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EXPLORATIONS OF THE RELATIONSHIPS BETWEEN UNDERSTANDING AND DRILL IN THE LEARNING PROCESS.

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FIVE EXPERIMENTS WERE RUN AS A SERIES OF INITIAL EXPLORATIONS TO DETERMINE A WORKABLE, RESEARCH DEFINITION OF THE TERM "UNDERSTANDING" AND TO EVALUATE EXPERIMENTALLY ITS RELATIONSHIP TO DRILL, OR ROTE LEARNING. THE FIVE EXPERIMENTS DEALT WITH THE EFFECTS OF A VISUALLY IMPOSED COGNITIVE STRUCTURE UPON ROTE LEARNING, THE EFFECTS UPON ROTE LEARNING OF STRUCTURES IMPOSED BY VISUAL AS OPPOSED TO AUDITORY STIMULI, THE TRANSFER EFFECTS AFTER PREFAMILIARIZATION WITH INTEGRATED AS OPPOSED TO PARTIALLY INTEGRATED VERBAL-PERCEPTUAL STRUCTURES, FURTHER EVALUATION OF DIFFERENCES BETWEEN INTEGRATED AND PARTIALLY INTEGRATED VERBAL-PERCEPTUAL STRUCTURES, AND THE ABSTRACTNESS OF COGNITIVE STRUCTURE AND RETROACTIVE INHIBITION. THE RESULTS OF THE EXPERIMENTS GENERALLY INDICATED THAT A VIABLE DEFINITION OF THE TERM "UNDERSTANDING" WAS ACHIEVED BY RELATING IT TO THE THEORETICAL TERM "COGNITIVE STRUCTURE," AND THAT EMPIRICAL EVIDENCE EVALUATING THE RELATIONSHIP BETWEEN COGNITIVE STRUCTURE AND ROTE LEARNING COULD BE OBTAINED. (GD)

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EXPLORATIONS OF THE RELATIONSHIPS BETWEEN UNDERSTANDING AND DRILL IN THE LEARNING PROCESS

Background and Objectives

Most educators agree that while rote learning is not the single or most important component of learning, a substantial degree of rote learning must necessarily be incorporated into any educational process. In the classroom, the question of the role of rote learning involves essentially a decision regarding the extent to which new learning materials should be taught simply by rote repetitive drill and the extent to which they can or should be taught by methods designed to give the student an understanding of the subject matter. Most teachers would agree that each technique has its place in the overall learning process, but neither empirical evidence nor theoretical treatments of learning give much information regarding the relative importance of the two procedures or the degree to which they interact.

The research reported here was an initial exploratory attempt to link the drill and understanding methods of instruction to concepts which exist in various theories of learning, and to evaluate their interrelationships. As such, it must be classified as theoretical research, the outcomes of which have no immediate application to classroom teaching technique. Rather, it is considered to be one of the series of steps which must be taken to develop a theory of learning which is broad enough to warrant application to instructional situations.

A basic assumption underlying the present research was that effective human learning cannot be characterized as either rote learning alone or as broad conceptual understanding alone, but that these two processes are interrelated and complement each other. This assumption is certainly not unique. Learning theorists, however, have tended to divide themselves into two broad groups, one tending to characterize the learning process as a series of rote associative formations and the other characterizing learning as the formation of a broad cognitive structure. Representatives of the former group include those theorists and experimentalists whose major interests and research are in rote verbal learning (e.g., Cofer, 1961, 1963), and theorists in the latter category include Tolman, Bruner, and many others. With few exceptions (e.g., Ausubel, 1963), proponents of each of these theoretical orientations have ignored the data, the experimental methods, and the concepts stressed by the other. Thus few attempts have been made to link these theoretical orientations with each other, and to link them both in turn to educational notions such as "drill" and "understanding."

One general procedure for forming such a linkage is to begin by defining various terms in ways which are at once measurable and consistent with already established theory, and then proceed to collect empirical data in ways which permit evaluation of the usefulness of those terms and the relationships among the defined processes which those terms signify. In this context, the major objectives of the present project were (1) to define the terms "drill" and "understanding" in language that relates them to existing concepts in learning theory and provides definitions sufficiently operational that they can be translated into experimental procedures, and (2) to conduct a series of experiments which would evaluate the interaction of these two defined procedures.

In reference to the first objective, it was considered that the term "drill" is synonymous with rote learning, and may be defined operationally as the repetitive presentation of discrete facts for study and learning; i.e., if a single and discrete set of words (or other discrete materials) is presented repeatedly in isolation from other sets until the learner gives evidence that he knows those words (or other discrete materials), then he has learned by a rote learning (synonymous with drill) procedure. Proceeding to the term "understanding," it becomes a little more difficult to formulate a definition which will be generally accepted. For present purposes, it was assumed that the term connotes the same conceptual meaning as Tolman's term "cognitive map," and the term "cognitive structure" as used by Ausubel (1963) and other learning theorists. Thus the concept "understanding" is taken here to mean the presence, in memory, of a structure or organization of two or more factual components of a complex situation which relate all of those components to each other. Operationally, the term cognitive structure (synonymous with understanding) was defined as follows: If a learner is presented with a complex stimulus configuration and gives evidence of being able to recall the relationships among the component parts of that configuration, then there exists for that learner a cognitive structure (understanding) of that configuration. An additional term, "meaningful," is also introduced because of its persistent use in discussing cognitive structure. The operational usage of this term is as follows: If a learner gives evidence of being able to recall relationships among component parts of a complex configuration and to assign those parts as members of the configuration, then the parts are meaningful.

Despite their lack of refinement, and admitting their susceptibility to perhaps endless semantic argument concerning their adequacies and failures, these definitions succeed in delineating two operations which can be distinguished from each other, measured, and compared. They provide the basis for the second objective of the project, which was to conduct research designed to impose a cognitive structure as defined upon the learner to determine whether, and how, this cognitive structure was related to rote learning of factual material. Experiments were conducted to answer the following four specific questions:

a. Does prior formation of a cognitive structure, using visually presented stimulus materials, facilitate subsequent rote learning of facts which are related to the cognitive structure?

b. Does prior formation of a cognitive structure, using auditory stimulus materials, facilitate subsequent rote learning of facts related to the cognitive structure?

c. Do the facilitating effects of cognitive structure upon rote learning depend upon the "wholeness" or "completeness" of the cognitive structure imposed?

d. Is rote learning following the imposition of a related cognitive structure less susceptible to retroactive inhibition than rote learning without previous imposition of a related cognitive structure?

The rationale, methods, and results of the experiments are presented in detail in the next section.

Research

Experiment I: Effects of a Visually-Imposed Cognitive Structure Upon Rote Learning

Tolman (1948) has attributed much of the learning of animals and men to their reliance upon a "cognitive map," into which new learning is meaningfully assimilated. His figurative expression refers to an assumed mental organization or structure, built up from past experience, which makes the learner's surroundings meaningful. It is hypothesized that if new situations, requiring learning, can be incorporated into a meaningful structure, learning is relatively easy; if not, learning is by rote, and more difficult. This basic hypothesis has been elaborated by other theorists (e.g., Ausubel, 1963; Bruner, 1957), and forms a theoretical basis for such school-learning practices as understanding versus drill, the use of visual aids to introduce new topics, and other methods designed to broaden the student's conceptual overview of academic subjects.

Experimental attempts to demonstrate the effect of cognitive structure upon human learning ordinarily employ a two-stage transfer paradigm. In the first stage the learner is familiarized with materials which provide opportunity for the formation of a meaningful organization or structure, and in the second stage new material which bears some relationship to that of the first stage is presented for learning. Observation of positive transfer in the second-stage learning task is taken as evidence that a cognitive structure was established by the first-stage treatment.

Ausubel (1963, Ch. 5) has reviewed the extensive research literature demonstrating by this method the effects of cognitive structure upon human learning. M c of this research, however, has employed strictly verbal materials in the first stage (e.g., essays, rule-learning), and tested for transfer to such broad and complex tasks as the learning of conceptual academic subject matter or the solution of difficult problems and puzzles. The effects of perceptual organization, and cognitive effects upon the learning of simple verbal tasks, have received little study. Also, in many investigations the cognitive condition was compared only with control conditions which in the first stage received no treatment relevant in any way to the second-stage learning task. Since cognitive material is usually complex in structure and consists of a variety of interrelated stimulus components, it is possible that the positive transfer obtained may be attributable not to the organization or meaningfulness of the first-stage task per se, but rather to certain discrete elements of that task. Were this the case, findings of positive transfer might be explained better by assuming a discrete stimulus-response (S-R) association process, rather than inferring a cognitive mechanism. Unless appropriate control conditions are employed, it is difficult to make a clear decision between these alternative explanations of the positive transfer obtained.

The present study was directed at extending and clarifying three aspects of the cognitive research available to date. First, the cognitive material presented in the first stage of the transfer paradigm was an integrated perceptual-verbal structure rather than the organized verbal structure often employed. The success of visual aids in facilitating learning, and the importance attributed to visual stimuli by Gestalt and other cognitive theories, suggest that a visual organization should have strong positive transfer effects to the learning of related verbal material. Taking Tolman quite literally, the cognitive material employed was a map-like drawing on which verbal stimuli were printed. Second, the learning task following the cognitive presentation consisted of learning specific facts related to the previously shown map, rather than learning broad concepts. This type of task was employed for two reasons: (a) much of academic learning can be characterized as the assimilation of new factual material into an existing cognitive structure (Ausubel, 1963), and (b) the simplicity of the task made it possible to analyze transfer effects in terms of S-R, as well as cognitive, relationships.

Finally, an attempt was made to determine the locus of the expected transfer by employing five control conditions. The map used in the cognitive treatment integrated several discrete stimulus components--for example, the drawings of certain objects in a specific relationship to each other, various verbal stimuli, and positional relationships between the verbal stimuli and the pictured objects. It was considered that only certain of these several stimulus aspects, and not the total structure itself, may be responsible for positive transfer. Also considered was the possibility that the map structure might serve simply to establish implicit verbal S-R associations which could mediate later learning and result in positive transfer. To evaluate the possible effects of these separate components upon second-stage learning, various control groups received in the first stage either the map and the verbal stimuli separately (i.e., not integrated into a meaningful structure), the verbal stimuli alone in varying configurations, verbal stimuli which provided only discrete S-R mediating associations, and the usual transfer control of no treatment prior to second-stage learning.

Method

Subjects

The subjects (Ss) were 60 college men at Colgate University who participated to fulfill a requirement for an introductory psychology course. All Ss were assigned to experimental conditions according to a pre-determined random order as they appeared individually for the experiment.

Design and Procedure

Stage II Task. A total of six groups were employed (N = 10 per group), Ss in each group being exposed to two experimental stages. The Stage II task was to learn the following eight simple sentences, each beginning with the three-letter initials of a hypothetical person and ending with a statement of that person's occupation: KOT is a pilot, NEB is a gas station attendant, BAF is a shopkeeper, PUM is a truckdriver, DOS is a policeman, RAZ is a cook, FER is a brakeman, and TUK is a farmer. The initials used were CVC's of 85-100% association value taken from Glaze's (1928) list. These sentences constituted factual material about eight hypothetical persons, and were also considered as eight paired associates, each with the initials serving as the S-term and a word of a certain class (occupations) serving as the R-term.

Following various Stage I treatments (described below), Ss in all groups were seated before a Stowe memory drum set in a 3 x 4-foot black screen and instructed to learn the eight sentences as quickly as possible. Seven learning trials were then administered. On each trial, the sentences were first presented, one at a time, at a 2-second rate in the drum window for silent study. After this study period the drum was stopped and S was given 75 seconds to write on a test sheet as many of the sentences as he could recall. Then the test sheet was returned and 15 seconds later a new trial began, again with a silent study period via the memory drum followed by a test. The sentences were presented in randomly varied orders on each trial to prevent serial learning, and S was told he could write the sentences in any order he wished on each test. The relatively long test period provided ample time for even the slowest writer to write all the sentences he could recall on every trial.

Stage I treatments--Cognitive Structure Group. The purpose of the Stage I treatment administered to the Cognitive Structure Group was to impose experimentally a meaningful and integrated cognitive representation of stimulus components related to the Stage II learning task. The integrative representation used was an 8½ x 11-inch map sketch depicting a highway intersection and its surroundings, including an airstrip, a gas station, a shopping center, a diner, a farm, and a railroad. A tractor-trialer and a police patrol car were drawn on the highways. Beside each of these eight major components of the map structure was typed a set of three-letter initials, the stimuli for the Stage II task. Figure 1 illustrates the map and the initials embedded in their appropriate positions.

The S was instructed to study the initials on this map for 30 seconds and memorize them so that he could reproduce them in their proper positions on a later test. After 30 seconds the map was removed and S had 1 minute to recall and write on a test map the missing initials in their correct places. Following the first test two more 30-second study periods were given, with a 1-minute test between each, providing adequate time for familiarization with the initials and their correct placement. At the end of this Stage I treatment, it was presumed (a) that S would be familiar with all of the initials to which he would later (Stage II) have to associate occupations, and (b) that the initials would be embedded in a representative and meaningful cognitive structure (i.e., the integrated map) which would aid in Stage II learning.

Map-List Group. The Cognitive Group received in Stage I familiarization of both verbal and perceptual stimuli in a specific relationship. The remaining groups were essentially control conditions, providing at Stage I varying degrees of familiarization with either verbal stimuli alone, nonintegrated verbal and perceptual stimuli, or neither type of stimuli, but never all of the components of the total map stimulus in an integrated relationship.

Stage I for the Map-List Group consisted of presenting to S for study (a) the map shown in Figure 1 without any embedded initials, and (b) a list of the eight sets of initials on a separate 3 x 8-inch strip of paper typed one beneath the other with double spacing between each. Instructions were to study the map and the initials for three 30-second periods; with a 1-minute test after each study period, in which S was to write down all the initials he could recall, in the correct list order, on a 3 x 8-inch test strip which contained only eight lines on which to write the correct responses. The separate map remained in view during both the study and test periods, but at no time were any initials placed on any part of the map. Thus, S was familiarized with the initials and with the map, but these two components were never meaningfully related in a single structure.

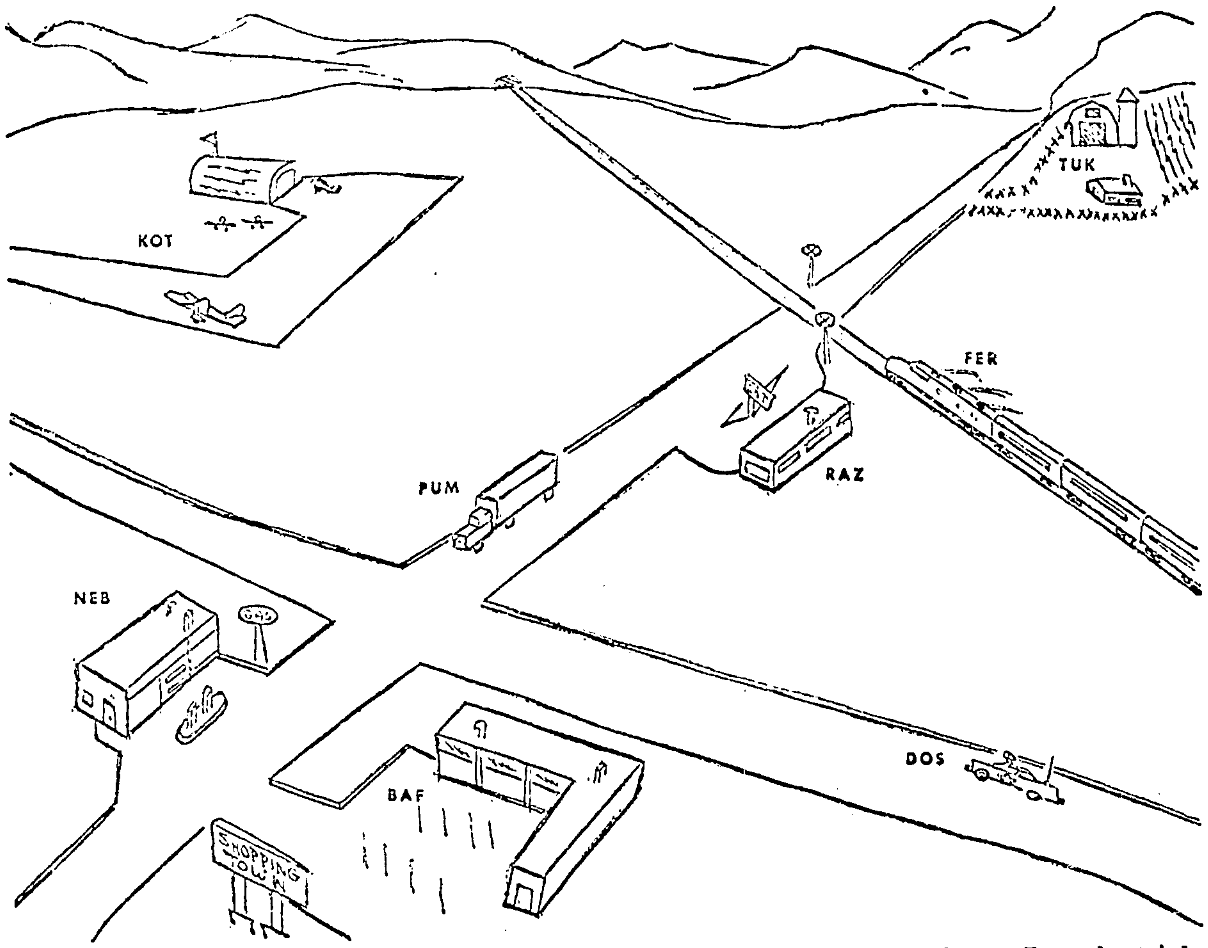


FIG. 1. Map structure presented to the Cognitive Group during the Stage I study trials.

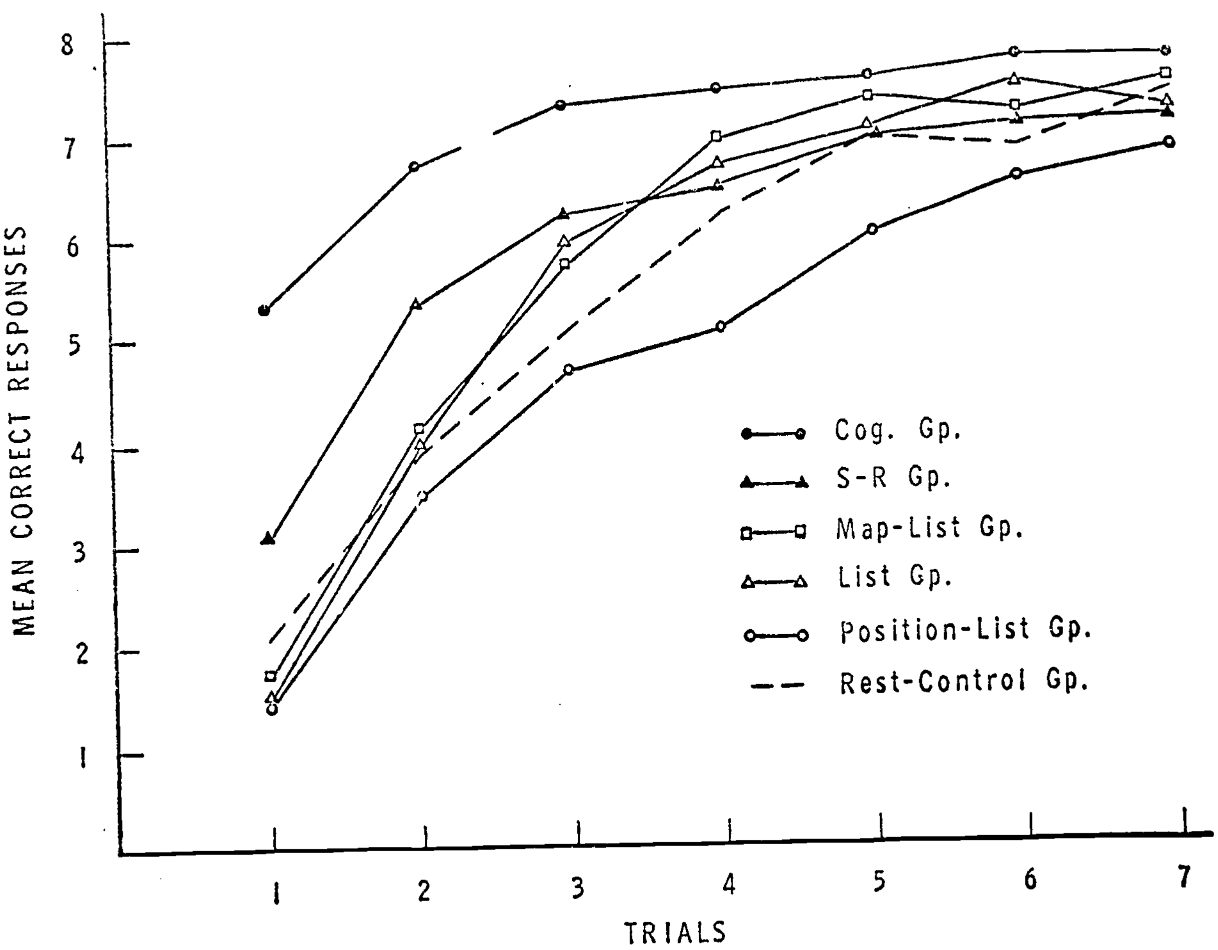


FIG. 2. Stage II learning curves for all groups.

List Group. The Stage I treatment for the List Group was identical to the Map-List Group except that the separate map was omitted from both the study and the test periods. Thus this treatment provided familiarization with the discrete verbal stimuli, but these stimuli were neither embedded in a perceptual structure nor was a potentially useful structure presented.

Positioned-List Group. Asch, Hay, and Diamond (1960) have shown that serial learning may be affected by the physical configuration or positioning of the items being learned. Therefore it was considered possible that the specific positioning per se of the initials on the map (Figure 1), for example, KOT in the upper left corner, DOS in the lower right corner, etc., might isolate the stimuli in a manner which would facilitate learning in Stage II regardless of whether the map was presented or not. As a control to evaluate this possibility, the Position-List Group received for study in Stage I an 8½ x 11-inch sheet of paper on which the eight initials were printed in the same relative positions as shown on the map in Figure 1, but with the map omitted. This group also received three 30-second study periods, interspersed with three test periods in which S wrote all the initials he could recall in their appropriate positions on an 8½ x 11-inch test sheet containing only lines on which to write the correct responses. This Position-List Group was similar, then, to the List Group, in that it received familiarization of the initials in the absence of the map structure; but differed from the List Group in that it learned the initials in a specific configuration identical to the map positions, rather than in a vertical list.

S-R Group. One alternative interpretation of the function of the map in Figure 1 is that it provides not a "cognitive structure" but (a) familiarization with the verbal stimuli, which may transfer positively to the Stage II task (Goss & Nodine, 1965, Ch. 6), and (b) an opportunity to learn a series of discrete verbal S-R associations, which may mediate Stage II learning and thus produce positive transfer. An example of the latter interpretation is that study of the upper left corner of the map may yield the implicit verbal association "airstrip-KOT" which, at Stage II, will mediate the association "KOT-pilot" because of the extraexperimental association existing between "airstrip" and "pilot." In transfer paradigm form, this is an A-B, B-A′ relationship; and Houston (1964) has reviewed evidence suggesting that this paradigm should yield positive transfer.

To evaluate the adequacy of this alternative explanation of the map function, an S-R Group received in Stage I a blank 8½ x 11-inch study sheet on which was typed, in the same relative positions as on the map in Figure 1, the following eight verbal paired-associates: airstrip-KOT, gas-NEB, shopping center-BAF, tractor-trailer-PUM, patrol car-DOS, diner-RAZ, train-FER, farm-TUK. The Ss in this group, also received three 30-second study periods, interspersed with 1-minute tests during which they wrote the initials in their correct positions on a test sheet which contained the eight nouns alone, typed in their proper places on the sheet. Thus the S-R Group received both familiarization with the initials and an opportunity to form discrete verbal associations of the type presumably available to the Cognitive Group, but no potentially integrative relationship among the items was provided.

Rest Group. A final control group learned the list of sentences in Stage II, but received no Stage I treatment at all. This Rest Group was used to evaluate the effects of all other Stage I treatments upon Stage II learning.

Results

Stage I learning. Despite the ease of the Stage I tasks, one to three Ss in every group failed to learn all of the initials in the three study periods administered. The mean number of correct initials given on the last test in Stage I ranged from 7.00 to 7.60 for the five groups receiving the Stage I treatment. A preliminary analysis of variance verified that the differences among these means were not significant, $F(4,45) < 1.00$, $p > .10$; indicating that while Stage I learning was not perfect, the conditions receiving the various Stage I treatments did not differ in degree of familiarization with the initials at the time Stage II began.

Stage II learning. The means and SD's for the total number of correct responses made by each group over the seven trials of Stage II learning are presented in Table I. The overall difference among the means, tested by analysis of variance, was highly significant, $F(5,54) = 3.77$, $p < .01$. Comparisons of individual control-group means, using the Newman-Keuls method, indicated no significant differences among the five groups which did not receive the Cognitive Group treatment. Neither familiarization of the initials alone, familiarization of the initials in the presence of the separate map structure, nor the provision for verbal mediating associations, resulted in positive transfer when compared to the Rest Group receiving no Stage I treatment at all. Turning to the cognitive

Table 1

Means and SD's for Total Number of Correct Responses Over Seven Stage II Trials

	Groups					
	Cognitive	Map-List	List	Position-List	S-R	Rest
M	49.5	39.8	39.6	33.9	41.6	38.2
SD	7.25	8.72	6.90	8.10	11.40	7.02

treatment, however, further Newman-Kuels comparisons showed that the difference between the Cognitive Group and each of the control conditions was significant beyond the 0.5 level of probability. Thus positive transfer was obtained, but only when the various components of the Stage I task were integrated into an organized perceptual-verbal structure.

Figure 2 presents the learning curves for each group over the seven Stage II learning trials, illustrating the consistent superiority of the Cognitive Group beginning with the first trial. Individual t tests indicated that the Trial 1 mean for the Cognitive Group was significantly higher than the second highest S-R Group mean, $t(18) = 2.59$, $p < .02$. The S-R Group, although it showed an initial trend toward higher performance than the other controls, did not differ significantly from the Rest Group on the first trial, $t(18) = 1.32$, $p > .10$. Differences among the remaining four control groups were also nonsignificant. Following the first trial the groups tend to converge, the Cognitive Group approaching the test ceiling by Trial 3 and the others approaching ceiling at a later point. Although learning was rapid in all groups, none of the conditions matched or exceeded the Cognitive Group after seven trials of learning.

Discussion

The data clearly indicate that prior exposure to an integrated and potentially meaningful perceptual structure may provide positive transfer to a related task in which simple factual materials are to be learned. The evidence is consistent with past findings demonstrating positive transfer from meaningful verbal structures to more complex tasks such as problem solving and the learning of conceptual materials, and confirms their results with another type of structure and a simple but common learning situation.

The S-R Group did not differ significantly from the other controls, despite a trend toward superior performance on the initial trials of the Stage II task. Thus the A-B, B-A paradigm, when used with discrete verbal associative materials, was found to be ineffective in producing positive transfer. In contrast the Cognitive Group, which received the equivalent A-B, B-A′ sequence but with integrated perceptual stimuli in the A-B stage, demonstrated strong positive transfer. Whether the superiority of the latter group was due to the perceptual aspect or the integrative aspect of the Stage I stimuli can not be determined from this comparison, but regardless of the specific locus there is a strong suggestion that the integrated perceptual stimuli presented to the Cognitive Group provided more than a series of discrete verbal mediators.

The Cognitive Group was also consistently superior to the three control groups which received various components of the total map structure during Stage I; but none of these three controls demonstrated positive transfer relative to the Rest Group, which received no Stage I treatment at all. This lack of positive transfer in the component control groups suggests that the transfer observed for the Cognitive Group was not attributable to the specific map components presented, either alone or in combination, but rather to the organization of the various components into a single structure. It is this integration or interdependence of the discrete components of an experience which is ordinarily implied by the term "meaning" as it is used in describing cognitive structure. The data indicate that it was the organizational or "meaning" aspect of the Stage I task, rather than the familiarization with either the initials alone or the initials and the map separately, which contributed to the positive transfer demonstrated by the Cognitive Group. The fact that this transfer was obtained with simple materials which were easily learned by rote makes it reasonable to conclude that, for human learners at least, this organizational aspect is a powerful factor in even basic learning processes.

Experiment II: Effects upon Rote Learning Imposed by Visual vs. Auditory Stimuli

The classroom teacher often attempts to impose a cognitive structure upon students by giving an "overview" of a new topic before intensive factual learning of that topic begins. At times this overview is presented with visual aids, and at times by auditory methods. The results of Experiment I, which employed a laboratory analogue of a visual overview, indicated clearly the positive effect of a visually-imposed overview upon later learning. In the present experiment, an attempt was made to compare the relative effects of an overview, or cognitive structure formation, presented by visual and auditory methods. It was predicted (a) that regardless of sensory mode (visual vs. auditory) employed, the presentation of meaningfully structured materials would produce superior learning on a later rote task relative to presentation of unstructured materials, and (b) that visually presented structured materials would produce superior learning on a later rote task relative to presentation of structured materials by an auditory method.

Method

Subjects. The Ss were 20 college men at Colgate University, all of whom were naive to psychological experiments involving cognitive transfer. Each S was assigned to one of the four experimental conditions (N = 5 per group) according to a predetermined random order as he appeared individually for the experiment.

Design. The basic design, similar to that used in Experiment I, consisted of exposing the Ss in each condition to a Stage 1 treatment which familiarized them with certain materials, and then in Stage 2 testing the speed of learning of rote sentences which were related to those materials. The following four Stage 1 conditions were employed: a Structured-Visual group, in which Stage 1 materials were presented in an integrated visual-map form, as in Experiment I; a Structured-Audio condition, in which Ss listened to a tape-recorded description of the map materials but did not see the map itself; an Unstructured-Visual condition, in which Ss studied a list of initials presented on an otherwise blank sheet of paper; and an Unstructured-Audio group, in which the Ss studied the initials by listening to them as they were spelled out via tape recorder. These groups were compared on Stage 2 learning performance by a 2 x 2 analysis of variance.

Materials and procedure. The map presented in Stage 1 to the Structured-Visual group depicted an old country town and its surroundings (see Fig. 3). Sets of 3-letter initials were printed approximate to eight distinctive features of the scene: the town itself, a plain north of town, the mountains, a forest, a lake, a bridge, a farm, and a castle-like country mansion. The S was told he would be given four 45-second periods to study and learn the map contents, with a 1-min. test following each study period. The Unstructured-Visual group received for study a blank sheet of paper on which the same sets of 3-letter initials were printed in the same relative positions as on the Structured-Visual map.

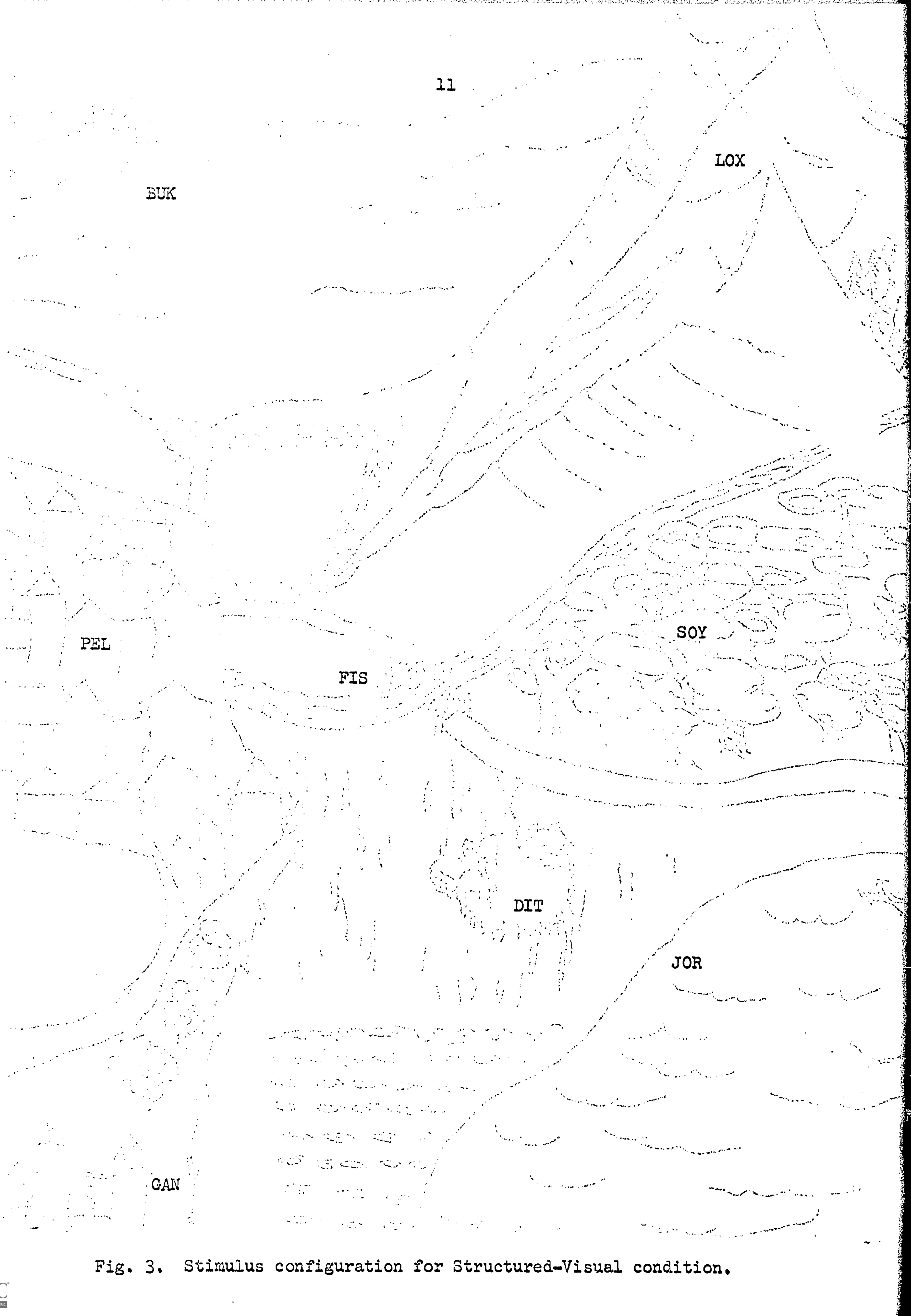


Fig. 3. Stimulus configuration for Structured-Visual condition.

The Structured-Audio group received for study four 45-second tape-recorded presentations of the following statement: "Picture an old country town surrounded by hills, a forest, a lake, and a plain. There is a stream running toward the town with a bridge across it. A large castle and a farm are in view. Here are the initials of some of the residents of this area. L.O.X. lives in the hills. G.A.N. lives in the castle and D.I.T. lives in the other country house. B.U.K. lives on the plain. J.O.R. lives by the lake and S.O.Y. lives in the forest. F.I.S. lives by the bridge. P.E.L. is the only one who lives in town." Between each presentation, the S was given one minute to repeat orally to E all that he could recall from the taped statement. The Unstructured-Audio group received four 45-second taped presentations of just the 3-letter initials, each being spelled once in a 5-second interval. Tests between each study period required S to spell, in correct order, the initials.

In Stage 2 all Ss learned the following eight sentences: L.O.X. is a goldminer, G.A.N. is a wealthy duke, D.I.T. is a farmer, B.U.K. is a shepherd, J.O.R. is a fisherman, S.O.Y. is a lumberjack, F.I.S. is a tollkeeper, P.E.L. is a tailor. These sentences were presented one at a time for study and testing on a Stowe memory drum, using the same procedure as described in Experiment I. All Ss learned to a criterion of one perfect test.

Results and Discussion

Means and SD's of trials to criterion on the Stage 2 task are presented for all groups in Table 2. A 2 x 2 factorial analysis of variance showed that the difference between the Structured and Unstructured treatments was between the .10 and .05 levels of significance, $F(1,16) = 4.25$, but that neither the Visual-Audio difference nor the interaction approached significance, $F(1,16) = 2.46$ and .55 respectively, $p > .10$.

Table 2

Data Summary for Experiment II

		Visual	Audio
Structured	M	3.80	6.60
	SD	1.30	1.02
Unstructured	M	7.20	8.20
	SD	4.12	3.11

Inspection of the cell means in Table 2 shows that, consistent with the data from Experiment I, the performance of the Structured-Visual group was substantially better in terms of absolute magnitude than the other three conditions. In fact, an individual comparison of the Structured-Visual group with the Structured-Audio condition indicated that the difference between them was statistically reliable, $t\ (8) = 3.78$, $p < .01$. Thus while the overall analysis failed to demonstrate a significant Visual-Audio difference, parts of the data do give suggestive evidence that the visual mode of presenting structured material may be advantageous.

A firm interpretation of this experiment is limited by the presence of two problems. First, it is apparent that the N's of each group were inadequate. This was necessitated by the close of the school term, making Ss from the defined population no longer available. Second, the taped statement presented to the Structured-Audio group is subject to question in terms of its adequacy in giving the details of the map scene. Relative to a picture, the audio statement lacks much of the richness and detail, with the probable consequence that the two conditions were not given equivalent information during Stage 1. This latter problem is difficult to control, and perhaps constitutes a qualitative difference between the visual and audio modes which cannot be controlled. In view of this difficulty, it was decided not to continue the experiment when the next term began (Fall 1966). It was clear that further investigation of this problem would require a series of experiments which would run beyond the time and scope of the present project. Consequently, the best interpretation that can be made of the relationship between visual and auditory modes of presenting structured material is that the initial evidence, using a single type of auditory presentation, suggests a superiority of the visual mode as expected.

Experiment III: Transfer Effects after Prefamiliarization with Integrated vs. Partially Integrated Verbal-Perceptual Structures

Experiment I showed that prefamiliarization of verbal stimuli embedded in an integrated and meaningful pictorial map produced positive transfer to the learning of simple sentences which contained factual material related to the previously-studied map. The transfer obtained was significantly greater than that obtained for any of five control conditions which received prefamiliarization with the verbal stimuli, the pictorial map, or nonintegrated combinations of each. It was concluded that the integration of the verbal and perceptual stimuli into a single meaningful structure, rather than familiarization with these components separately, was responsible for the positive transfer observed. The theoretical explanation of this result was that the integration of verbal and pictorial stimuli into a single meaningful whole permitted the formation of an assumed mental organization akin to Tolman's (1948) concept of a "cognitive map," which persisted in memory and aided later rote learning of the related sentences.

Experiment III attempted to explore further the effects of a verbal-perceptual structure upon transfer to a rote verbal task. The main problem investigated was whether the positive transfer obtained in Experiment I was due to the wholeness or completeness of the verbal-perceptual stimulus configuration, or to the pairing of two types of stimuli--letters and pictures. A cognitive interpretation would assume that the wholeness of the perceptual configuration (i.e., the integrated map) provided a structure in which each part was meaningfully related, and thus could be recalled and utilized at the time of the learning task. Alternatively, it is possible that the pictorial characteristics of the map simply provided discrete perceptual stimuli which, added to the discrete verbal stimuli, provided stronger but still not necessarily integrated stimulus learning at the time of prefamiliarization. The latter alternative permits an S-R interpretation of the previous results by stating that the individual verbal stimuli were learned better when associated with discrete picture components during prefamiliarization than when presented alone, and thus the presence of discrete pictorial stimuli--and not the wholeness of the total map structure--was responsible for the transfer observed.

To evaluate these alternatives, the present experiment compared groups which received prefamiliarization with a single, integrated map structure with other groups receiving the same verbal-pictorial stimulus combinations but fragmented so that the S was exposed to a series of separate word-picture stimuli rather than an integrated and meaningful whole. Controls received only verbal stimuli during prefamiliarization. The main hypothesis, in accordance with a cognitive theory, was that the integrated-map groups would demonstrate greater transfer to a related sentence-learning task than would the groups familiarized with the discrete word-picture materials.

A second problem investigated dealt with retention of prefamiliarized cognitive material. In the initial experiment, the transfer learning task was presented immediately following the prefamiliarization period. It is possible that, although the cognitive-map treatment yielded superior transfer in this immediate-memory situation, its positive effect may have been due to short-term memory of the preceeding stimulus configuration rather than to the presence of a stable cognitive structure built up during the prefamiliarization period. Were this the case, the effect might be expected to dissipate over a short rest interval, in a manner similar to that demonstrated by Peterson and Peterson (1959) and others using different types of stimulus material. To test this possibility, in the present study a 10-minute rest interval was inserted between the end of the prefamiliarization period and the beginning of the transfer learning task.

Finally, an attempt was made to test the generality of the previous findings by using Ss from a different age group, employing two differing pictorial-map configurations, and administering the learning tasks at two different presentation rates by a study-test, rather than a free-recall, method.

Method

Subjects

The Ss were 36 boys and 36 girls between the ages of 15 and 18, all enrolled in a summer special-study program conducted by Colgate University for high school students of above-average ability. All Ss volunteered, and were paid a nominal sum for participation. For each sex, Ss were assigned to one of the six experimental conditions according to a predetermined order as they appeared individually for the experiment. The assignment method provided equal numbers of boys and girls in each condition.

Design

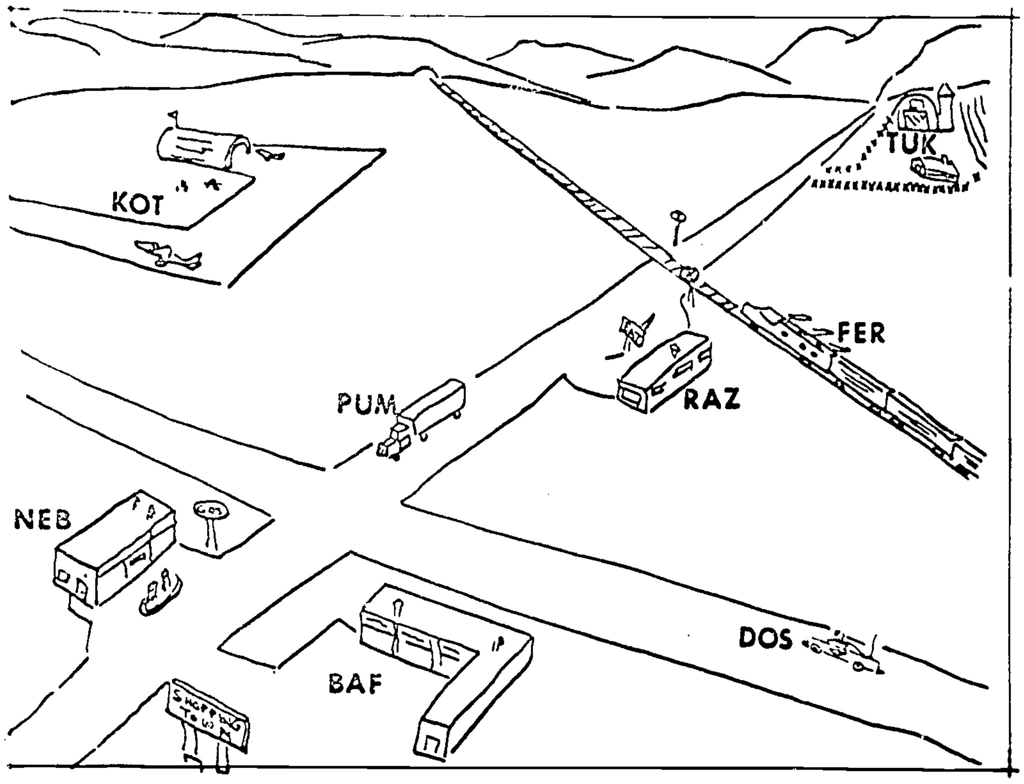
The general design was similar to that described in detail in Experiment I. In the first stage of the experiment, map sketches of varying degrees of meaningful structure were presented for learning to Ss in the different groups. Following this first, or prefamiliarization, stage all Ss received a 10-minute rest interval during which they worked on a puzzle which was unrelated to the experimental tasks. In Stage 2, all Ss received a rote sentence-learning task in which the sentences to be learned were related to the structure materials used in Stage 1. The main hypothesis was that a meaningful and integrated map structure presented in Stage 1 would provide S with a cognitive structure which would be retained over the 10-minute rest interval and would transfer positively to the Stage 2 learning task, whereas Ss given Stage 1 maps which were not integrated into a single meaningful context would fail to form and maintain a cognitive structure and thus would demonstrate less positive transfer to the Stage 2 task.

Materials and procedure

Stage 1. Three types of materials, designating three levels of cognitive structure, were used in Stage 1. The Cognitive Group received for study an 8½ x 11-inch map sketch depicting a common scene which contained eight parts. Each of the eight parts was labelled with a CVC of 85-100% association value (Glaze, 1928). At a second level, the Picture Group received for study an 8½ x 11-inch sheet on which were depicted the same eight labelled parts making up the map presented to the Cognitive Group; but these parts were separated from each other by borders, so that the sheet contained eight separate pictures with CVC labels rather than a single integrated scene containing eight meaningfully related parts. At a third level, the Label Group received for study in Stage 1 an 8½ x 11-inch sheet on which were printed the eight CVC labels but which contained no pictures.

At each of these three levels of structure, two types of task stimuli were employed. Half of the Ss in the Cognitive Group were presented with the same map used in the previous experiment, and shown in Fig. 4(a). This map, designated the crossroads (CR) map, showed a modern highway intersection and its surroundings, including eight labelled parts: an airstrip, gas station, shopping center, diner, farm, train, trailer-truck, and patrol car. The other half of the Ss in the Cognitive Group received for study a map showing an old town (OT) and its surroundings. This map, shown in Fig. 4(b), contained CVC labels embedded at eight points in the total scene: in the town, on a flat plain above town, in the mountains, in the forest, on a lake, by a farm, by a bridge, and by a large castle-like building. As Figs. 4(c) and 4(d) illustrate, the Picture Groups for the CR and OT conditions received fragmented variations of the CR and OT maps, these variations showing each labelled part in the same relative position as it appears on the integrated map, but separated from other parts by a border and blank space. The CR and OT Label Groups received white sheets of paper on which were printed CVC's in the same relative positions as shown in Figs. 4(a) and 4(b), respectively.

The S was told he would be shown a sheet containing eight three-letter initials in specific positions, and the task was to learn the initials and their positions. After a 30-second study period, the sheet was removed and S was given a test page which was identical to the map, picture, or label sheet just studied except that the initials were omitted. The S had 1 minute in which to recall and write on the test page all of the initials, in their appropriate positions. After this test, a second 30-second study period and 1-minute test period were given, and so on until the S was able to write all of the initials correctly, in their correct positions, on a single test. Thus in Stage 1 all Ss in all conditions learned the initials; and in addition the Ss in the Picture and Cognitive Groups had opportunity to associate these initials, respectively, with separated pictures or with parts of an integrated and potentially meaningful whole.



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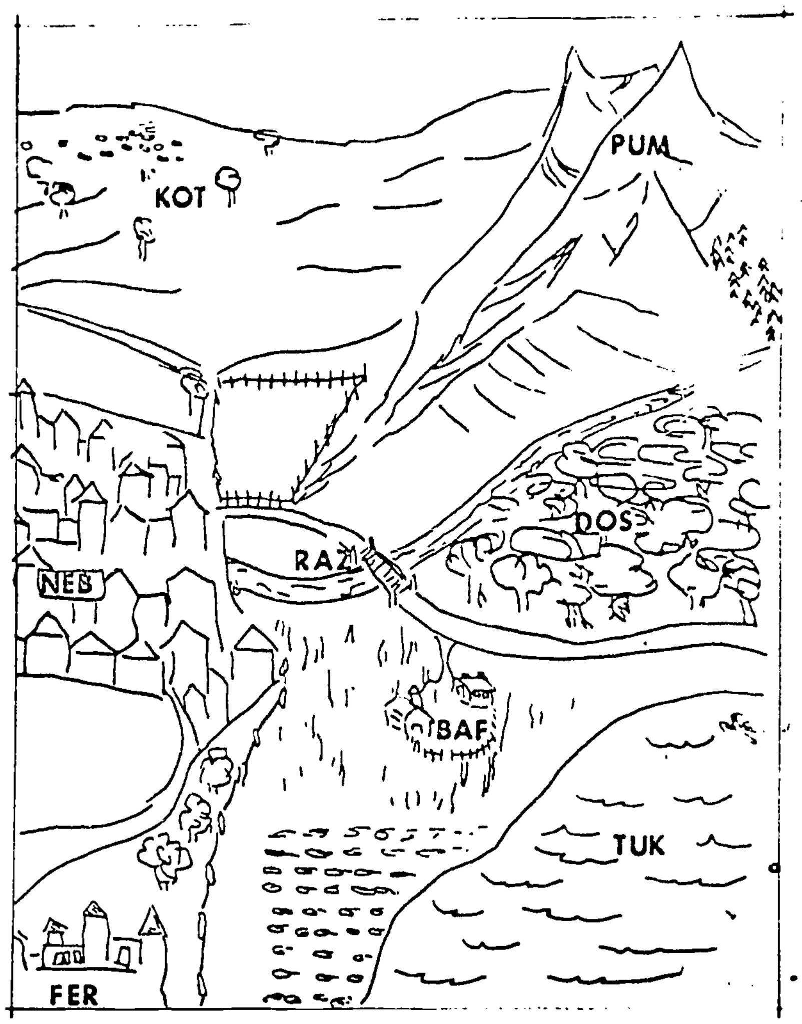

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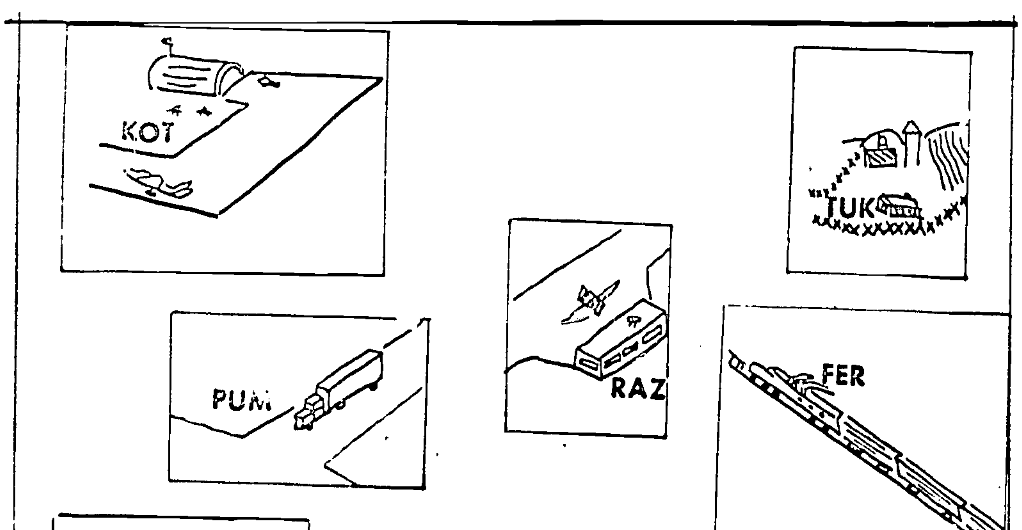

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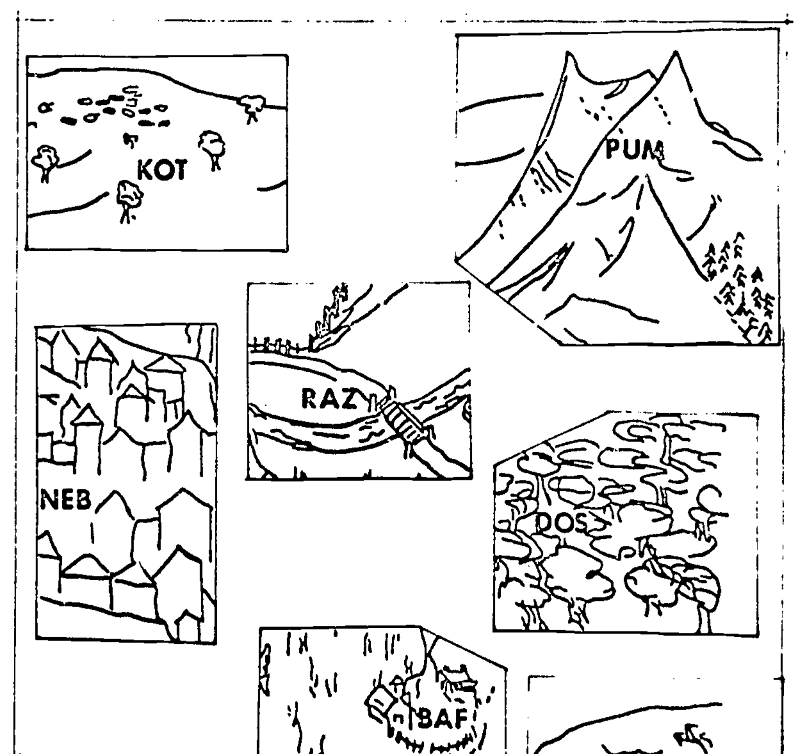

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Fig. 4. Stimulus configurations for Experiment III.

Forgetting-interval. Following a perfect test trial in Stage 1, all Ss were given a 10-minute forgetting interval which was filled by attempting to solve a letter puzzle. The puzzle consisted of a 12 x 12-cell matrix, with the letters A-L inserted in the 12 cells of the left column. The S was instructed to try to fill in the rest of the matrix cells with the letters A-L in such a manner that (a) no letter appeared twice in the same row, (b) no letter appeared twice in the same column, and (c) no letter appeared immediately before or after another letter more than once in the entire matrix.

Stage 2. Following the forgetting interval the S was seated before a Stowe memory drum set in a black wooden screen, and was given instructions for the Stage 2 learning task. The learning task consisted of eight simple sentences, each beginning with a set of initials which had been learned in Stage 1 and ending with a word indicating an occupation. The sentences for the CR conditions were: KOT is a pilot, NEB is a gas station attendant, BAF is a shopkeeper, PUM is a truck driver, DOS is a policeman, RAZ is a cook, FER is a brakeman, and TUK is a farmer. For the OT conditions, the sentences were: KOT is a shepherd, PUM is a goldminer, DOS is a lumberjack, RAZ is a tollkeeper, NEB is a tailor, FER is a wealthy duke, BAF is a farmer, TUK is a fisherman.

The sentences were presented for 10 trials by the study-recall method. On each trial, the sentences were first presented one at a time in the drum window for study. Following the study period, the initials were presented alone, one at a time and in a different order from that used in the study period, and S was instructed to recall and say aloud the occupation of each initial as it came into view. At the end of each trial there was a 6-second rest before starting the next trial. Three different orders of presentation were used on successive trials to prevent serial learning.

To determine possible effects of study-recall time upon learning under the various cognitive conditions, half of the Ss in each condition received the study and recall presentations at a 2-second (2-Sec.) rate, and half at a 3-second (3-Sec.) rate. Within each condition, Ss of both sexes were distributed evenly over these two levels of presentation time.

Results

Since both sexes and a range of age levels were represented in each of the experimental treatments, preliminary analyses were made to determine possible effects of these S variables upon the data. Mean ages for each condition ranged between 15.75 and 16.16 years, a difference which did not approach statistical significance. To evaluate possible sex differences, the mean number of correct responses over the 10 trials of Stage 2 learning was calculated for boys and girls in the Cognitive, Picture, and Label conditions. These means, pooled over presentation times and the CR-OT variable, were $\bar{B} = 66.00$ and $\bar{G} = 64.83$ for the Cognitive condition, $\bar{B} = 60.25$ and $\bar{G} = 58.17$ for the Picture condition, and $\bar{B} = 61.25$ and $\bar{G} = 55.25$ for the Label condition. Although boys demonstrated a slight superiority over girls in Stage 2 performance, the highest t value obtained in comparing the means for each condition was 1.03 ($p > .10$). Therefore, the data from boys and girls was pooled in the subsequent analyses.

Stage 1 Learning. To determine if the various presentation modes had differential effects upon Stage 1 learning, the mean number of Stage 1 trials taken to learn all stimuli was calculated for the OT-Cognitive, CR-Cognitive, OT-Picture, CR-Picture, OT-Label, and CR-Label groups. The means ranged from 2.33 to 2.92 trials, and did not differ significantly from each other, $F(5,66) < 1.00$. These data indicate that the Stage 1 learning task was relatively easy, and that neither the varying structure treatments nor differences in task stimuli (CR vs. OT) produced differences in speed of learning the initials.

Stage 2 Learning. Table 3 presents means and SD's of number of correct responses over the 10 trials of Stage 2 learning for all groups. A preliminary test for homogeneity of variance indicated that differences in variance were not significant, $F_{max}(12,5) = 17.47$, $p > .05$. In a 3 x 2 x 2 analysis of variance, no significant difference was found in comparison of the OT and CR conditions, $F(1,60) = 1.99$, $p > .05$. The difference between the 2-Sec. and 3-Sec. presentation rates was highly significant, as expected, $F(1,60) = 20.15$, $p < .001$. Also, as hypothesized, a significant difference was obtained for the main effect of cognitive structure, $F(2,60) = 3.41$, $p < .05$. The F value for the Presentation Time x Structure interaction was 2.11, $p > .05$, and F's of all other interactions were less than 1.00.

Table 3

Experiment III: Means and SD's of Total Correct Responses over Ten Trials of Stage 2 Learning

			Map	Picture	Label
2-Sec.	OT	M	61.00	51.83	49.00
		SD	3.90	12.48	16.30
	CR	M	66.50	50.33	53.17
		SD	10.95	16.00	[illegible].95
3-Sec.	OT	M	68.33	63.17	62.33
		SD	4.89	10.38	10.76
	CR	M	67.50	71.50	68.50
		SD	8.36	5.96	7.06

Inspection of the individual group means in Table 3 shows clearly that performance of the Cognitive condition was superior to the performance means of the Picture and Label conditions at the 2-Sec. presentation rate. At the 3-Sec. presentation rate, however, the superiority of the Cognitive Group is less evident, and in fact is reversed among those groups receiving the CR task. These differences in relative performance as a function of presentation rate seem to be due mainly to the facilitating effects of the slower rate upon the learning of the Picture and Label conditions, each of which attained considerably higher means at the 3-Sec. rate than at 2-Sec. In contrast, the Cognitive groups performed at a high and relatively stable level regardless of rate of presentation of the Stage 2 learning task.

In view of these subtle differential effects of time upon performance, further statistical analyses were made to compare the effects of structure separately at each presentation rate. Since no significant difference between the CR and OT tasks was found in the first analysis, these tasks were pooled for the three structure conditions at each time. Variation due to the simple main effect of structure at each level of rate was then evaluated, using the error term from the original analysis of variance according to a procedure described by Winer (1962, Pp. 256-257). The results indicated a highly significant difference among the Cognitive, Picture and Label conditions at the 2-Sec. level of presentation, $\underline{F}(2,60) = 5.35$, $p < .01$, but no significant difference among the structure conditions at the 3-Sec. level, $\underline{F}(2,60) < 1.00$. Subsequent individual comparisons among the structure conditions at the 2-Sec. rate, using the Neuman Keuls procedure (Winer, 1962, P. 238), demonstrated that the mean for the Cognitive condition was significantly higher than both the Picture and Label group means, $p < .05$, but that the latter two means did not differ reliably.

Discussion

The performance of the Cognitive condition on the Stage 2 task was superior to both the Picture and Label conditions under all treatments except CR-3-Sec., and the differences obtained were statistically significant both in an overall test and at the 2-Sec. level of presentation rate. These results, obtained with varying materials and a 10-minute rest interval between the Stage 1 and Stage 2 tasks, confirm and extend those of Experiment I, suggesting that the assumed cognitive structure imposed by prefamiliarization with a meaningful structure has relatively stable and general positive effects upon later learning. The finding of a general superiority of the Cognitive treatment over the Picture treatment also confirms the main hypothesis that it is the wholeness or integration of the total verbal-perceptual structure, and not simply the presence of associated verbal and pictorial material regardless of structure, which facilitates transfer to a related learning task.

The failure to obtain a statistically significant superiority of the Cognitive treatment at the 3-Sec. rate of presentation requires further explanation, since it appears to detract from the clarity of the results. Table 3 shows that at the 3-Sec. rate, all groups achieved means over 62, and four of the means were over 67. Since the highest possible score on the learning task was 80 correct responses over the 10 trials, it seems reasonable to consider that all of the groups receiving the slower rate were performing at or near the ceiling level for the task, and consequently significant differences among treatments were not observable at this rate. Alternatively, the 2-Sec. rate made the learning task more difficult, allowing differences among the structure treatments to become evident. The data indicate that under this more difficult learning condition the performances of the Picture and Label groups drop considerably, while those of the Cognitive Groups are maintained at near-ceiling level.

Thus it appears that the failure to obtain significant results at the 3-Sec. rate was due to the ease with which materials were learned at that rate, and does not constitute a contradiction of the original hypothesis that prefamiliarization with an integrated and meaningful structure establishes a cognitive representation which will transfer positively to a rote learning task. Even so, further research using different Stage 1 conditions and more difficult Stage 2 learning tasks is desirable before a full specification of the effects of cognitive structure upon rote learning can be made.

Experiment IV: Further Evaluation of Differences Between Integrated and Partially Integrated Verbal-Perceptual Structures

Experiment III indicated that the positive transfer effects of a wholly-integrated structure were superior to the effects of a partially-integrated structure. This finding has potential importance for psychological theories of learning, being related to Gestalt hypotheses which assume that the organism learns and remembers best those stimuli which form a total pattern. In view of the potential importance of the finding, it was decided to try to repeat the results in a small study which utilized different materials and a different Stage 2 task from that used in Experiment III, and which also evaluated the effects of structural differences both immediately following Stage 1 learning and ten minutes following Stage 1 learning. Consistent with the preceding experiment, it was predicted that Ss receiving in Stage 1 a whole-map configuration would perform better on a related Stage 2 guessing task than Ss exposed in Stage 1 to varying degrees of partially-integrated map configurations.

Method

Subjects

The Ss were 24 college men who volunteered for the experiment. None had had previous experience with this type of task.

Design and Materials

Stage 1. The Ss were assigned by a random procedure to one of four Stage 1 cognitive conditions (N = 6 per condition) as they appeared individually for the experiment. Those assigned to the Map Treatment received for study an integrated picture (See Fig. 5) of a beach scene, which included initials placed approximate to a ship, a surfer, a lifeguard, a skin diver, two girls sunbathing, a group playing in the sand, a group walking on a boardwalk, and a police patrol car. The initials used were eight CVC's of 60% association value taken from the Glaze (1928) list.

One of two partially-integrated Stage 1 conditions received a Picture condition, similar to that described in Experiment III, in which the Map was

Fig. 5. Stimulus configuration for Experiment IV.

fragmented into eight separate pictures and these pictures were distributed on an 8½ x 11-inch page in the same relative positions as they appear in the integrated map (for example, the ship was placed at the top center of the sheet, the patrol car in the lower right corner, etc.). The second partially-integrated condition, called here a Scrambled-Picture condition, received the eight separate pictures distributed in a random or scrambled placement on the 8½ x 11-inch sheet--for example, the patrol car appeared at the top right corner of the sheet, the ship appeared directly beneath it, the surfer appeared in the lower left corner, etc. The rationale for this latter condition was that the Picture treatment, while it did separate the isolated parts of the map, may still have contained some degree of structure in that the separate pictures were placed in potentially logical relationships to each other. By scrambling the pictures, any such potential organization would be less likely to occur.

The fourth group was a Label condition, identical to that described in Experiment III, in which Ss received for study in Stage 1 only the initials, placed on a blank sheet in the same relative positions as they were printed on the original map.

All conditions were given four 30-second periods in which to study the respective Stage 1 materials. These study periods were interspersed with 1-minute test periods in which the S was required to recall the various initials studied and place them correctly on appropriate test sheets. This Stage 1 procedure was the same as that described in greater detail in Experiment I.

Stage 2. Half of the Ss in each Stage 1 condition received the Stage 2 task immediately following completion of Stage 1, and the other half received a 10-minute rest before beginning Stage 2. This time variable was introduced to determine the extent to which Stage 1 effects might dissipate over a short retention period. At their respective time intervals (Immediate vs. Delayed), all Ss received the following Stage 2 task. The S was told he would now participate in a guessing task. He was given a booklet of eight 4 x 5-inch sheets of paper, stapled together in the upper left corner. At the top of each sheet appeared one of the sets of initials the S had studied previously in Stage 1. Under the initials, typed in a double-spaced vertical column, were the following phrases: is a captain, is a beachcomber, is an actress, is a lifeguard, is a skindiver, is a student, is a policeman, is a surfer. (The vertical order of these phrases varied at random on each of the pages in the booklet.) The S was instructed to read the initials at the top of the page, and then "guess which of the eight descriptive phrases is most appropriate for the person with those initials." The S went through the booklet a page at a time, reporting his guesses orally to the E. It was predicted that Ss receiving the Map condition in Stage 1 would guess consistently for each set of initials, because of a clearly organized cognitive structure, while Ss in other Stage 1 conditions would demonstrate less consistency because an adequate cognitive structure had not been developed.

Results

Preliminary inspection of the Stage 1 test data showed that all Ss learned all of the initials within the four trials administered, suggesting that the groups had equivalent familiarity with the CVC's at the end of Stage 1. Table 4 presents the means and SD's of number of correct responses on the Stage 2 guessing task for all groups. A 2 x 4 analysis of variance indicated significant differences among Stage 1 treatments, $F(3,16) = 19.20$, $p < .01$. The difference between the Immediate and Delayed conditions, and the Structure x Time interaction, were not significant, $F < 1.00$ in each case.

Table 4

Experiment IV: Data Summary for Stage 2 Task

			Stage 1 Treatment			
			Map	Picture	Scrambled-Picture	Label
Stage II Test	Immediate	M	7.0	5.67	6.00	.66
		SD	.00	2.08	1.00	.58
	Delayed	M	7.3	5.00	4.33	0.00
		SD	1.73	1.73	1.52	.00

Since the time variable was not significant and the N's in each of the eight conditions were very small, the Immediate and Delayed conditions were pooled within each Stage 1 treatment before making subsequent analyses. Individual comparisons indicated that the Map condition was superior to the Picture condition, $t(10) = 2.36$, $p < .05$, supporting the findings of Experiment III. The Scrambled-Picture group was also superior to the Label group, $t(10) = 4.32$, $p < .05$; but no significant difference between the Picture and Scrambled-Picture conditions was obtained, $t(10) = .27$, $p > .10$.

Discussion

The data confirm, with different materials and a differing Stage 2 task, the previous finding that an integrated map structure produces a cognitive organization which is superior to the cognitive structure imposed by a fragmented stimulus configuration. In contrast to Experiment III, the present study also indicates that the Picture condition is superior to the Label group. This latter finding is probably accounted for by the differing natures of the Stage 2 task in Experiments III and IV. In the former, it was possible to learn the rote sentences with no structure at all, and apparently the weak structure imposed by the Picture condition did not substantially facilitate rote learning. In the present study, however, correct guessing was virtually impossible without some form of structure, and in this case even the relatively weak cognitive organization of the Picture and Scrambled-Picture groups proved to be far superior to no structure at all.

The near equality in Stage 2 performance of the Picture and Scrambled-Picture conditions suggests that whatever organization these two groups did attain was due to the individual pictures, and not to any particular interrelationships among them. This finding may be interpreted, in fact, as an indication that the performance of these groups on Stage 2 was not facilitated by anything which might be labelled "cognitive organization," but rather was due to discrete rote associations formed during Stage 1 between pictorial and verbal stimuli.

A final point regarding the procedural aspects of Experiment IV deserves mention here. The Stage 2 guessing task was constructed so that it follows closely certain tasks which can be analyzed in terms of information theory (see Attneave, 1959). Briefly, the initials can be construed as stimulus information which, processed through an effective channel, transmits appropriate and adequate response information. In this model, the assumed cognitive structure is analogous to the channel in an information-transmission system, and the adequacy of its properties as an effective channel may be evaluated quantitatively in information-theory terms. The data collected to date are not sufficient to make a formal analysis of this type at present, but further exploratory work along these lines is being planned at the Colgate laboratory. Thus an interesting outcome of Experiment IV may prove to be the incentive it has provided for further explorations directed at linking cognitive hypotheses to information-theory.

Experiment V: Abstractness of Cognitive Structure and Retroactive Inhibition

The final experiment dealt with two problems. The first problem concerned the abstractness of Stage 1 cognitive materials. Previous studies had employed, with considerable success, pictorial maps as the stimuli for imposing a cognitive structure. However, many common learning situations involve materials in which the structural aspects of the stimuli are considerably more abstract than a simple pictorial scene. In the present study, therefore, a more abstract structural configuration was used in the Stage 1 portion of the experiment. The Ss in the Cognitive condition were exposed to a flow chart, in which various verbal materials were embedded. It was assumed that the flow chart, while considerably more abstract than a simple pictorial scene, nevertheless implied a hierarchical structure which could be utilized in forming a cognitive organization of the verbal materials. One objective of the experiment, then, was to evaluate the effectiveness of more abstract materials in imposing a cognitive structure.

The second objective was to evaluate the effect of an imposed cognitive structure upon retroactive inhibition (RI) of rote verbal materials. In rote paired-associate learning tasks, it is well established (e.g., Postman, 1961) that when an S learns two S-R tasks in which the stimuli are the same but the responses differ (A-B, A-C), the learning of the second task retroactively inhibits retention of the associations formed in the first task. The hypothesis tested in the present study was that the presence of a cognitive structure into which the first rote task can be embedded will diminish the degree to which memory for the first rote task is inhibited by the learning of a second rote task. Alternatively stated, if a rote memorization task is embedded in a cognitive structure, it will be more resistant to RI than if it is not.

Method

Subjects

The Ss were 60 college students who participated in the experiment as part of a course requirement. Each S was assigned by a predetermined random order to one of the six conditions (N = 10 per group) as he appeared for the experiment.

Design and Materials

The experiment consisted of three stages. In Stage 1, all Ss were exposed to one of three treatments (20 Ss in each treatment): a Flow Chart condition, in which S studied a flow chart configuration designed to impose a cognitive structure; a List condition, in which S was given for study a list of the verbal materials contained in the flow chart; and a Rest condition, in which control Ss were given no Stage 1 treatment.

Fig. 6 illustrates the flow chart presented to the Flow Chart group, showing a series of 10 terms arranged in a hierarchical order. The S was told that the chart illustrated the various departments of a company, and that his task was to learn the departments and their positions on the chart. The List group received for study the same 10 words, also with instructions that these terms signified departments of a company. However, for this group the words were presented in a vertical list on an otherwise blank sheet of paper, and were listed in random positions so that no hierarchy was apparent. The Ss in each of these groups received a series of 30-second study and 1-minute test trials, until they demonstrated perfect mastery of the words and their relative positions on a test trial. The Ss in the Rest group received no prefamiliarization with the 10 terms before beginning the Stage 2 task.

Stage 2 consisted of learning two lists of word-initial pairs, in which the words were the 10 terms which appeared in the Stage 1 task and the initials were CVC's of 80-100% association from the Glaze (1928) list. The word stimuli in both lists were the same but responses differed, constituting an A-B, A-C relationship.

On List 1, S was told that he would be required to learn the initials of various department heads in a hypothetical Company A; i.e., for each pair the stimulus term signified a company department and the response to be learned represented the initials of the head of that department. List 1 was then presented on a memory drum by the study-test method, using a 2:2-second rate. All Ss learned List 1 to a criterion of one perfect test trial.

Following completion of List 1 learning, half of the Ss in each of the Flow Chart, List, and Rest conditions learned List 2 for 15 trials. These Ss, constituting the Flow Chart-RI, List-RI, and Rest-RI groups, were told that the List 2 task represented learning of the initials of department heads in a hypothetical Company B. The other half of the Ss did not learn List 2, but instead were given a pencil-and-paper personality test as a filler task for 10 minutes before Stage 3 began. These latter Ss, serving as controls for the RI conditions, will be designated the Flow Chart-Control, List-Control, and Rest-Control groups.

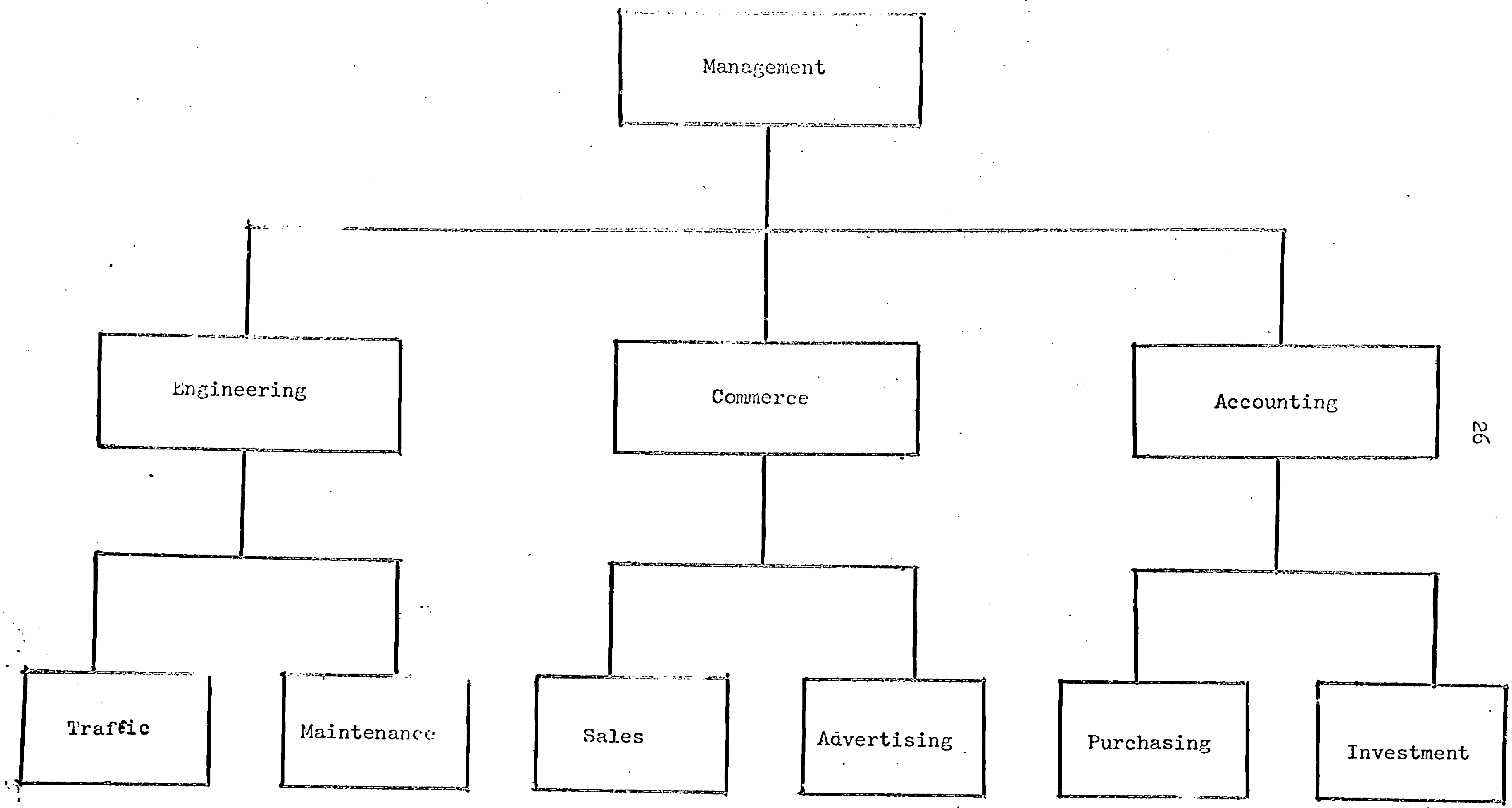

Fig. 6. Flow Chart stimulus for Experiment V.

At the end of Stage 2, all Ss received an RI test. This Stage 3 test consisted of presenting the stimulus words from the Stage 2 lists, one at a time, with instructions to recall and spell the correct initials from Company A (list 1) which were paired with each word. The RI test was unpaced, permitting each S to spend as much time as needed to give the correct response before going to the next item.

Results

The data were analyzed in three parts. First, the 20 Ss per condition who received either the Flow Chart, List, or Rest treatments in Stage 1 were compared on speed of learning List 1 at the beginning of the Stage 2 task. Second, the performances of the 10 Ss per RI condition who received both List 1 and List 2 in Stage 2 were compared. Finally a 3 x 2 analysis of variance was employed to determine the relative effects of the three Stage 1 conditions and the two Stage 2 conditions on the RI test given in Stage 3. Each analysis is presented separately below.

Structure effects upon rote learning. The mean numbers of trials to criterion on List 1 were 12.90 (SD = 6.46), 14.55 (SD = 7.35), and 16.35 (SD = 8.52) for the Ss receiving the Flow Chart, List, and Rest conditions, respectively. Although these means indicate faster learning following exposure to the structured flow chart than to the other Stage 1 treatments, an analysis of variance showed that the differences among the groups were not significant, $F(2,57) = 1.05$, $p > .10$.

This finding indicates that the Flow Chart treatment, in contrast to the map treatments used in previous studies, had no reliable effect upon subsequent rote learning, and suggests that the flow chart structure was not sufficient to impose a cognitive structure. The failure to demonstrate a significant difference is due in part to the large variances obtained within each group. Nevertheless, the finding constitutes a serious problem in terms of interpreting the other data in the experiment.

Other Stage 2 comparisons. Table 5 presents the means and SD's for both List 1 and List 2 trials to criterion achieved by the Ss in the Flow Chart-RI, List-RI, and Rest-RI groups (N = 10 per group). A 3 x 2 analysis of variance, using a repeated-measures technique in comparing the List variable (Winer, 1962, pp. 302-306), again showed no significant differences among the Flow Chart, List, and Rest conditions, $F(2,27) < 1.00$. The difference between List 1 and List 2 was highly significant, $F(1,27) = 23.21$, indicating superior learning on the second list. The F value for the interaction was 1.33, $p > .10$.

RI comparisons. The mean number of correct responses made by each group on the RI test (Stage 3) is presented in Table 6. A 3 x 2 analysis of variance performed on these data verified the expected highly significant difference between the RI and Control treatments, $F(1,54) = 86.15$, $p < .01$. However, no significant differences were found among the Flow Chart, List, and Rest groups, $F(2,54) = 1.63$, $p > .10$, and the interaction was not significant, $F(2,54) = 1.84$, $p > .10$.

Table 5

Means and SD's of RI Groups on List-1 and List-2 Learning (Trials to Criterion)

		Flow Chart-RI	List-RI	Rest-RI
List 1	M*	13.50	13.90	15.40
	SD	7.63	7.97	5.54
List 2	M*	12.26	8.99	5.71
	SD	4.31	3.27	1.95

*N = 10 per group

Table 6

Means and SD's of Number of Correct Responses for all Groups on the Stage 3 RI Test

		Flow Chart	List	Rest
RI	M	4.1	6.2	5.3
	SD	2.3	2.3	2.3
Control	M	9.5	9.4	9.8
	SD	.8	1.2	.4

Discussion

It is immediately apparent that, since no evidence was obtained to indicate the formation of cognitive structure, no conclusions may be drawn from this study concerning the effects of cognitive structure upon RI. The single relevant finding from the experiment is that the flow chart structure did not produce a reliable cognitive structure.

This negative finding deserves further comment. It seems clear that cognitive structure, as defined and evaluated in this series of experiments, is sensitive to the degree of abstraction of the materials which are used in its formation. When pictures of common scenes were used, they were apparently specific enough and concrete enough to impose in memory of both high school and college Ss a meaningful organization into which new rote material could readily be assimilated. Even Ss at college level, however, were unable to utilize the potential information contained in a more abstract structure such as a flow chart. Translated into educational terminology, the data suggest that the impact of an "overview"--i.e., instruction designed to produce a general understanding or "feel" for a new topic--may be highly sensitive to the concreteness of the materials employed. Certainly the negative findings of a single laboratory experiment are insufficient basis for making specific conclusions. The findings of Experiment V point out, however, that the development of a cognitive structure which is useful in subsequent learning is a complex and sensitive process about which not enough is known. Obviously, further research in this area is needed.

Conclusions and Implications

The research reported is interpreted as a series of initial explorations to determine a workable research definition of the term "understanding," and to evaluate experimentally its relationship to rote learning. The results of the experiments generally indicate that a viable definition of the term "understanding" was achieved by relating it to the theoretical term "cognitive structure," and that empirical evidence evaluating the relationship between cognitive structure and rote learning could be obtained.

Specifically, these experiments gave evidence of the following relationships:

a. Formation of a cognitive structure, using visually presented and concrete stimulus materials of varying configurations with both high school and college Ss, facilitates subsequent rote learning of facts related to the cognitive structure.

b. The positive effect upon rote learning of a cognitive structure imposed by concrete visual materials is attributable to the wholeness or completeness of the materials.

c. The cognitive structure imposed by concrete visual stimulus materials is not a short-term memory phenomenon, but is effective in facilitating rote learning over at least a 10-minute period.

d. Evidence collected to date regarding the adequacy of auditory stimuli for imposing cognitive structure is inconclusive, but suggests that auditory methods may not be as effective as visual methods.

e. An initial study using abstract visual materials indicates further that cognitive structure formation is sensitive to the type of stimuli employed, and suggests that cognitive formation is difficult or ineffective when abstract structural materials are used.

The exploratory nature of the research is apparent, but perhaps its most important long-range implication is that broad concepts such as "understanding" can be studied experimentally and, if a clear understanding of their role in learning and instructional processes is to be achieved, must be subjected to continuous intensive examination in the psychological laboratory.

References

Asch, S.E., Hay, J. & Diamond, R.M. Perceptual organization in serial rote learning. Amer. J. Psychol., 1960, 73, 177-198.

Attneave, F. Applications of information theory to psychology. New York: Holt, Rinehart, and Winston, 1959.

Ausubel, D.P. The psychology of meaningful learning. New York: Grune and Stratton, 1963.

Bruner, J.S. Going beyond the information given. In Contemporary approaches to cognition: Report of a symposium at the University of Colorado, May 12-14, 1955. Cambridge: Harvard University Press, 1957.

Cofer, C.N. (Ed.) Verbal learning and verbal behavior. New York: McGraw-Hill, 1961.

Cofer, C.N. and Musgrave, B.S. (Eds.) Verbal behavior and learning. New York: McGraw-Hill, 1963.

Glaze, J. The association value of nonsense syllables. J. genet. Psychol., 1928, 35, 255-269.

Goss, A.E. & Nodine, C.F. Paired-associates learning. New York: Academic Press, 1965.

Houston, J.P. Verbal transfer and interlist similarities. Psychol. Rev., 1964, 71, 412-414.

Peterson, L.R. & Peterson, M.J. Short-term retention of individual verbal items. J. exp. Psychol., 1959, 58, 193-198.

Postman, L. The present status of interference theory. In C. N. Cofer (Ed.) Verbal learning and verbal behavior. New York: McGraw-Hill, 1961. Pp. 152-179.

Winer, B.J. Statistical principles in experimental design. New York: McGraw-Hill, 1962.