DOCUMENT RESUME

ED 029 305 24 CG 003 714

By-Wittrock, M.C.; Hill, Claude E.
Children's Preferences in the Transfer of Learning. Final Report.
California Univ., Los Angeles.
Spons Agency-Office of Education (DHEW), Washington, D.C. Bureau of Research.
Bureau No-BR-5-0598
Pub Date Nov 68
Contract-OEC-6-10-303
Note-69p.
EDRS Price MF-$0.50 HC-$3.55
Descriptors-Concept Formation, Elementary School Students, *Learning Processes, *Research, *Transfer of Training, Verbal Stimuli, Visual Stimuli

The purpose of these four studies (two pilot studies and two experiments) was to investigate the effects of verbal processes and dimensional preferences in children's learning and transfer. Experiment I investigated the effect of verbal instructions upon motor responses. Discriminate verbal instructions produced statistically significant higher scores on the transfer task than did instructions used indiscriminately. Experiment II investigated the effects of children's dimensional preferences in the learning and transfer of concepts. Both experimental designs consisted of an original learning phase followed by two tests of transfer. The results of the studies suggest the importance of these variables in children's learning and the need for further study of such proactive processes. (NS)

FINAL REPORT
Project No. 3264
Contract No. OE-6-10-303

CHILDREN'S PREFERENCES in the TRANSFER OF LEARNING

M. C. Wittrock and Claude E. Hill

University of California
Los Angeles, California

November, 1968

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Bureau of Research

FINAL REPORT
Project No. 3264
Contract No. OE-6-10-303

CHILDREN'S PREFERENCES IN THE TRANSFER OF LEARNING

M. C. Wittrock and Claude E. Hill

University of California
Los Angeles, California

November, 1968

The research reported herein was performed pursuant to a contract with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Bureau of Research

To the children who drew the lines and sorted the cards.

Acknowledgments

The research described in this final report represents the time, energy, and thinking of many people. We especially want to recognize and thank Dr. Harold Cook. He played a significant role in the inception and development of the project.

We would like to express our appreciation to Dr. Thomas Reece, Area Superintendent, Elementary Area Valley-West, Los Angeles, for arranging for us to conduct Experiment I at the Twenty-Fourth Street Elementary School. The principal of the school, Dr. William Lucas, and his staff gave their cooperation to the study, even when it disrupted their busy schedules.

Thanks are due also to Mr. Fred C. Sander, Assistant Superintendent of Schools, Lawndale, for arranging for us to conduct Experiment II at the Anderson and Will Rogers Schools, Lawndale. The Principals, Mr. James Orr and Mr. E. A. Giacomelli, and their staffs were most cooperative and understanding.

Mr. Charles Norwood was of invaluable assistance in all phases of Experiment II but particularly with the data analyses. Miss Noreen Yamamoto was the secretary for the project.

Most of all we wish to thank the children who participated in the study.

M. C. Wittrock and Claude E. Hill

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Summary

The purpose of these studies was to investigate the effects of verbal processes and dimensional preferences in children's learning and transfer. Four studies - two pilot studies and two experiments - were conducted. In Experiment I we studied verbal instructions. In the process we began to learn of the importance of children's backgrounds and preferences. As a result we pursued this fruitful area of study in Experiment II. We have decided to identify this report with a title that reflects our most important findings, which involve children's dimensional preferences, and pre-experimentally acquired associations.

Verbal instructions are a powerful variable for facilitating children's learning and transfer. It was the subject of Experiment I, where we investigated its effects upon motor responses. We predicted and found that verbal instructions discriminate for motor responses would facilitate learning and transfer, compared with less discriminately used verbal instructions.

This prediction was tested with three types of instructions across two types of practice. The differences between the treatments occurred only during original learning. All treatment groups received the identical transfer task during interpolated learning. The verbal instructions given during original learning were either 1) nonspecific, 2) identical to, or 3) different from the verbal instructions given during interpolated learning and the tests. Two tests were administered. The first test was administered following completion of interpolated learning and the second test was administered two weeks later. Each subject was reinforced during original learning for making a response identical to or different from the one reinforced during interpolated learning.

Three hundred thirty-six fifth and sixth grade children from a school located in a culturally deprived area were randomly assigned to the six treatments. The subjects were blindfolded and run individually in the experimental task.

By a planned comparison test, two specific orthogonal contrast tests, and Newman-Keuls multiple comparison tests, the verbal instructions were found to have significantly affected transfer. Discriminate verbal instructions produced statistically higher mean scores than did instructions used indiscriminately. Training with one response produced statistically greater mean scores than training with two different responses.

The results support and extend earlier research regarding the transfer effects of discriminate verbal instructions upon children's motor learning. Verbal instructions and reinforced practice are each important in motor learning.

The purpose of Experiment II was to investigate the effects of children's dimensional preferences in the learning and transfer of concepts. The design of Experiment II was similar to that of Experiment I, and consisted of an original learning phase followed by two tests of transfer.

One hundred forty-eight fourth grade students from a school in a culturally deprived area were randomly assigned to six treatment groups and a control group. Training was given with a card sorting task. A deck of 32 stimulus figures was generated from all possible independent combinations of five bi-valued dimensions.

A pretest indicated that the children had preferences among the five stimulus dimensions. During original learning all subjects received training on either one or two dimensions, either relevant or irrelevant to the bidimensional transfer problem. Original learning covaried with the dimensional preferences found in the pretest.

Transfer to the bidimensional problem was related to the children's preferences. When the children's preferred dimensions were relevant to the problem, transfer was facilitated.

The most interesting finding was the interaction between training and preferred dimensions. Provided both dimensions were relevant to the transfer task, training on the less preferred dimension enhanced transfer, while training on the more preferred dimension did not increase transfer.

Proactive variables, such as children's dimensional preferences, are important in designing training, whether or not there are measurable individual differences in the proactive processes. Instruction and teaching of children should be designed with recognition of the effects of specific proactive variables, which may be more important in determining learning and transfer than gross proactive variables, such as age, sex, and IQ. Specific, relevant proactive variables can explain otherwise perplexing results. They can be used to design instruction appropriate for the subject's learned tendencies and to give him reinforced practice for responses uncommon in his hierarchy, but relevant to the learning and transferring of concepts.

Chapter I

VERBAL INSTRUCTIONS IN CHILDREN'S LEARNING AND TRANSFER

Many culturally disadvantaged children have not had adequate opportunities to develop the ability to compare, differentiate, and to abstract. They also often lack the ability to deal effectively with language used in schools, and often have difficulty thinking about similarities, differences, and relationships in their environments (Bloom, Davis, and Hess, 1965).

If we can teach them to make verbal discriminations and differential responses to stimuli slightly different from each other, we can help them acquire ability to learn effectively in school. The objective of Experiment I was to see how learning something new interacts with previous learning when the same words or different words are given to two similar responses. We hypothesized that learning and transfer are enhanced by teaching verbally mediated discriminations to culturally disadvantaged elementary school children.

Review of Related Research

Studies of retention are relevant to the understanding of transfer. Ebbinghaus (1913) indicates that retroactive inhibition is primarily responsible for forgetting. In recent years (Bilodeau, Sulzer, and Levy, 1962; Postman, 1961; Seidel, 1959; Underwood, 1957, 1964) there is evidence for seriously doubting the earlier conclusions. Retroactive inhibition is no longer synonymous with forgetting (Underwood, 1957, 1964). A proactive design was used in this study because of these recent findings that indicate proactive inhibition to be a primary factor in retention, and perhaps in transfer.

There is support from the literature on verbal learning and transfer to indicate that language is a powerful independent variable in learning and transfer. The effects of verbal mediation have been shown in paired-associates learning (Norcross and Spiker, 1958) and concept learning (Carey and Goss, 1957; Goss, 1961). These studies give support to the notion that learning and transfer are affected by verbal mediation, and that dissimilar stimuli can be grouped together because of verbalizations or verbal training which associate these dissimilar stimuli with one another.

Spiker, Gerjuoy, and Shepard (1956) found that children who verbalized the concept "middle-sizedness" learned a relational task more readily than did those subjects who did not know this concept. A study by Kuenne (1947) also gives evidence that previously acquired verbal concepts influence later learning.

More convincing evidence about the effects of language upon learning comes from attempts to train children during experiments. Cantor (1955) found that five year old children, trained to name with feminine names two pictures of faces of females, could later discriminate two objects that were alike except that each of them was labeled with one of the two pictures of the females. This group, called the Relevant Subject Group, performed better than did a group trained on irrelevant pictures (pictures of males), or a group that was told simply to attend to the stimuli.

Shepard (1956) found an increase in generalization following verbal training which involved learning a common name for the training and test stimuli. Learning the common response for the stimuli resulted in a mediated generalization.

A very interesting study is reported by Luria (1961). By describing foreground and background in terms of rainy days (gray) or bright, sunshiny days (yellow) he was able to teach children to attend to the background stimulus and to make discriminations on the basis of its color. Without these verbal cues, the discriminations were very difficult for the children to learn.

Other studies related to the effects of verbal generalization, pretraining, pre-differentiation, and verbal labeling include: Dietze (1955), Ervin (1960), Gagné and Baker (1950), Jeffrey (1957), Robinson (1955), Rossman and Goss (1951), and Staats, Staats, and Schultz, (1962).

From a series of experiments (Wittrock, 1963, a, c, and d; Wittrock, 1964; Wittrock, Keislar, and Stern, 1964; Wittrock and Keislar, 1965) we concluded that verbal instruction enhances retention and transfer by eliminating incorrect responses which produce negative transfer. Both retention and transfer were facilitated by explicit verbalizations by E of the name for the correct concept, followed by practice and reinforcement for applying the label.

Jensen (1964) presents a cogent and detailed argument for attempting verbal training and manipulation of culturally deprived youngsters. He argues for using principles from verbal learning, including mediated generalization, semantic generalization, transposition, paired-associates, and serial learning to prepare training materials for culturally deprived youngsters.

The task used in the present study was derived from one used by Bregman, Thorndike, and Woodward (1943) in their study of the ability to draw lines of a given length. In the present study, we borrowed from Bregman, et al., the idea of teaching subjects to draw lines of a given length within an acceptable margin of error, and we also tested retention and transfer of this ability. Recently, other line drawing experiments have appeared in the literature (Bilodeau and Ryan, 1960; Greenspoon and Foreman, 1956; Saltzman, Kanfer, and Greenspoon, 1955) and have aided in the formation of the research described in this chapter.

The following experiment builds also upon earlier work by Wittrock, summarized above, where he adopted a mediated generalization approach to the teaching of verbal discriminations. If part of what is meant by cultural deprivation involves learning names indiscriminately, one way to improve the learning of culturally deprived children, it is hypothesized, is to teach verbally mediated discriminations appropriate to the motor responses they are asked to learn.

Objectives. The purpose of Experiment I was to show that an appropriate verbally mediated discrimination enhances the learning and transfer of two separate classes of responses. The hypothesis was: among culturally disadvantaged children the learning of two separate classes of responses to two different sets of stimuli is enhanced by associating two separate and appropriate verbal labels to those two stimuli. A mediated discrimination between two highly similar stimuli is produced by adding different names to the stimuli.

PILOT STUDY 1

The purpose of the pilot study was to provide a preliminary evaluation of the proposed procedure, apparatus, and methodology, so that, if necessary, modifications in them might be made prior to the beginning of Experiment I.

Method

Subjects. A sample of 20 fifth grade children was drawn at random from an elementary school located in the greater Los Angeles area and assigned to the five treatment groups.

Materials. The apparatus used in Pilot Study 1 is depicted in Figure 1. The apparatus consisted of a carpenter's square, a roll of white shelf paper, and a pencil. The standard guide lines were marked off on the shelf paper.

Procedure. The independent variable was the type of label E gave to S during original and interpolated learning. The dependent variables were the number of responses required to relearn the interpolated response. Another dependent variable was affectivity measured by the responses made by subjects to the question, "Would you like to play this game again?" asked at the end of the experimental session. (See Table 1 for a diagram of the design.)

Each S was called individually into the experimental room. Upon entering the room he was seated at a table which held the apparatus and told that he would have an opportunity to win a prize. The E then recited the following instructions: "I would like to play a line drawing game with you. You are to draw a 3-inch straight line (E demonstrated by drawing a horizontal line in the air) starting from the handle of this square (E pointed to the vertical handle of the carpenter square). When you have completed one line, return your hand to the edge of the square. If it is "right," I'll say "right" and then you are to wait for me to say "draw" before you begin your next 3-inch line. If the line

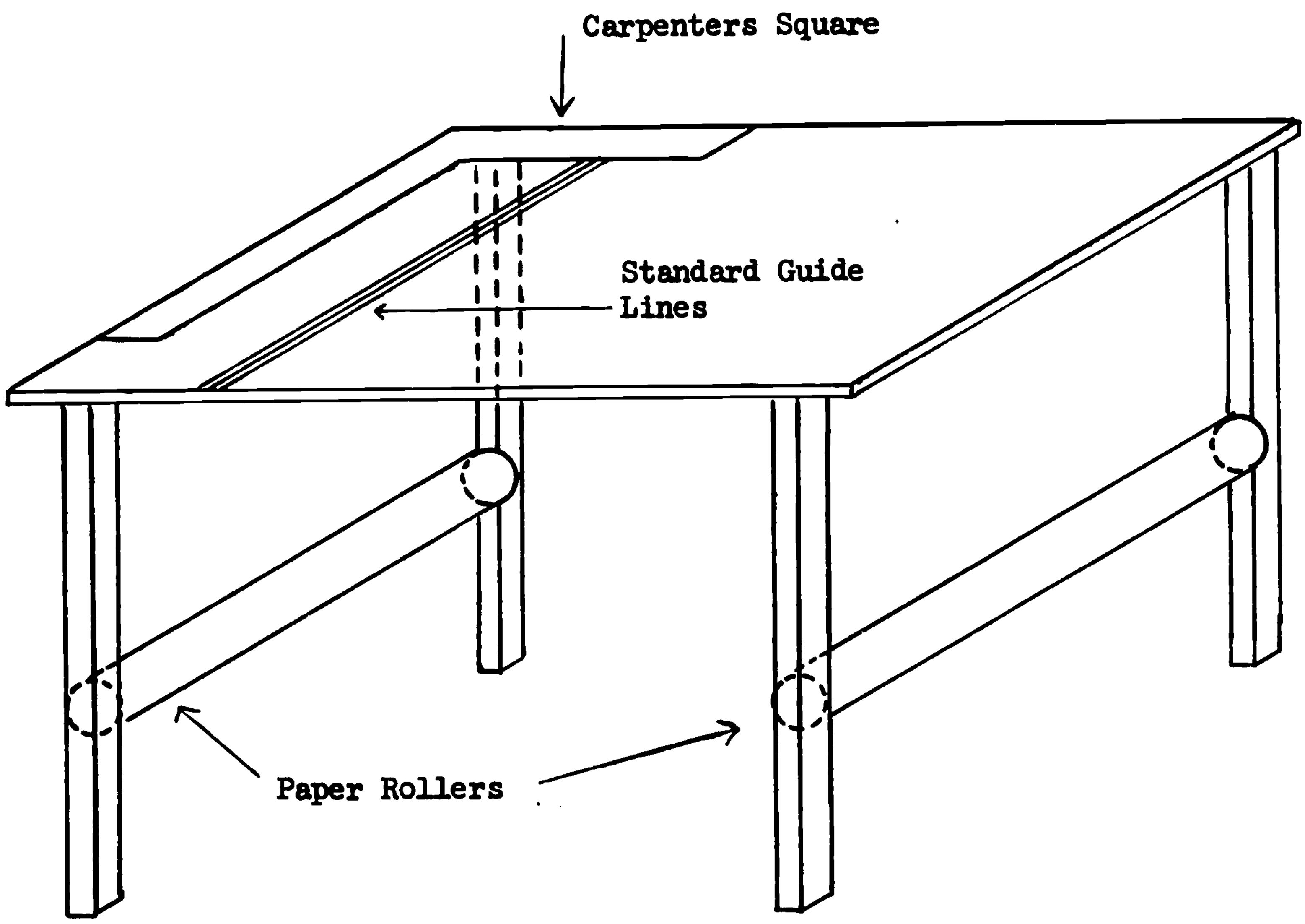

Figure 1. Apparatus used in Pilot Study 1.

Table 1

Experimental Design of Pilot Study 1.

	OL	IL	T_1	T_2
1. Mediated Generalization	S-3 → R-3½	S-3 → R-3	S-3 → R-3	S-3 → R-3
2. Mediated Discrimination (Response)	S-3½ → R-3½	S-3 → R-3	S-3 → R-3	S-3 → R-3
3. Mediated Discrimination (Stimulus)	S-3½ → R-3	S-3 → R-3	S-3 → R-3	S-3 → R-3
4. No-label	S-"line" → R-3½	S-3 → R-3	S-3 → R-3	S-3 → R-3
5. No-task	Conditioning to pronouns	S-3 → R-3	S-3 → R-3	S-3 → R-3

you drew is too short, I'll say "short." If I say "long," that will mean the line you drew is too long. You can win the prize only when the line you draw is 3-inches and that's when I'll say "right." You are to have only the point of your pen touching the paper. Try to keep your arm and hand off the table while you're drawing. Don't stop in the middle of drawing a line. Try to draw each line without stopping. Do you have any questions? The Ss were blindfolded at this point. The Ss hand was then placed at the vertical start position and he was instructed to "draw." Immediately after completion of the line, S was informed as to whether the line drawn was "right," "short," or "long."

During original learning each of the five groups received different treatments. For the Mediated Generalization Group, a "right" response was given to a line drawn between the standard 3-1/4 inches to 3-3/4 inches when the instruction called for a 3-inch line. A "short" response was given to a line drawn less than 3-1/4 inches in length. A "long" response was given to a line more than 3-3/4 inches in length.

For the second group, the Mediated Discrimination Response Group, a "right" response was given when the line was between the same two extremes (3-1/4 and 3-3/4 inches) as in the Mediated Generalization group, but here the instruction called for a 3-1/2 inch line. The Mediated Discrimination Stimulus Group, Group 3, was instructed to draw a 3-1/2 inch line and was reinforced with the word "right" for a line drawn between 2-3/4 inches to 3-1/4 inches. Any line less than 2-3/4 inches was considered "short" and any line longer than 3-1/4 inches was considered "long." The fourth group, the no-label group, was instructed just to draw a line and was told "right," for a line drawn between 3-1/4 inches to 3-3/4 inches. A line drawn less than 3-1/4 inches was "short" and a line drawn longer than 3-3/4 inches was "long." The fifth group, the No-Task Group, practiced saying personal pronouns and was told the word "right" to control for number of reinforcements.

For original learning the criterion was five correct in seven trials. As soon as the S reached criterion, he was allowed a two minute rest. During the rest period, E prepared the apparatus for the next segment of the experiment, interpolated learning (IL).

In interpolated learning all children received the same treatments. They were instructed to draw a 3-inch line and were corrected to the 2-3/4 to 3-1/4 inch standard. Thus, the Ss in the Mediated Generalization Group learned to draw a different line (1/2 inch shorter than the one learned during OL) to the same verbal label. The Mediated Discrimination Response Group learned to draw a different line (1/2 inch shorter) to a different verbal label. The Mediated Discrimination Stimulus Group learned to draw the same line to a different verbal label. The No-Label Group learned to draw a line to a verbal label, (not having had a verbal label in original learning). The fifth group, the No-Task Group, learned to draw a 3-inch line to the verbal label 3-inches. They did not learn line drawing in OL.

During the final segment of the experiment two tests were administered to all groups. The first test (T_1) was given two minutes after IL.

All groups were treated as in interpolated learning. They were instructed to draw a 3-inch line, and they were appropriately corrected for drawing a 3-inch line. The second test (T_2), identical to T_1, was administered two weeks after T_1.

Results and Discussion

Because of the small number of subjects in each treatment, and the wide variability in the scores, the median was used as the most representative score to summarize the results of the Pilot Study. The results of the Pilot Study (see Table 2) indicated that verbal discriminations were an important variable. Comparisons of treatment groups T_2, T_4, and T_1 indicated an increasing amount of facilitation as the verbal labels became more appropriate and discriminative. The data of T_2 and T_3 indicated that the response variable was also an important variable in the learning of the motor responses.

Based on the results of Pilot Study 1, several methodological changes were incorporated into the main experiment. These changes are enumerated below and are further elaborated in the text of Experiment 1.

1. The apparatus used in the Pilot Study allowed for too much variability in responding, such as arm movements, position of the pencil, etc. The apparatus was redesigned.

2. Because of a wide variability in the training scores the criterion of 5 correct out of 7 was abandoned in favor of a set number of trials (50).

3. Reinforcement was eliminated from the tests and the number of trials of these tests was fixed at 10 to increase possible proactive differences among the treatment groups.

4. The number of treatments was increased to form a complete 3 x 2 factorial design, with three types of verbal instructions crossed with two types of responses.

5. No apparent differences were noted in response to the question, "Would you like to play this game again?" asked at the end of the experimental session. The affectivity measure was changed from a verbal query to a paper and pencil rating of 5 items.

EXPERIMENT I

The results of Pilot Study 1 provided some evidence that verbal instructions are an important variable in children's motor learning and transfer. If they are an important variable in the motor learning of children, instructions discriminate for motor responses should facilitate

Table 2

Median Number of Correct Responses in Tests T_1 and T_2:

Pilot Study 1

Treatment Group	Median Number of Correct Responses in Test 1 (T_1).	Median Number of Correct Responses in Test 2 (T_2).
T_1. Mediated Generalization	8.0	7.0
T_2. Mediated Discrimination (Response)	15.0	13.0
T_3. Mediated Discrimination (Stimulus)	9.0	5.5
T_4. No-label	11.0	12.5
T_5. No-task	6.0	5.5

learning when compared with indiscriminately used instructions.

To test this prediction, the three types of instruction used in the pilot study were crossed with two types of practice, resulting in the six conditions presented in Table 3. As indicated in Table 3, there were two learning sessions, original learning (OL) and interpolated learning (IL), and two tests T_1 and T_2. The differences among the treatments occurred only during OL.[1] The verbal instructions during OL were either nonspecific, identical to, or different from the verbal instructions given by E during IL and the two tests. The child was reinforced during OL for making a response identical to or different from the one reinforced during IL.

Provided the IL and OL scores are fairly constant across the six treatments, the delayed test (T_2) should indicate the different proactive effects of OL. Because proactive effects are more readily found on a two-week later test than on an immediate test, no predictions were made regarding the first test (T_1).

It was predicted that the six-treatment means would rank in the following descending order on the delayed test: 1) $S_I R_I$, 2) $S_N R_I$, 3) $S_D R_I$, 4) $S_D R_D$, 5) $S_N R_D$, and 6) $S_I R_D$. This prediction was derived from the results of the studies mentioned previously and from the literature on proactive inhibition and transfer of learning.

The logic of the derivation is as follows. Practice at identical responses tends to produce positive transfer, even when stimuli change. (This is a common finding which dates at least as far back as Bruce, 1933.) Therefore, because they have identical responses, the first three treatments should each produce higher scores on the delayed tests than should the last three treatments.

Within these first three treatments, where the responses are identical, scores should increase as the verbal instructions used in OL become increasingly similar to the appropriate verbal instructions used in IL. The first three treatment means should rank from high to low as indicated above.

However, when the responses are different from OL to IL, as in treatments 4, 5, and 6, increasing the similarity of the verbal instructions produces an indiscriminate use of them, and scores should decrease. The last three treatment means (4, 5, and 6) should rank from high to low as indicated above, and in Table 3. In Table 3, the six treatments are numbered from 1 to 6 to indicate the predicted rank order derived above.

Method

Subjects. The subjects were 336 fifth and sixth grade children from three Los Angeles public elementary schools located in a lower socioeconomic area, as measured by a shortened version of the Brown (1965) SES Index given to each child in the study. Within each grade,

Table 3
Design of Experiment I

Treatments	OL Original Learning		IL Interpolated Learning		T_1 Test	T_2 Test
	S	R	S	R	S	S
1. $S_I R_I$	3	3	3	3	3	3
2. $S_N R_I$	Line	3	3	3	3	3
3. $S_D R_I$	3-1/2	3	3	3	3	3
4. $S_D R_D$	3-1/2	3-1/2	3	3	3	3
5. $S_N R_D$	Line	3-1/2	3	3	3	3
6. $S_I R_D$	3	3-1/2	3	3	3	3

Note.- subscripts are read as follows.

I. Stimulus

S_I - OL stimulus identical to IL stimulus

S_N - OL stimulus non-specific

S_D - OL stimulus different from IL stimulus

II. Reinforced Response

R_I - OL response identical to IL response

R_D - OL response different from IL response the Ss were balanced for sex and were individually assigned at random to the six treatment groups.

Apparatus. The apparatus consisted of a vertical stylus, 7 inches in length, attached to the end of a 10-inch long telescoping horizontal tube fixed to a metal stand. The criterion lengths, 3 and 3-1/2 inches, visible only to E, were marked on the tube. A set of earphones, a blindfold, and tape recorder were also used with each subject.

Affectivity Scale. The affectivity scale consisted of an 8-1/2" by 11" piece of paper depicting a child engaged in five different activities: drawing lines, eating, studying, painting, and doing school work. Four different orders of arrangement of the pictures were prepared, and Ss were randomly assigned to one of the four orders. The directions for the affectivity measure were as follows: "Here are five pictures. You are to find the picture that shows what you would like to do best. Then put a number 1 in the box in the corner of that picture. Now find the picture which shows what you would like to do second best. Put a number 2 in the box. Put a number 3 in the box which shows your third choice; a number 4 for your fourth choice, and a number 5 for the picture that shows what you would least like to do."

Procedure. Each subject was run individually by one of four Es in all parts of the experiment. One week prior to the beginning of the OL Session, the Ss were brought to the experimental room for a familiarization period. They were instructed in the use of the earphones and blindfolds. Each S also selected the trinket that he would try to win for drawing lines.

At the start of OL, S put on the earphones and E gave the following instructions to him if he was in the $S_I R_I$ Group. "I would like to play a line-drawing game with you. You are to try to draw a 3-inch line." (E demonstrated by drawing a horizontal line in the air.) "Now, I'll tell you how to play the game. You take hold of the pen like this and pull it out. Then you let go of the pen like this. Remember to let go of the pen after you draw the line. I'll tell you whether your line was 'Right,' or whether your line was 'Short' or 'Long.' Only when I say 'Right' does it count toward winning the prize. Then I'll say 'Draw' and you take hold of the pen and draw another 3-inch line. We'll keep doing this until I tell you to rest. You will probably get better at drawing the lines as you play the game, so do your best. Do you have any questions?" (E answered relevant questions by restating appropriate parts of the directions.) "Good. Now we will play the game. Please put on your blindfolds. Take hold of the pen and draw a 3-inch line." After S had drawn the line, E gave the appropriate reinforcement, as explained below. He then ended the trial by returning the stylus to the start position.

The instructions for the other groups were identical, except for the statement of the length of the line. Instead of "Draw a 3-inch line," they were instructed either to, "Draw a line," or "Draw a 3-1/2 inch line," depending on their treatment. See Table 3.

During each OL trial, *E* verbally reinforced each *S* in the S_IR_I, S_NR_I, and S_DR_I Groups by saying "Right" when *S* drew a line between 2-3/4 inches and 3-1/4 inches. A "short" response was given by *E* for a line drawn by *S* less than 2-3/4 inches in length, and *E* said, "Long" when the line drawn by *S* was over 3-1/4 inches. For the S_DR_D, S_NR_D, and S_IR_D Groups, *S* was verbally reinforced by "Right" for a response between 3-1/4 inches and 3-3/4 inches. A "Short" reinforcement was given to responses less than 3-1/4 inches; and *E* said, "Long" to responses over 3-3/4 inches. Fifty trials were given to each subject during OL.

After a two-minute rest, *E* instructed *S* to replace the blindfold, and interpolated learning began. In IL, each *S* in each group was instructed to draw a 3-inch line. The instructions for IL for each *S* were as follows: "Let's continue playing our game. I'm going to ask you to draw lines again. Remember, when I say 'Right,' that counts toward winning a prize. Take hold of the pen and draw a 3-inch line." Before each response, *E* repeated the words, "Draw a 3-inch line." Each *S* was reinforced to the 3-inch standard. After 50 trials *S* was told to stop and was given a two-minute rest period.

After two minutes, *S* was instructed to replace his blindfold and the immediate test (T_1) was given. Each *S* was asked to draw a 3-inch line on each of 10 trials. No reinforcement was given.

Two weeks later the delayed test (T_2), a repeat of the first test, was administered. After completion of T_2, each *S* was administered the affectivity scale and then given his previously selected prize, regardless of his performance in the experiment.

Results and Discussion

The dependent measures were the number of correct responses in each of the four parts of the experiment: OL, IL, T_1, and T_2. From analyses of variance and from planned comparison tests, no significant main effects or differences among pairs of means were found in either OL or IL.

T_1. A planned comparison test (Winer, 1962, pp. 207-211) on the data of the immediate test produced an F of 5.10 ($p < .05$). The linear polynomial coefficients were 5, 3, 1, -1, -3, -5 respectively for the six treatment means ordered according to the predicted rank order.

Two specific, orthogonal contrast tests (Winer, 1962, pp. 207-211) were performed to test for the hypothesized effects of the response training and the verbal instructions. The coefficients for the means of the treatments numbered 1 - 6 were respectively 1, 1, 1, -1, -1, -1 for the specific contrast test of the response variable. For the specific contrast test of the instructions variable, the coefficients for the means were respectively 1, 0, -1, 1, 0, -1. As is indicated in

Table 4, only the effect of the response variable was statistically significant ($p < .05$).

A Newman-Keuls test for differences among the six means indicated that the $S_N R_I$ mean was statistically significantly higher than the mean of the $S_D R_D$ Group.

$\underline{T_2}$. A planned comparison test of the predicted rank order of the treatments on the second test (T_2) gave an F of 11.68, ($p < .01$). Two specific orthogonal contrast tests, comparable to the two described above, provided statistically significant effects for the response variable ($p < .01$) and for the instructions variable ($p < .05$). See Table 4.) A Newman-Keuls test for the differences among the six means indicated that the means of Groups $S_N R_I$, $S_I R_I$, and $S_D R_I$ were significantly higher than the mean of the $S_I R_D$ Group.

Analysis of the affectivity scores resulted in no statistically significant differences.

Conclusions and Implications

The purpose of this experiment was to test a prediction about children's motor learning and transfer derived from earlier work with verbal instructions. The results of the earlier studies were largely supported in this experiment, as explained below:

On the delayed test (T_2), both the instructions variable and the response or practice variable reached statistical significance. The predicted rank order of the means also occurred at a statistically significant level, although the rank of the $S_N R_I$ Group and the $S_I R_I$ Groups were not as predicted.

Either discriminate and appropriate instructions or nonspecific instructions produced higher mean scores on the delayed test than did instructions used indiscriminately. The group given one type of instruction for two different responses ($S_I R_D$) produced the lowest mean score. Giving one verbal stimulus for two different responses negatively affected the learning of a motor response. This is an interesting result, because these children were of low average verbal abilities and low socioeconomic level. Yet they were able to use discriminate verbal instructions to facilitate learning of a motor response.

The response or practice variable also produced a statistically significant effect upon T_2 as well as a statistically significant effect upon the immediate test (T_1) scores. Increasing the amount of practice with the one response improved the learning of that response. Although the study of the response variable was not the primary purpose of this study, the response variable was found to be at least as important as the instructions variable in children's motor learning.

Table 4

Results of Specific Contrasts of the Test Scores on T_1 and T_2 for the Six Treatments: Experiment I

Source	SS	df	MS	F
T_1				
Specific Contrasts				
Response	36.67	1	36.67	5.95*
Verbal Instructions	.16	1	.16	--
Error	2,032.52	330	6.16	--
T_2				
Specific Contrasts				
Response	36.01	1	36.01	7.21**
Verbal Instructions	24.44	1	24.44	4.89*
Error	1,646.00	330	4.99	--

* $p < .05$

** $p < .01$

The prediction of the study was largely supported, as indicated above. However, one can ask whether the differences among the means in the delayed test also occurred among the means of the OL or IL scores. If mean differences occurred in OL or IL, the results of this experiment may not be due to proactive effects, but instead to differences in the level of original learning or interpolated learning. If the differences occur only on the delayed test, support is given to the interpretation that proactive effects, which often increase with an increase in length of the retention interval of up to two or three weeks, are producing the observed differences among the means.

Neither the analyses of variance nor the planned comparison tests among pairs of means produced any statistically significant effects, or differences among the treatment means, in either OL or IL. The means of the six treatment groups during OL, and especially during IL, are strikingly similar to one another, (See Figure 2) indicating no differential transfer effect from OL to IL, but indicating instead a uniformly positive transfer effect from OL to IL.

No predictions about T_1 were made because, up to intervals of two or three weeks at least, proactive effects tend to increase with time. Therefore, the proactive effects may not be indexed on T_1, a test given immediately after IL.

The response variable produced a statistically significant effect on T_1. It is difficult to attribute this finding either to initial learning or to proactive effects upon learning. It seems, rather, to emphasize the importance of the response variable in children's learning.

The results of this study support and add generality to earlier research regarding the transfer effects of discriminate verbal instructions upon children's learning. Verbal instructions and reinforced practice of responses are each important in at least some types of children's learning, even when the children are below average in verbal abilities and socioeconomic status, as they were in this study.

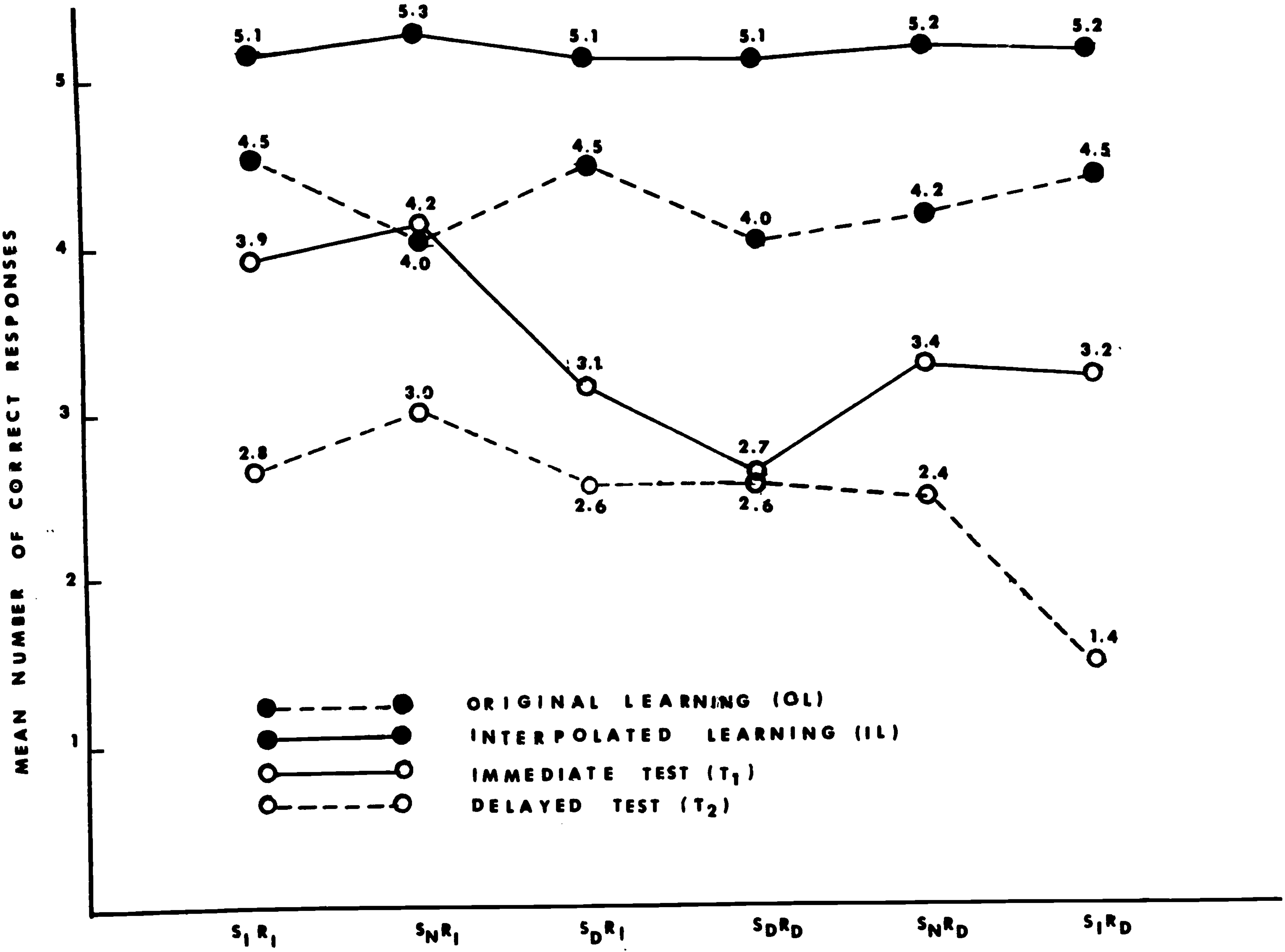

Figure 2. Mean number of correct responses for the six treatment groups during each phase of Experiment I.

Chapter II

CHILDREN'S DIMENSIONAL PREFERENCES IN LEARNING AND TRANSFER

In the second experiment of this project, our attention was directed toward more complex concepts and hierarchical relationships in the verbal learning of children. The senior author has done intensive work on these problems (e.g., Wittrock, 1963 a and b, 1964, 1966, 1967; Wittrock, Keislar, and Stern, 1964), finding some of the ways verbal processes and stimuli affect children's learning and transfer.

As we shall see below, a proactive variable, children's dimensional preferences, became a most important factor and explanation of the results of the second experiment, nearly overriding all of our experimental manipulations of variables, and indicating that type of training interacts with children's preferences.

Review of Related Research

In the learning of simple concepts, a child is usually required to group or categorize stimuli using relevant dimensions. A unidimensional concept requires him to classify or sort a series of stimuli by a single dimension such as color or size. A bidimensional conjunctive concept requires classification by two dimensions such as size and color.

As a child matures, according to Luria (1957, 1961) and Kendler (1963), his behavior becomes increasingly under the control of self-generated stimuli, and his own verbal behavior becomes a most important source of self-stimulation. Verbal responses, especially words as symbols, either overt or implicit, come to mediate and regulate overt behaviors. For example, children learn to use labels to name objects, and to transfer behavior associated with one object to another. Two explanations of these changes in children's behavior are relevant to Experiment II and are discussed next.

Mediation Theory. Tracy and Howard Kendler have used a "reversal-nonreversal shift technique" to study children's transfer from a first to a second discrimination. In the initial discrimination they present stimuli that differ in at least two dimensions, only one of which is relevant to the correct concept. In the second discrimination they use the same or similar stimuli but shift the correct answers.

To make one type of shift, called a "reversal shift," a child would continue to respond to the previously relevant dimension - but in an opposite way. For example, black instead of white becomes the correct answer, while brightness continues to be the relevant dimension. In the nonreversal shift the child's problem is to respond to the previously irrelevant dimension, such as form instead of brightness.

A simplistic S-R theory assumes a direct association between the external stimulus and the overt response, and from it we would predict a reversal shift to be more difficult to learn than a nonreversal shift.

This is because a reversal shift requires the learning of a new response that has not been previously reinforced. In a nonreversal shift, previous training has reinforced responses occasionally to some of the now correct stimuli. Strengthening these associations does not require as much extinction of their competitors as in a reversal shift, and the nonreversal shift should therefore be acquired more easily.

A two-stage theory (S-r-s-R) that includes a mediating response between the external stimulus and the overt response leads to a different prediction. Verbal labels for stimulus dimensions (Kendler and Kendler, 1962) or verbal labels for cues within a dimension can function as verbal mediators, which either cue the resulting overt response (R), or direct an orienting reaction (Kendler, 1964). In a reversal shift, the initial dimension maintains its relevance, hence, so does the mediated response, which makes the reversal shift easier for subjects. In the nonreversal shift, both the relevant verbal mediators for the dimension and for the cues within a dimension must be shifted, which makes this type of shift more difficult than a reversal shift.

In their studies of concept learning, the Kendlers and others have found evidence for a developmental process. College students and children older than six years find reversal shifts easier (Kendler and D'Amato, 1955; Kendler, Kendler, and Learnard, 1962), while nursery schoolers (Kendler, Kendler, and Wells, 1960), and animals (Kelleher, 1956) find nonreversal shifts easier. These findings indicate that the behavior of young children is explained by a single unit (S-R) model, while that of older children and adults is more adequately explained by a two-stage (S-r-s-R) model.

In recent years considerable debate has arisen over whether a mediational model is needed to account for shift in concepts. Several interpretations of concept-shift behavior have been proposed which do not require a mediational model (Wolff, 1967a).

Dimensional Preferences. Zeaman and House (1962, 1963) have developed an alternative model. In contrast to the Kendlers' model, they do not use verbal mediators, but explain concept shifts with a chain of two responses: 1) a dimensional observing response, and 2) an instrumental approach response to one of the cues in the attended-to-dimension.

Several studies have shown that children have definite preferences for stimulus dimensions (Suchman and Trabasso, 1966; Smiley and Weir, 1966; and Wolff, 1966), and that these preferences are manifested in discrimination and discrimination-reversal learning. Children four years of age and younger tend to prefer color to form, while after age four this preference is reversed.

The Kendlers, while recognizing the importance of observing responses in concept-shift behavior (Kendler, Glucksberg, and Keston, 1961), have continued to emphasize the role of verbal mediators (Kendler and Kendler, 1966). Within the concept-shift paradigm it is difficult to test verbal mediation because of the methodological problems involved in controlling implicit verbal responses. One method of control requires subjects overtly to verbalize labels for the dimensional cues (Kendler and Kendler, 1961; Silverman, 1966) or to differentiate verbal mediators from nonmediators on a pretest (Wolff, 1967b).

Regardless of which of these two models is more useful, the research on each of them has identified variables which may be useful for understanding learning and instruction in schools.

The problem for Experiment II. It would seem important in education to explore the implications of verbal mediation and dimensional preferences in the learning of school age children.

One of the variables indicated by the two explanations above is verbalization by S of the concept to-be-learned. This variable tends to increase transfer, and it is studied below. A second variable is the number of training problems (Wittrock and Twelker, 1964), which tends to vary positively with transfer.

Third, is the learning of relevant rather than irrelevant dimensions. The research previously cited indicated that transfer is increased by directing attention to relevant dimensions (Wolff, 1967a).

Fourth, are the effects upon transfer of the number of relevant dimensions learned by S. Kendler and Vineberg (1954) investigated this variable using adult subjects, and found transfer to be directly related to the number of relevant unidimensional concepts learned during training. That is, subjects who learned both components of the transfer problem demonstrated greater transfer than those who learned only one of the components. Appropriate verbal cues were strengthened during training, and transfer was facilitated.

Underlying the study of these four variables is our basic interest in the effects of the dimensional preferences of children. This proactive variable may be more important in school learning and instruction than are the variables mentioned above. These preferences either facilitate or interfere with transfer, depending on the congruence of the S's preference with the relevant dimensions of the problems.

PILOT STUDY 2

From the above discussion of research in mediation and dimensional preferences we concluded that transfer should be enhanced by 1) verbalizations by S during learning (which should also increase learning scores); 2) increasing the number of training problems; 3) learning relevant rather than irrelevant dimensions; and 4) by increasing the number of relevant dimensions practiced during training. In Pilot Study 2, we tested these four predictions; and we were also interested in the effects of dimensional preferences upon children's transfer.

Method

Design. In Pilot Study 2 we used a transfer design, similar to the design of Experiment I. There were four different treatment groups and a control group. The design is shown in Table 5. The transfer task for all groups consisted of a problem based on the conjunction of two dimensions (size and brightness) with two levels each (large, small; black, white). The training groups differed in the number of relevant or irrelevant dimensions and numbers of problems they practiced. Group D_{1R} (size) was given one problem with one relevant dimension (size), as was Group D_{1R} (brightness). Group D_{2R} was given two problems and two relevant dimensions (size, then brightness). Group D_{2Ir} was trained with two problems and two irrelevant dimensions (shape, then number). The Control Group (C) received training on pencil mazes. Each of the four training groups was divided in half into a verbalization group and a nonverbalization group.

Subjects. The Ss were 140 fifth grade students from a public school in the greater Los Angeles area. The school is located in a culturally disadvantaged area. The Ss were randomly assigned to the four treatment groups and the control group.

Materials. The stimulus dimensions were size (large or small), brightness (black or white), shape (triangle or circle), number (one or two), and border (present or absent). All possible independent combinations of these dimensions gave a total of 32 (or 2^5) stimulus figures, as shown in Figure 3. The stimulus figures were drawn in black ink on 3" x 5" white file cards, which were then laminated in plastic. Two cards, which differed on all five dimensions, were selected as the category cards for the two unidimensional training problems; and four different cards were selected for the bidimensional four category transfer problem (see Figures 4 and 5). This reduced the training stimuli to twenty-six cards arranged in random order. Two additional decks of twenty-six cards, identical in order to the first deck, were prepared and combined with the first deck forming a single deck of seventy-eight response cards.

Procedure. The subjects (Ss) were seated at a table facing the Experimenter, and were tested individually. The Experimenter (E) instructed each subject that he was going to play a special card game with a chance to win a prize. The S was then shown the category cards for the unidimensional problem and the first stimulus card. Each S was told only that the card went into one of the two piles indicated by the category cards, and that there was a way in which he could tell into which pile the card should go. The S indicated where the stimulus card belonged by pointing to one of the two category cards. After S pointed to one of the category cards, he was given appropriate verbal reinforcement by E (right or wrong) and presented with the next stimulus card. Training was continued until S reached a criterion of 10 consecutively correct responses, or a total of 78 trials.

Table 5
Experimental Design of Pilot Study 2

Treatment Group *	Training (Unidimensional)	Transfer I (Bidimensional)	Transfer II and Recall
D_{1R} (size) one relevant dimension	Size	Size and Brightness	Size and Brightness
			Recall
			Size and Brightness
			Recall
D_{1R} (brightness) one relevant dimension	Brightness	Size and Brightness	Size and Brightness
			Recall
			Size and Brightness
			Recall
D_{2R} (size, brightness) two relevant dimensions	Size, Brightness	Size and Brightness	Size and Brightness
			Recall
			Size and Brightness
			Recall
D_{2Ir} (shape, number) two relevant dimensions	Shape, Number	Size and Brightness	Size and Brightness
			Recall
			Size and Brightness
			Recall
Control	Pencil Mazes	Size and Brightness	Size and Brightness
			Recall
			Size and Brightnesss
			Recall

* One half of the subjects in each of the five treatment groups verbalized the basis for their category response following appropriate reinforcement of that response.

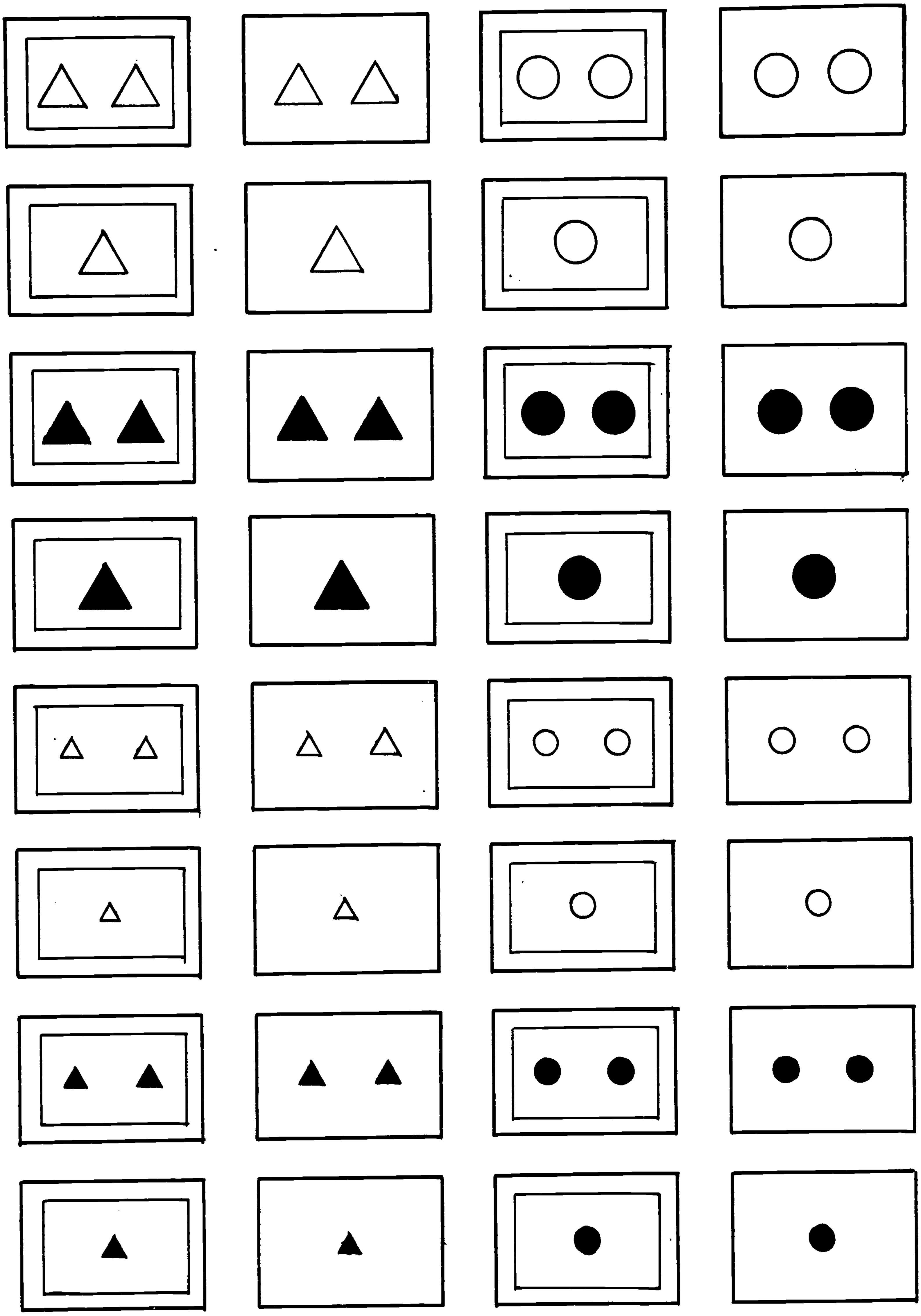

Figure 3. Stimulus materials for Pilot Study 2.

Figure 4. Category cards for the unidimensional training problems: Pilot Study 2.

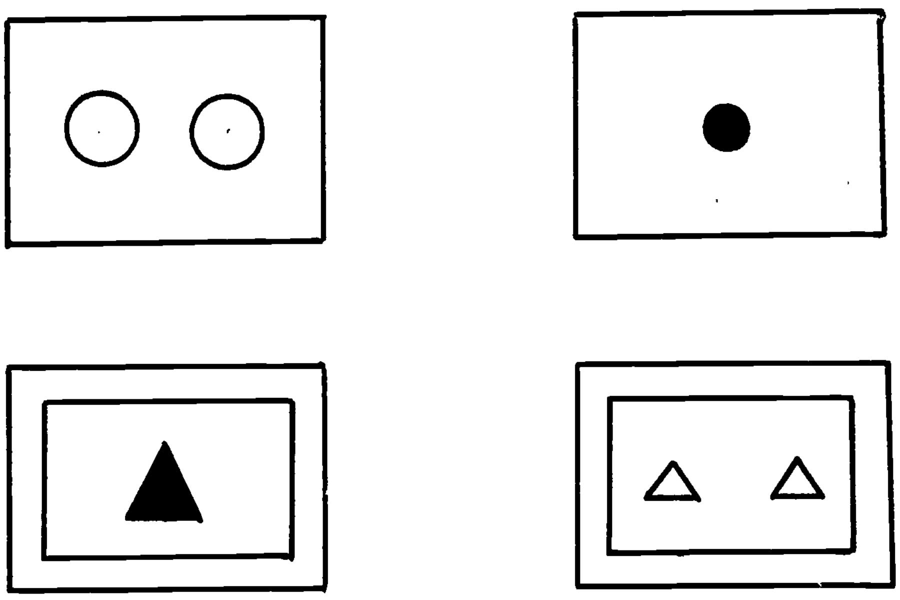

Figure 5. Category cards for the bidimensional transfer problems: Pilot Study 2.

Instructions for the verbalization groups were identical to those for the nonverbalization groups, except that following reinforcement of the category response, the Ss were asked why they had made that response.

Ss who learned two dimensions were given a two minute rest before beginning the second problem. Instructions for the second problem were identical to the first, except that S was told that the second problem was different from the first.

Following completion of the unidimensional problems, all Ss were given a two minute rest period before beginning the transfer problem. No additional instructions were given S except to indicate that there were now four categories; and S was to indicate where the stimulus card belonged by pointing to the correct category card. The Ss were not required to verbalize during the transfer problem. They were trained either to a criterion of 10 consecutively correct responses or to a total of 78 trials.

Two weeks after completion of the training, all of the Ss were brought back to the experimental room and were given two tests: 1) a readministration of the transfer problem using the identical materials and procedure used initially, and 2) a test of recall of dimensions. This recall test consisted of asking each S to tell E everything he could remember about the design on the cards. E recorded each dimension recalled by S. One half of the Ss within each treatment group were administered either test 1 or 2, which resulted in 4 cells with 7 subjects in each cell within each treatment group.

Results and Discussion

The results of the analysis of each dependent variable will be presented first. We will then discuss these results in relation to each of the four predictions.

The Statistical Analyses of the Four Dependent Variables. The first dependent variable was the measure of training. An analysis of variance of these data indicated a statistically significant effect ($p < .01$) due to the type of problem, but no statistically significant effect due to verbalization (see Table 6).

The data from the first test of transfer were summarized by an ANOVA and by three planned comparisons. The ANOVA produced a statistically significant effect for the treatments (see Table 7). And of the three planned comparisons, only the one between two relevant and two irrelevant dimensions was statistically significant ($p < .01$). See Table 8.)

By an analogous procedure the second test of transfer was also statistically analyzed. The ANOVA did not produce any statistically significant effects (df 4 and 60, and $F = 1.83$, $p > .01$). The principal effect shown on this test was a general facilitation for all groups.

Table 6

Analysis of Variance of the Training Data: Pilot Study 2.

Source	df	ss	MS	F
Verbalization	1	12.40	12.40	< 1
Treatment	2	5,390.98	2,695.49	26.47**
Verbalization X Treatment	2	224.14	112.07	<1
Error	78	7,943.80	101.84	--

** = p < .01.

Table 7

Analysis of Variance of Transfer
Test I: Pilot Study 2.

Source	df	ss	MS	F
Verbalization	1	10.9	10.9	< 1
Treatment	4	5,154.3	1,288.6	5.04**
Verbalization X Treatment	4	436.7	109.18	1
Error	130	33,209.9	255.46	--

** = $p < .01$

Table 8

Planned Comparisons Among the Mean Errors to Criterion, Transfer Test I: Pilot Study 2

	Treatment Group					
	D_{1R} (size)	D_{1R} (brightness)	D_{2R} (size) (brightness)	D_{2Ir} (shape) (number)	Control	t
Mean Errors To Criterion	35.43	39.79	34.86	49.64	47.32	
1. One vs Two Dimensions	-.5	-.5	.5	.5	0	1.63
2. Relevant vs Irrelevant Dimensions	0	0	1	-1	0	-3.47**
3. One Relevant vs Two Relevant Dimensions	-.5	-.5	1	0	0	-.74

** = $p < .01$ for a two-tailed test.

Note. - Comparisons 1 and 3 are not orthogonal.

The trend of the means of this test showed the same pattern as the means of the first transfer test.

The fourth and last dependent variable was a measure of recall of dimensions. An ANOVA run on these data showed no statistically significant effects due to any experimental variable. Figure 6 shows the percentages of responses recalled by the five dimensions used in this study. A high proportion of "shape" responses was recalled after treatment, while size and brightness were recalled frequently and approximately equally after the treatment and testing.

<u>The Statistical Analyses Related to the Four Predictions</u>. The first of our four predictions was that verbalization increases learning and transfer. The four analyses of variance described above indicated that this prediction was not supported.

To test the second, third, and fourth predictions mentioned above, planned comparisons were made on the data of the first transfer test between: 1) those groups that had one training problem versus those that had two; 2) those that had two relevant training problems versus those that had two irrelevant training problems; and 3) those that had one relevant training problem versus those that had two relevant training problems. The coefficients of these tests and the means on which the comparisons are based are shown in Table 8. Only the comparison between two relevant training problems and two irrelevant ones was statistically significant ($p < .01$) on this first test of transfer.

The failure of the planned comparison between one and two irrelevant dimensions to approach statistical significance does not support the findings of Kendler and Vineberg (1954). However, nonstatistically significant results are always open to question, and indicate a change is required in our experimental procedure, rather than indicating any other interpretation is warranted.

<u>Dimensional Preferences</u>. Because of the interesting results of the recent experiments on dimensional preferences mentioned earlier, we examined this proactive variable and its effects upon children's transfer. Training which reinforces already preferred dimensions should produce less change in behavior than training which reinforces dimensions not previously preferred. If an unpreferred dimension is relevant to the transfer task, training and reinforcement for choosing it should increase transfer, compared with training and reinforcement for perseveration on a pre-experimentally preferred dimension.

To test the above prediction about an interaction between dimensional preferences and training, we computed the percentage of children in each treatment group who solved the training problem; and we also computed the percentage of children in each treatment group who solved the first transfer problem. These data are reported in Table 9. Brightness apparently was a highly preferred relevant dimension during training, because 100% of the children were able to solve the training problem when brightness was the correct answer. Size apparently was a less preferred dimension before training; only 68% of the children

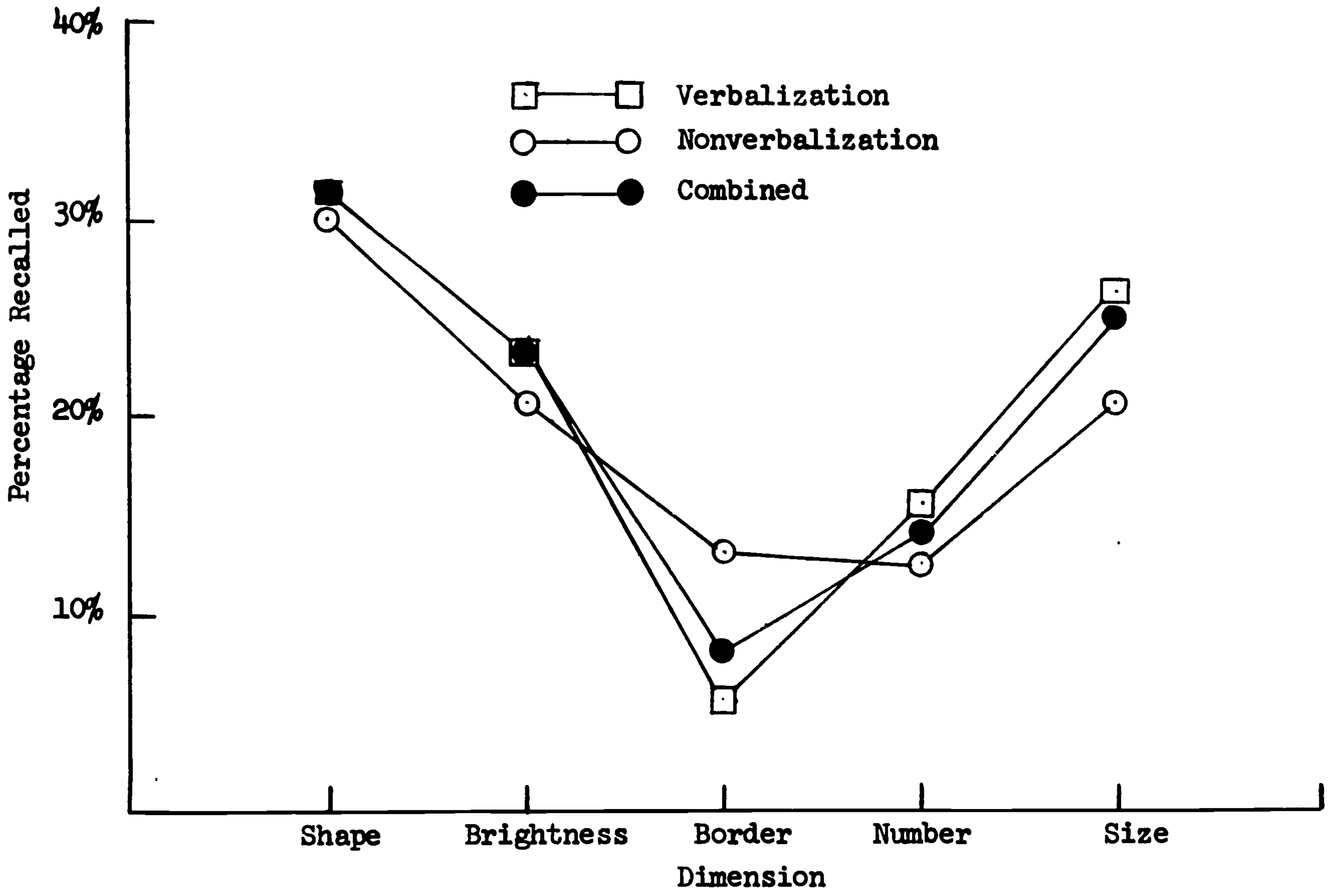

Figure 6. Percentage of responses grouped by dimension during recall test of dimensions: Pilot Study 2.

Table 9

Percentage of Problem-Solvers Within Treatments: Pilot Study 2.

	Treatment Group				
	D_{1R} (size)	D_{1R} (bright-ness-)	D_{2R} (size) (bright-ness)	D_{2Ir} (shape) (number)	Control
n	28	28	28	28	28
Training	68	100	61	93	71
Transfer Test I	36	18	29	4	7

solved the training problem when size was the correct answer.

However, the transfer scores of these two groups are reversed in magnitude. The group trained on a preferred dimension, brightness, scored less well on a transfer test, where both size and brightness were relevant, than did the group trained on a less preferred dimension, size. Practice and reinforcement for the less preferred but relevant dimension, size, increased transfer scores. The means of Table 10 also support this finding.

Apparently the type of training most effective for increasing transfer does interact with the child's preferences. As common-sense would indicate, reinforcing a child for choosing a relevant but not preferred basis for solving a problem helps him to choose that basis later, when it is again relevant to solving a problem.

If this argument is sound, then reinforcing him during training for choosing preferred but irrelevant dimensions should interfere with transfer. Shape and number were preferred dimensions, because shape and number problems were solved 93% of the time during training, according to the data of Table 9. Both of these preferred dimensions were irrelevant to the transfer problem.

As we see from the low percentage (4%) of correct solutions on the transfer test, the relationship between preferred dimensions and type of training occurs as predicted. This time transfer is reduced because the preferred dimensions and the reinforcement during training interact to make more salient two of the dimensions irrelevant to the transfer problem. Again the data are understandable if we remember that children's preferences are interacting with the experimental training. This finding seems to be a fundamentally important one, relevant to a wide variety of research studies in children's learning and instruction.

Conclusions and Implications

Pilot Study 2 was a most informative one. In it we learned that two variables commonly studied in the literature of verbal learning (verbalization by S and number of problems practiced) were not as important for our data as were the children's preferences and the relevancy of training. In particular we found that the transfer data could be explained by recognizing the interactions between children's preferences and the reinforcement and practice they are given during training. Training and reinforcement for less preferred but relevant dimensions increased transfer, while training and reinforcement for either more preferred and relevant dimensions, or for irrelevant dimensions, interfered with transfer.

Table 10

Mean Errors on Transfer Test I with the Training Nonsolvers Removed: Pilot Study 2

	Treatment Group				
	D_{1R} (size)	D_{1R} (brightness)	D_{2R} (size) (brightness)	D_{2Ir} (shape) (number)	Control
Verbalization	25.25	40.14	33.00	51.00	50.35
n	8	14	10	8	14
Nonverbalization	35.09	39.43	30.4	51.8	44.28
n	11	14	7	11	14
Total	29.79	39.79	31.47	51.47	47.32

EXPERIMENT II

The results of Pilot Study 2 indicated that verbalization by S and the number of relevant unidimensional problems learned were probably not factors significantly affecting transfer. However, the results did indicate that Ss entered the task with dimensional preferences, and that the training interacted with these preferences.

In Experiment II our aim was further to explore these results using basically the experimental procedure of the Pilot Study. Assuming that each S enters the experimental task with preferences for dimensions, then training on any single dimension should strengthen the preference of that dimension relative to the other dimensions. The results of the Pilot Study suggested that training on a highly preferred dimension resulted in relatively slight improvement in transfer, compared to training on a less preferred dimension, relevant to the transfer task.

In Experiment II, we continued to examine this relationship. To increase the number of correct solutions and S's motivation for learning, we used two relatively highly, yet unequally preferred dimensions for the transfer test - shape and brightness. If the above interpretation is substantiated, training should become increasingly effective in facilitating transfer as the relevant, trained dimension becomes less preferred.

Verbalization by S was not studied because of the insignificant results obtained in Pilot Study 2. A pretest to establish dimensional preferences was added to the design, however, and the following predictions were made: 1) training on two problems produces greater transfer than does training on one problem; 2) training on a less preferred dimension produces greater transfer than does training on a more preferred dimension; 3) training on relevant dimensions facilitates transfer while training on irrelevant dimensions produces interference; 4) training on two relevant problems produces greater transfer than does training on one relevant problem. In addition, we also examined the relationships between initial learning and dimensional preferences.

Method

Design. The design of Experiment II was similar to the design of Pilot Study 2, and it is shown in Table 11. Two treatment groups were added to test the effects of training with a single irrelevant dimension, making a total of six treatment groups and a control group. Half of the Ss within each treatment group and the control group were randomly assigned either to the pretest condition or to the familiarization condition.

Materials. The stimulus dimensions used in Experiment II were identical to those used in Pilot Study 2, with the exception that the border dimension was changed from present or absent to solid or dotted.

Table 11

Experiment Design of Experiment II

Treatment Group*	Training	Transfer I	Transfer II
D_{1R} (shape)	Shape	Shape & Brightness	Shape & Brightness
D_{1R} (brightness)	Brightness	Shape & Brightness	Shape & Brightness
D_{2R} (shape brightness)	Shape, Brightness	Shape & Brightness	Shape & Brightness
D_{1Ir} (border)	Border	Shape & Brightness	Shape & Brightness
D_{1Ir} (number)	Number	Shape & Brightness	Shape & Brightness
D_{2Ir} (border number)	Border, Number	Shape & Brightness	Shape & Brightness
Control	Line Discrimination	Shape & Brightness	Shape & Brightness

* One half of the subjects within each treatment group were administered a pretest to measure dimensional preferences.

The other four dimensions were size (large or small), brightness (black or white), shape (triangle or circle), and number (one or two). Using all possible combinations of these dimensions, a total of 32 (2^5) stimulus figures were generated, as shown in Figure 7. The stimulus figures were drawn in black ink on 3" x 5" white file cards. Two cards, which differed from each other on all five dimensions, were used as the category cards for the unidimensional training problems, and four other cards represented the bidimensional four category transfer problem (see Figures 8 and 9). The removal of these 6 cards reduced the training stimuli to twenty-six cards, which were arranged in random order. Two additional decks of twenty-six cards, arranged in separate random orders, were combined with the first deck, forming a single deck of seventy-eight cards.

For the pretest of dimensional preferences, sixteen different cards were drawn from the deck and placed on the table in front of S in 4 rows and 4 columns, as shown in Figure 10. The 16 cards had the values of each of the 5 dimensions equally represented. Thus for the size dimension there were eight large figures and eight small figures.

The pencil mazes used in the study are shown in Figure 11. For the line discrimination training a deck of 24 (3""x 5") cards was prepared, consisting of 6 groups of 4 cards each, on which were drawn lines of the following lengths: 2", 2 1/4", 2 1/2", 3 1/2", 3 3/4", and 4". The two stimulus cards contained lines of 2" and 4". The 24 cards were arranged in random order, with the restriction that two cards containing lines of identical length were not presented in sequence.

Subjects. The Ss were 148 fourth grade students from a public school in the greater Los Angeles area. The school is located in a culturally disadvantaged area. The Ss were randomly assigned to the six treatment groups and the control group.

Procedure. All the Ss were run individually. During all sessions of the experiment, E read prepared instructions to the S and answered questions by repeating appropriate sections of the instructions.

The Ss were brought into the experimental room for pretesting and familiarization training. They were seated at a table facing E, on which the 16 response cards and the two stimulus cards were arranged. E read the following instructions to S: "Hello, (S's name). Today we are going to play a special kind of card game. Listen carefully and I will tell you how to play the game. Look at the cards with designs on them. I want you to pretend you are going to sort the cards into two piles. Half of the cards should go in this pile (E indicated stimulus cards) and half of the cards in this pile. Now, can you tell me which cards go in each pile?" If S gave an appropriate response E said, "That's fine; now can you tell me another way you could sort the cards?" This procedure was repeated as many times as was necessary or until S stated that he could not find another way to sort the cards. (His first card sort was used as the measure of his most preferred dimension, and we also recorded each of his dimensional responses.)

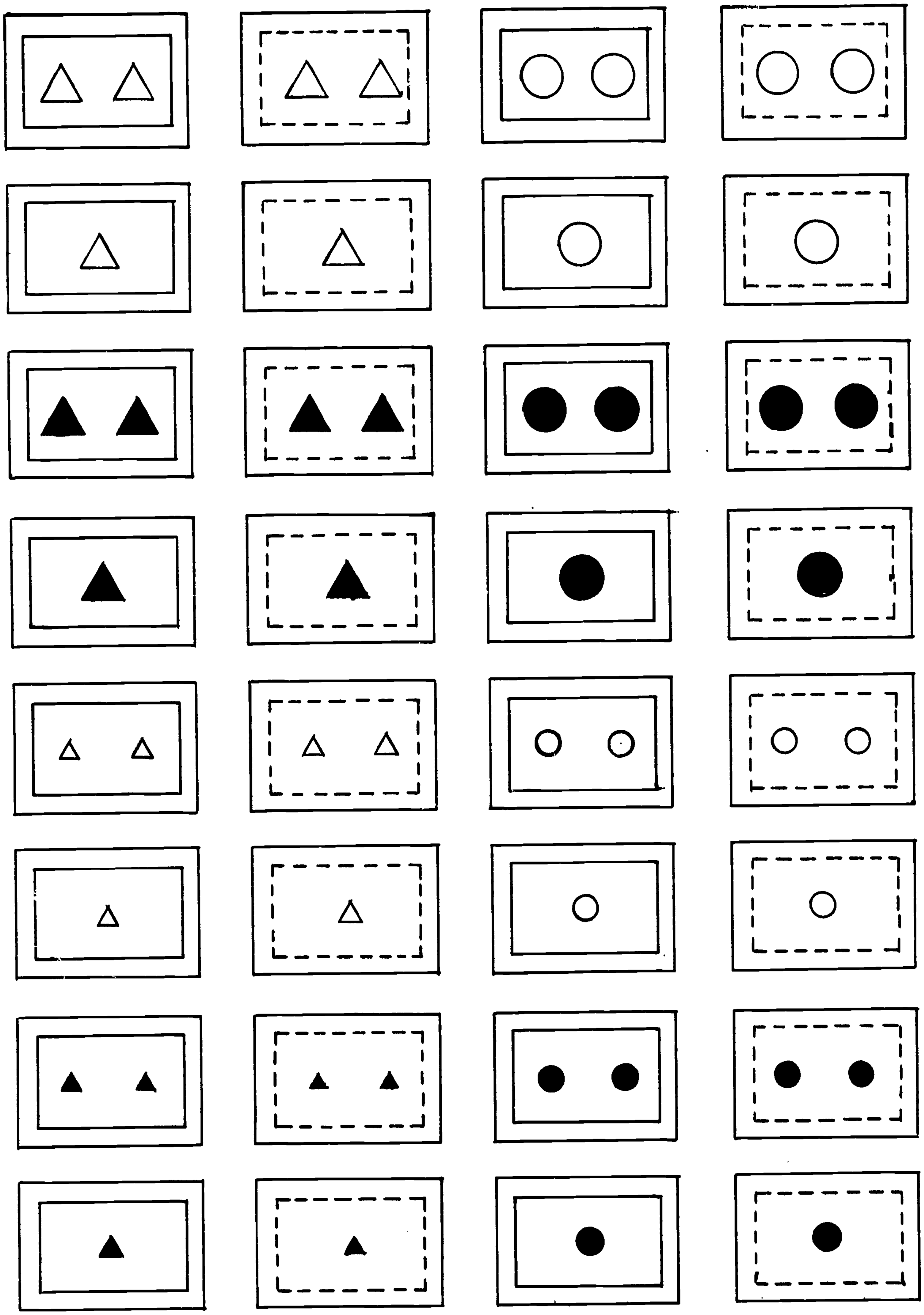

Figure 7. Stimulus materials for Experiment II.

Figure 8. Category cards for the unidimensional training problems: Experiment II.

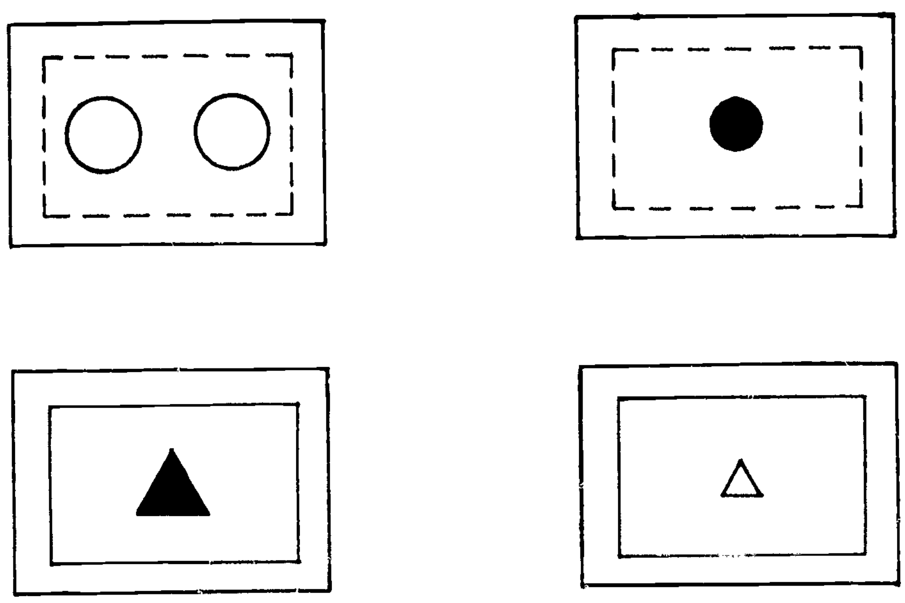

Figure 9. Category cards for the bidimensional transfer problems: Experiment II.

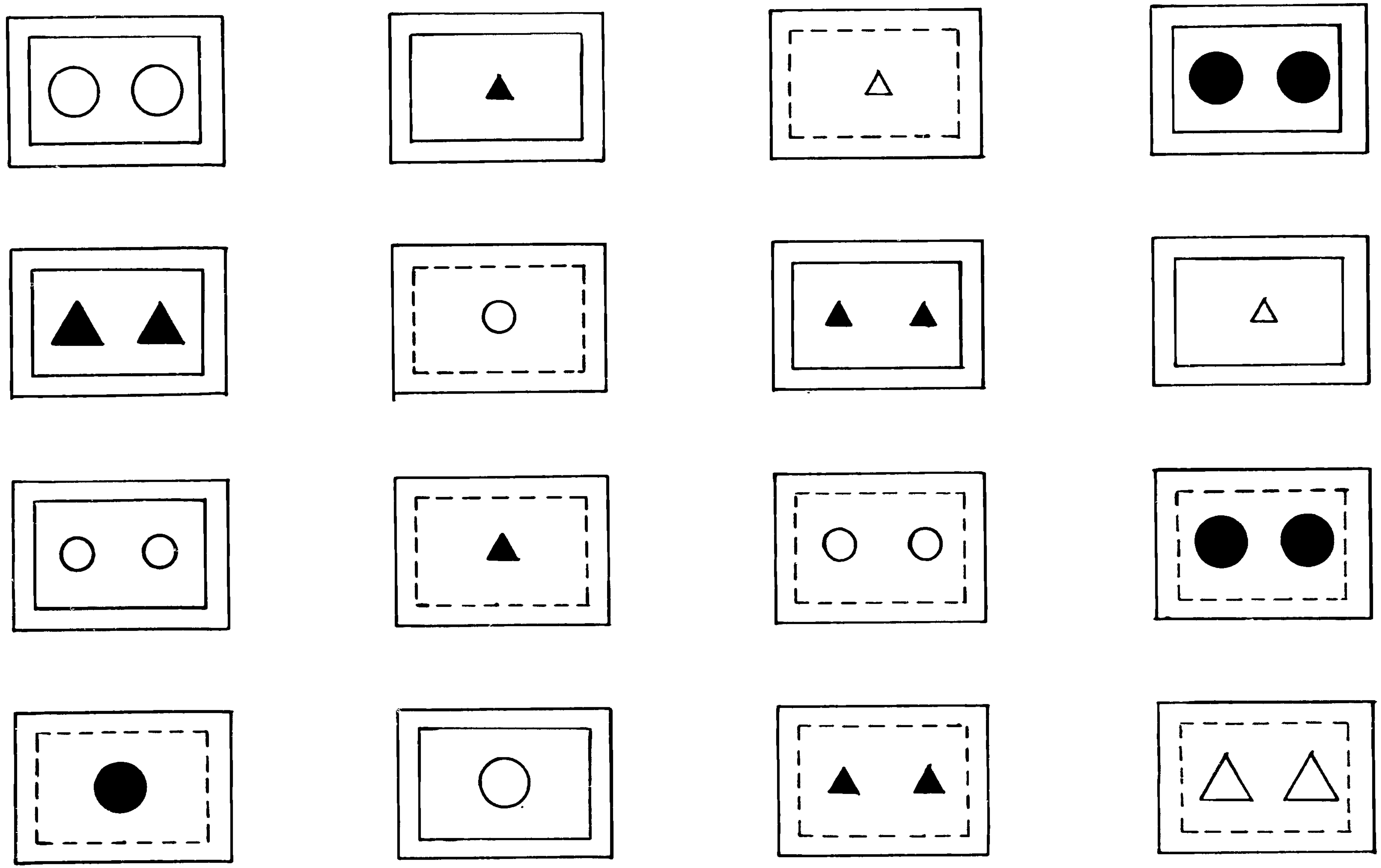

Figure 10. Stimulus cards arranged for the pretest of dimensional preferences: Experiment II.

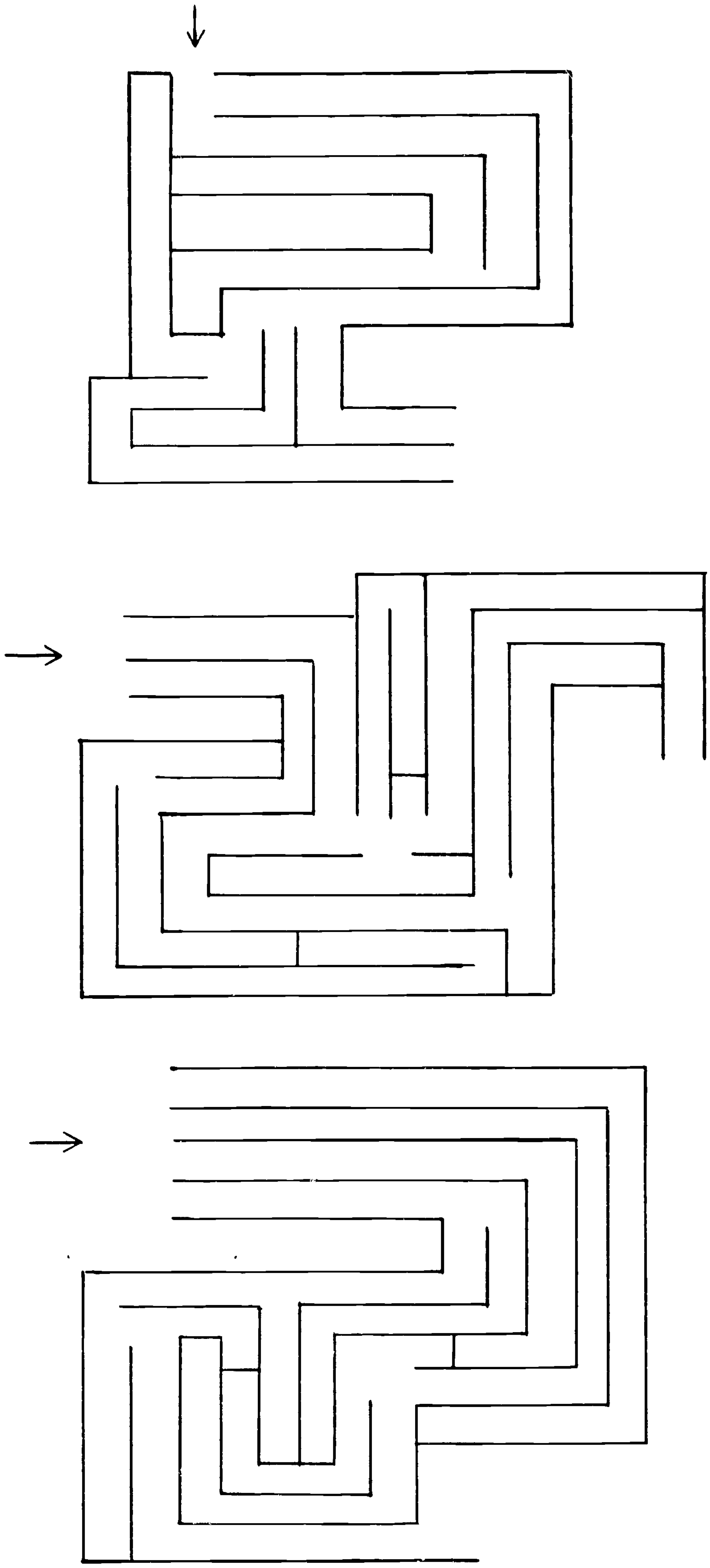

Figure 11. Pencil mazes: Experiment II.

All Ss in the familiarization group received the following instructions: "Hello, (S's name), today we are going to play a game. Listen carefully and I will tell you how to play the game. I'm going to show you some mazes. Here is the first one. You follow the paths through the maze with your pencil. Start at the arrow."

The Ss were administered the learning and first transfer problems one day after the pretesting or familiarization session. The procedure followed was identical to that of the nonverbalization groups of Pilot Study 2. E told S that he was going to play a special card game with a chance to win a prize. S was then shown the category cards for the unidimensional problem and the first stimulus card. Each S was told only that the stimulus card went in one of the two piles indicated by the category cards; and that there was a way he could tell where the card should go. S indicated his choice by pointing to one of the two category cards. After S pointed to one of the category cards, E said either "right," or "wrong," and presented the next stimulus card. Training was continued until S reached a criterion of either 10 consecutive correct responses or a total of 78 trials.

Ss learning two consecutive unidimensional problems (Groups D_{2R}, shape, then brightness; and D_{2Ir}, border, then number) were given a two-minute rest before beginning the second problem. Instructions for both problems were identical, except that S was told that the second problem had a different answer. Following completion of the unidimensional problems, all Ss were given a two minute rest before beginning the bidimensional conjunctive transfer problem. No additional instructions were given S, except to indicate that there were four category cards. All Ss were trained either to a criterion of 10 consecutive correct responses or to a total of 78 trials.

Two weeks later each S was given the second transfer test, which consisted of a readministration of the transfer problem.

After the completion of each section of the experiment, S was cautioned not to tell anyone else "how to play the game." Based on the Ss' verbal reports, and the unique nature of the task involved, it seems unlikely that Ss had prior knowledge of the solution to the problems.

The procedure for the Ss who received the line discrimination training (Control group) was identical to that used for the other treatments with the exception that the word "lines" was substituted for the word "designs" in the instructions.

Results and Discussion

Pretest of Dimensional Preferences. Figure 12 reports S's most preferred dimension among the five dimensions used in this study: shape, brightness, border, number, and size. The data of Figure 12 are taken from the pretest for Experiment II, and they represent the children's first preference for dimensions before training and reinforcement were begun in this experiment. In agreement with Suchman and Trabasso (1966) and others, shape was most often chosen as the most preferred dimension (66% of time), followed by brightness (21.5%), border (9%), number (1.5%), and size (1.5%).

An estimate of how training and reinforcement can alter these preferences is available by comparing the data of Figures 6, 12, and 13. Figure 13 presents the percentage of responses grouped by dimension. The data in this figure were computed in the same manner as the comparable data reported in Figure 6 for Pilot Study 2. These two figures provide a comparison of children's preferences before training (Figure 13) and after training (Figure 6). The data for Figures 6 and 13 were computed by totalling dimensional responses without regard to the rank of the child's preferences. For example, his most preferred dimension was scored as a dimensional response equivalent to his least preferred response. (Figure 12 provides the data regarding his most preferred dimension.)

One notable difference between the two sets of data in Figures 6 and 13 is that size is more frequently preferred after training than it was before training. It is not completely clear why this change occurred, because the data of the Experiment and the Pilot Study are not exactly comparable. The procedure was different in the two studies, and this may have affected the percentages of responses. However, a likely cause of the difference is the reinforcement during the Pilot Study given to Ss for responding to size.

Statistical Analyses of the Data. There were three dependent variables in Experiment II: 1) a measure of training, 2) an initial transfer test, and 3) a retest of transfer. An analyses of variance was run on each of these three dependent variables. There three analyses of variance are reported in Tables 12, 13, and 14 respectively. (Because there were unequal cell ns - not due to systematic factors - the harmonic mean of the cell n was used to estimate cell size.)

When the ANOVAs mentioned above were statistically significant, four planned comparisons were then run on the data. Actually these planned comparisons could have been run even if the ANOVAs produced nonsignificant F ratios, but we chose the more conservative route.

The four planned comparisons tested the four predictions presented above. They involved the following: 1) one training dimension with two training dimensions, 2) shape training with brightness training, 3) two relevant with two irrelevant problems, and 4) one relevant with two relevant problems.

Training Test. The ANOVA for the training test produced a statistically significant F ratio for the treatment effect, $F = 3.34$, $p < .05$. (See Table 12.) From Table 15, we see the percent of solvers during training was 90 or better for shape, brightness, and border. Only number dropped to 86 percent.

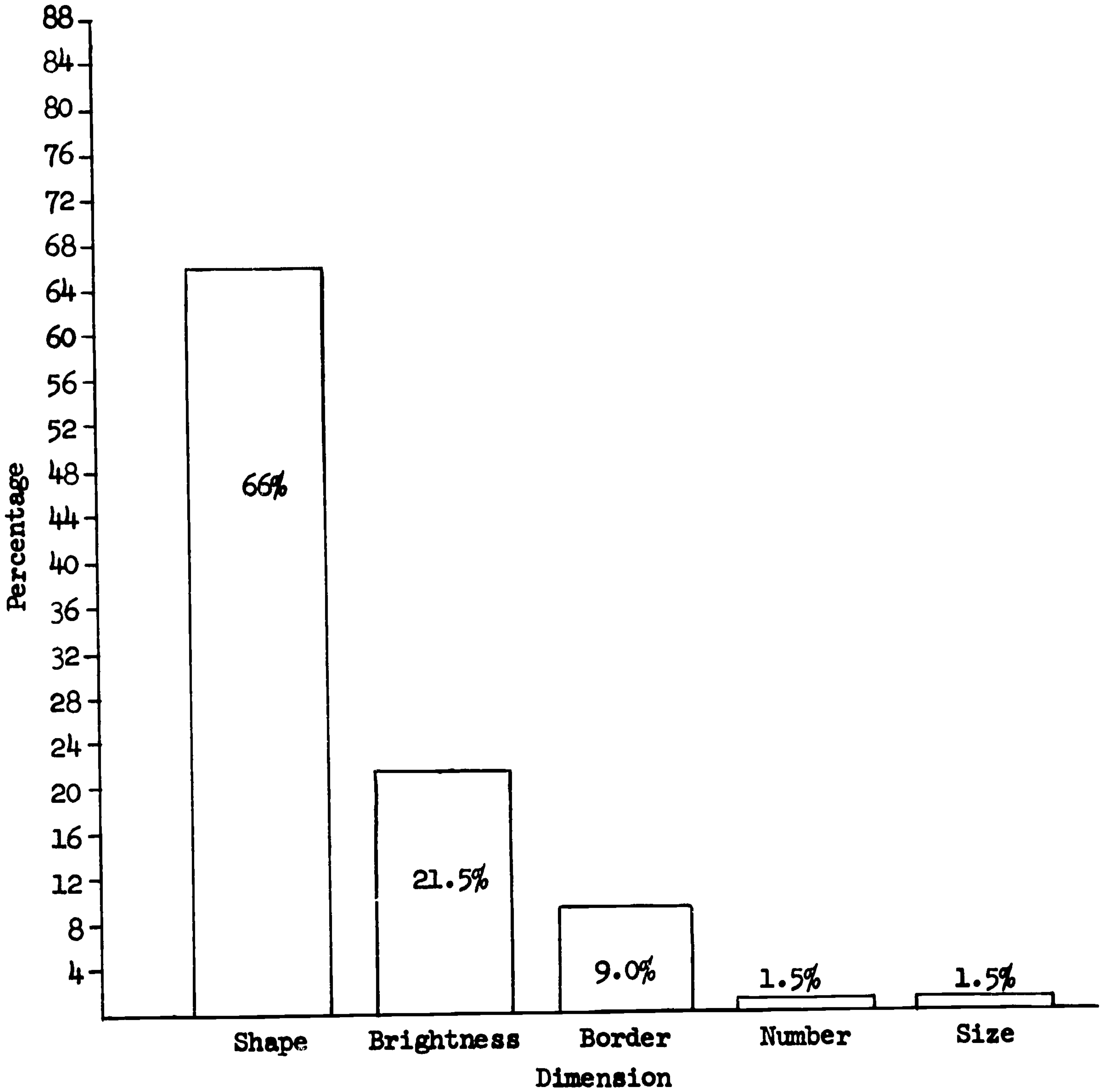

Figure 12. Frequency of most preferred dimensions, pretest: Experiment II.

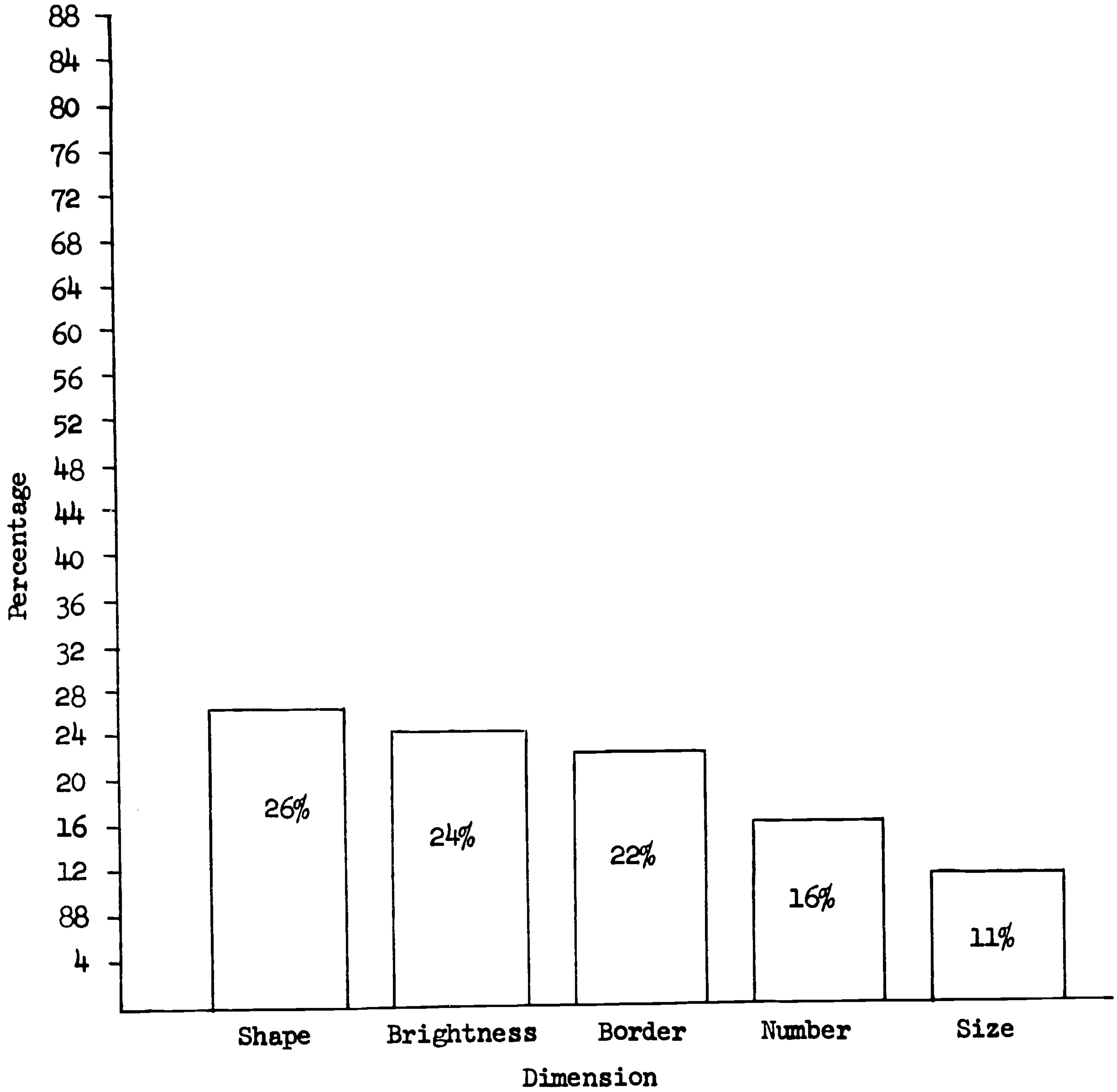

Figure 13. Percentage of responses grouped by dimension, pretest: Experiment II.

Table 12

Analysis of Variance,
Training Data: Experiment II.

Source	df	ss	MS	F
Pretest	1	18.1	18.1	< 1
Treatment	3	897.39	299.13	3.34*
Pretest X Treatment	3	313.42	104.47	1.16
Error	73	6,528.66	89.43	--

* = $p < .05$

Table 13

Analysis of Variance,
Transfer Test I: Experiment II.

Source	df	ss	MS	F
Pretest	1	237.68	237.68	1.65
Treatment	6	11,950.43	1,991.74	13.84**
Pretest X Treatment	6	126.95	21.58	< 1
Error	128	18,408.56	143.81	--

** = $p < .01$

Table 14

Analysis of Variance, Transfer Test II,
Training Nonsolvers Included: Experiment II.

Source	df	ss	MS	F
Pretest	1	7.5	7.5	.05
Treatment	6	4,278.7	713.11	4.92**
Pretest X Treatment	6	629.61	104.9	.72
Error	118	17,089.2	144.8	--

** = p < .01.

Table 15

Percentage of Solvers in Training and in Transfer Test I: Experiment II

	Treatment Group						
	$D_{1}R$ (shape)	$D_{1}R$ (brightness)	$D_{1}R$ (shape) (brightness)	$D_{1}Ir$ (border)	$D_{1}Ir$ (number)	$D_{2}Ir$ (border) (number)	Control
n	21	19	18	20	21	21	22
Training	95	100	95	95	86	90	--
Transfer Test I	96	100	100	55	90	76	91

First Transfer Test. The ANOVA for this test produced significant F ratios for the treatment, and for two of the four planned comparisons. See Tables 13 and 16. Brightness training was better for transfer than was training for shape. Two relevant dimensions during training were better for transfer than two irrelevant dimensions. These results support the findings of Pilot Study 2.

An analysis of variance and planned comparisons for this transfer test were also performed after removing those subjects who failed the training problem. As could be expected, the removal of these few subjects did not substantially change the results shown in Tables 13 and 16.

Retest of Transfer. The analysis of variance of the data from the second transfer test (Table 14) showed that training was the only significant variable. Another ANOVA was performed, removing those children who failed the transfer task. Training again was statistically significant ($p < .01$). The same two planned comparisons statistically significant on the first test of transfer were again statistically significant, indicating that the facilitation of transfer was associated with training on brightness, the less preferred dimension. Also training on relevant dimensions, compared with training on irrelevant dimensions, facilitated transfer. (See Table 17.)

Discussion

The results of Experiment II, which are graphically presented in Figures 14, 15, and 16, agree closely with the results of Pilot Study 2. Predictions 2 and 3 of Experiment II were supported, which were the same as the two predictions supported in Pilot Study 2.

The second prediction of Experiment II was that training on a less preferred, relevant dimension enhances transfer. The pretest data of Experiment II showed that brightness was a less preferred dimension than shape. The data of the two transfer tests clearly indicated that brightness training facilitated transfer more than shape training, indicating training on the less preferred but relevant dimension was better for transfer than was training on a more preferred, relevant dimension.

The third prediction of Experiment II was that training with relevant dimensions facilitates transfer compared with training with irrelevant dimensions. This rather obvious hypothesis was again supported in the data of both transfer tests.

Table 16

Planned Comparisons Among the Mean Errors,
Transfer Test I: Experiment II

	Treatment Group							
	D_{1R} (shape)	D_{1R} (brightness)	D_{2R} (shape) (brightness)	D_{1Ir} (border)	D_{1Ir} (number)	D_{2Ir} (border) (number)	Control	t
Mean Errors	9.33	.68	2.28	27.30	12.29	18.52	9.14	
n	21	19	18	20	21	21	22	
1. One Problem vs Two Problems	-.25	-.25	-.5	-.25	-.25	-.5	0	
2. Shape vs Brightness	1	-1	0	0	0	0	0	3.23**
3. Two Relevant vs Two Irrelevant	0	0	1	0	0	-1	0	3.70**
4. One Relevant vs Two Relevant	-.5	-.5	1	0	0	0	0	

** = $p < .01$

Table 17

Planned Comparisons Among the Mean Errors,
Transfer Test II: Experiment II

	Treatment Group							
	D_1R (shape)	D_1R (bright ness)	D_2R (shape) (bright- ness)	D_1Ir (border)	D_1Ir (number)	D_2Ir (border) (number)	Control	t
Mean Errors	7.8	.4	1.5	16.8	8.1	13.4	3.55	
n	19	19	18	17	18	19	22	
1. One Problem vs Two Problems	-.25	-.25	.5	-.25	-.25	.5	0	
2. Shape vs Brightness	1	-1	0	0	0	0	0	2.75**
3. Two Relevant vs Two Irrelevant	0	0	1	0	0	-1	0	4.42**
4. One Relevant vs Two Relevant	-.5	-.5	1	0	0	0	0	

** = $p < .01$

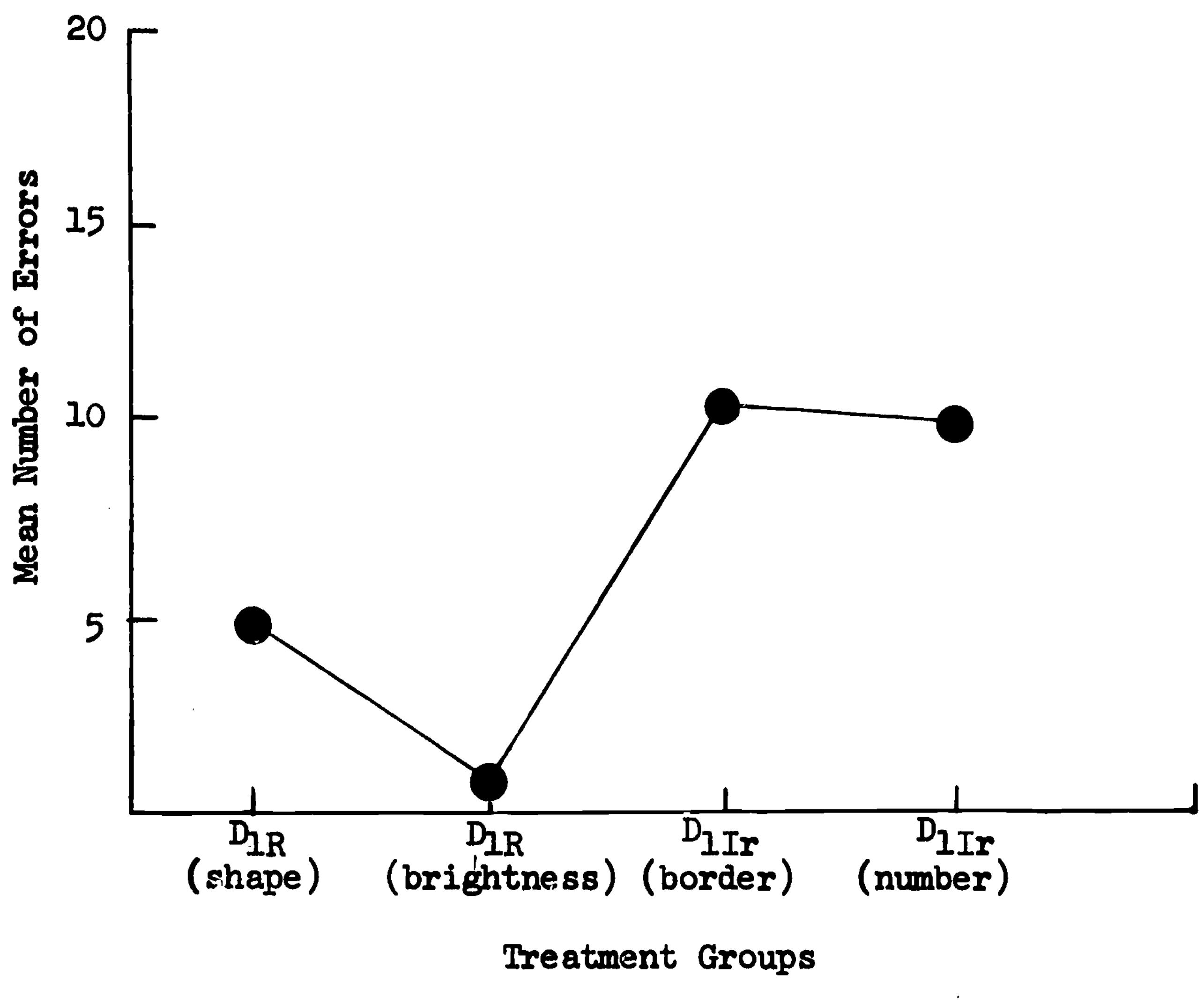

Figure 14. Mean number of errors during training: Experiment II.

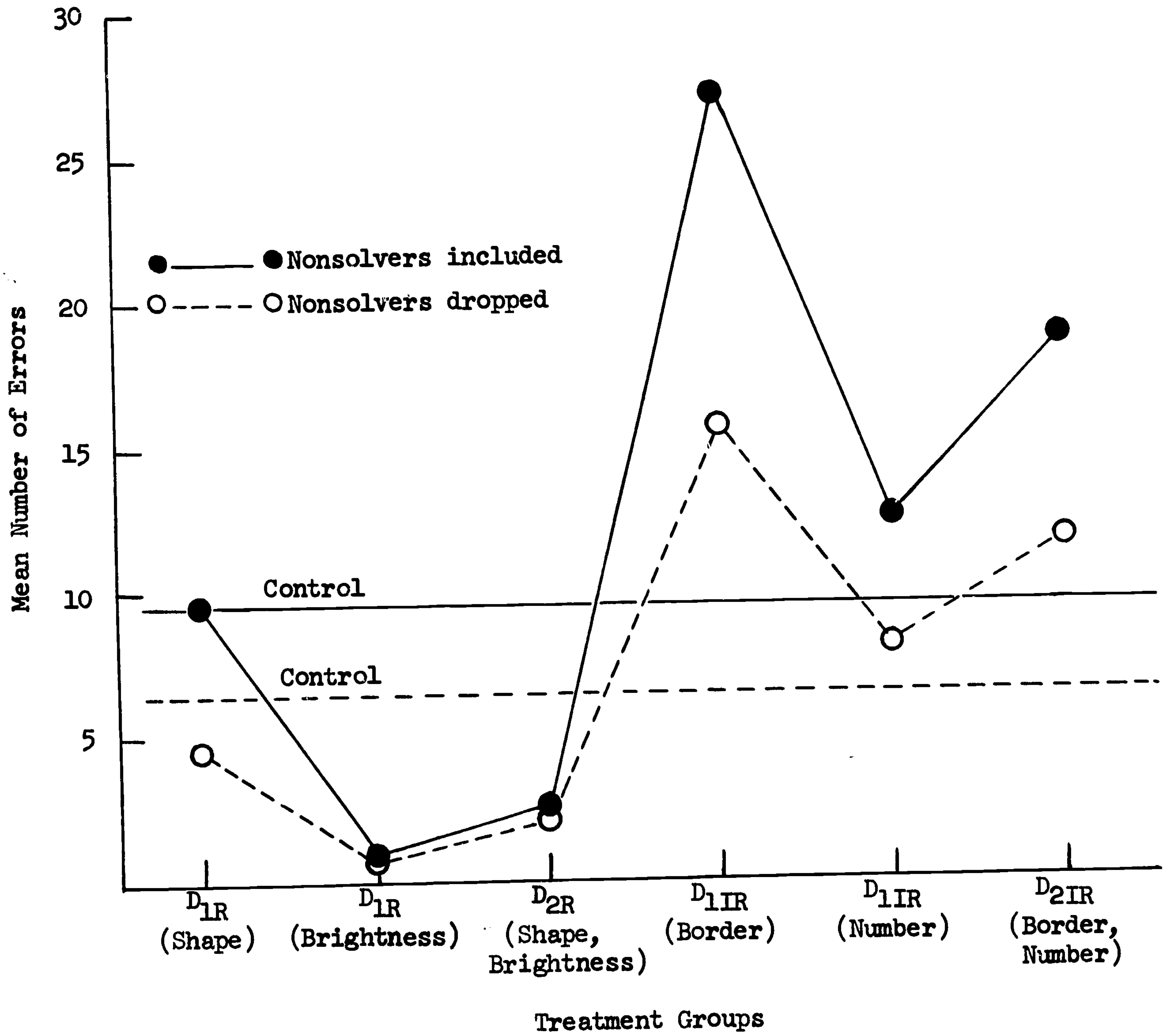

Figure 15. Mean number of errors, Transfer Test I: Experiment II.

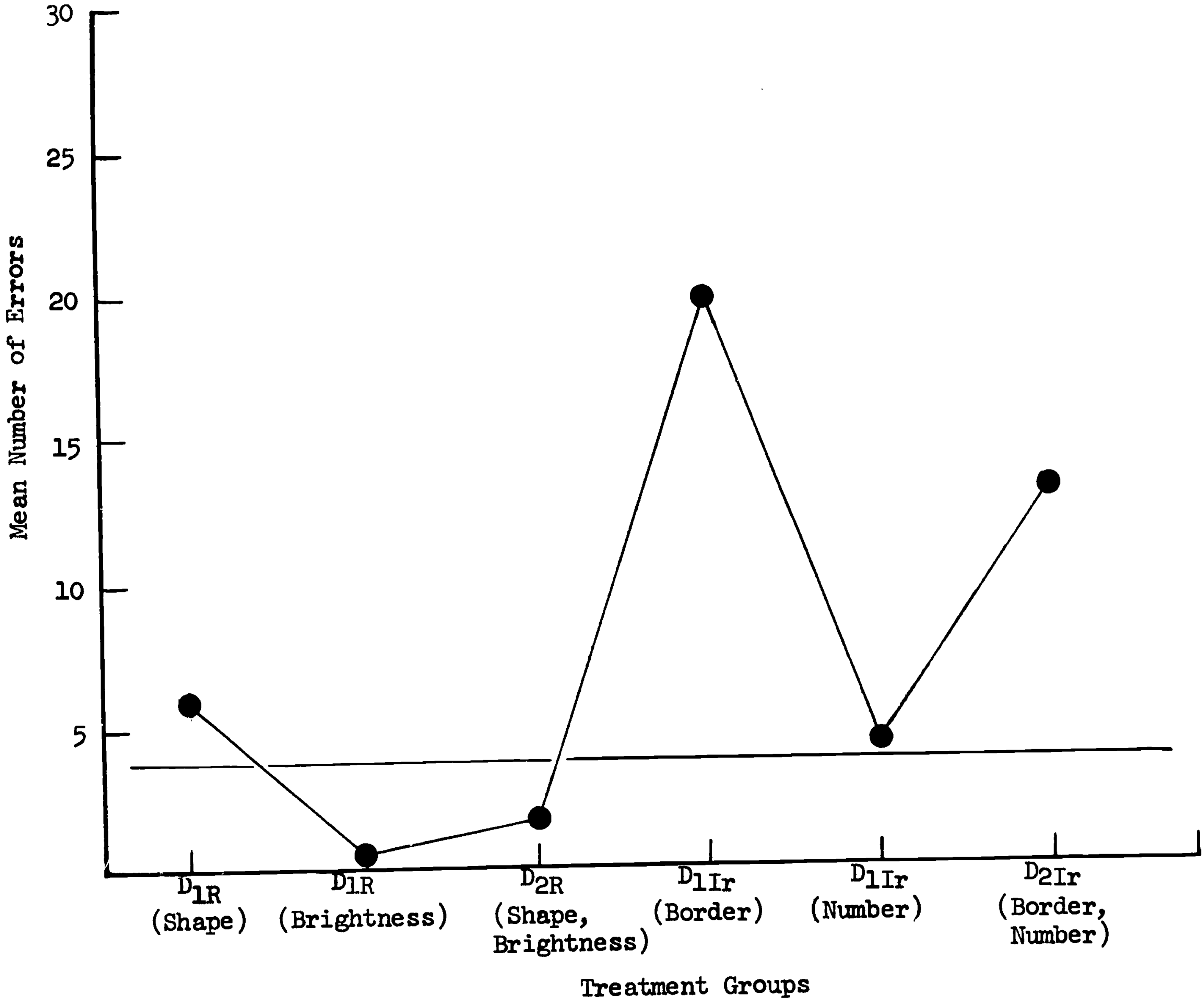

Figure 16. Mean number of errors, Transfer Test II: Experiment II.

Conclusions and Implications

Conclusions. In Pilot Study 2 and in Experiment II the relevance of the training and the children's preferences for dimensions were the two variables that affected transfer. The other independent variables, e.g., verbalization by S and number of problems practiced, did not produce statistically significant results.

The results indicate that dimensional preferences exist in children 9 to 11 years of age, thus extending findings with children of a younger age group. Suchman and Trabasso (1966) found that younger children preferred color to form, while older children preferred form. The median transitional age was 4 years, 2 months. The results of the present study indicate that shape (form) is the dimension (among the five dimensions used in this study) most preferred by children 9 to 11 years of age.

The data of the present study also demonstrated the role of dimensional preferences in transfer. Children whose preferred dimension is relevant to the problem solve the transfer problem more quickly than children whose preferred dimension is irrelevant to the problem. This facilitation of learning was shown to exist in both learning and transfer.

By far the most interesting, and we believe most important, result of Pilot Study 2 and Experiment II was the interaction between training; i.e., the dimension reinforced during training, and the children's pre-experimentally acquired preferences for dimensions. Two dimensions were differentially preferred by children. Shape (form) was preferred over brightness. Given this situation, we found that training which reinforced the child for choosing the less preferred but still relevant dimension - brightness - increased transfer compared with a procedure which reinforced him for choosing only his more preferred dimension - shape.

Implications. The finding summarized in the preceding sentence seems to us to be of fundamental importance in instruction and teaching. It implies at least two consequences. First, instruction and teaching involve interactions between children's preferences - the previously acquired or proactive factors the subject brings to the learning situation - and the training appropriate to teach him to solve problems. It implies that measures of the learner's preferences be obtained, and that these measures be used to locate the children's less frequently chosen dimensions relevant to learning and to transfer. These less frequently chosen, relevant dimensions are ones which should be trained to increase transfer.

Identifying proactive variables, such as children's preferences, that interact with training is not the same as identifying individual differences among learners, nor the same as identifying interactions between individual differences among learners and types of instruction. Even if all children chose the same dimension, the interaction between their preference and training found in Pilot Study 2 and in Experiment II would still be very much in existence. In fact, its effect would then be maximal, in the type of data analysis we used.

The sentences in the above paragraph do not imply that individual differences among learners are unimportant in instruction, nor that we are uninterested in them. On the contrary, individual differences are most significant in instruction. They reflect the differential effects of proactive processes.

Our point is that proactive variables are fundamentally important in instruction. They do not disappear, as individual differences may disappear, when a given dimension is universally chosen by children. Measuring individual differences is a useful way to measure proactive processes, but the proactive processes are not to be equated to the individual differences. The proactive processes are a fundamental commodity involved in choices among types of instruction.

The second implication is that research in children's learning and instruction can be better understood by recognizing and accounting for the effects of the proactive processes, such as children's preferences. They offer alternative explanations of results of studies, and they help to explain other-wise perplexing, mind-boggling data. Without data on the dimensional preferences of children, we would not have an empirical basis for explaining the greater transfer produced by training on brightness, compared with training on shape.

A last implication we will discuss is that the study of proactive processes important in instruction is an area which educational research has scarcely begun to examine thoroughly. The measurement of gross proactive variables such as age, sex, and IQ does not exhaust the proactive processes important in the understanding of data in children's learning and instruction. Our findings in this report indicate that proactive variables specifically relevant to learning and transfer should be measured and studied. They can be useful for explaining why one type of training works, when another equally plausible one does not work.

REFERENCES

Bilodeau, E. A. & Ryan, F. A. A test for interaction of delay of knowledge of results and two types of interpolated activity. Journal of Experimental Psychology, 1960, 6, 414-418.

Bilodeau, E. A., Sulzer, J. L. and Levy, C. M. Theory and data on the interrelationship of 3 factors of memory. Psychological Monographs, 1962, 76, No. 539.

Bloom, B. S., Davis, A., and Hess, R. Compensatory Education for Cultural Deprivation. New York: Holt, Rinehart and Winston, Inc., 1965.

Bregman, E. O., Thorndike, E. L. & Woodward, E. The retention of the ability to draw lines of a given length blindfolded. Journal of Experimental Psychology, 1943, 33, 78-80.

Brown, E. Index of Socio-economic Status. Institute for Developmental Studies. New York, 1965.

Bruce, R. W. Conditions of transfer of training. Journal of Experimental Psychology, 1933, 16, 343-361.

Cantor, G. N. Effects of three types of pretraining on discrimination learning in preschool children. Journal of Experimental Psychology, 1955, 49, 399-442.

Carey, J. E., & Goss, A. E. The role of mediating verbal responses in the conceptual sorting behavior of children. Journal Genetic Psychology, 1957, 90, 69-74.

Dietze, D. The facilitating effect of words on discrimination and generalization. Journal of Experimental Psychology, 1955, 50, 255-260.

Ebbinghaus, H. Memory: A Contribution to Experimental Psychology. (Trans. H. A. Ruger and C. E. Bussenius), New York: Teachers College, Columbia University, 1913.

Ervin, S. M. Transfer effects of learning a verbal generalization. Child Development, 1960, 31, 537-554.

Gagné, R. M. & Baker, K. E. Stimulus pre-differentiation as a factor in transfer of training. Journal of Experimental Psychology, 1950, 40, 439-451.

Goss, A. E. Verbal mediating responses and concept formation. Psychological Review, 1961, 68, 248-274.

Greenspoon, J., & Foreman, S. Effect of delay of knowledge of results on learning a motor task. Journal of Experimental Psychology, 1956, 3, 226-229.

Jeffrey, W. E. Effect of meaning and direction of training on mediated association. Psychological Reports, 1957, 3, 555-560.

Jensen, A. R. Social Class and Verbal Learning. Unpublished Manuscript. University of California, Berkeley, 1964.

Kelleher, R. T. Discrimination learning as a function of reversal and nonreversal shifts. Journal of Experimental Psychology, 1956, 51, 379-384.

Kendler, H. H., & D'Amato, M. F. A comparison of reversal and nonreversal shifts in human conceptual behavior. Journal of Experimental Psychology, 1955, 49, 165-174.

Kendler, H. H., Glucksberg, S., and Keston, R. Perception and mediation in concept learning. Journal of Experimental Psychology, 1961, 61, 186-191.

Kendler, H. H., & Kendler, T. S. Vertical and horizontal processes in problem-solving. Psychological Review, 1962, 69, 1-16.

Kendler, H. H., & Kendler, T. S. Selective attention versus mediation. Some comments on Mackintosh's analysis of two-stage models of discrimination learning. Psychological Bulletin, 1966, 66, 282-288.

Kendler, H. H. & Vineberg, R. The acquisition of compound concepts as a function of previous training. Journal of Experimental Psychology, 1954, 48, 252-258.

Kendler, T. S. Development of mediating responses in children. Monographs of the Society for Research in Child Development, 1963, 28, (whole No. 6), 33-51.

Kendler, T. S. Verbalization and optimal reversal shift among kindergarten children. Journal of Verbal Learning and Verbal Behavior, 1964, 3, 428-436.

Kendler, T. S. Kendler, H. H. & Wells, D. Reversal and nonreversal shifts in nursery school children. Journal of Comparative and Physiological Psychology, 1960, 53, 83-88.

Kendler, T. S. & Kendler, H. H. Inferential behavior in children: II The influence of order of presentation. Journal of Experimental Psychology, 1961, 61, 442-448.

Kendler, T. S., Kendler, H. H. & Learnard, B. Mediated responses to size and brightness as a function of age. American Journal of Psychology, 1962, 75, 571-586.

Kuenne, M. Experimental investigation of the relation of language to transposition behavior in young children. Journal of Experimental Psychology, 1947, 36, 471-490.

Luria, A. R. The role of language in the formation of temporary connections. In B. Simon (Ed.) Psychology in the Soviet Union. Stanford University Press, 1957.

Luria, A. R. The role of speech in the regulation of normal and abnormal behavior. New York: Liveright, 1961.

Norcross, K., & Spiker, C. C. Effects of mediated associations on transfer in paired-associate learning. Journal of Experimental Psychology, 1958, 55, 129-134.

Postman, L. The present status of interference theory. In Charles N. Cofer (Ed.) Verbal Learning and Verbal Behavior. New York: McGraw-Hill, 1961, 152-179.

Robinson, J. S. The effect of learning verbal labels for stimuli on their later discrimination. Journal of Experimental Psychology, 1955, 49, 112-114.

Rossman, I. L., & Goss, A. E. The acquired distinctiveness of cues: The role of distinctive verbal responses in facilitating the acquisition of discriminative motor responses. Journal of Experimental Psychology, 1951, 42, 173-182.

Saltzman, I. J., Kanfer, F. H. & Greenspoon, J. Delay of reward and human motor learning. Psychological Reports, 1955, 1, 139-142.

Seidel, R. J. The concurrent effects of proactive and retroactive inhibition. Journal of Experimental Psychology, 1959, 57, 397-402.

Shepard, W. O. The effect of verbal training on initial generalization tendencies. Child Development, 1956, 27, 173-178.

Silverman, I. W. Effect of verbalization on reversal shifts in children: Additional data. Journal of Experimental Child Psychology, 1966, 4, 1-8.

Smiley, S. S., & Weir, M. W. The role of dimensional dominance in reversal and nonreversal shift behavior. Journal of Experimental Child Psychology, 1966, 4, 211-216.

Spiker, C. C., Gerjuoy, I. R. & Shepard, W. O. Children's concept of middle-sizedness and performance on the intermediate size problem. Journal of Comparative and Physiological Psychology, 1956, 49, 416-419.

Staats, C. K., Staats, A. W., & Schutz, R. E. Effects of discrimination pretraining on textual behavior. Journal of Educational Psychology, 1962, 53, 32-37.

Suchman, R. C. & Trabasso, T. Stimulus preference and cue function in young children's concept attainment. Journal of Experimental Child Psychology, 1966, 3, 188-198.

Underwood, B. J. Interference and forgetting. Psychological Review, 1957, 64, 49-60.

Underwood, B. J. Laboratory studies of verbal learning. In Ernest R. Hilgard (Ed.) Theories of Learning and Instruction. Chicago: NSSE, 1964, 63, 133-152.

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

Wittrock, M. C. Effect of certain sets upon complex verbal learning. Journal of Educational Psychology, 1963, 54, 85-88.(a).

Wittrock, M. C. Response made in the programing of kinetic molecular theory concepts. Journal of Educational Psychology, 1963, 54, 89-93.(b)

Wittrock, M. C. Set to learn and proactive inhibition. Journal of Educational Research, 1963, 57, 72-75.(c)

Wittrock, M. C. Verbal stimuli in concept formation: learning by discovery. Journal of Educational Psychology, 1963, 54, 183-190. (d)

Wittrock, M. C. Transfer through verbal cueing in concept identification. U.S. Office of Education, Cooperative Research Project, Number 1684, University of California, Los Angeles, 1964.

Wittrock, M. C. The learning by discovery hypothesis, chapter in Learning by Discovery, Keislar, E. R. & Shulman, L. (Eds.), Rand McNally & Co., 1966.

Wittrock, M. C. Replacement and nonreplacement strategies in children's problem-solving. Journal of Educational Psychology, 1967, 58, 69-74.

Wittrock, M. C. & Keislar, E. R. Verbal cues in the transfer of concepts. Journal of Educational Psychology, 1965, 56, 16-21.

Wittrock, M. C., Keislar, E. R. & Stern, C. S. Verbal cues in concept identification. Journal of Educational Psychology, 1964, 55, 195-200.

Wittrock, M. C. & Twelker, P. A. Verbal cues and variety of classes of problems in transfer of training. Psychological Reports, 1964, 55, 195-200.

Wolff, J. L. The role of dimensional preferences in discrimination learning. Psychonomic Science, 1966, 5, 455-456.

Wolff, J. L. Concept-shift and discrimination reversal learning in humans. Psychological Bulletin, 1967, 68, 369-408. (a)

Wolff, J. L. The effects of verbalization and pretraining on concept attainment by children in two mediation categories. Journal of Educational Psychology, 1967, 58, 19-26. (b)

Zeaman, D., & House, B. J. Approach and avoidance in the discrimination learning of retardates. Child Development, 1962, 33, 355-372.

Zeaman, D., & House, B. J. The role of attention in retardate discrimination learning. In N. R. Ellis (Ed.), Handbook of Mental Deficiency, New York: McGraw-Hill, 1963, 159-223.