations do not render the study totally contradictory.

One obvious hindrance was the fact that Ss were pretrained on an identical task and were tested on a similar task. Poorer performance by the shorter delay groups in the pretraining phase may be related to the fact that Ss were counting columns rather than actually learning relevant characteristics of schema patterns. This could not be done in the test phase, as the task was to choose a pattern similar to the priming stimulus. Failure to learn the method may have been a point of frustration to Ss, as they were not instructed of this fact. Having established set on identical patterns in the pretraining task, the Ss then performed the test task on similar patterns. Their inability to respond to the similar schema patterns, after establishing mental set on identical patterns, caused frustration and lack of motivation.

Complicated with already poor motivation, as denoted by poor attendance and extreme tardiness, the task itself was boring and perhaps too long for most Ss to maintain attention. When confronted with a different test task, these uninterested Ss possibly suffered negative transfer, as shown by comparing Figures 1 and 2. Figure 1 definitely shows a deterioration of performance in blocks of trials.

For replication, some problems recognized in this study should be observed. The number of Ss was limited, due to department size and university regulations limiting mandatory participation. Fifteen Ss per group, as suggested by Abbamonte (1967), would provide a better sample of Ss for a study of this size.

The apparatus, using booklets, (Abbamonte, 1967), was too crude for a professional appearance. The bulkiness of the booklets did present minor problems. However, some motivation was lost as Ss approached the end of the booklets due to the fact that they could see the end of the task. If booklets are to be utilized for future studies, it is recommended that additional trials pad the end of both booklets, thus preventing inattention, boredom and possibly end spurt. Also, the use of asterisks for columns in the schema patterns should be replaced with solid columns, to prevent counting. The use of three response stimuli perhaps made both recognition and reproduction tasks too simple. An increase to 5 or 6 response stimuli could provide a more suitable task for schema learning.

An apparatus design as described by Evans and Mueller (1967) in their recognition task might be adopted for future study. Priming stimulus and response patterns would be projected at such distance that counting would be eliminated. The projection of blackened columns might be equally effective. Abbamonte (1967), in forcing Ss to focus attention on the overall configuration, eliminates counting and encourages the proper kind of learning.

Although the significant main effect of trials in the test phase were not supported in this study, for relication it would be recommended that 70 per cent redundant patterns be used, based on the results of Evans and Mueller (1967). This study was reliable in allowing schema learning in trials practical for experimental study.

As a result of this study, it seems necessary to recommend that the pretraining task be identical to the test task. In addition, it is suggested that different memory requirements, 0, 4, 8, 16, or 32, be imposed on each delay group in the pretraining phase, while an identical memory requirement of each group be used in the test phase. Performance differences then would be due only to different pretraining requirements. These suggestions would more precisely test the effect of memory on schema learning.

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APPENDIX A

Pretrain Instructions

The booklet you have before you contains a sequence of twenty (20) trials which will test your ability to recognize patterns. Each trial will proceed as follows:

1. The first page is blank, as you can see. These blank pages appear before each single pattern and the response patterns.

2. On the second page of each trial will be one pattern which you will have eight seconds to observe.

3. At my instruction, "Turn", you will turn the page to the next blank sheet.

4. You will be delayed at this point for a few seconds and at my instruction, "Turn and answer", you will turn to the next page where you will see three patterns.

5. You will have 15 seconds to scan the three patterns and mark the slot number corresponding to the pattern which is identical to the one just seen. You will note the answer slots are numbered across the page.

6. At the end of 15 seconds I will again say, "Turn", and you will again turn to the next blank sheet. If you have not answered by this time, do so immediately.

7. After a few seconds I will ask you to turn the blank page. When you do you will again have a single pattern before you and the entire sequence will begin again. Are there any questions?

APPENDIX B

Test Instructions

The booklet you have before you contains eighteen (18) trials which will test your ability to recognize patterns. Each trial sequence will proceed as before with the following exceptions:

1. Following the single stimulus pattern, you will again have three patterns from which to choose. At this point you choose the pattern most similar rather than identical, as you did before.

2. You will have 15 seconds to scan the three patterns and mark the slot number corresponding to the pattern which is most similar to the one just seen. You will note the answer slots are numbered across the page.

3. At the end of 15 seconds I will again say, "Turn", and you will again turn to the next blank sheet. If you have not answered by this time, do so immediately.

4. After a few seconds I will ask you to turn the separator page. When you do you will again have a single pattern before you and the entire sequence will begin again. Are there any questions?