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PSYCHOLOGICAL AND EDUCATIONAL FACTORS IN TRANSFER OF TRAINING, PHASE I. QUARTERLY REPORT 6.

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DESCRIPTORS- *LEARNING PROCESSES, *TRANSFER OF TRAINING, PSYCHOEDUCATIONAL PROCESSES, TASK PERFORMANCE, *PROMPTING, *CONCEPT FORMATION, *MODELS, VERBAL LEARNING, TEACHING TECHNIQUES, LOGIC, RESEARCH PROJECTS, *COGNITIVE PROCESSES,

A 3-MONTH STATUS REPORT WAS MADE ON THE ACTIVITIES PURSUED IN PHASE 1 OF A LARGER 10-YEAR PROJECT DEALING WITH THE PSYCHOLOGICAL AND EDUCATIONAL FACTORS INVOLVED IN TRANSFER OF TRAINING. REPORTS OF ONGOING PROJECTS AND THEIR CURRENT STATUS WERE PRESENTED. THEY INCLUDED (1) A STUDY OF THE TRANSFER EFFECTS OF WRITTEN INSTRUCTIONS TO TASK PERFORMANCE AND OF TASK PERFORMANCE TO TASK PERFORMANCE, (2) LEARNING HOW TO LEARN UNDER SEVERAL CUE CONDITIONS, (3) THE EFFECTS OF SEQUENCE AND STRUCTURE ON COMPLEX CONCEPT FORMATION, (4) THE USE OF A MODEL AND A GENERALIZED PREVIEW TO FACILITATE THE LEARNING AND RETAINING OF COMPLEX SCIENTIFIC MATERIALS, (5) A STUDY OF TRANSFER EFFECTS OF VERBAL LEARNING, AND (6) EXPERIMENTAL ANALYSES OF THREE PATTERNS OF PRESENTING A STANDARD LOGIC TASK. A LIST OF ARTICLES ABSTRACTED WAS ALSO PRESENTED. (GD)

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PSYCHOLOGICAL AND EDUCATIONAL FACTORS IN TRANSFER OF TRAINING

USOE Contract 2-20-003

Quarterly Report No. 6

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TRAINING RESEARCH LABORATORY

University of Illinois
Urbana, Illinois

PSYCHOLOGICAL AND EDUCATIONAL FACTORS IN TRANSFER OF TRAINING

Phase I

Quarterly Report No. 6

Period:

October 1, 1963 - December 31, 1963

Principal Investigator:

Lawrence M. Stolurow
Professor, Department of Psychology
Bureau of Educational Research

Project Sponsor:

Educational Media Branch
U. S. Office of Education
Title VII

Project No. 2-20-003

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Chapter One

Nature of Project

General Purpose

This project is concerned with the psychological and educational factors in Transfer of Training. While transfer is probably one of the most important and pervasive psychological processes in education, it has not been studied with the vigor and systematic determination that is required. Nor have the data thus far accumulated been applied to the development of media or materials.

One of the potentially more important instructional media for efficient study of transfer of training is programed self-instruction using the teaching machine. This educational medium provides laboratory-like conditions such as stabilized methods, stimulus control including the control of teacher personality, plus a step-by-step record of the student's behavior. These recordings are an important source of data which can be used for the continuous improvement of the instruction. There is, therefore, an advantage to be gained from research on transfer of learning with this new concept of instruction. Such research could be particularly useful in contributing to the development of new psychological knowledge about school related instruction.

The background of thinking and research on transfer that is pertinent to the new media and, in particular to teaching machines and self-instructional programing needs to be summarized and evaluated. The theoretical positions of transfer such as the following need to be related to one another and to these developments in instruction: Thorndike and Woodworth's identical elements, the concept of mental discipline, current conceptions of mediation, and the cybernetic theorizing grounded in models that include a feedback mechanism such as those of Simon and his colleagues, and of Miller, Gallanter, and Pribram (1960).

Objectives

This proposal to study transfer is for a long range program that will accomplish the following objectives in Phase I, the first two years.

The primary objectives of Phase I are: (1) to relate and crystalize existent information on transfer by determining its relationship to learning, problem solving, and individual differences in abilities and aptitudes, (2) to determine the implications of the existent knowledge for education and in particular for the educational media, (3) to conduct pilot empirical research on transfer, and (4) to prepare a research plan for Phase II.

Sub-goals for the project are to develop reports which (a) summarize and analyze the pertinent research, (b) examine theoretical issues and concepts, (c) analyze the relationships between transfer and learning, (d) study the relationships between transfer, abilities and aptitudes, and (e) examine the relationships between transfer and the development of cognitive structures and strategies.

It is anticipated that some comparative educational studies will be conducted to see if the principles derived from existent research can be used in educational settings where different cultural and/or language factors are operating. An effort will be made to conduct studies of cumulative transfer, longitudinal in nature.

General

1. Sample plan. For the library research the sampling plan will be to review existing treatments of transfer and the research on the topic. For empirical studies, the plans will vary with the specific designs but in general will use college and high school students, and assignments to treatments will be random.

2. Treatments. Variations in the programs used for learning will probably include a variety of treatment comparisons with the same task, e.g., inductive vs. deductive. In addition, analytical studies of the relative contribution of different types of task information will be conducted. Reliable treatment effects will be re-examined to determine their potential generalizability by introducing language and cultural differences in groups. The initial studies will use programed materials in logic, mathematics and statistics since materials of this type are designed to teach cognitive structures that could have the widest possible transfer potential for the student.

3. Controls. Programed instruction procedure employing printed texts, paper transport type of machine and a film device under computer control, will be used as the means of presenting the treatments. Socio-economic and intellectual differences will be studied in relation to the intercultural and interlanguage differences and transfer effects of instructional strategies.

Data-types to be gathered and methods to be used

Two types of instruments will be used to measure performance: (a) written tests and (b) performance tasks. Evaluations will be made to determine the dimensions of transfer as well as to estimate the amount and direction of the effects. Some dimensions are: (a) learning new and related material, (b) problem solving in which knowledge taught is directly relevant and sufficient, (c) problem solving where the knowledge is not necessary but the strategy required is relevant and useful, and (d) inferring and extending the knowledge taught to new materials.

Methods of statistical or other analysis

The analyses of variance will be used to determine the relative effects of the different treatments. Correlational analyses will be used to determine the relationships between the ability measures and performance on the learning and transfer tasks.

Approximate time schedule

Phase I is to take two calendar years (24 months). The work outlined above will constitute Phase I of the 10-year program.

Publication plans

The results of the studies completed in Phase I will be prepared as technical reports and possibly as monographs and articles. The following chapters report the status of this work and briefly summarize findings.

LIST OF PERSONNEL

October 1, 1963 - December 31, 1963

Lawrence M. Stolurow -- principal investigator

Research Assistants	% Time	Period of Employment
Daniel Davis	50%	1 October - 31 December
Henry Lippert	50%	1 October - 31 December
Eleanor Dobbins	25%	1 October - 31 December
Ellen Rosen	50%	1 October - 31 December
Tom McHale	50%	1 October - 31 December
Julie McHale	25%	1 October - 31 December
Clerical		
Amy Henschen	50%	15 October - 31 December
Freda Blecher	50%	1 October - 31 December
Verna Vaughn	50%	1 October - 31 October
Dolores Fairbanks	60%	1 October - 31 December
Bonnie Anderson	50%	1 October - 31 December
Hourly		
Valerie Anderson		1 October - 31 December
Richard McNabb		1 October - 31 December
Carolyn Olson		November
Gavin Courtney		15 November - 31 December

Chapter Two

Study of the Transfer Effects of Written Instructions to Task Performance and of Task Performance to Task Performance

L. M. Stolurow and T. J. McHale

A series of three studies which investigated the effects of various types of transfer in complex concept-formation tasks were conducted. Only two different tasks were used, and they were different only in minor aspects since each was generated from the same multiple-correlational model (see Azuma, 1960; Cronbach and Azuma, 1961, a & b). Two basic types of transfer were studied: (1) transfer to task performance from written instructions giving various amounts of information, and (2) transfer from one task to the other where the relationships between tasks are specified. This is a continuing series of studies designed to get at the informational value of different aspects of the task, effects of encoding, and the development and role of verbal mediating mechanisms (hypotheses) of the learner.

Experiment I

Amount of Information Conveyed by a Knowledge of Either the Principle or Cues Given in Algebraic or Geometric Form

Status: Data in process

<u>Purpose</u>

Pilot work suggested that information about the task principle is no better than no information, whereas information about the critical cues does facilitate performance. Furthermore, in a written questionnaire administered at the end of the task, many Ss verbalized a geometric approach to the solution of the task, whereas the original information was given in algebraic form. These verbalizations suggested that information given in geometric form would be more beneficial since the geometric approach seemed a more natural way to attack the problem.

Hypotheses

The following specific hypotheses were tested:

1. Type and amount of information: The rank-order of performance will be (a) full-information, (b) cue-information, (c) principle information and (d) no information.

2. Encoding: Whenever two groups are given the same information in different form, the group given the information geometrically will perform better than the group given the information algebraically.

3. Principles vs. cues: Though cue-information will lead to better overall group performance than principle-information, a knowledge of the principle is a requisite for criterion performance. Therefore, more Ss in the principle-groups than in the cue-groups will attain criterion performance.

Task

Each stimulus presentation consisted of a 2.5 inch by 2.5 inch square with a small red cross and a small green cross drawn inside it. The left side of the square and the bottom of the square represent coordinate axes. The location of each cross is specified by its distance from the left side and the bottom of the square. These distances are its coordinates.

In the task stimuli, each of the four coordinates; x', y', x'', and y'', may take on one of four values; 3, 6, 9, or 12. These four values correspond to actual distances of .5, 1.0, 1.5 and 2.0 inches. The number of possible combinations of the coordinate values is 4^4, or 256. However, since the crosses were not allowed to occupy the same location in any stimulus presentation, only 240 (16 x 15) combinations were actually possible. Not all of these possible stimuli were used.

Presentation of stimuli. Stimuli were presented in a booklet, each page showing six different stimuli. The booklet consisted of 160 stimuli or trials. Subjects responded by marking with an X one of 10 possible response categories. On the answer sheet, there were 10 numbers for each trial, one number for each of the 10 possible numerical answers. An X was drawn through the appropriate number. *Ss* were allowed 20 sec. for each trial, and verbal feedback in the form of the correct answer, was given at the end of each trial.

The 160 learning trials can be considered as 10 sets of 16 presentations each. Within every set of 16 possible combinations of x' and x'' each appears only once. This automatically made $r_{x'x''}=.00$. The distribtuions of y' and y'' were very close to rectangular. $r_{x'y'}$, $r_{x''y'}$, and $r_{x''y''}$ did not exceed .12 in any block. Thus, for practical purposes, these variables can be considered to be uncorrelated.

Criterion k. The formula used by *E* to define the correct response *k* is $(2x' + x'')/3$. Since x', y', x'', and y'' are uncorrelated within our set of stimuli, the definition of *k* determined their validities as follows: $r_{x'k}=.89$, $r_{x''k}=.45$, $r_{y'k}=.00$. Though the actual correlations of x' and x''

with k vary between -.12 and +.12. Since the 10 discrete response categories are exact numerical answers, S had to use precisely a 2 to 1 weighting to receive 100% reinforcement.

Measure of performance. The basic measures of performance were the criterialities* of the individual cues and of the construct k: product-moment correlations coefficients of the actual responses of each S with the responses he would give if he were to make his judgments solely in terms of x', x'', y', y'', or k. This yields a 5 x 5 matrix of correlations for each S: rows for x', x'', y', y'', and k; columns for each block of 32 trials which were analyzed separately. Correlations were computed over blocks of 32 trials -- 1-32, 33-64, 65-96, 97-128, 129-160.

Subjects

The Ss were University of Illinois students from the introductory psychology class. Their participation was the class requirement. The task was administered to Ss in groups that ranged in size from 3 to 20. With the larger groups, at least two, and sometimes three, Es helped with the administration. There were 15 Ss in each experimental group for a total of 120 Ss.

Experimental Design

There were seven groups in the basic design of this study. (An eighth group was run in an auxiliary experiment which will be discussed). There was a no-information group as a control, and two sets of principle-, cue-, and full-inf rmation groups. One set was given information in algebraic form; the other in geometric form. This design allowed a comparison of principle- vs. cue-information, and algebraic vs. geometric information.

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*Criteriality according to Bruner (1956) means how much a cue is actually used by an S.

Results

The correlational analysis of the data has been completed, but statistical analyses of the questionnaire data has not yet been completed. The statistical analyses which have been completed lead to the following conclusions about the experimental hypotheses:

1. The predicted rank-order order of performance was confirmed. That is, full-information was best, then cue-information, and there were no major differences between the principle-information and no-information groups.

2. There were no overall differences between the geometric and algebraic information groups. However, the geometric groups tended to do a little better with full- and cue-information and a little worse with principle-information. None of these differences was significant.

3. The hypothesis that there would be more solvers in the principle groups than in the cue groups was not confirmed. This failure of confirmation is related to the overall superiority of performance of the cue-groups.

Experiment 2

A Comparison of Transfer Effects From Written Instructions
Under Paced and Self-Paced Conditions

Purpose

This study is basically a replication of some of the groups in Experiment 1. The main difference is that in this experiment, each subject worked at a teaching machine and consequently was self-paced. Comparisons were, therefore, possible between a paced and a self-paced condition, with major emphasis on two variables: (1) trials to criterion, and (2) time to criterion.

Hypotheses

The following specific hypotheses were tested:

(1) Since the self-paced condition allows each subject to proceed more slowly in the early trials when time to think is more necessary, subjects in this study should attain criterion performance in fewer trials than comparable subjects in Experiment 1.

(2) Time to criterion should also be facilitated in the self-paced condition, though the difference between pacing and self-pacing should not be as large here as in trials to criterion.

Method

Task stimuli. Only one minor change distinguishes the task stimuli from those of Experiment 1. Instead of using red and green crosses, the red cross was replaced by a black circle and the green cross by a black cross. These changes facilitated filming for the teaching machine, and also eliminated the difficulty encountered by color-blind subjects.

Presentation of stimuli. Stimuli were presented on a teaching machine. Only one stimulus frame was seen at a time by the subject; the correct answer for each frame was given on the following frame. The subject could return only to the immediately prior frame to investigate any discrepancy between his answer and the correct answer. Therefore, the presentation of stimuli was equivalent to a straight linear program.

Subjects

The subjects were college students from the University of Illinois from an introductory psychology class. Their participation was a class requirement. Subjects were run in groups of not more than five each. There were 15 subjects in each experimental group for a total of 60 subjects.

Experimental design. There were six experimental groups in this study; three of the four were replications of the no-information and full-information (both algebraic and geometric) groups of Experiment 1. The fourth group, also a full-information group, is comparable to the column-group in Experiment 3. The fifth and sixth groups are cue and principle groups for whom the information is given in terms of the column-group's model.

Status

All of the subjects have been run. The data are being processed.

Experiment III

Some Perceptual and Verbal Factors in the Transfer From One Task to Another One Generated From the Same Model

Purpose

When the verbalized rules of the solvers in Experiment 1 were categorized, seven categories were needed. These verbalizations ranged from general and abstract to very specific. If different verbalized rules mean that the subjects have really learned different concepts even though their overt behavior is the same, then differences in transfer to a second task should be predictable. This study was designed to test the hypothesis that differences in transferability of training can be demonstrated on the basis of different verbalized rules, even though all subjects have solved the same training task. It was designed to determine whether the solution of the training task is as relevant to transfer as a subject's own verbalizable rule for solution. It also was designed to study the transfer effects of different symbol systems (ways of encoding).

Hypotheses

The following specific hypotheses were tested:

1. From a comparison of the verbalized rules used by Ss in Task 1 with the rule they must learn to solve Task 2, rank-order predictions of the speed of solving Task 2 can be made.

2. Perceptual similarity of the cues in each task should lead to faster solution of Task 2 than perceptual dissimilarity of cues.

3. When the stimuli of two tasks are not obviously similar and Ss may not suspect that the two tasks are related, instructions stating that the two are related should facilitate the speed of solution for Task 2.

4. When two tasks are perceptually dissimilar, the predicted transfer effects should occur only among those Ss who consciously relate the two tasks. There should be no transfer effects among those Ss who do not consciously relate the two tasks. That is, their behavior should not be distinguishable from that of the Ss in a control group.

Method

Task stimuli. The training task in this study was essentially the same as the task used in Experiments I and II. There were two minor changes:

1. A small black circle and small black square replaced the red cross and green cross.

2. The stimuli were presented to S on individual cards. The transfer task used 3 x 5 stimulus cards on which a circle, square, triangle, and rhombus appeared. Either a 1, 2, 3, or 4 appeared within each geometrical figure. The numbers within the figures replaced the four coordinates in

the training task. Only two of the four figures were relevant. The correct rule to obtain k (criterion response) was the sum of two products, either: (a) 2 (number in the circle) +1 (number in the square), or (b) 2 (number in the triangle) +1 (number in the rhombus).

Presentation of stimuli. After the subject(S) read one of three sets of full-instructions, the experimenter gave him stimuli for Task 1 one at a time. The S gave his numerical response and the rule he was using on each trial in both tasks. After attaining criterion in each task, E switched the formula by reversing the weightings of the two relevant cues. In neither task was the subject informed that a switch was being made, nor was he allowed to ask questions at this time. This switching of rules was included to investigate the transfer effects of a first reversal shift to a second. After solving the first task and its shift, the subject was read the instructions for Task 2 and began it immediately. Post-experimental interviews were conducted after each task.

Experimental design. The four sets of instructions were: (a) full-information row [k=2 (row of the circle) +1 (row of the square)], (b) full-information column [k=2 (column of the circle) +1 (column of the square)], (c) full-information algebraic, and (d) a solution in which the 2:1 weighting was only implicit. These sets of instructions were suggested by verbalizations of the subjects in Experiment I. In this sense, the instructions given were second generation solutions to the problem. The three types of transfer task were differentiated by (a) correct formula, and (b) knowledge of the relatedness of the two tasks. There were two types of correct formula:

(a) 2 (number in circle) +1 (number in square), (b) 2 (number in triangle) +1 (number in rhombus). The third type, also given Formula 1, included a hint that the training and transfer tasks were related.

Design. This generated a 4 x 3 factorial design, with both factors fixed.

Subjects

Five S were run in each cell for a total of 60 experimental Ss. A control group of 20 Ss was also run, half solving each of the two formulae. The control group was allowed to warm up on a neutral memory task, before working on Task 2.

Results

The data for the study have not been completely processed. An effort is now being made to scale Ss into positive, negative, and no-transfer groups on the basis of what they said they attempted to relate from the first to the second task. The rest of the data is still being analyzed. The following tentative conclusions can be made:

(a) Hypotheses 1, 3, and 4 were confirmed.

(b) The conclusion about hypothesis 2 is not clear. It seems that perceptual similarity of cues facilitates performance if the verbalized principles of solution are similar for the two tasks but that it has no noticeable effect on transfer if the verbalized principles are not similar.

Chapter Three

Learning How to Learn Under Several Cue Conditions

Dale Mattson*

Status: COMPLETED--See Technical Report No. 1**

Purpose

This was an experimental study with two major purposes. The first objective was to determine the effects of several kinds of training on the subsequent mastery of a modified form of a problem solving task developed by Azuma (1960). The second major purpose was to evaluate the usefulness of cue-response criterialities in explaining transfer effects.

Hypotheses

1. Three kinds of transfer effects can be identified and compared: an effect associated with cue repetition, a learning-to-learn effect, and a warm-up effect.

2. Cue repetition is expected to result in a negative effect under a condition similar to a nonreversal shift (relevant cues during training become irrelevant during the criterion task) and a positive effect under a condition in which the same cues are relevant for training task and criterion task.

3. On the first trial of the transfer task, single-trial criterialities will be higher for cues previously relevant than for cues previously irrelevant.

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*This study was done in partial fulfillment of the requirements for a Ph.D. degree.

**Mattson, Dale. Learning How to Learn Under Several Cue Conditions. USOE-Title VII Project No. 2-20-003, Technical Report No. 1, August, 1963.

Method

Design. The design of this study was a factorial design involving two degrees of similarity between training tasks and the criterion task, and three degrees of similarity between the cues used for the training task and those used for the criterion task. In addition to the six groups (16 Ss per group) necessary for this design, an additional group of 16 Ss was used as a control group. These control Ss performed only the criterion task. The entire experiment was duplicated--once using large group testing procedures and once testing groups of either 7 or 14 at a time.

Subjects

The Ss for this experiment were all undergraduate college students. For the first experiment in which large group testing procedures were used, the Ss participated in the experiment as a part of a course requirement either in psychology or in educational psychology. For the second experiment all Ss volunteered to take part.

Results

The results of the study may be summarized as follows:

1. A learning to learn effect was identified. Those Ss that received training on a series of training tasks similar to the criterion task solved the criterion task in fewer trials than Ss for whom training tasks were not similar to the criterion task.

2. No transfer effect was found for the similarity of cues between the training tasks and the criterion task. For some Ss relevant and

irrelevant cues remained constant for all tasks; for some Ss relevant and irrelevant cues were reversed on the criterion task; and for some Ss completely new cues were introduced during the criterion task. The number of trials needed to solve the criterion task was not affected by any of these three cue conditions.

3. A warm-up effect was identified. Subjects who performed a series of four tasks quite different from the criterion task, using four cues unlike those used on the criterion tasks solved the criterion task in fewer trials than Ss in a control group.

4. The use of the same two cues in the solution of a number of training tasks resulted in an increased use of these cues on the first trial of the criterion task. The criteriality (correlation) between cues and responses was higher on the first trial of the criterion task for cues which had previously been relevant than for cues which had been irrelevant.

Since no differences were found between experiments for all tables data from both experiments was combined.

Chapter Four

The Effects of Sequence and Structure
on Complex Concept Formation

Daniel Davis and L. M. Stolurow

Status: COMPLETED--See Technical Report No. 4*

Purpose

Since there are several different principles that can be invoked in structuring or sequencing the training trials of a task, it is important to know the transfer effects produced by the different principles. In this study, four groups of Ss were given different training conditions as specified by four different principles in order to determine the effects produced in the learning of a transfer task.

Hypotheses

Three questions were examined:

1. What is the effect of adding asynchronous trials?

2. What is the best order of presentation of the asynchronous (A) and synchronous (S) training trials?

3. During the asynchronous trials, is it better to present the more relevant cue varying first?

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* Davis, Daniel J. The Effects of Sequence and Structure on Complex Concept Formation. USOE-Title VII Project No. 2-20-003, Technical Report No. 4, January, 1964.

Method

Several ways of structuring and sequencing the early trials of a complex task were compared. Four experimental groups received both structured (asynchronous) and unstructured (synchronous) training trials. The asynchronous trials were divided into two segments: A-MAX (the more relevant cue was free to vary) and A-MIN (the less relevant cue was free to vary). The four experimental conditions were generated by the different sequential orders of presenting the structured and unstructured trials (A-S vs. S-A) as well as the two types of asynchronous trials (MAX-MIN vs. MIN-MAX). A control group received only synchronous training.

The task was the same as used by McHale and Stolurow (1962). Each S was given 160 presentations in five blocks of 32 trials. The design used is in Table 1.

Table 1

Experimental Procedure

	Training		Task
	(1-32)	(33-64)	(65-160)
Exp. 1	A(MIN-MAX)	S	S
Exp. 2	A(MAX-MIN)	S	S
Exp. 3	S	A(MIN-MAX)	S
Exp. 4	S	A(MAX-MIN)	S
Control	S	S	S

Subjects

Subjects were taken from the Introductory Psychology course at the University of Illinois. There were 11 subjects in each treatment.

Results

It was found that asynchronous training did not significantly improve performance. It is felt that this lack of improvement was due to the following two factors:

1. The lack of generalized learning due to training on only one member of the class of asynchronous blocks.

2. The over-emphasis of the less relevant cue.

For the experimental groups, it was found that the presentation of synchronous training trials prior to asynchronous training did not improve performance. Therefore, the hypothesis that this would aid transfer by familiarizing subjects with the transfer task prior to synchronous training was not founded.

It was found that presenting a sequence in which the maximally pertinent cue varied first (A-MAX condition) led to improved transfer task performance. This is an indication that the order of training on a complex task should proceed from the more relevant to the less relevant aspects.

Further research. The conclusions arrived at in this experiment will serve as the basis for future investigations. In particular, the following questions are of interest:

1. How does the type of asynchronous training affect transfer? On the basis of this experiment, it is expected that training which involves only maximally pertinent cues should be superior to that which involves only minimally pertinent cues.

2. How does the amount of asynchronous training affect transfer? There are several issues here. First, there is the question of how much training should be given for each type of asynchronous block (fixed cross in a given position).

Second, there is the question of how many types of asynchronous blocks should be presented for optimum transfer. These two questions relate to the multiple problem training issue as discussed by Morissett and Hovland.

Third, there is the question of apportioning training among the more pertinent aspects. Is it better to decrease the amount of training for the less pertinent aspects of a problem as compared with the more pertinent aspects? There is some slight evidence that this is the case. However, a direct test of this hypothesis is necessary before a definite conclusion can be made.

3. How does the order of asynchronous training affect transfer? It was demonstrated in this experiment that transfer is greater when the more pertinent cue is allowed to vary first. This suggests that there is an order relationship in training which is based on the relevancy of the aspects. That is, the more relevant or pertinent aspects should be presented first.

This should be demonstrated for the case of three or more aspects, each differing in their relevancy to the solution before this order effect is accepted.

Figure 1A: Average Criterialities of the (A-S) Groups and the Control Group

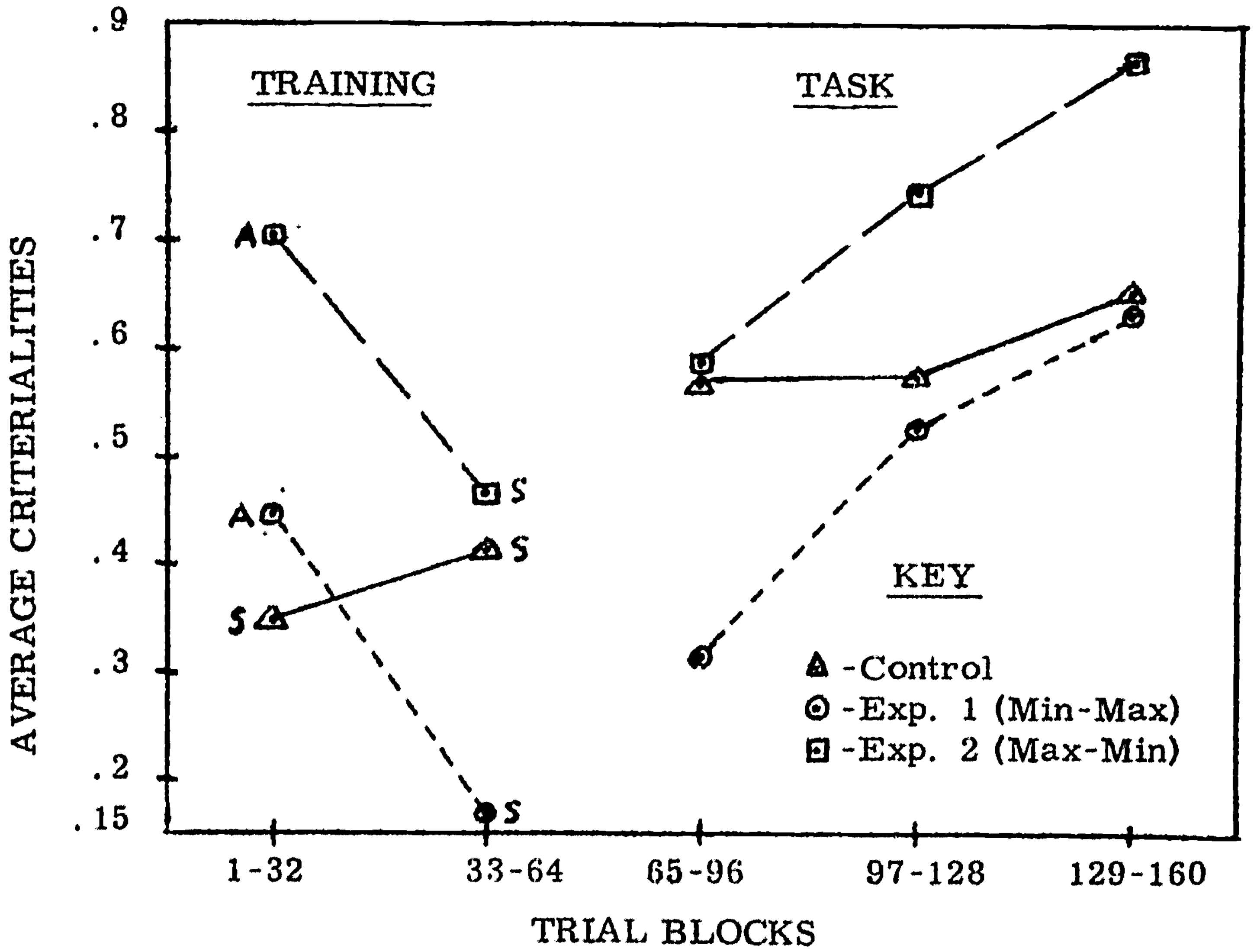

Figure 1B: Average Criterialities of The (S-A) Groups and the Control Group

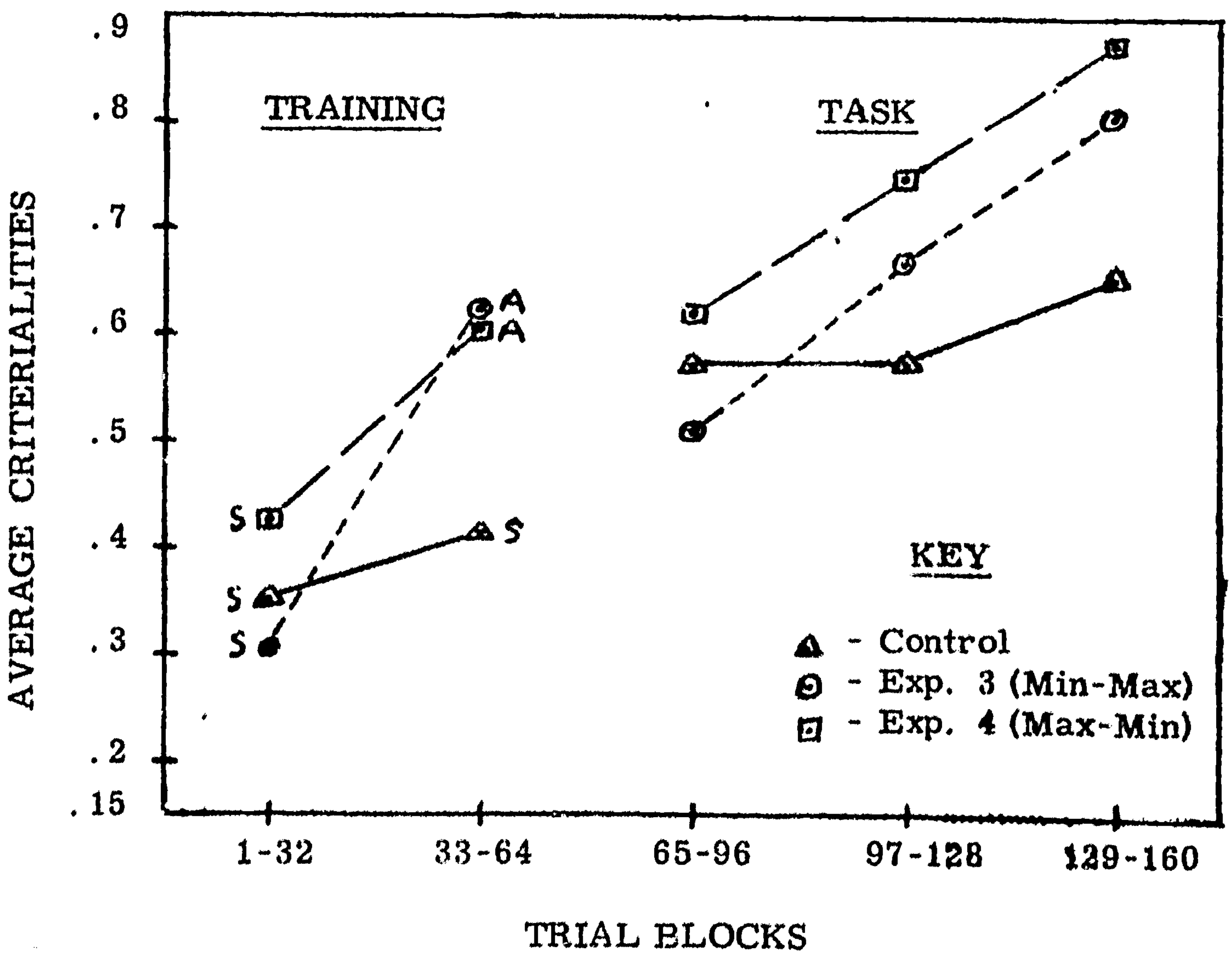

Table 2

Summary of Analysis of Variance
of Task Scores for the
Experimental Groups[a]

Source	SS	d.f.	MS	F
Between Subjects	33.383	43		
A(S-A Order)	.858	1	.858	1.188
B(MAX-MIN Order)	3.180	1	3.180	4.404[b]
A X B	.447	1	.447	.619
Subj. within grps.	28.898	40	.722	
Within Subjects	18.112	88		
C(Trial Blocks)	6.781	2	3.391	24.396[c]
A X C	.050	2	.025	.180
B X C	.162	2	.081	.583
A X B X C	.021	2	.021	.079
C X Subj. within a groups	11.098	80	.139	

aThe K-criterialities were transformed to Fisher-Z scores for this analysis.

b$F_{.95}(1, 40) = 4.08$

c$F_{.99}(2, 80) = 4.92$

Chapter Five

The Use of a Model and a Generalized Preview to Facilitate the Learning and Retaining of Complex Scientific Materials

M. David Merrill*

Status: COMPLETED--See Technical Report No. 3**

Problem

There is need for guidance in the organization of materials to promote learning and transfer. Several competing principles exist in the case of education and educational psychology. Programed instruction provides a useful medium for the examination of these principles since they can be used to prepare self-instructional programs and the effects can be readily determined in terms of performance differences of students. This general problem was examined using Ausubel's subsumption theory.

Hypotheses

Based on Ausubel's subsumption theory and its implications for the use of advance organizers, it is hypothesized that presenting a model and/or a preview prior to the presentation of complex verbal materials will facilitate the learning and retention of those materials.***

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*This study was done in partial fulfillment of the requirements for a Master of Science degree in education.

**Merrill, M. David, Learning and Retention Effects of a Model and a Preview in Teaching an Imaginary Science. USOE-Title VII Project No. 2-20-003, Technical Report No. 3, November, 1963.

***Experimental program is on file in University of Illinois Library under the title "Xenograde Systems: An experimental program" by M. David Merrill (unpublished).

Experiment 1

Subjects

Four groups of high school students were divided into high and low IQ groups.

Method

Group 1 was presented a model and a preview prior to learning a complex imaginary science; Group 2 was presented the model prior to the science and received a review in place of a preview; Group 3 was presented a preview prior to the science; and Group 4 was presented only a review but no model or preview. The same mode of presentation was used for all groups -- linear programed booklets. Students were tested both immediately after completing the program and two weeks later.

Experiment 2

Subjects

Two groups of college students learned the materials that were learned by Groups 1 and 4 in Experiment 1.

Method

The mode of instruction was by MIN-MAX teaching machine. The subjects were tested immediately following learning.

Results

Results indicated no significant main effects; there were two significant interaction effects: (a) retention as measured by Application items was best for high IQ students when presented a model but best for less gifted students when no model was presented; and (b) retention as measured by items measuring Taught Knowledge was best when no model or preview was presented and poorest when only a model but no preview was presented. Thus, this theory did not prove to be useful and, in fact, indicated that the opposite practice should be followed.

Implications. An analysis of test performance seems to indicate that the teaching machine program was effective in teaching knowledge of terminology and knowledge of specific facts, but was ineffective in teaching understanding necessary for problem solving. It was suggested that before one would be justified in failing to reject the null hypothesis, one would want to replicate the experiment with a revised program that would enable students to attain a higher level of understanding as measured by problem solving ability.

Chapter Six

A Study of Transfer Effects of Verbal Learning

L. M. Stolurow and George E. Brehman

Status: Report is being written

Purpose

A study of mediation under a special set of conditions, namely, when directional associations exist between the individual words in two serial lists. The effects of this relationship between words is being examined in terms of (a) transfer to the second list, and (b) the recall of both lists following their mastery. The study would extend a mediational interpretation of transfer by revealing the potential duality of effect that can occur if the terms used in the two lists are both cues and responses to the corresponding word position in each list.

Hypotheses

The hypothesis tested was that bi-directional associates will produce inhibition rather than facilitation of the mastery of the second list.

Method

The initial and transfer lists "A" and "B" were presented by visual projection. The words in each serial list were presented for an interval of approximately one and three fourths seconds. Three experimental conditions were presented. The first, or E-1, condition consisted of an "A" list whose words were positionally opposite bi-directional associates of the words in the standard "B" list. The second, or E-2, condition consisted of an "A" list whose words were bi-directional associates of the words in the standard "B" list but random as to position. The third, or Control, condition consisted of an "A" list whose words were associationally neutral with regard to the standard "B" list but equal in difficulty and average syllable length with regard to the "A" lists of conditions E-1 and E-2. Equation as to difficulty was achieved by use of the trigram frequency method.

Subjects

Volunteers from student teacher sections of Educational Psychology 211 were randomly assigned to the three experimental conditions.

Results

Obtained data indicated that, in contrast to earlier findings by Stolurow and Swenson (unpublished study), under uni-directional association conditions; n egative transfer does, in fact, occur when the words in the second list to be learned are bi-directionally associated with the words in the first list. In addition, accuracy of recall was found to be less when the associates were not opposite from one another but not significantly affected when the associates were placed opposite to one another.

Table 1

Experimental Conditions for Learning and Transfer

Experimental Groups				Control Group	
E-1		E-2		C	
List A	List B	List A	List B	List A	List B
10 stimulus words from free association lists	10 response words from free association lists matched as to position across lists	10 stimulus words from list A in E-1 but random in their order	Same 10 response words in same order as in E-1	10 neutral words equated with list A in experimental groups as to difficulty and syllable length	Same 10 response words in same order as in E-1

Table II

Experimental Condition Means and Significant Differences

Measure	E-1	E-2	Control	F	H
List A Trails to Criterion	13.65	12.60	17.94	2.87	-
List B Trails to Criterion	9.65	10.60	7.84	-	10.81*
List A Accuracy of Recall	9.05	5.90	8.56	5.75*	-
List B Accuracy of Recall	9.85	9.80	9.87	-	-
Errors-Actual and Potential	2.45	5.00	2.00	3.59**	-
Inter-list Association Errors	0.50	0.00	0.00	-	9.20**
Intra-list Association Errors	1.20	2.90	1.12	5.98*	-

Note: E-1 N is 20
E-2 N is 10
Con.N is 16

Note: *significant at .01 level
**significant at .05 level

Table III

Experimental Condition Standard Deviations

Measure	E-1	E-2	Control	X^2	$X^{2*}(.05)$
List A Trials to Criterion	5.41	6.65	7.22	1.42	5.99
List B Trials to Criterion	4.89	3.27	5.66	8.32*	5.99
List A Accuracy of Recall	2.16	3.45	2.06	3.85	5.99
List B Accuracy of Recall	0.37	0.63	0.35	-	-
Errors-Actual and Potential	2.58	4.03	2.48	3.56	5.99
Inter-list Association Errors	0.76	0.00	0.00	-	-
Intra-list Association Errors	1.38	1.79	1.15	2.21	5.99

Note 1: d.f. equals two for all measures
Note 2: *significant at .05 level

Chapter Seven

Experimental Analyses of Three Patterns of Presenting a Standard Logic Task

Lawrence T. Frase, L. M. Stolurow, and David Suh

Status: Analysis completed.

Purpose

To study some specific ways in which the learning of logic transfers to problem solving (as defined by application test items).

Hypotheses

The study was concerned with the validity of branching sequences. More specifically, it was a study of the effects of presumed "remedial" branches on learning and transfer. The branches of the program were prepared in the usual manner, by having the programer (an experienced teacher) insert materials that students would read if they made an incorrect response.

Students

Three groups of students enrolled in an introductory course in philosophy, totaling 141 people, were subjects. In addition, 23 students enrolled in a speech course were included for an additional comparison.

Method

The patterns of presentation of the logic program are the independent variables to be investigated in relation to learning and transfer. All Ss read the same material in Book I. After that, they received different treatments as indicated in Table 1.

Table 1

Programing Pattern (Main Treatments)

Maximum Linear						Minimum Linear						Branching					
Books II III						Books II III						Books II III					
						Dependent Variables											
1	2	3	4	5	6*	1	2	3	4	5	6	1	2	3	4	5	6

The dependent variables used to measure transfer were application and knowledge items on the test administered after the program was completed.

Results

Analyses of variance. Analyses of variance indicated that there were no significant differences between groups using the branching, maximum linear, or minimum linear programs on any of the dependent variables or on pretest measures of logic performance.

*The arabic numerals 1, 2, 3, 4, 5, and 6 represent the following respective measures; pretest scores on knowledge and application of logic; errors made in the program; scores on a review test; scores on a post-test of logic; the gains made in application (pretest/post-test differences); the gains made in knowledge (pretest/post-test differences). The same Book I was used in all groups.

Auxiliary analysis of variance. An additional comparison group was included to provide an index of the amount of improvement of students in philosophy courses as compared to those in courses which do not pursue topics directly related to the content of the programed logic materials used in this experiment. In addition, it was desirable to verify that consistent differences could be obtained between groups divided on the basis of academic pursuits. With such group differences in pretest performance, further experiments could be conducted (factorial and discriminant analyses) to indicate specific abilities which contribute to superior performance in logic tasks and/or information would be gathered concerning the effect of further classroom logic experience.

For purposes of this comparison, a group of 23 students from a class in introductory speech was included in the analysis. Pretests of logic indicated that the speech group did not differ significantly from the three groups of philosophy classes.

The speech group was significantly lower than the philosophy groups on the post-test of logic (both knowledge and application items). The speech group was also significantly lower on the amount of gain (post-test minus pretest scores), but only on knowledge items. These results are summarized on the following pages.

Table 2

Means and Standard Deviations for Logic Post-test Scores and Gain Scores

	Logic Post-test						Gain Scores					
	Total		Application		Knowledge		Total		Application		Knowledge	
Group	$\overline{X}$	S.D.	$\overline{X}$	S.D.	$\overline{X}$	S.D.	$\overline{X}$	S.D.	$\overline{X}$	S.D.	$\overline{X}$	S.D.
Philosophy 1	22.57	6.75	29.16	5.06	51.73	3.18	8.02	5.65	.32	4.41	8.52	3.38
Philosophy 2	23.09	7.65	28.28	5.45	51.57	3.22	8.84	5.50	-.38	4.36	8.64	4.30
Philosophy 3	22.62	6.90	28.76	4.73	51.38	3.21	8.26	5.63	.44	3.75	8.36	3.69
Speech	17.22	26.70	23.22	16.30	40.43	12.37	4.30	7.95	1.22	4.76	3.48	3.65

Table 3

Analysis of Variance for Post-test Knowledge Items

Source	SS	DF	MS	F
Between	614.80	3	204.93	6.86*
Within	4780.15	160	29.88	
Total	5394.95	163		

*Significant at .01 level.

Table 4

Analysis of Variance for Post-test Application Items

Source	SS	DF	MS	F
Between	617.28	3	205.76	3.49*
Within	9432.33	160	58.95	
Total	10049.61	163		

*Significant at .01 level.

Table 5

Analysis of Variance for Total Post-test

Source	SS	DF	MS	F
Between	2447.34	3	815.78	5.31*
Within	24573.65	160	153.59	
Total	27020.99	163		

*Significant at .01 level.

Table 6

Analysis of Variance for Gain Scores (Knowledge)

Source	SS	DF	MS	F
Between	501.27	3	167.09	11.618*
Within	2301.09	160	14.38	
Total	2802.36	163		

*Significant at .01 level.

Table 7

Analysis of Variance for Gain Scores (Total)

Source	SS	DF	MS	F
Between	2447.34	3	815.78	5.31*
Within	24573.65	160	153.59	
Total	27020.99	163		

*Significant at .01 level.

It seems reasonable to conclude from these results that the philosophy groups were superior in logic performance. This result can be attributed to further class experience in logic beyond the subject matter of the programed logic texts used in this experiment. The significant differences in knowledge without commensurate gains in application item performance indicates that, although students in philosophy may gain more in knowledge of the subject matter with which they deal, this does not mean that they make superior gains (relative to groups not studying philosophy) on items which provide a measure of transfer (application items).

Pretest

Students who scored high on application items of the pretest tended to make fewer errors on the program than those who did not score high on application items. Application items of the pretest were better predictors of the number of errors a student made in the program than knowledge items.

The correlation of application items with the number of errors made in the program was -.43; the correlation of knowledge items with errors, however, was -.22 (N=161). These results are for Book I of the logic program, but the results were in the same direction for Books II and III, although the third book had the lowest correlations among those variables (knowledge x errors; r=-.15 (non-significant) application x errors; r=-.25).

The pretest total score correlation with errors in the program reflected these correlations. The correlation of the total pretest score with errors in the program for the three books was; I, r=-.37; II, r=-.40; III, r=-.39.

Review Test

The review test scores of the three booklets were also correlated with the errors in the program. For Book I, the correlation was -.38, for Book II, -.37; and for Book III, -.49. Again, N=161.

Post-test

Errors in the program were more highly correlated with application items on the post-test than with knowledge items on the post-test. Application items tended to be consistently related more highly to errors in the program than knowledge items, which represent simple recall of information. The correlations of knowledge items with errors in Books I, II, and II, were -.40, -.31, and -.32 respectively. The correlation of errors in the program with post-test application items was, for Books I, II, and III; -.43, -.47, and -.37 respectively: N=154.

For the total post-test score, the correlation with the number of errors made in the program was, for Books I, II, and III respectively; -.50, -.48, and -.41.

These data are consistent with the data obtained by Frase (1963) using Booklet I of the logic program. These correlations are statistically, and what is more important, practically significant. For one thing, they show that application items seem to have the greatest import for use in predicting and assessing student performance. The correlation of the knowledge and application test scores on the pretest was .16 (non-significant); on the immediate post-test the correlation was .43; and on the retention test (here N=57) the correlation was actually -.25 (significant at .05). This result is especially interesting. This suggests a highly specific sort of learning. It seems that students who retained the material the best were the least able to transfer their knowledge. This effect only occured sometime after the initial learning experience, since the correlation at the time of the immediate post-test was in the opposite direction. At best, this is a bothersome finding. Further, consider the knowledge and application items of the retention test as two subsets of the composite retention test. The correlation of the total retention test with the knowledge items was .92, with the application items .06 (non-significant). This difference in correlations was obtained in spite of the fact that the standard deviations of the two variables were comparable (3.2 and 3.8).

The number of errors made on one book tended to be correlated with the number of errors made on other books. The errors on the first book with those on the second (r=.39); II-III (.55); I-III (.36).

The relationship of knowledge and application items to the total pretest score is not so clear. The correlation of knowledge items to the total test was .59, of application items to the total, .89 (N=161). In this case, the standard deviations were 2.9 and 4.8 respectively, which complicates the picture since the correlation of a subtest with the total is in part dependent upon the variance of the subtests in question.

Relationship of the Pretest and Post-test Scores

The correlation of pre-and post-test scores was .62. The pretest application items were correlated .62 with the post-test total, while the pretest knowledge items were correlated .23 with the post-test total (N=155). Application items were not only predictors of the errors subjects made in the program, but also of the scores they made on the post-test.

The correlation of the application items on the pretest with the application items on the post-test was .63. The correlation of the knowledge pretest scores with knowledge post-test scores was .24. This is consistent with the finding that knowledge items contribute the most to retention test scores, since the difference in these correlations reflects greater changes in knowledge than they do changes in success of application items.

Retention Test Scores

The total retention test score was related to the number of errors made in the three booklets; the correlation of retention scores with Book I was -.32; with Book II -.30; with Book III -.47.

The total retention test was correlated with the total pretest and post-test scores (.49 and .63 respectively). The retention test was more highly related to application item scores on both the pre- and post-tests than to the knowledge items on those tests, in spite of the fact that knowledge items contributed largely to the retention test scores. For the pretest, the retention test was correlated .07 (non-significant) with knowledge items and .56 with application. For the post-test, the retention test was correlated .41 with knowledge items and .64 with application items.

It will be recalled that the total retention test correlated .06 with the application items (as a subtest) and .92 with the knowledge items. On the post-test total correlation with the application and knowledge subtests, the correlations were .90 and .77 respectively. On the pretest, because of variance differences, we can most likely assume that both subtests contributed equally.

It is a particular characteristic of logic materials (in the type used in the booklets) that to answer any question involving ordinary language, one must know and apply specific rules. The knowledge and application items of the retention and post-tests are supposed to index the degree to which students know and apply those rules. But the materials of the booklets themselves contain many examples of ordinary language arguments, i.e., examples of application items. This is part of the instruction. As a student goes through a program, he learns, by repetition, a series of rules and also a series of application items. Since the programs contain a good number of the application items, immediate testing using applications of rules would most likely yield fairly high scores. Since the application items represent a more difficult case of memorizing, i.e., there are semantic contexts involved, students cannot merely memorize all possible application items. They can memorize the specific rules and names of propositions, etc. This means that the drop in scores of application items (relative to knowledge items) on the retention test does not necessarily represent a change in the degree to which students can apply the rules. It may represent the decay of the memory for the specific application items contained in the logic materials. In other words, "application items" on the immediate post-test may not be "application items" in the same sense as they are on the retention test. They provide a more adequate index of application on the retention test by virtue of the very frequency with which they occur in the materials during the learning experience. In short, the post-test may not reveal any true transfer to application items at all. It may merely indicate that these types of items have been dealt with recently. The relative difficulty of retaining the application material would be expected to yield a different decay function than the memory for rules.

Chapter Eight

List of Articles Abstracted

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