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ABSTRACT

This report investigates those factors, necessary for, or facilitative of, stimulus organization. Part I considers three experimentally controlled factors: (1) stimuli; (2) responses; and (3) temporal organization of stimuli. The results revealed that temporal specing accounted for different findings. When the intertrial interval (ITI) was present chunking occurred, however, this was not the case when there was no ITI. Part II investigates the nature of the organization changes observed in Part I, by use of the free recall clustering technique. Clustering results were in the appropriate direction, while recall pointed to an incompatibility of recognition and recall tasks. Thus the nature of the stimulus organization in Part I remains unclear. Part III investigates four individual difference factors (channel capacity, immediate memory, span of attention, and intelligence) and their influence on S-R learning and stimulus organization. Results showed that none of the factors had any effect on S-R learning. The data from the study is suggestive of the role of these factors in concept formation. (EK)

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THE RELATION OF INFORMATION PROCESSING BEHAVIOR
TO CONCEPT FORMATION

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Summary

The research presented in this report was conducted to investigate those factors, other than stimulus attributes, which are necessary for, or facilitative of, stimulus organization. A study of such factors would seem to be a basic requirement for the understanding of the formation of concepts. This information is not presently available due to the overwhelming concern of investigators with the stimulus attribute basis of concept formation. This report has been divided into three parts, each concerned with a different aspect of the problem. Part I considers three experimentally controlled factors which were derived from the studies of Richman and Trinder (1968), in which the development of stimulus organization was demonstrated, and Kendler, Kendler and Sanders (1967), in which it was not. In this section it is argued that the term "chunk" is a more appropriate label than "concept" for the type of stimulus organization produced. The second part of the report investigates the nature of the stimulus organization using an alternative measure, clustering (Bousfield, 1953). Finally, Part III was concerned with individual difference factors conducive to chunking.

The primary purpose of Part I was to determine the variable(s) that produced stimulus organization (chunking) in a study performed by Richman and Trinder (1968) when Kendler, et al., (1967) failed to show such an effect. Three factors were considered. They were the nature of the stimuli, responses and temporal organization of the stimuli. Experiment 1 investigated two of these factors, the nature of the stimuli and responses. A 2 x 2 x 2 x 3 factorial design contained the following treatments: Two types of shift (reversal and half-reversal shift), two types of stimuli (nonsense figures and nonsense syllables), two types of responses (verbal and motor), and three levels of training (undertraining, criterion, and overtraining). The results indicated that for each combination of stimulus and response a statistically significant Shift x Training interaction occurred, such that as a function of increased a amounts of original training reversal learning improved and half-reversal learning remained relatively stable, demonstrating the development of chunks. It was concluded that neither the nature of the stimuli or responses were responsible for the divergent findings of Richman and Trinder (1968) and Kendler et al. (1967). In addition Experiment 1 offered support of Kendler and Kendler's (1962) two stage model, which states that early in original learning Ss learn on an S-R association basis with chunking occurring late in training. Experiment 2 investigated a prediction generated from this hypothesis, that a half-reversal shift is an easier task to master when Ss are given little original training (before) chunking begins) as a half-reversal shift involves fewer transferred S-R associations than a reversal-shift. Experiment 2 consisted of a 2 x 7 design with two types of shift and seven levels of pre-shift training. The results of this experiment were equivocal. The primary concern in Experiment 3 was the third variable, the temporal organization of the stimuli which differed between the Richman and Trinder (1968) and Kendler et al. (1967) studies. The experimental design consisted of a 2 x 3 x 3 factorial with two types of shift, three levels of training, and three types of intertrial interval (ITI). One ITI group replicated Richman and Trinder (1968) with a 20 sec. ITI following each block of eight stimuli, a second group replicated the Kendler, et al. (1967) study with no ITI and a third group, a constant time control, had the 20 sec. ITI placement

occurring in a random fashion. The results demonstrated that temporal spacing accounted for Richman and Trinder's (1968) and Kendler et al. (1967) different findings. That is, when the ITI was present chunking occurred, however, this was not the case when there was no ITI.

Part 2 was conducted to further investigate the nature of the organization changes observed in Part I, by the use of the free recall clustering technique (Bousfield, 1953). It was predicted that stimulus sets should show clustering with the greatest amount of clustering occurring under conditions showing the greatest reversal shift over half-reversal shift superiority. Experiments 1 and 2 failed to demonstrate stimulus organization, as measured by clustering, in the free recall of items subjected to training procedures which had produced such effects in shift studies. There was however a significant degree of clustering observed in Experiment 2 for Ss trained on a half-reversal shift but not for Ss trained only on original learning or a reversal shift. This result was diametrically opposed to the stated prediction. Experiment 3 was then conducted to investigate the first of two accounts of this result. Moely, Olson, Halves, and Flavell (1969) have suggested that stimulus organization may exist, but is not utilized by Ss during recall. They have called this phenomena "production deficiency in mediation." In these studies the half-reversal shift condition may be thought of as being more confusing than a reversal shift, resulting in the actualization of the potential organization. "Production efficiency" was manipulated by informing Ss of the potential stimulus organization. It was predicted that the number items recalled would be greater for Ss who were encouraged to use the potential stimulus organization. The results however indicated no recall differences between Ss instructed to organize and those without prior instructions, ruling out the "production deficiency" hypothesis. The second account of these findings suggests that the stimulus organization produced with the recognization procedures of Part I may be inaccessible to Ss when they are asked for free recall. That is, a distinction was made between recognition and recall processes in stimulus organization. The exact nature of the distinction, whether it is a difference in the retrieval cues for the chunk, or a difference of recognition and recall memories, is not clear. This hypothesis was tested by manipulating the Ss learning strategies via instructions. That is, it was predicted that informing the S that recall of the items would be required, would result in a modification of the S's strategy, an increase in the memorization of the items and an increase in clustering. It should be noted that in Experiments 1 and 2 this additional information, that the items would have to be recalled, was not given in any of the experimental conditions before original learning. The results of this study show that Ss who are instructed that they will be asked to recall the items, before organization training, cluster the items in free recall to a greater extent than Ss who are not so instructed, or, who do not receive organization training. These Ss also recall more items than Ss who do not receive recall instructions. The hypothesized effect of instructions was therefore confirmed. It should be pointed out however, that the degree of clustering achieved was not great. The amount of clustering, represented as a percentage such that 50% is that expected by chance, was 39.5%, 53.0% and 58.5% for the Recall, Training and Training + Recall Conditions respectively. As can be seen from these percentages the

addition of recall instructions to Ss who received organization did not add appreciably to the amount of clustering. In view of this, the data cannot be said to unequivocally confirm the basic hypothesis, which distinguishes between the availability of the stimulus chunks in recognition vs. recall procedures. The clustering results were in the appropriate direction, while the recall data confirmed the expected relationships and pointed to an incompatibility of recognition and recall tasks. Finally, as the relationship between these two procedures was not completely resolved the nature of the stimulus organization achieved in the studies of Part I remains unclear.

Part III was designed as an exploratory study to investigate four individual difference factors (channel capacity, immediate memory, span of attention, and intelligence) and their possible influence on S-R learning and stimulus organization. Subjects were first divided into high and low individual difference performance groups and then trained to criterion or overtrained in either the reversal or half-reversal shift task. As before stimulus organization was based upon the ratio of reversal to half-reversal shift and S-R learning speeds were determined by rates of original learning criterion. The results indicated that none of the four individual difference factors had any effect on S-R learning. However, three of the four factors showed either a more rapid development of stimulus organization over levels of pre-shift training (channel capacity and intelligence) o. a higher level of conceptual organization at each level of pre-shift training (span of attention). Low Immediate Memory Ss showed a higher amount of stimulus organization than high Ss. The reason for this latter finding was not clear.

It was concluded that individual difference factors play an important role in stimulus organization. The exact nature of this role is as yet unclear.

Part I. The Role of Stimulus, Response, and Temporal Factors in Stimulus Organization

General Introduction

Traditionally concept formation studies in adult humans have been concerned with problems of concept or stimulus identification rather than with the investigation of processes involved in the development of concepts. This situation has resulted, experimentally at least, in an assumed isomorphism between concepts and physical dimensions of stimuli and has left unclear the necessary conditions for the development of conceptual organization. In fact, in order to study the factor involved in the development of stimulus organization it seems necessary to make all stimulus attributes irrelevant. For this reason the use of the label "concept" is inappropriate if one wishes to consider the processes involved in the development of stimulus organization. A more descriptive term is the "chunk," which was originally used by Miller (1956) to refer to units of immediate memory. The term has come to have wider usage and can be used to refer to an organization of stimulus elements which act as a functional unit. Throughout this report the term chunk will be used to denote the organization of stimuli inferred from the S's behavior in

the experimental situation. On the other hand stimulus set will be used to indicate the experimental manipulation of placing stimuli in experimentally defined groups.

In two papers Richman and Trinder (1968) and Trinder, Richman, and Gulkin (1969) (see Appendix A) investigated the development of chunks which were based upon stimulus sets not discriminable on the basis of known stimulus attributes. By using novel stimuli in these studies, random figures, with which human adults were unlikely to have had prior experience the development of chunks was demonstrated utilizing a reversal shift (RS)--half reversal shift (HRS) paradigm, while varying the amount of pre-shift training. The most important aspect of these studies was that the only defining characteristic of the stimulus sets was the common response made to each stimulus member. The stimulus sets could not be distinguished on the basis of any known physical attribute. This allowed for the investigation of factors which are important for the development of concepts, rather than simply identifying pre-experimentally developed concepts.

A study that raised some questions concerning the above analysis was conducted by Kendler, Kendler, and Sanders (1967). Utilizing the RS-HRS technique to investigate the effect of the availability of a verbal mediator on RS and HRS problems they did not demonstrate the formation of chunks. There were however, three major methodological differences between the studies. First, Kendler et al. (1967) used motor responses (left and right push buttons) while Richman and Trinder (1968) used verbal responses ("soft" and "strong"). If the availability of verbal mediators is an important variable in stimulus organization then this factor could have accounted for the differences. However, a more recent study by Trinder et al. (1969) obtained the chunking effect using motor responses, suggesting the type of response was not an important variable. Second, Kendler et al. (1967) used trigrams as stimulus material whereas Richman and Trinder (1968) and Trinder et al. (1969) used random figures. Third, Kendler et al. (1967) presented stimuli in a continuous series with no intertrial interval (ITI) whereas both Richman and Trinder (1968) and Trinder et al. (1969) used a 20 sec. ITI between each presentation of the two stimulus sets. McLean and Gregg (1968) have shown that the grouping of stimulus material during presentation sequences can affect the organization of the stimuli as measured by the form of recall. Thus, the temporal organization of the stimuli could well be a contributing factor to the production of chunks. The experiments reported in this paper were conducted to investigate these three factors as potential variables influencing the organization of stimulus material into chunks.

Experiment 1

Introduction

This experiment considers the effect of two variables, the type of stimuli and responses, which could have accounted for the demonstration by Richman and Trinder (1968) and Trinder et al. (1969) of organizational effects using nondimensional stimuli while Kendler et al. (1967) failed

to find such an effect. The first of these two factors was of some interest as the main postulate of our early studies was that the stimuli did not contribute to the chunking effect, and because of this, the technique enables the study of other factors which could account for stimulus organization. On the other hand some evidence negates the fact that the nature of the response is an important variable. Trinder et al. (1969) demonstrated the chunking effect by using motor responses (two buttons). There remains however the possibility that the nature of the stimuli and responses interact in such a way as to eliminate chunking.

Method

Subjects.--Four hundred and eighty male and female undergraduate students who were enrolled in the first year psychology courses at the University of Cincinnati served as Ss to fulfill course requirements.

Procedure.--Subjects were run in groups of 2 to 10 and were seated 6 to 8 ft., depending on the location of their chair, in front of a screen. Attached to each S's chair was a response box with a red reinforcement light placed in the center. A left and right response button was located to each side and 1 in. below the light. The response box buttons, reinforcement light, carousel, and ten cumulative counters were wired to a control panel and tape programmer that automatically flashed an S's reinforcement light for 1 sec. following a correct response and activated the carousel and cumulative counters, the latter being used to record each S's correct responses.

The stimuli were eight nonsense figures (NF) or eight nonsense syllables (NS). They were each divided into two sets of four. In the case of the NFs the dimensions of the stimuli have been identified by Steinheiser (1968) using similarities data. The two sets of NFs were constructed such that they could not be distinguished on the basis of the identified physical attributes. For the NSs this was achieved by visual inspection of the stimulus sets. A trial consisted of the presentation of eight stimuli with the S making one of the two responses to each stimulus (left vs. right or "soft" vs. "strong"). For one set of four stimuli one response was correct while the other response was correct for the remaining set. Stimulus duration was 6.5 secs. with an ITI of 20.0 secs. and a 600 msec. ISI.

Instructions.--The Ss were told they were in a learning experiment in which they had to learn the associations between the stimuli shown on the screen and one of two responses. They were instructed to depress either the left or right ("soft" or "strong") button once during a stimulus presentation with the red reinforcement light indicating if the response was correct or not. The Ss were further instructed to attempt to flash the light as many times as possible as the S scoring the most points, by lighting the light the most times, would receive two instead of one hours credit. It was emphasized that any errors in responding were the S's since the apparatus had been tested and worked at 100% accuracy. This was to avoid response perseveration after the shift due to a S's belief that the equipment had broken.

Design.--A 2 x 2 x 2 x 3 factorial contained the following treatments: Two types of shift, stimuli, and responses, and three levels of original training. Twenty Ss were randomly assigned to each of the 24 subgroups. Half the Ss were trained on a reversal-shift problem (RS) and the remaining on a half reversal shift task (HRS). In a RS the stimulus sets reverse their correct responses, whereas in a HRS half of each set are reversed while the other half retain their preshift responses. Therefore, during a RS all S-R associations are changed while during a HRS only half the S-R associations are changed. The correct S-R associations were identical for the RS and HRS groups during the original training phase and therefore different during the shift phase.

Subjects were equally divided according to the type of stimuli they were required to learn. For one half of the Ss the stimuli were eight 16-point Vanderplas-Garvin (1959) NFs while for the remaining Ss the stimuli were eight Glaze (1928) high meaningful NSs. Subjects were also equally divided in terms of the type of response they were to use. Half the Ss were instructed to press eit' :r the left or right button during a stimulus presentation; this group was called the motor method group (MM). The other half of Ss were told that the word "strong" was correct for half the stimuli and "soft" for the others; this group was called the verbal method group (VM). Subjects in the VM group had "soft" printed over one of their buttons and "strong" over the other. The relationship of "left" and "right" to "soft" and "strong" was randomized between Ss as was the appropriate response to each of the stimulus sets.

There were three preshift levels of training. Group UT (undertraining) received six preshift trials in the case of NFs and four for NSs. (Pilot work had indicated that it took about 12 and eight trials for the NF and NS groups, respectively, to learn to an original learning criterion of eight out of eight correct in one trial). The UT group was therefore defined as half the mean number of trials it took an average S to reach a criterion of one perfect trial. Group C (criterion) Ss were trained to a criterion of one perfect trial. Group OT (overtraining) Ss were trained to criterion and then given four additional overtraining trials prior to the shift. Shift criterion was defined as one perfect trial.

Results and Discussion

Throughout the text of this paper, unless otherwise indicated, when statistical effects are discussed, trials then errors to criterion data will be reported.

Original learning.--A 2 x 2 x 2 x 2 analysis of variance consisting of two types of shift (HRS and RS), two types of responses (VM and MM), two types of stimuli (NF and NS), and two levels of training (C and OT) was performed on both the trials and errors scores to original learning criterion. Except for the Shift main effect, $F(1,304) = 22.71$, $p < .01$; $F(1,304) = 40.33$, $p < .01$; the Stimuli main effect, $F(1,304) = 6.48$, $p < .025$; $F(1,304) = 4.15$, $p < .05$; and the trials to criterion Shift x Stimuli interaction, $F(1,304) = 4.33$, $p < .05$, all other main and interactive effects were shown to be statistically nonsignificant, ($p > .10$).

Because UT groups were given six (NF) or four (NS) undertraining trials prior to a shift, a separate 2 x 2 x 2 analysis of variance was performed on the undertraining groups' error scores. Again, both Shift and Stimuli main effects proved to be statistically significant, $F(1,152) = 9.07$, $p < .01$ and $F(1,152) = 147.91$, $p < .01$, respectively. No other main or interactive effects were statistically significant ($p > .10$).

Both the trials and errors to original learning criterion data showed that the nonsense syllables were easier to learn than the nonsense figures. These findings were not unexpected. It was surprising, however, to find that the HRS groups reached original learning criterion faster and with significantly fewer errors than the RS groups. The only apparent explanation for this difference is sampling error, since both groups learned the same S-R associations and were procedurally treated in exactly the same way during original training. The effects of this result on the shift phase are discussed below.

Shift learning.--Neither the trials nor errors to shift criterion scores met the requirement of homogeniety of variance; the shift scores were therefore treated with a square root transformation prior to statistical analysis. A 2 x 2 x 2 x 3 analysis of variance was performed on both the trials and errors to shift criterion data. Both trials and errors to shift criterion revealed a statistically significant Training main effect, $F(2,456) = 22.43$, $p < .001$ and $F(2,456) = 15.63$, $p < .001$ and a Shift x Training interaction, $F(2,456) = 19.74$, $p < .001$ and $F(2,456) = 21.86$, $p < .001$. The errors data also showed a statistically significant Stimulus x Training interaction, $F(2,456) = 5.39$, $p < .01$. No other main nor interactive effects were statistically significant. Table 1 shows the ANOV for both trials and errors to shift criterion.

The statistically significant Shift x Training interaction confirmed the results obtained by Richman and Trinder (1968) and Trinder et al. (1969). The improved performance of the RS condition with increasing levels of preshift training while HRS remained constant reflected the increased organization of the stimulus sets. Figure 1 shows this overall Shift x Training interaction. To further investigate the Shift x Training interaction four Shift x Training Analyses of Interactions were performed on the Trials and four on the Errors data for each combination of mode of response and stimulus (Myers, 1966). Using 2 and 114 df for the interaction analyses a statistically significant Shift x Training interaction was found for Group NS-VM, ($F = 8.17$, $p < .001$ and $F = 12.11$, $p < .001$); Group NS-MM ($F = 5.83$, $p < .01$ and $F = 5.81$, $p < .01$); Group NF-VM ($F = 7.16$, $p < .01$ and $F = 5.42$, $p < .01$); and Group NF-MM ($F = 3.32$, $p < .05$ and $F = 3.93$, $p < .05$). These analyses demonstrated that regardless of type of response and stimuli used, a statistically significant Shift x Training interaction was evidenced. At this juncture it is appropriate to return to the statistically significant Shift effect obtained in original learning. It is unlikely that it could have accounted for, or in any way modified, the above interaction results. More probably it resulted in an overall faster HRS performance and could have contributed to the faster HRS than RS performance for the undertrained groups. This difference at undertraining will be discussed more fully in Experiment 2.

Table 1

Analysis of Variance for Trials and Errors to Shift Criterion Following a Square Root Transformation

Source	df	Trials		Errors	
		MS	F	MS	F
Stimulus	1	1.62	2.23	11.26	3.80
Response	1	0.00	< 1.00	0.33	< 1.00
Shift	1	0.23	< 1.00	0.01	< 1.00
Training	2	15.33	22.43**	46.36	15.63**
Stimulus x Response	1	0.16	< 1.00	6.59	2.44
Stimulus x Shift	1	0.87	1.28	2.83	< 1.00
Stimulus x Training	2	0.63	< 1.00	16.00	5.39*
Response x Shift	1	0.08	< 1.00	0.18	< 1.00
Response x Training	2	0.69	1.01	0.44	< 1.00
Shift x Training	2	13.49	19.74**	64.85	21.86**
Stimulus x Response x Shift	1	1.81	2.65	1.09	< 1.00
Stim. x Response x Training	2	0.64	< 1.00	9.10	3.06
Response x Shift x Training	2	0.28	< 1.00	2.58	< 1.00
Shift x Stimulus x Training	2	1.74	2.55	0.88	< 1.00
Stimuli x Response x Shift x Training	2	1.77	2.60	0.55	< 1.00
ERROR	456	0.68		2.97	

* $p < .005$

** $p < .001$

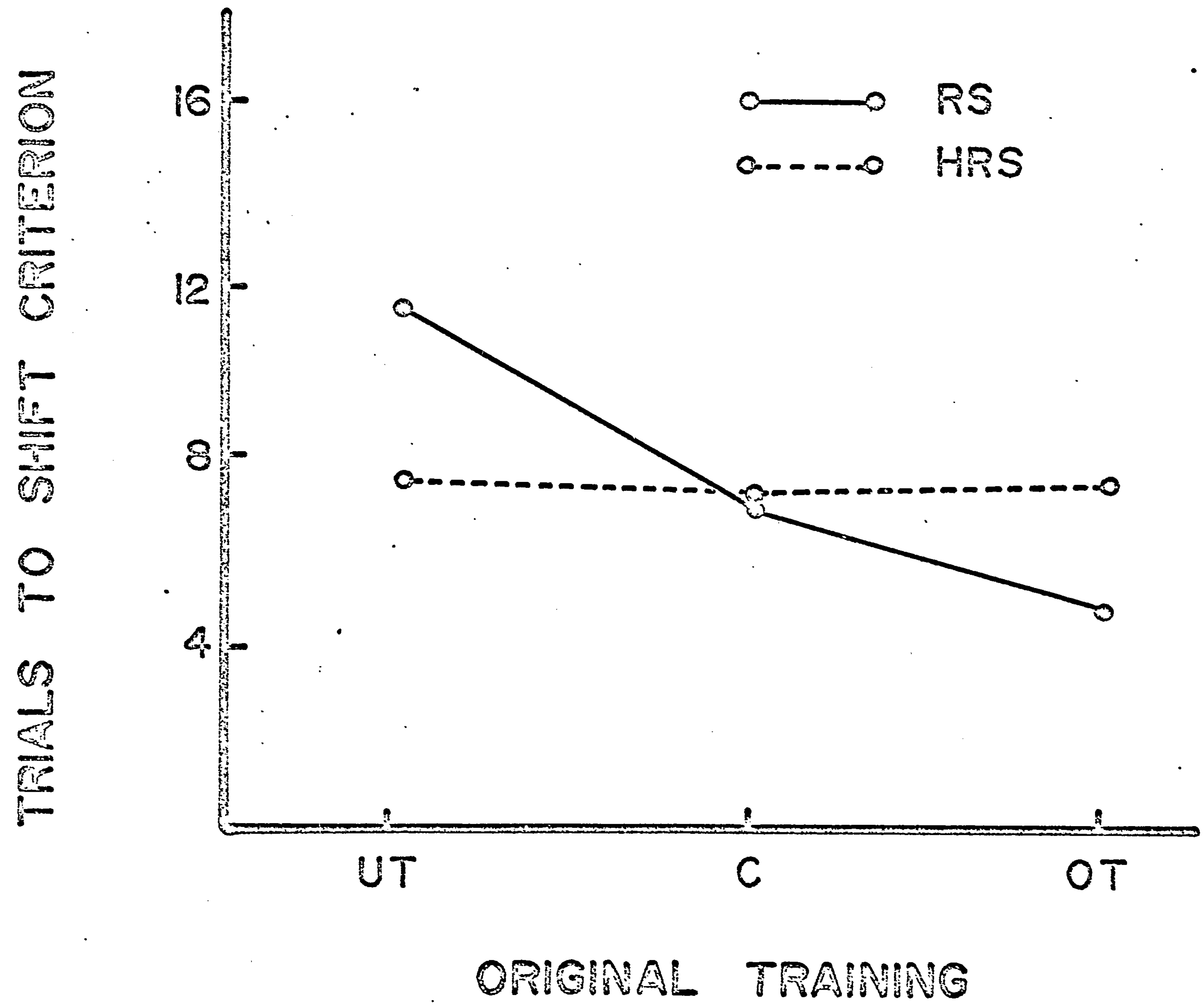

Figure 1. Mean number of trials to shift criterion as a function of the amount of preshift training for reversal and half reversal shift groups

The results of this experiment did not reveal a Shift, Stimulus, or Response main effect nor, with the exception of the Stimulus x Training interaction, were there any interactions significant that included the modes of the stimuli and responses. It therefore must be concluded that neither the type of stimuli nor the use of verbal labels could account for variant findings of Richman and Trinder (1968) and Kendler et al. (1967). As discussed in the introduction, the failure to find a Response effect had been anticipated from an earlier study (Trinder et al., 1969). The absence of a Stimulus effect confirms the lack of involvement of the type of stimuli used in the formation of chunks.

One interesting result that deserves mentioning here was the Stimulus x Training interaction. During UT the NS were much easier to shift than NF; however, as training progressed (C and OT groups) stimulus (NF-NS) difference effects disappeared. This finding is particularly relevant if one assumes that in shift training two processes develop in sequence. At the onset of original training the dominant process is stimulus discrimination: the S accumulates information from each of the stimuli so that he is able to distinguish one from the other. Then, during the latter stages of discrimination training, the process of chunking begins to develop; it is during this stage that the S may then treat an entire chunk of information (a stimulus set) as one. According to this hypothesis a Stimuli x Training interaction would be predicted since the UT groups' learning rates during the shift phase would be primarily governed by the discrimination process and since learning nonsense syllables is an easier task than learning nonsense figures the former would also be easier tasks than the latter during shift training. However, if extended original training (C and OT groups) initiates the chunking process then one would predict that all stimulus shift differences should disappear. Thus, the Stimuli x Training interaction would seem to reflect a change from stimulus-response associations to organizational factors as the level of preshift training increases.

Experiment 2

Introduction

This experiment was designed to clarify one of the issues raised by previous research (Richman and Trinder, 1968; and Experiment 1). It was proposed in Experiment 1 that only early in original learning do Ss learn on an S-R association basis, with chunking of the stimulus sets later in training. Kendler and Kendler (1962) and Kendler, Kendler and Marken (1969) have suggested a similar hypothesis in accounting for ontogenetic development. A prediction generated from this hypothesis is that a HRS is an easier task to master than a RS when Ss are given little original learning; that is, before the chunking begins, as a HRS involves fewer transferred S-R associations than a RS. Richman and Trinder (1968) and Experiment 1 of this paper confirmed this prediction, but in a recent study Trinder et al. (1969) failed to replicate a faster HRS than RS learning during undertraining. In the former studies the HRS and RS tasks differed during shift learning whereas in the latter experiment the two shift tasks were identical. Slamecka (1968) has criticized transfer designs of this nature for not holding the shift

constant. Also in Experiment 1 of this paper the results may have been confounded by the significant shift differences in original learning.

The purpose of the study was to appropriately test the prediction that early in original training Ss learn by S-R associations alone, by considering in detail the RS-HRS paradigm with a number of undertrained groups.

Method

Subjects.--The 320 Ss used in this experiment were from the same S pool as those in Experiment 1.

Procedure.--The apparatus, seating arrangement, instructions, and general experimental procedure were the same as Experiment 1 with the following three exceptions: 1) The Ss response boxes did not contain verbal labels 2) Only 16-point Vanderplas-Garvin (1959) figures were used 3) The RS-HRS tasks were different during original learning but identical during the shift phase.

Design.--This experiment consisted of a 2 x 7 factorial design with two types of shift (RS and HRS) and seven levels of original training (1, 2, 4, 6, 9, 12, and 15 trials). Twenty Ss were run in each group. To assess the possibility that RS and HRS tasks differed in difficulty during original learning, two control groups were run. One group learned the RS original learning S-R associations and the other group the HRS S-R associations, to a criterion of 8 out of 8 correct responses during one trial.

Results and Discussion

Original learning.--Seven independent t-tests were performed on the errors to original learning criterion for the seven RS-HRS experimental groups for each training level. In no case was t greater than 1 (df = 38). To assess further whether the RS task during original learning was more difficult than the HRS task a t-test was performed on the RS and HRS groups run to original learning criterion. The trials and errors to criterion data revealed no differences in difficulty between the RS and HRS tasks (t's < 1.00, df = 38, N.S.). These findings showed that for each level of original learning the RS-HRS tasks were of identical learning ease.

Shift learning.--Because of the violation of the homogeniety of variance assumption for the ANOV all shift scores were treated with a square root transformation. A 2 x 7 ANOV was computed on the trials and errors to shift criterion. These analyses revealed a significant Training main effect, $F(6,266) = 5.66$, $p < .01$ and $F(6,266) = 6.34$, $p < .01$. However the Shift main effect, F's$(1,266) < 1.00$, N.S. and Shift x Training interaction, $F(6,266) < 1.00$, N.S. and $F(6,266) = 1.14$, $p > .10$ were not significant. Although the obtained differences between RS and HRS at each level of preshift training were in the appropriate direction, with the HRS learned faster at 2, 4, 6, and 9 and the RS learned faster with 12 and 15 pre-training trials, the Shift x Training

interaction was not statistically significant. The hypothesis was therefore not supported. It was also not completely disconfirmed as the direction of the shift differences were as expected and the effect may, consequently, be rather small. This conclusion is supported by the results of Experiment 3.

Experiment 3

Introduction

This study considers the effect of temporal spacing on the formation of chunks. There are a number of reasons to expect that temporal spacing of stimulus material will affect stimulus organization. Historically, the principles of stimulus organization formulated by the Gestalt psychologists suggest that temporal spacing would be important. More recently a number of studies have considered the effect of stimulus organization, during presentation, on the nature or level of subsequent performance, as a means of studying human information processing behavior. Typically the procedures used in achieving organization of stimulus material have involved, as a necessary component of the various techniques, temporal spacing. For example, McLean and Gregg (1967) presented information on cards, varying the amount of information on each card, in a serial learning task. One component of the distinction between cards was therefore temporal. The grouping of items during presentation was reflected in the nature of recall. Furthermore, Bower and Winzenz (1969) segmented digit strings by pauses and found that recognition and recall performance was retarded when the pause location was varied in repeated strings.

These studies indicate that temporal spacing of stimulus sets during stimulus presentation could have an important effect on the nature of the storage process. The present experiment investigates this possibility by utilizing the RS-HRS paradigm used in Experiment 1 and 2 and varying the form of the ITI, that is, the nature of the temporal spacing. Following the implications drawn from the McLean and Gregg (1967) and the Bower and Winzenz (1969) studies one would predict that stimulus chunking would take place with an ITI, while in its absence chunking should be reduced or possibly eliminated. This distinction corresponds to the difference between the studies of Richman and Trinder (1968) and Kendler, et al. (1967) in which the latter study failed to find chunking effects in the absence of an ITI.

Method

Procedure.--The 360 Ss used in this study were from the same source as those in Experiment 1 and 2. The general procedures were the same as those used in Experiment 2.

Design.--The experimental design consisted of a 2 x 3 x 3 factorial with two types of shift (RS and HRS), three levels of training (UT, C, and OT) and three types of ITI. The ITI groups were as follows: A 20 sec. constant ITI (20 Con.) in which the ITI occurred between each block of eight nonsense figures; a 20 sec. variable ITI group (20 Var.)

with the ITI occurring randomly between two stimuli, such that there was an average block length of eight figures; and a .600 sec. ITI group (No ITI) so that the ITI equalled the ISI. Group 20 Con. replicated that used in previous studies (Richman and Trinder, 1968; Trinder et al., 1969) while Group No ITI was similar to that used by Kendler et al. (1967). Group 20 Var. was a control group used to test the possibility that any difference attributable to a 20 sec. ITI was a result of the additional time between blocks of stimuli rather than temporal grouping. There were, of course, other ways in which total time could have been held constant. The present method was selected for this study under the implicit assumption that the long ITIs may be used by _Ss_ to reorganize material _following_ input rather than the organization of stimulus elements _at_ input.

Results and Discussion

Original learning.--Two 2 x 2 x 3 analyses of variance, consisting of two types of shift (RS and HRS), two levels of original training (C and OT) and three types of ITI (20 Con., 20 Var., and No ITI) were performed on the trials and errors to original learning criterion. For both the trials and errors data all main and interaction _F_ ratios were less than 1.00. A separate errors analysis was performed on the UT groups which again resulted in _F_ ratios less than 1.00. The most important aspect of these findings was that the type of ITI did not affect performance in original learning. Trials to original learning criterion for the 20 Con., 20 Var., and No ITI groups were 10.86, 10.90, 10.74 respectively. This finding agreed with the conclusions of Brown and Archer (1956) and Oseas and Underwood (1952) that varying the ITI duration has little effect on initial learning in concept identification and utilization tasks.

Shift learning.--In the shift phase of this experiment the point of issue is the development of chunking over increasing levels of preshift training (an increased RS-HRS ratio) in each of the ITI conditions. Following a square root transformation both trials and errors to shift criterion scores were subjected to a 2 x 3 x 3 analysis of variance. This analysis showed an improvement in post-shift performance as a function of increased amounts of original learning, $F(2,342) = 13.64$, $p < .001$ and $F(2,342)$ 39.74, $p < .001$, and a significant interaction between training and type of shift, $F(2,342) = 3.36$, $p < .05$ and $F(2,342) = 3.46$, $p < .05$. Further analysis of this interaction effect, with a test of the interaction for each of the ITI conditions, revealed significant effects for the Group 20 Con., $F(2,114) = 8.99$, $p < .001$ and $F(2,114) = 6.50$, $p < .01$, and Group 20 Var. conditions, $F(2,114) = 4.62$, $p \leq .05$, and $F(2,114) = 3.84$, $p < .05$, while the interaction for Group No ITI did not approach statistical significance, $F(2,114) < 1.00$, $p > .10$ and $F(2,114) < 1.00$, $p > .10$. In the main analysis of variance the third order interaction, Shift x Training x ITI, did not prove statistically significant, $F(4,342) = 1.45$, $p > .10$ and $F(4,342) = 1.56$, $p > .10$; this lack of statistical significance was probably due to the strong Shift x Training interactions.

The ITI main effect proved to be statistically nonsignificant, $F(2,342) < 1.00$, $p > .10$ and $F(2,342) < 1.00$, $p > .10$, as well as the Training x ITI interaction, $F(4,342) < 1.00$, $p > .10$ and $F(4,342) < 1.00$, $p > .10$. These findings confirmed the results obtained in original learning showing that the ITI does not affect S-R learning, but rather the chunking process.

Figure 2 clarifies these results for the three ITI groups. When blocks of stimuli were separated by a 20 sec. constant ITI the data clearly showed the chunking effect. Stimulus organization also took place when a 20 sec. interval occurred randomly between stimuli. On the other hand when there was no ITI no chunking occurred. These findings can further be illustrated using the index of conceptual organization (CO). The CO was defined by Kendler et al. (1969) as $\frac{HRS}{(RS + HRS)} - .50$, using trials to shift criterion, and is a measure of the developmental level of a subject population with a set of stimulus material; as such the measure is an assessment of chunking. The development of chunking for each ITI condition, as reflected by the CO ratio, is illustrated in Figure 3. This graph shows that the 20 Con. groups demonstrated a steady increase in the CO ratio as a function of increased preshift training (-.08, -.02, and +.11 for UT, C, and OT groups respectively) while the No ITI groups showed little change (+.02, +.01, and 0.00 for UT, C, and OT groups respectively) across training levels. These curves, again, confirmed the role of ITI in accounting for the differences under investigation. The CO value obtained by Kendler et al. (1967) for conditions equivalent to OT in this study was +.02. This value is represented by the single point at OT (see Figure 3). As can be readily seen it is not different from that obtained for the No ITI-OT group in the present study. Figure 3 also shows that the variable ITI groups produced similar CO ratios (-.01, -.06, and +.09 for UT, C, and OT respectively) to that of the constant ITI condition. This finding suggests that the ITI effects are of importance following stimulus input and involve a reorganization of the stimulus material to produce the chunking effect.

Conclusions

The three experiments reported in this paper demonstrated that the absence of an ITI in the Kendler et al. (1967) study was the contributing factor for their not finding a chunking effect. In Experiment 1 of the present paper both the nature of the stimuli and the responses contributed little towards the development of chunks. The failure to find a Stimulus effect adds credence to the Trinder et al. (1969) argument that chunking effects can be observed in the absence of relevant physical attributes or known dimensions of the stimulus sets. Certain aspects of the results also support the ontogenetic model of Kendler and Kendler (1962) and Kendler et al. (1969). The model proposed that young children learn principally by S-R relationships which are later replaced by the formation of concepts. Experimentally this was shown by Kendler et al. (1969) by the increasing value of CO as a function of age. The data of the present studies has relevance to two predictions of the model: (1) The model predicts that concepts

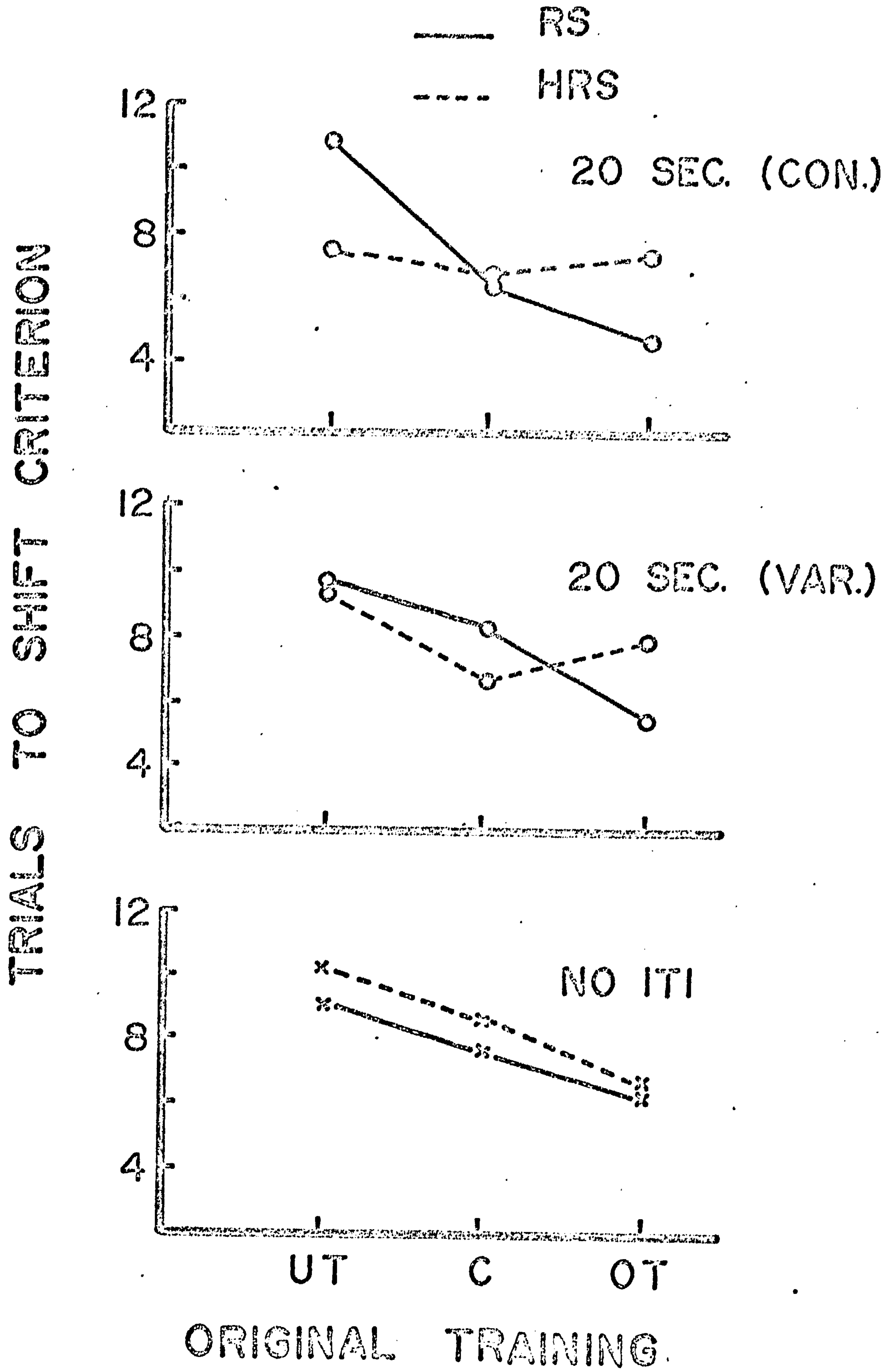

Figure 2. Mean number of trials to shift criterion as a function of the amount of preshift training and type of shift, for the 20 sec. Constant ITI (Top), 20 sec. Variable ITI (Middle), and No ITI (Bottom) conditions.

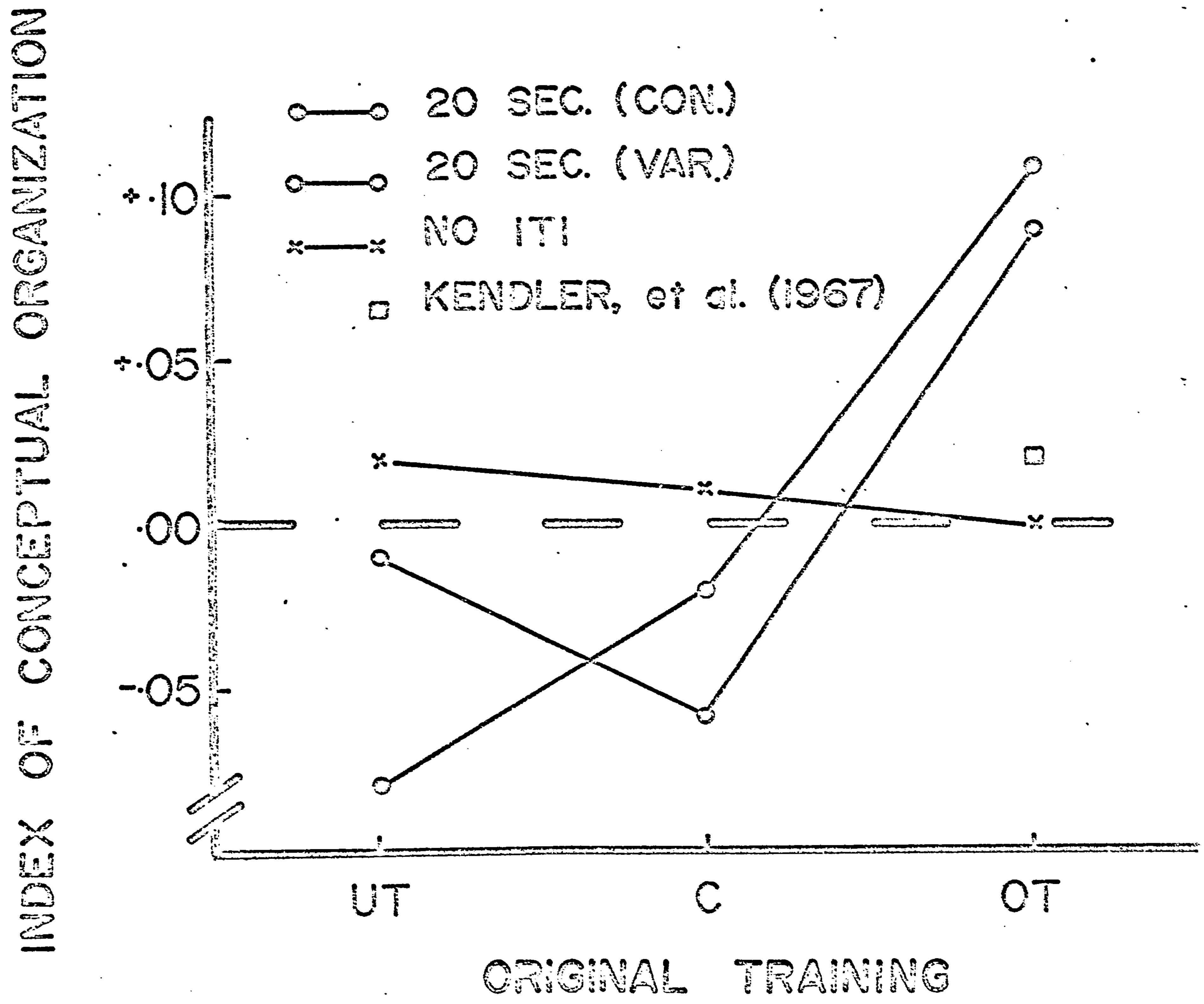

Figure 3. Index of conceptual organization as a function of the amount of preshift training. For the 20 sec. constant ITI, 20 sec. variable ITI and no ITI conditions. The single data point at OT represents the value obtained by Kendler, et al., (1967) in the absence of an ITI. The no ITI condition at OT is equivalent to this group.

develop in children only after S-R relationships have been learned. If this is true then a HRS should be superior to a RS during the early stages of training because fewer S-R relationships are transferred. This prediction was confirmed in Experiment 1, then in Experiment 2, a more adequate test of the prediction, the results were statistically nonsignificant, although were in the appropriate direction. In Experiment 3 the 20 Con. UT groups also showed the predicted HRS superiority to RS, giving a CO ratio of -.08. It seems quite possible that the relationship holds, although under the conditions of these studies it is not a particularly strong one. (2) Experiment 1 also indicated that differences in stimulus learning difficulty (between NFs and NSs) were only apparent in the shift phase with low levels of training and disappeared with the development of chunking.

Attention must now be turned to the function of the ITI in producing the observed chunking effect. To begin with it is clear that the role of the ITI was <u>not</u> to facilitate S-R learning as neither the ITI main effects in Original or Shift learning were significantly different from chance expectancy. The ITI would thus seem to be involved in the differential effects of training on RS as opposed to HRS tasks, that is, on chunking. The question remains as to whether the constant ITI condition owed its effects to encoding organization based on the temporal properties of the stimulus input, or to stimulus reorganization subsequent to encoding. The data of this study suggests that the ITI effects the latter, as both conditions show significant interaction effects or shift over levels of pre-shift training.

The results of this research are open to at least one other interpretation. The evidence for chunking has been the observation of a Shift x Training interaction, such that, the CO ratio increases with increasing levels of preshift training. Slamecka (1968) has criticized shift paradigms and has discussed several possible methodological shortcomings which are relevant to the present report. First, Slamecka (1968) criticized studies which have varied the postshift task while maintaining constancy in the preshift task. The last two studies of Part I of this report were run under the conditions suggested by Slamecka. Furthermore Trinder et al. (1969) demonstrated that this factor was not an important one when nondimensional stimuli were used. Second, he argued that in a RS task it is clearer that "something has changed" at the time of shift than in a HRS. Thirdly, he maintained that it is clearer to an <u>S</u> what has happened and what the new solution is in an RS than an HRS. In other words, there is more information inherent in an RS to facilitate shift performance. In the case of the present studies, if one makes the additional assumption that this information is directly related to the amount of preshift training Slamecka's second and third points are relevant. If Slamecka is correct the inference from a Shift x Training interaction to the development of stimulus organization is incorrect and one possible interpretation of the present data supports Slamecka's position. If one can show an increase in CO in the <u>absence</u> of a known concept then studies demonstrating the development of concepts using this technique are obviously confounded. Kendler and Kendler (1969) have disagreed with Slamecka, arguing that the additional information contained in RS is the specific phenomena under study.

Part II. The Relationship Between Clustering and Shift Behavior

General Introduction

Part I of this project confirmed the results of Richman and Trinder (1968) and Trinder, et al. (1969) in demonstrating the development of stimulus organization, analogous to the development of concepts, which is not dependent on sets of stimuli being discriminable on the basis of physical attributes of the stimuli. All of these studies have utilized a reversal shift (RS)--half reversal shift (HRS) paradigm while systematically varying the preshift level of training. For each experiment it was found that RS performance improved, relative to HRS, with increasing levels of original learning. This technique is one form of a basic shift paradigm frequently used for demonstrating the existence of such organizational concepts as mediational responses, attentional responses and the formation of concepts. Slamecka (1968) has criticized the shift technique for failure to control for several factors and suggested that any demonstration of stimulus organization could be a methodological artifact. In fact, as was pointed out in Part I, one possible interpretation of the phenomenon demonstrated supports Slamecka's position. If one can demonstrate the formation of an organizational response, without stimulus attributes to discriminate the stimulus sets, then studies that have used shift paradigms and demonstrated the formation of mediational responses to stimulus sets varying along a stimulus attribute, lacked the appropriate experimental controls. That is, a condition in which there is no relevant dimension has typically not been included. However, as suggested above, the data can also be interpreted as showing the formation of the organization of stimulus sets analogous to the formation in children of concepts more formally based (Richman and Trinder, 1968). The experiments reported in this section were conducted in order to differentiate between the two alternatives.

It seems reasonable to expect that if the pretraining procedures used in previous studies actually result in an organizational change or development in the stimulus sets then this organization should be reflected in other measures of stimulus organization. The technique of clustering in free recall, developed by Bousfield (1953), is one possible method which could be used to test this hypothesis. That is the stimulus sets should show clustering in free recall. On the other hand if the results are a methodological artifact, as suggested by Slamecka (1968), then free recall should not show clustering. In addition, the clustering should be maximally found in those conditions showing the greatest degree of RS over HRS superiority in post shift performance.

Experiment 1

Introduction

The obvious way to test whether clustering occurs in the free recall of items which demonstrate organizational characteristics, using a RS-HRS comparison, is to test for it after preshift training procedures which, in the past, have shown faster RS than HRS performance.

The level of clustering should be greater under those conditions than under procedures which would not lead to the proposed stimulus organization. This hypothesis was tested in the following experiment.

Method

Design.--Experiment 1 consists of two groups of 15 Ss each. An organization training group (OG) which received twenty training trials using the preshift training procedures used in previous studies. A stimulus training group (SG) which received twenty training trials in which a different response was paired with each stimulus. At the end of the training stage Ss in both groups received free recall instructions and wrote down the items on a blank sheet of paper.

Procedure.--The experimental procedures used in this study were very similar to those used in Part I. The stimulus material consisted of eight stimuli presented serially for a number of trials, the order being randomized between trials. The stimuli were Glaze (1928), high association value nonsense syllables, rather than nonsense figures which have typically been used. This allowed Ss to write down the items in free recall. Experiment 1, of Part I of this report, demonstrated that the same organizational phenomenon is obtained with nonsense syllables as with nonsense figures. Both groups received twenty trails rather than being run to a behaviorally defined criterion. Shift performance in previous studies have demonstrated maximum organization with high levels of original training, thus, clustering should maximally occur with such levels of original training. Twenty trials was assumed adequate in this respect as Part I Experiment 1 found original learning to a criterion of one correct trial for nonsense syllables to take approximately eight trials. For both groups stimuli were presented via a Kodak Carousel Projector with a stimulus duration of 6.5 secs. The presentation of all eight stimuli once was considered a trial. The intertrial interval was approximately 20 sec. and consisted of blank slides in the continuously revolving projector tray, while the inter-stimulus interval was .600 sec. Subjects were group tested with group size varying from two to ten. Only one condition was run at a time and care was taken to ensure that either of the two conditions were not always run with large or small numbers of subjects.

The two groups differed in the nature of the required responses. For the OG the responses were two push buttons (left vs right). Feedback was provided by a red light which came on after a correct response and was situated between and slightly above the two buttons which were 3 in. apart. The two buttons and the light were displayed on a response box placed on the desk arm of a chair. Correct responses were recorded on counters. The Ss in the group were told that they were in a learning experiment in which they had to learn the association between the nonsense syllables shown on the screen in front of them and the buttons on their response boxes. They were then given instructions concerning the duration of the stimuli and the meaning of the feedback light. It was explained that they should get as many responses correct as possible. They were also told that on the first trial there was no way they could tell whether a stimulus was left or right and that they would therefore have to guess.

In the SG _S_s responded to the eight stimuli with eight different responses rather than with one of two responses for each stimulus. The response for each stimulus was self provided by each _S_ on the first trial with the only restriction being that they be digits. Responses were written on a sheet of paper which the provided the data record. No feedback was provided, although for purposes of scoring the level of performance in original learning a response was counted correct if it was the same digit as the previous trial. The instructions to the SG _S_s were as follows.

"You are a _S_ in a learning experiment. Your task will be to identify nonsense syllables flashed on the screen before you. As each nonsense syllable appears on the screen you will assign it a number. The number which you assign any particular syllable will be your own choice. This arbitrary number which you have chosen, will remain the identifying symbol throughout the experiment. So whenever a particular nonsense syllable appears you will respond with the assigned number. Each of you have a response sheet on the desk in front of you. As each nonsense syllable appears you will record the number assigned to that particular nonsense syllable in the appropriate space. Each time a new stimulus appears you will assign it a number, not previously used. A new nonsense syllable is one which has not yet appeared before on the screen. Whenever an old stimulus appears respond with the number you had originally assigned to it. An old stimulus is one which you have seen before. As you can see nonsense syllables will be presented a number of times. If you cannot remember the correct response guess. You must respond to each stimulus."

At the completion of the original task all _S_s were instructed to write the items down on a sheet of paper which was distributed immediately upon the end of this instruction. No instructions concerning the recall were given before the original task. Subjects were allowed unlimited time to record the items.

Results and Discussion

The organizational training condition was easier than the stimulus training condition as reflected by the number of errors in the original training trials. The mean number of errors were 20.20 and 58.53 respectively. This difference was statistically significant ($t(28) = 3.549$, $p < .01$). The differences between the two tasks did not, however, result in superior recall of the nonsense syllables during the testing period. The mean item recall for the OG being .593 items while for the SG it was .587. This difference was not statistically significant ($t(28) < 1.00$).

Measure of Clustering.--The degree of clustering was measured by the method proposed by Bousfield and Bousfield (1966) and later modified by Hudson and Dunn (1969). The method calculates the expected number of repetitions for an _S_ taking into account the number of items recalled from each category. The expected number of repetitions are then subtracted from the observed number. Hudson and Dunn (1969) have proposed that this figure then be divided by the standard deviation of

the distribution to give a standard score. A method for obtaining the SD is given in their paper. When this score for each S was obtained the two groups were compared by means of a t test. The two groups did not differ from each other in the degree of clustering they showed ($t(28) < 1$). Thus the results of this experiment failed to demonstrate stimulus organization, as measured by clustering, in the free recall of items subjected to identical pretraining procedures as previous studies which did show organization using a RS-HRS technique.

Experiment 2

Introduction

Experiment 2 lends support to Slamecka's (1968) argument that the demonstration of chunking using the RS-HRS technique is a methodological artifact as no clustering in free recall was in evidence. However, the support of Slamecka's position, using the present experimental approach, requires the proof of the null hypothesis. Thus there may be many other reasons for the failure of the above study to demonstrate clustering. One possible reason, which will be investigated in this study, relates to the effect of the shift itself. The argument in Experiment 1 was that any stimulus organization should be in evidence at the end of original training, at the point of the shift. However it is possible that the chunking does not manifest itself until the post shift phase of the experimental task. This experiment investigates this possibility.

It would be expected, if this argument is correct, that clustering should be greater following a RS than after either original learning or a HRS. This would be predicted as a RS reaffirms the same organization of the stimulus sets and thus may result in a manifestation of the organization in clustering.

Method

Design.--The design consists of three groups of 20 Ss each. Group OT, original training group, was asked for free recall at the end of original learning. The second group (Group RS) was asked for free recall after completing a RS. Finally, the third group (Group HRS) performed a HRS before free recall.

Procedure.--All Ss received organization training similar to the studies in Part I of this report with the following modifications. Subjects were run individually and responded verbally to the two groups of four NS stimulus sets with the responses "strong" and "soft," rather than pressing left or right buttons, while feedback was provided by the experimenter saying "correct" or "wrong" appropriately after the Ss response. These procedures replicated identically those of Richman and Trinder (1968). In all other respects the experimental situation was the same as previous studies in this report. Assignment of Ss to each of the three groups was such that each successive three Ss were randomly assigned, one to each of the groups.

Subjects in all conditions were run to an original training criterion of three successive correct trials (a strict overtraining criterion) at which time the original training group received free recall instructions and wrote the items down on a blank sheet of paper. After reaching the original training criterion the RS and HRS groups were subjected to a RS and HRS respectively. Both groups were then run to a post shift criterion of one correct trial, followed by the free recall instructions.

Results and Discussion

An analysis of errors in original learning indicated no difference between the conditions ($F(2,57) = 2.20$, $p > .10$). The analysis of clustering in free recall gave a significant treatment effect ($F(2,57) = 3.32$, $p < .05$). Figure 1 illustrates the degree of clustering under each condition. Inspection of clustering for the original learning condition and the RS and HRS conditions in the post shift stage (hatched bars) indicates that only the HRS condition shows clustering. A comparison of the three conditions using a Newman-Keuls post hoc test, shows the degree of clustering to be significantly greater, statistically, for the HRS than for the RS (d.f. 3,57, $p < .05$), but not for the HRS over the original training condition, although the difference did approach statistical significance (d.f. 3,57, $.05 < p < .10$). This finding is diametrically opposed to that anticipated under the assumptions of the study. It is clear that the shift plays a role in producing the clustering, but not in the way suggested earlier.

Some suggestion as to the possible factors involved in the production of this clustering comes from further analysis of the data. Consideration of the clustering of the two possible stimulus sets in HRS, the preshift and post shift sets, shows that the clustering exists in the post shift organization. Figure 4 illustrates this difference, it being statistically significant ($t(19) = 2.23$, $p < .05$). In addition, the level of recall is significantly greater in the HRS condition, a mean recall of 6.25 items as opposed to 4.90 and 4.85 for the original learning and RS conditions respectively ($F(2,57) = 3.91$, $p < .05$). This result replicates the typical positive relationship between level of recall and degree of clustering and suggests one explanation for the present data. The training procedures in all of the previous studies, and in the present one, involve what is essentially a recognition procedure. Thus, the stimulus items are not normally required to be recalled. If a distinction is made between recognition and recall performance, where the performance of interest is the development of stimulus organization, it would not be surprising to find a lack of stimulus organization as reflected by clustering, a recall phenomenon, when the training procedures involve a recognition task. The discrepant results of the HRS condition are explainable if it is assumed that the S's response to receiving a HRS is to reject a recognition strategy and begin to utilize a more complete storage of the items, resulting in a clustered and increased recall. Although this hypothesis is speculative it is fortunately testable experimentally. Experiment 3 develops this hypothesis and tests it.

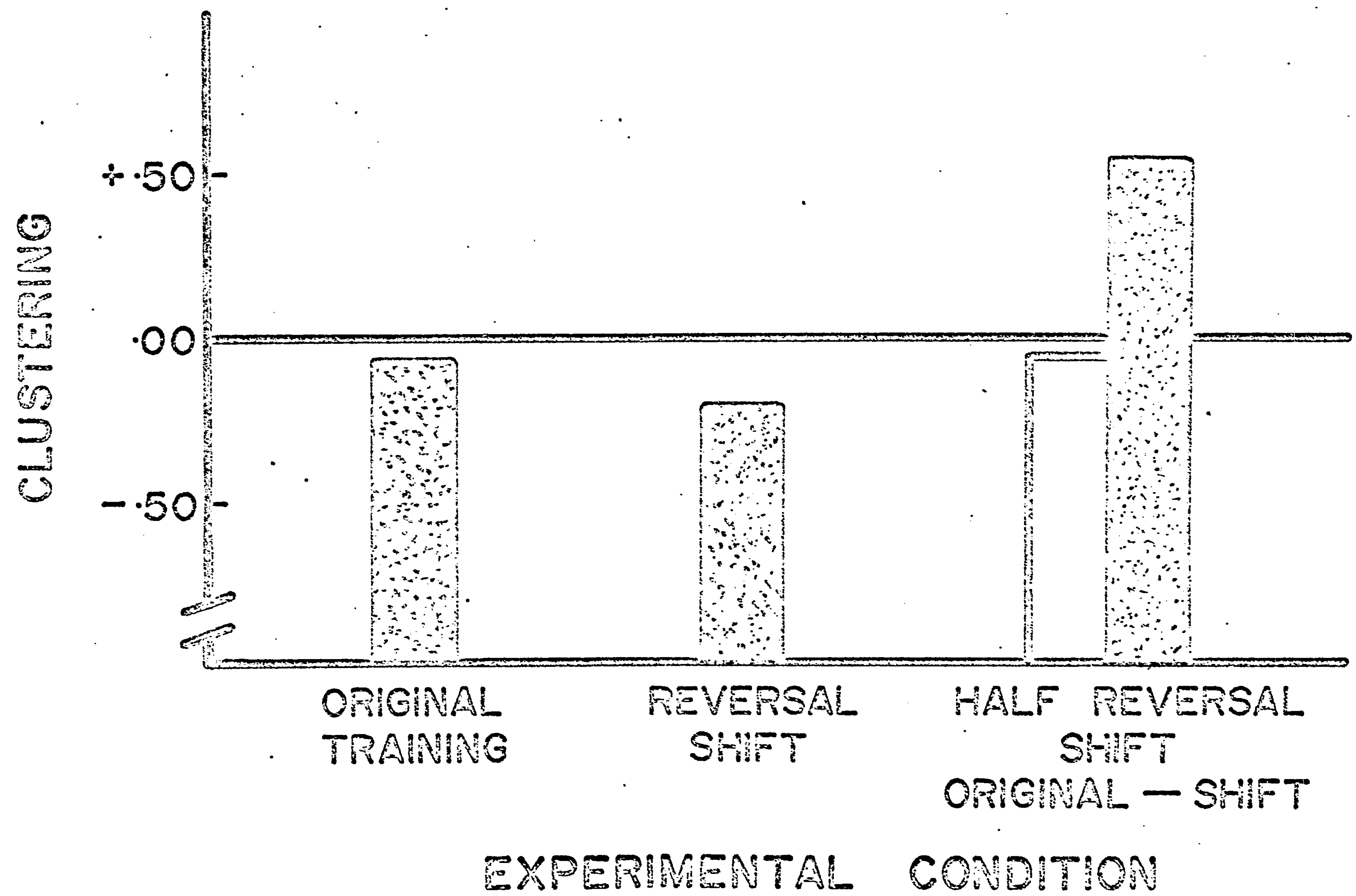

Figure 4. Amount of clustering for each experimental condition in Experiment 2. The degree of clustering in the HRS condition is shown for both the original training and shift stimulus sets.

A second possible interpretation of the anomalous results of this experiment, relates to what Moely, Olson, Halves and Flavell (1969) have termed "production deficiency in mediation." As this notion refers specifically to this study it suggests that the stimulus organization exists, but is not utilized by Ss during recall. In this case the manipulations of a HRS, involving a certain amount of confusion, results in the actualization of the potential organization. This possibility will be investigated in the following experiment.

Experiment 3

Introduction

The production deficiency argument has been developed to account for the observation that, in children, conceptual skills can be available but not utilized (Flavell, Beach and Chinsky, 1966). This condition is distinguished from that in which mediation does not exist at all. A production deficiency, of clustering the free recall, may exist under the training conditions of these studies. If this were true, instructions to Ss which emphasize the potential stimulus organization would increase the probability of the organization being utilized. Moely, et al. (1969), using the known relationship between clustering and amount of recall, demonstrated production deficiency in childrens conceptual skills by showing an increase in recall when clustering was induced in recall. This same relationship can be used to investigate the hypothesis that a production deficiency accounts for the failure to demonstrate clustering in free recall after original training in Experiments 1 and 2 and its appearance after a HRS. It would be predicted that the number of items recalled would be greater for Ss who are encouraged to utilize the potential stimulus organization.

Method

Design.--Two groups of 20 Ss each were trained in original learning to a criterion of three successive correct trials. Group one then received the normal recall instructions, while for group two the recall instructions were modified. Subjects were instructed to write down the items on a blank sheet of paper with the items which were correct for the left button on the left side of the paper and the items which were correct for the right button on the right side of the paper.

Procedure.--The general training procedures were again similar to those used in previous studies. The stimuli were the same eight (Glaze, 1928), high association value nonsense syllables which were presented in the same manner as in Experiment 1 and 2. The Ss responded using left versus right buttons and were given feedback via a red light for correct responses. Pretraining instructions emphasized the nature of the dichotomous responses, left and right. This aspect did not differ from previous studies. Each S was trained to a criterion of three successive correct trials at which point the relevant recall instructions were administered. For Group I instructions were identical to previous studies, while for Group SO the instructions emphasized the stimulus organization. Subjects were run individually. Assignment of Ss to each

of the groups followed an ABBA procedure for successive Ss, with some modification when necessary to equate groups on trials to original learning.

Results and Discussion

The matching procedure in original learning had the desired effect of equating groups during this stage. Comparisons of the two groups for trials and errors to criterion indicated no statistical differences (t (28) < 1 N.S. and t (28) = 1.05, p > .10 for trials and errors respectively).

The hypothesis to be tested in this experiment was that instructions which emphasize and force the S to use the stimulus sets would increase the level of recall. A comparison of the level of recall of the two groups does not allow the rejection of the null hypothesis (t (28) < 1 N.S.). This result suggests that a production deficiency hypothesis cannot explain the results found in the previous studies.

Experiment 4

Introduction

The pattern of results found in Part II of this project has suggested the hypothesis that the stimulus organization found in the studies of Part I, is restricted to recognition performance, as the chunking effect were not reflected in clustering during free recall. Superior recognition over recall performance is, of course, well documented. However, previous comparisons of these two tasks have been concerned with the number of items recalled versus the number recognized. The issue in the present studies has been the extent to which stimulus organization is reflected in performance. These studies have been of two types: Those which have demonstrated chunking using a RS-HRS paradigm (Richman and Trinder, 1968; Trinder et al., 1969 and Part I, Experiments 1 and 3), and those which have measured clustering in free recall (Experiments 1 and 2). The experimental procedures used to test for stimulus organization in the former studies identify the task as one of recognition, while in the latter group it is a recall task. In each case the training stage has involved recognition procedures. This difference may account for the failure of stimulus organization to be reflected in clustering. In one case the training procedures are compatible with the measure of stimulus organization while in the other they are incompatible.

Bower, Lesgold and Tieman (1969) and Kintsch (1968) have shown that recall performance is retarded by training procedures which disrupt stimulus organization while leaving recognition performance unaffected. Although the performance measure was either item recognition or recall, these studies do relate stimulus organization differentially to recall and recognition. Additional support for the hypothesis under discussion comes from Experiment 2. In this study clustering was found when recall was measured after HRS performance while no clustering was evidenced following RS performance. This, seemingly discrepant result, can be account for if it is assumed that following a HRS an S shifts strategy from one which

satisfies the recognition requirements of the task to a more complete storage of the items such that recall of the items is facilitated.

The hypothesis under investigation in the present study was as follows: Chunking of stimuli during original learning under a recognition procedure leaves the stimulus organization inaccessible to the S when he is asked for free recall. The exact nature of the inaccessability, whether it is a difference in the retrieval cues for the chunk or a difference of recognition and recall memories, is not clear. The hypothesis was tested by manipulating the Ss learning strategies via instructions. That is, it was predicted that, informing the S that recall of the items would be required, would result in a modification of the S's strategy and an increase in clustering in free recall. It should be noted that in Experiments 1 and 2 this additional information, that the item would have to be recalled, was not given in any of the experimental conditions before original learning.

Method

Design.--The nature of the instructions and the number of items in each stimulus set were varied in a 3 x 2 factorial design. The instruction conditions were as follows: Two conditions received the original training instructions as have been given in previous studies. In addition, in one condition (Training + Recall) Ss were instructed that they would be required to write the items down on a sheet of paper at the end of the experiment, (Group T + R). In the other (Training Ss were not given the additional instructions, (Group T). This latter condition replicated the procedures of previous studies. Finally, the third two groups (Recall) were given recall instructions only and did not receive organization training during the learning stage, (Group R). Clustering in free recall for this condition should then represent the optimal organization of the stimuli. As such, these groups act as the control condition against which the extent of clustering of the stimulus sets in the remaining conditions can be measured. The number of items in each of the stimulus sets was either 4 or 8 items. This meant that the total number of items was 8 or 16 for the two conditions respectively.

Procedure.--The experimental procedures for the Training and Recall and Training conditions during original learning replicated exactly those of Experiment 1. Those procedures are briefly summarized. Subjects received twenty training trials in which the dichotomous responses were left vs. right push-buttons, while information feedback was provided by a red light which flashed for correct responses. Stimulus presentation was via a Kodak Carousel Projector. Stimulus duration was 6.5 sec. with an ISI of .600 sec. and an ITI of approximately 20 sec. The instructions were also the same as in previous studies with the following additional instructions given to Ss in Group T + R).

"At the end of the experiment you will be required to write down the nonsense syllables you will have seen. This means, of course, that you will have to remember the exact nature of the nonsense syllables. You will be given a sheet of paper on which to write the stimuli at the appropriate time."

Training procedures and instructions differed for Group R. Subjects were instructed that they would be presented with a series of nonsense syllables and that these stimuli would be presented for a number of trials. Twenty trials were given, although Ss were not informed of this prior to the start of the experiment. The Ss task was to learn the stimuli preparatory to recalling them at the end of the series of trials. A blank sheet of paper was given to each S at the end of the training stage upon which he was instructed to write the nonsense syllables.

Subjects were group tested with group size varying from 2 to 10. Groups of Ss were randomly assigned to conditions with the restriction that neither small nor large groups were consistently run in a given condition.

Results and Discussion

The analysis of errors in original learning did not include the Recall condition as Ss in these groups did not overtly respond during the training stage. The 2 x 2 factorial analysis of variance consisted, therefore, of two types of instructions (Training + Recall and Training) and two list lengths (8 and 16 items). As would be expected the 16 item list had more errors than the 8 item list ($F(1,76) = 36.59$, $p < .001$). The effect of instructions ($F(1,76) = 1.616$, $p > .10$) and the interaction between instructions and list length ($F(1,76) < 1$, N.S.) were not statistically significant.

The degree of clustering in free recall was effected by the nature of the instructions ($F(2,114) = 5.38$, $p < .01$). Figure 5 illustrates the particular nature of the Effect. As can be seen the greatest degree of clustering was found in those groups which received organization training plus recall instructions. However a comparison of group means, using a Newman-Keuls post hoc test, indicates that both of the Recall + Training groups showed significantly more clustering than only one other group, the 8 item Recall group ($p < .05$). As was expected Group R showed the least amount of clustering. The List Length main effect ($F(1,114) = 1.74$, $p > .10$) and the Instructions x List Length interaction ($F(2,114) < 1$, N.S.) were not statistically significant.

The percentage of items recalled for all groups is presented in Figure 6. The instructions main effect was significant ($F(2,114) = 14.274$, $p < .001$) and as would be expected, recall was improved when Ss were informed it would be required. A Newman-Keuls post hoc test indicated that all comparisons between the Groups R and Groups T + R and Group T condition, except for 8 item Recall + Training vs. 8 item Training, gave significant differences ($p < .05$). This confirms the hypothesis that Ss in the training condition do not follow a learning strategy which is compatible with the free recall of the items. In addition a comparison of the Recall with Recall + Training condition suggests that these strategies are not only different, but may also be incompatible. Subjects who received both Recall and Training instructions did not recall as many items as Ss who received only recall instructions ($p < .05$ and $.10 > p > .05$ for 8 and 16 items respectively). This indicates that the experimental procedures of the organization training in some way

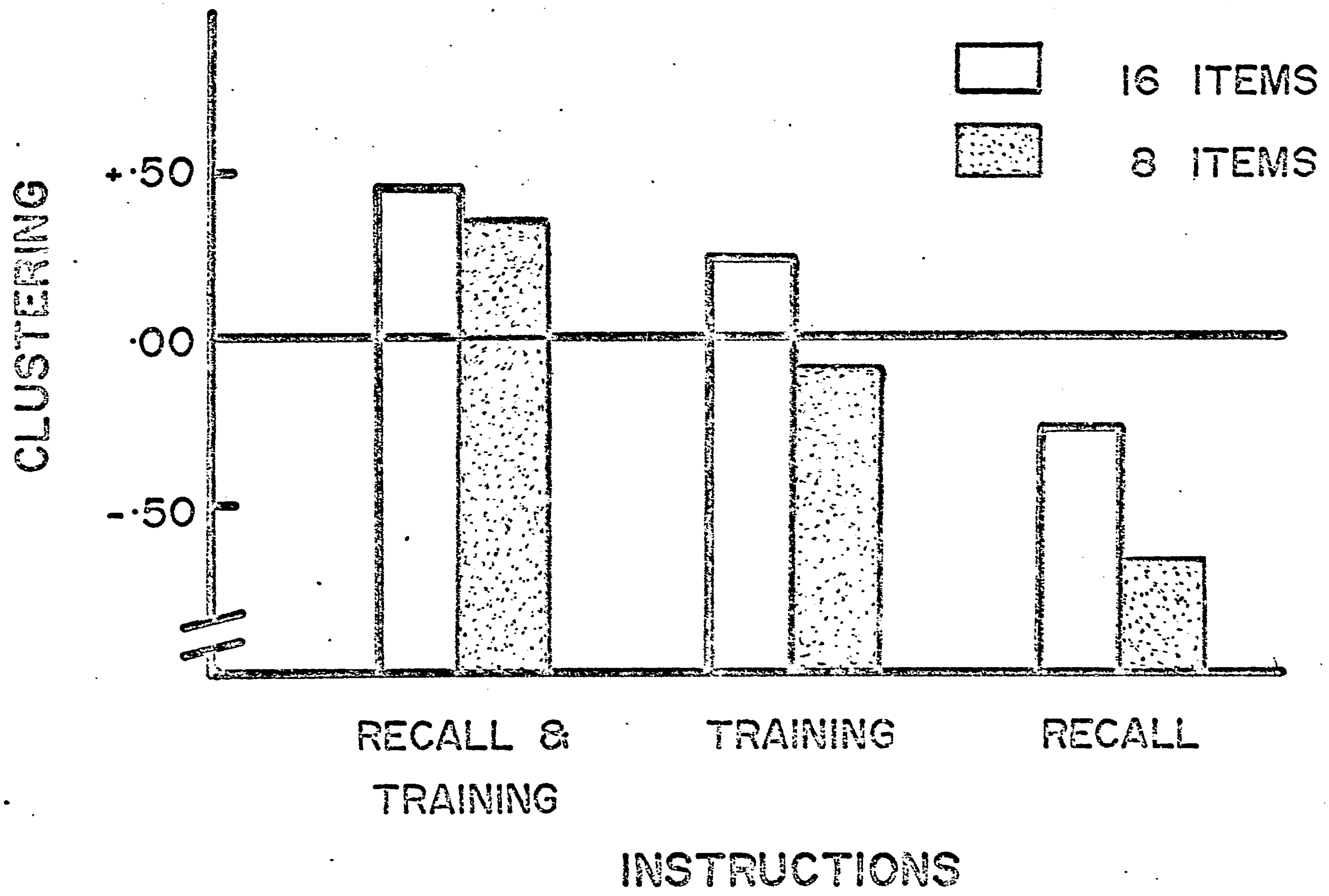

Figure 5. Amount of clustering for each experimental condition in Experiment 4.

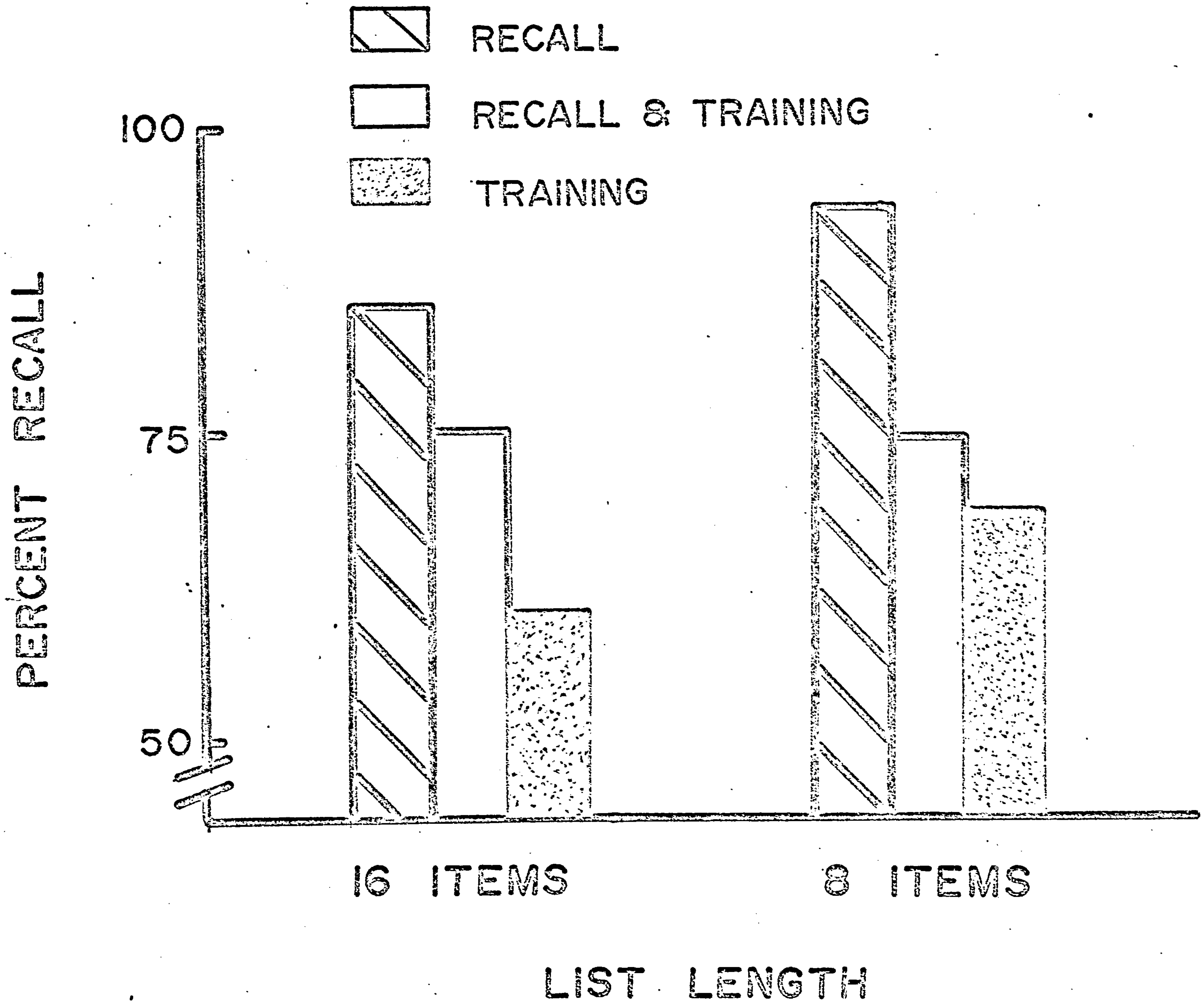

Figure 6. Percent recall for each experimental condition in Experiment 4.

interferred with the recall of items. The absolute number of items recalled was greater for the 16 item list ($F(1,114) = 146.255$, $p < .001$) although as Figure 6 suggests the percentage of items recalled was very similar for the two list lengths.

The results of this study showed that Ss who are instructed that they will be asked to recall the items, before organization training, cluster the items in free recall to a greater extent than Ss who are not so instructed, or, who do not receive organization training. These Ss also recall more items than Ss who do not receive recall instructions. The hypothesized effect of instructions was therefore confirmed. It should be pointed out however, that the degree of clustering achieved was not great. The amount of clustering, represented as a percentage such that 50% is that expected by chance, was 39.5%, 53.0% and 58.5% for the Recall, Training and Training + Recall Conditions respectively. As can be seen from these percentages the addition of recall instructions to Ss who received organization did not add appreciably to the amount of clustering. This, of course, is also reflected in the post hoc tests reported above. In view of this, the data cannot be said to unequivocally confirm the basic hypothesis, which distinguishes between the availability of the stimulus chunks in recognition vs. recall procedures. The clustering results were in the appropriate direction, while the recall data confirmed the expected relationships and pointed to an incompatibility of recognition and recall tasks.

Conclusions

The studies reported in this section of the paper were conducted to determine if the stimulus organization found with a RS-HRS paradigm could be replicated using the technique of clustering in free recall. Slamecka (1968) has criticized the shift paradigm, suggesting that results obtained with these procedures are methodological artifacts. Thus, if stimulus organization could be demonstrated using an alternative measure, clustering, then the results of Experiments 1 and 3 of this report would be supported.

The first two studies, Experiments 1 and 2 failed to demonstrate clustering in the appropriate experimental conditions and thus support Slamecka's position. On the other hand the results of Experiment 2, which showed a development of clustering after a HRS, suggested two accounts of the data alternative to Slamecka's. Experiment 3 tested, and disconfirmed, the possibility that a production deficiency of the stimulus organization accounted for the failure to obtain clustering in free recall. The second hypothesis, which distinguished between recognition and recall performance in the development of chunking, was tested in Experiment 4. Specifically, the hypothesis stated that stimulus organization developed under recognition training procedures would be inaccessible when a S was required to recall the items. A position was not taken on the nature of this inaccessibility. Experiment 4 tested the hypothesis by attempting to manipulate the S's learning strategies via instructions. It was predicted that the effect of the instructions would be to produce clustering in those conditions in which the S was both informed that he had to recall the items and received organization training. The results confirmed this prediction, and although the degree of clustering produced

was not extensive, the data suggested that this was because of a basic incompatibility between the recall and recognition requirements of the task.

In conclusion, Part II of this report in part supported the studies of Part I. Although several studies failed to show clustering it was demonstrated that this was because of a failure to distinguish between recognition and recall aspects of the situation. When recall instructions were added some clustering was produced. In addition, the data point to a distinction between recognition and recall in terms of stimulus organization. A distinction, which in the past, has only been made between the probably of item recall or recognition.

Part III. Individual Difference Factors Affecting Stimulus Organization

Introduction

The aim of this research was to consider the effect of individual differences on the development of stimulus organization. In previous studies our concern had been with the effect of experimentally imposed variables on chunking (Richman and Trinder, 1968; Trinder, Richman and Gulkin, 1969; and Part I). Variables such as the nature of the stimuli, responses and stimulus organization have been investigated. The present study considered four individual difference variables using the reversal shift (RS) - half reversal shift (HRS) paradigm while varying preshift training. The factors considered were channel capacity, immediate memory, attention span and intelligence. The primary concern of the study was to isolate those factors which facilitate the development of stimulus organization.

Method

Design.--The experimental design consisted of two phases. During Phase I measurements for the appropriate individual difference variables were taken for each _S_. For each variable _Ss_ were classified into subgroups, high or low, according to their performance on that particular variable. Phase II involved the study of the development in chunking for groups of _Ss_ defined by stage one. Thus each of the subgroups, eight in all derived from high and low groups for each of the four variables, were further subdivided into the four independent conditions of a 2 x 2 factorial: Two levels of preshift training [criterion (C) and overtraining(OT)] and two types of shift (RS and HRS). The resultant design consisted of four separate 2 x 2 x 2 factorial designs, one for each of the individual difference variables. Each 2 x 2 x 2 factorial involved two levels of the particular variable [high (H) and low (L)], two levels of preshift training (C and OT) and two types of shift (RS and HRS).

Measures of immediate memory and attention span were obtained from 47 introductory psychology students at Wake Forest University. For 24 _Ss_ immediate memory measures were obtained first, followed by attention span, while for the remaining 23 _Ss_ the order was reversed. Fifty six introductory psychology students were run in an absolute judgment task

to measure channel capacity. Finally, SAT scores were available from the University records for 66 of the above 103 Ss.

Procedure.--The stimuli used to measure attention span were a series of dots placed randomly in a circle on a stimulus card with 1 to 15 dots per card. The stimuli were presented through a tachistoscope (Electrotach Model 2500, Lafayette Instrument Company). The dots were made by an electric typewriter to insure uniformity and were positioned on the stimulus card so as to be in the center of the tachistoscope's viewing field. Three different copies of each number of dots were made giving a total of 45 stimuli. Before the test was formally begun, each S was shown four stimuli which were representative of the stimuli used in testing. Subjects were told that these were for practice and that they were to familiarize themselves with the stimuli to be used. Subjects were told to seat themselves at a distance from the tachistoscope which they found comfortable. During the practice session Ss were informed if their responses to stimuli were correct and if incorrect, they were told the correct response. The tachistoscope, which was controlled by E, presented the stimuli for .10 sec. every 5-10 seconds depending on the rate at which the S estimated the number of dots presented to him.

For the measure of immediate memory the stimuli were a series of numbers which ran from 4 to 10 digits. These stimuli were selected from a table of random numbers. Three different sets of stimuli of each length were used yielding a total of 21 stimuli. As in the test of attention span, each S was shown four practice stimuli and told if his response was correct or incorrect. The E presented the stimuli for 1.0 sec. and at a rate of 1 stimulus every 5-10 sec.

The stimuli used for the measure of absolute judgment were series of 4, 6, 7, 8, or 10 circles of varying diameters. The stimuli were again presented via a tachistoscope. The S sat facing the tachistoscope and was instructed to label the smallest circle in the series "1" and to number the circles consecutively as they increased in size. An S was shown the set of 4 circles in order of increasing magnitude. Next, the S was shown the series twice, but in a random order. He was told if his response was correct and if incorrect, was told the correct response. Subjects were then shown the first experimental set of circles three times in random order. The stimuli were presented for 1.0 sec. every 5-10 sec. depending upon the rate at which the S responded. This process was then repeated with all series of circles in the order of increasing number of circles, i.e. 6, 7, 8, and 10. Feedback was not given during the testing phases of Attention, Memory, or Channel Capacity.

The stimuli were circles made with a compass placed on stimulus cards in such a manner that they appeared in the center of the tachistoscope's viewing field. The smallest and largest circles of all five sets were of identical dimensions. The sizes of the circles of all five series are listed in Appendix B.

Subjects were run in Phase II of the experiment five to 20 min. following their Span of Attention, Memory, or Absolute Judgment tests. The experimental procedures used in this phase replicated exactly those used by Trinder, et al. (1969), and are formally the same as those

of Part I of this report. The division of Ss into high and low Span of Attention (HA and LA), high and low Memory (HM and LM), high and low Absolute Judgment (HJ and LJ) groups, or high and low SAT score (HS and LS) were made after all testing. High and low dichotomies were based upon the median for each group. The total number of dot, digit or circle sets correct determined the placement of high and low Ss in each of their respective individual difference categories.

Results and Discussion

Span of Attention.--The results of a 2 x 2 x 2 analysis of variance performed on trials to criterion for original learning showed no main or interactive effects ($p > .05$). The important finding was that Span of Attention did not effect speed of S-R learning. A subsequent 2 x 2 x 2 ANOV was performed on the shift scores to criterion. This analysis demonstrated a statistically significant shift main effect ($F(1,39) = 10.00$, $p < .01$) with RS being faster than HRS. The Shift x Span of Attention interaction was also significant ($F(1,39) = 4.79$, $p < .05$). The interaction effect was due to the severely retarded performance of the HA-HRS condition.

These results can be illustrated using the index of conceptual organization (CO). This index has been proposed by Kendler, Kendler and Marken (1969) as a measure of stimulus organization and is defined as $\left[\frac{HRS}{RS+HRS} - .50\right]$. The extent of CO for each of the attention span conditions, at each level of pretraining, can be seen in Figure 7. The Shift x Span of Attention interaction is reflected in the higher level of CO for the HA groups.

Immediate Memory.--In a 2 x 2 x 2 ANOV no main or interactive effects reached statistical significance for either original or shift learning scores ($p > .05$) with the exception of the Shift main effect in the shift phase ($F(1,39) = 13.33$, $p < .001$).indicating faster RS than HRS behavior. The CO index, however, shows that the LM condition chunks to a greater extent than the HM condition (see Figure 7). This difference is in the opposite direction to attention span although it is not supported by a statistically significant Shift x Immediate Memory interaction ($F(1,39) = 2.82$, $p > .05$).

The Ss run in the immediate memory and attention span sections were the same. It is therefore of interest to determine the relationship between the two variables. For Ss given the memory test first the correlation between memory and attention scores was +.18, whereas for Ss given the attention task first the correlation was -.26. Neither correlation was statistically significant ($p > .05$).

Absolute Judgment.--A 2 x 2 x 2 ANOV was performed on the trials to original learning scores revealed no significant main nor interactive effects. The analysis of shift scores indicates that HJ Ss learn faster than LJ ($F(1,48) = 4.05$, $p < .05$). A second main effect, that of level of preshift training, was significant such that OT performance was superior to C ($F(1,48) = 11.55$, $p < .01$). Two interaction effects also

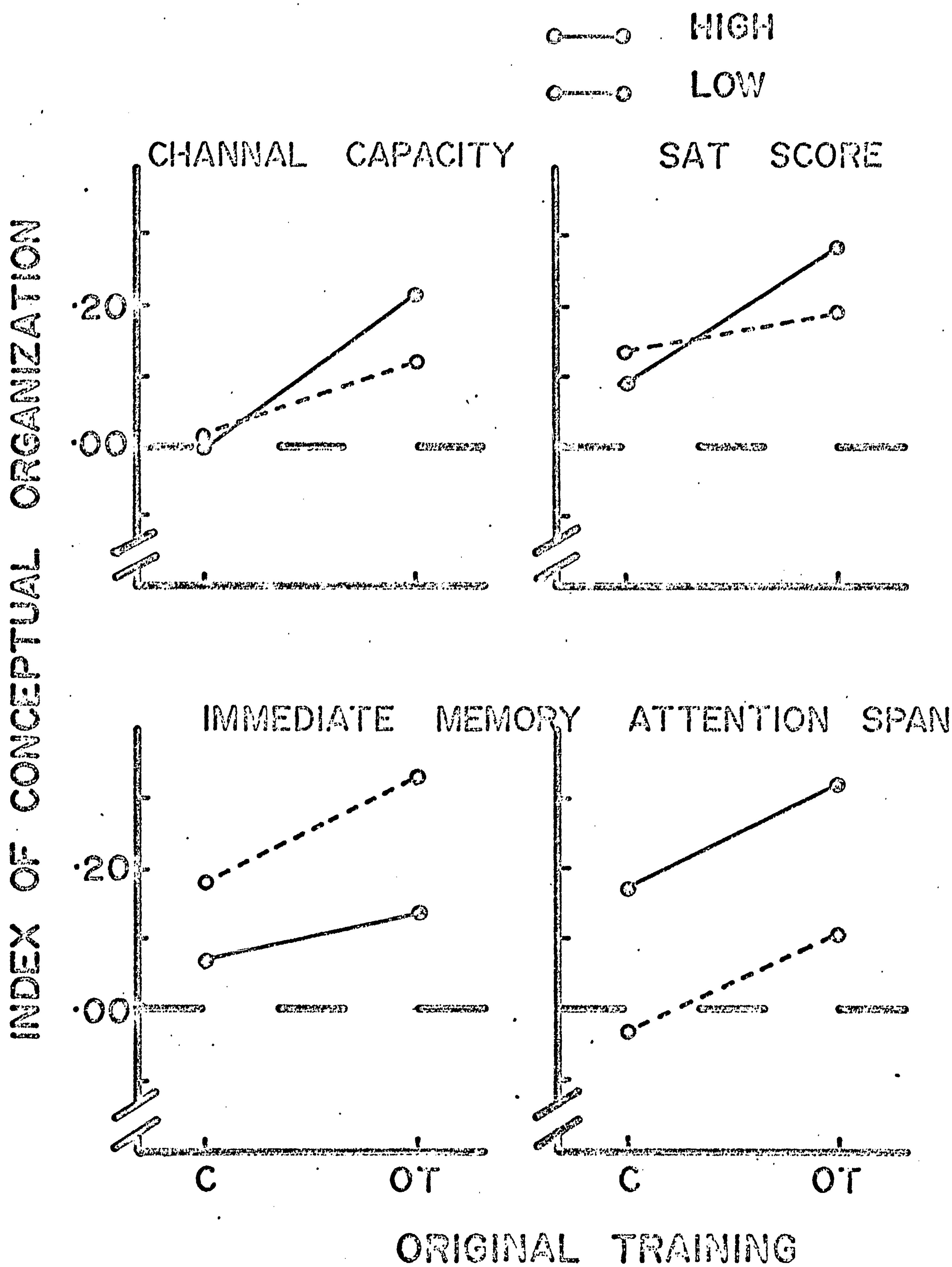

Figure 7. Index of conceptual organization at each degree of original training and individual difference level, for each of the individual difference variables.

proved to be statistically significant: Shift x Training ($F(1,48) = 4.53$, $p < .05$) and Absolute Judgment x Training ($F(1,48) = 5.47$, $p < .05$). The Shift x Training interaction was primarily due to a lack of difference between shift groups at criterion with an improvement of RS relative to HRS at overtraining, while the Absolute Judgment x Training interaction indicated a faster overall shift for the HJ Ss at C, but no difference at OT. The analysis of variance did not reveal an effect of channel capacity on the development of chunking as both the Shift x Absolute Judgment ($F(1,48) < 1.00$, N.S.) and Shift x Absolute Judgment x Training ($F(1,48) < 1.00$, N.S.) were not statistically significant. On the other hand inspection of Figure 7 indicates a faster growth rate of CO for the HJ condition as compared to the LJ condition. This difference is, however, not supported by the statistical analysis.

Scholastic Aptitude Test.--All Ss having SAT data available were pooled and divided into above (high) and below (low) median SAT score groups. The median SAT score was 1150. A 2 x 2 x 2 ANOV was performed on the trials to original and shift criterion. The original learning analysis showed all main and interactive effects to be statistically nonsignificant ($p > .05$). The shift scores show a significant training main effect ($F(1,60) = 12.33$, $p < .001$) with OT being faster than C and in addition a significant shift main effect ($F(1,60) = 8.27$, $p < .01$) such that RS was superior to HRS. The analysis shows a statistically significant effect of the SAT conditions on the development of chunking as the third order interaction was statistically significant ($F(1,60) = 4.22$, $p < .05$). The CO index, shown in Figure 7 illustrates the faster development of stimulus organization, over levels of preshift training, for the HS condition as compared to the LS condition.

The analysis of the data using the CO index indicates that three of the four individual difference variables show either a more rapid development of stimulus organization over levels of preshift training, in the case of channel capacity and SAT scores, or a higher level of CO at each level of preshift training, in the case of attention span, for high levels of each variable as compared to low. Immediate memory shows the opposite relationship, with low immediate memory Ss having a higher level of CO than high immediate memory Ss. This pattern of results is not completely supported by the statistical analysis. For SAT scores and attention span the above mentioned results are statistically significant, while for channel capacity and immediate memory they are not.

There were several aspects of the study which may have contributed to the marginal nature of the results. As is always the case when using a homogeneous population, such as college students, the high-low groups do not differ to any great extent. This was particularly true in this study as the high-low conditions were not extreme groups. In addition the number of Ss per group was rather small, being approximately six for immediate memory and attention span, seven for channel capacity and eight for SAT conditions. This number is well below the 12 to 20 Ss per group r n in our previous studies using these procedures, and which have been found to be the optimal number in relation to the expected error variance. In conclusion, the results are very

suggestive of individual difference effects on the development of chunking. The particular nature of the effects are discussed below.

To date in this report the two stage model of Kendler and Kendler (1962) has been used successfully to account for the data. It is therefore of interest to investigate the extent to which it can account for the present results. The model states that concept formation consists of two processes, S-R association learning followed by the development of stimulus organization. The effect of the individual difference variables would therefore be expected to be on one of these two processes. The original learning data suggests that in each of the cases the effect is on stage two, the extent or rapidity of chunking, as the differences between high and low conditions were never statistically significant. If S-R learning was effected one would predict differences in original learning. It follows that those conditions which show superior CO for high groups are readily accounted for by the model. Subjects who are classified as high SAT, channel capacity or attention span more readily organize the material into chunks. On the other hand the immediate memory data is not as simply accounted for. It is not clear why Ss with "poor memory" should chunk the stimulus material more proficiently. A some what speculative account of the data suggests that the low immediate memory Ss cannot remember all of the S-R associations and to get all of the items correct have to form chunks. On the other hand high immediate memory Ss do not need to chunk the stimulus material to get it correct. Thus Ss with "poor memory" chunk the material to a greater extent. There are, however, several problems with this account. To begin with it predicts a difference in original learning, with low Ss taking longer to reach criterion. A difference which was not obtained. Secondly it is not clear why immediate memory should have this particular effect while the other factors have the alternative effect.

Conclusions

This study offers tentative support of the hypothesis that individual difference variables are related to the development of stimulus organization. Although the effects obtained in this particular study were not always convincing, several aspects of the procedures used could have accounted for the borderline nature of the results. The data is certainly suggestive of the role of these particular factors in concept formation. Kendler and Kendler's (1962) two stage model was found to be able to account for much of the data, although some aspects of the present results are inconsistent with this model.

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EFFECTS OF A SLAMECKA SHIFT ON REVERSAL AND HALF-REVERSAL SHIFT TASKS[1]

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Attentional or mediational models in human concept formation have been concerned largely with concept identification tasks. In this situation, attentional or mediational responses are considered to be aspects of the stimulus attributes which then have to be identified by attaching some form of experimenter-imposed overt response to the mediational one. Studies in this area rarely have been concerned with the development of the stimulus attribute, or with identifying its attendant mediational response. Part of the reason for this is the innate isomorphism between stimulus dimensions and mediational responses typically assumed for many attributes, for example, color. It is not clear, however, that structural units such as concepts or mediational responses must be identified always with stimulus attributes.

Richman and Trinder (1968) used a technique for investigating the development of "concepts" in humans in the absence of relevant stimulus attributes. By using novel stimuli with which adult humans were unlikely to have had prior experience, and which could be placed into two groups such that no known stimulus attribute was present to discriminate the groups, they demonstrated the formation of concepts by comparing Reversal Shift (RS) and Half-reversal Shift (HRS) performances. However, Richman and Trinders' (1968) study was left open to two criticisms: (*a*) Slamecka (1968) asserted that theoretical conclusions, based upon the results of shift studies, were confounded by employing identical original learning tasks and different shift (transfer) tasks, e.g., Richman and Trinder (1968) and Kendler, Kendler, and Sanders (1967). By employing different transfer tasks, differences in the rate of shift behavior may be a function of the intrinsic difficulties of the shift tasks; (*b*) The nondimensionality of the stimulus groupings were based on the subjective judgments of the experimenters.

It was the purpose of this study to investigate the development of concepts using identical shift tasks, different levels of preshift training, and novel stimuli for which stimulus dimensions are known from a more objective source.

METHOD

Subjects

The *S*s were 96 male and female students enrolled in first year psychology courses at Wake Forest University.

Procedure

Two *S*s were seated across a table facing each other with a solid barrier placed between them so they could not see each other. A Kodak Carousel 800 projector was used to present the stimuli and was located 2 ft. to the left (right) of the *S*s and 8 ft. in front of a blank wall. The *E* sat behind the projector and was blocked from the *S*s' view. In front of each *S* was a response box with a red reinforcement light fastened to its center and a left and right response button located to the left and right of the light. The *E* flashed *S*s' reinforcement light for about 1 sec. following a correct stimulus-response association.

Eight stimuli were selected from a list of 16-point nonsense figures (Vanderplas & Garvin, 1959), by using a stimulus similarity technique provided by Steinheiser (1968). Steinheiser demonstrated that the Vanderplas and Garvin (1959) figures may be described in three dimensions: the number of points; the disposition of the figure; and the number and degree of acuteness of extruding points. The *S*s' task was to learn an association between four of the stimuli and the left button and the other four stimuli and the right button. In addition, *S*s received one of two shifts during the task (RS or HRS). The eight stimuli were assigned so that in any of the three combinations, a group of four stimuli could not be discriminated from the other group on the basis of the dimensions described by Steinheister (1968). That is, the task could not be solved by attending to any known stimulus dimensions of two groups of figures.

A trial consisted of the random presentation of the eight stimuli once each for 8 sec. with an ISI of 600 msec. The ITI was 17.0 sec. Subjects were instructed to depress either the left or right button only once during a figure presentation. They were told that if the light flashed on, they had made a correct association and scored a point; and, if they scored more points than their adversary, they would receive two experimental credit hours instead of one.

The experiment was a 2 X 3 factorial design consisting of two types of shifts, RS and HRS, and three levels of preshift training, i.e., undertraining (UT), criterion (C), and overtraining (OT). A RS involved the reversal of all associations, e.g., each figure associated with the right (left) button during preshift training became associated with the left (right) button during the shift phase. A HRS was executed by changing only two of the right (left) preshift figures to the left (right) button during the shift. This meant that four of the S-R associations were changed during the HRS and all eight were changed during a RS; *S*s in both RS and HRS groups were shifted to the same postshift figure-response associations as suggested by Slamecka (1968). The three preshift training level groups were as follows: the UT group was defined as reaching 6 out of 8 correct responses in a single trial; the C group 8 out of 8; and the OT group 8 out of 8 for three consecutive trials. A strict behavioral, rather than fixed trial, definition of OT

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APPENDIX A

was used to ensure that all *S*s actually had attained the "overtrained state" (Richman, 1969). Shift criterion was set at 8 out of 8 correct responses during a single trial.

RESULTS

Table 1 presents the mean number of trials to criterion in both original and shift conditions for all groups. During shift training, RS and HRS groups figure-response pairings were identical; however, during original learning, four of the RS-HRS pairings differed. A t test was performed on the trials to original learning undertraining criterion (6 out of 8 correct) for the RS and HRS UT groups resulting in statistical nonsignificance ($p > .05$). A 2 X 2 ANOVA performed on the original learning scores to criterion (8 out of 8 correct) compared C and OT, RS and HRS and their interaction. The two Main Effects and Interaction proved to be statistically nonsignificant ($p > .05$). Therefore, even though RS and HRS *S*s had different initial tasks, there were no differences in their learning rates, suggesting no intrinsic differences in difficulty between the two tasks.

Since the shift scores based on trials to shift criterion did not meet the requirement of homogeniety of variance, they were treated with a square root transformation. A 2 X 3 ANOVA was performed on transformed trials to shift criterion scores and revealed statistically significant Shift, Training, and Shift X Training Effects ($F = 10.00$, $df = 1/90$, $p < .005$; $F = 5.63$, $df = 2/90$, $p < .01$; and $F = 4.37$, $df = 2/90$, $p < .025$). A Duncan multiple range test performed on the RS groups found UT significantly different from C and OT ($p < .05$). None of the comparisons within the HRS groups were statistically significant ($p > .05$). Comparisons between RS and HRS groups at the three training levels showed no differences at undertraining ($p > .05$) but significant differences at the criterion and overtraining levels ($p < .05$).

Resistance to extinction was measured in the RS groups by the number of consecutive errors following the shift. The ANOVA on the shift error scores showed that consecutive errors increased significantly as a function of the amount of original training ($F = 3.29$, $df = 2/45$, $p < .05$).

DISCUSSION

The results of this study clearly indicate the development of some form of structural units (concepts) as a function of preshift training. Subjects showed faster RS performance while HRS performance remained constant as the amount of preshift training increased. Two tentative conclusions may be reached: (*a*) The formation of structural units is not solely dependent on the presence of a relevant stimulus attribute. The conditions which were present in this study seem to be sufficient for their development. These conditions include a common response to a number of stimuli and possibly the nature of the temporal spacing (Richman and Trinder, 1968). (*b*) The status of the units achieved is not clear. It should be noted, at this point, that the extinction data were strikingly similar to that of other shift behavior studies reported in the rat literature (e.g., Mackintosh, 1965). Resistance to extinction, defined in terms of the number of consecutive errors immediately following a RS, showed that as training increased so did resistance to extinction. The data does suggest, however, that structural units may exist at levels other than those provided by known stimulus attributes.

TABLE 1

Mean Number of Trials to Criterion in Original and Shift Training

Preshift training	Original training		Shift training	
	RS trials	HRS trials	RS trials	HRS trials
UT	4.69	4.13	9.19	8.44
C	11.19	11.13	4.56	7.13
OT	10.44	11.19	2.38	8.00

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Diameter Sizes of the Circles of the Five Absolute Judgment Series

Number of Stimuli	Diameters in Inches									
4	.50	1.50	2.50	3.50						
6	.50	1.10	1.70	2.30	2.90	3.50				
7	.50	1.00	1.50	2.00	2.50	3.00	3.50			
8	.50	.92	1.35	1.78	2.21	2.64	3.07	3.50		
10	.50	.86	1.19	1.52	1.85	2.18	2.51	2.84	3.17	3.50

APPENDIX B