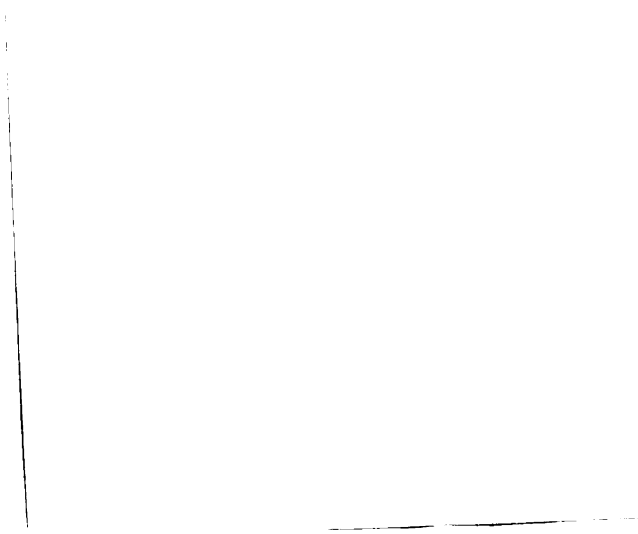
EFFECTS OF STRATEGY AIDS IN PAIRED-ASSOCIATE LEARNING: A DEVELOPMENTAL STUDY

Thesis for the Degree of M. A.

MICHIGAN STATE UNIVERSITY

David L. Cox

1965



ABSTRACT

EFFECTS OF STRATEGY AIDS IN PAIRED-ASSOCIATE LEARNING: A DEVELOPMENTAL STUDY

by David L. Cox

One purpose of this study was to determine whether children in the elementary grades could effectively verbalize about cues which they used to form associations on a paired associate (PA) task. If so, this would enable the experimenter (E) to analyze the types of strategies reported as a function of developmental level. It was also of interest to determine the relationships between these reported strategies and learning and retention as a function of age and sex.

Another purpose was to investigate whether the administration of high level strategy aids to elementary school children would facilitate acquisition and retention of the PA material. It would consequently be of interest to determine the differential effect of giving associational cues on the performance of slow (S) and fast (F) learners.

Two hundred forty-two students from three 4th, 6th, and 8th grade classes served as subjects (Ss) in a low-high, PA task with 3 identical treatment conditions at each grade level. Subjects given treatment 1 received no aid and served as the control group at each grade level. Subjects given treatment 2 received high level strategy

aids on half the pairs, and, in treatment 3, Ss received strategy aids on all pairs.

The developmental analysis of the unaided control groups showed that elementary school children could effectively verbalize about cues which they used to form associations. Moreover, these strategies could be rank ordered along a continuim of complexity and quantified. In brief, the data for groups which had treatment 1 revealed that acquisition and retention scores increase with age as do the number of higher level strategies, and that better performers used higher level strategies at every grade level. Females also performed better than males at all grade levels and consistently used higher level strategies.

The analysis of groups which received treatments 2 and 3 revealed a significant facilitation on acquisition and retention when Ss were provided with strategy aids. Furthermore, giving associational cues on all pairs seemed to be more beneficial than giving aids on only half the pairs. Subjects also performed better on the acquisition and retention of unaided items within a list which had other items aided. This was shown to be related to an increase in the number of high level strategies associated with these pairs. Finally, the data revealed that strategy aids facilitated the performance of slow learners significantly more than fast learners.

The significance of these findings is discussed in the light of developing more appropriate teaching materials and methods for the classroom.

EFFECTS OF STRATEGY AIDS IN PAIRED-ASSOCIATE LEARNING: A DEVELOPMENTAL STUDY

By

David L. Cox

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

College of Education

1965

ACKNOWLEDGEMENTS

To the people who made this study possible I wish to express my gratitude. I am indebted to Dr. Clessen J. Martin, advisor and project director, who afforded the opportunity for a study of this magnitude, and for his valuable suggestions and guidance throughout my program. To Dr. Frederick J. Boersma and Cornelius Vanderveen I also owe a special word of thanks. Without their kind assistance in experimentation and performing the many analyses, completion would not have been possible. Finally, to the 243 grade school children, their teachers and principals, who eagerly gave their time and participation, I am grateful.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

The study of conscious thought processes in scientific psychology has an old and interesting history. Early discussions of consciousness were either philosophical and/or theological in character and were most often couched in terms of a dualism like mind vs. matter, rational vs. irrational, or soul vs. body. From the ancient Greeks through the time of Descartes discussions of this nature dominated much of the conversations of learned men. Then in the 19th century British Empiricism brought dualism and the concept of consciousness into psychology. Locke, Berkeley, and Hume, the main representatives of this philosophy, were all interested in how the mind gets to know about the external world (Russell, 1945). But their investigations of this external world led to a departure from traditional dualism and to a doctrine of association which dealt mainly with the relations among the items of mind, with a corresponding de-emphasis on the other half of the dualism.

The founders of the new experimental psychology, Fechner, Wundt, Mach, Helmholtz, etc., were interested in studying consciousness and their chief method was introspection. In general they believed conscious events were dependent on brain events, but completely separate and different from them. Therefore, some kind of introspection or inner perception through which one obtains evidence about mental events was necessary. James (1890) was of the opinion that introspective observation is all human beings

have to rely on to know of their existence. He defined introspection as looking into our own minds and reporting what we discover there. He further stated, "Every one agrees that we there discover states of consciousness." By this reasoning the introspective technique soon came to be used in the experimental laboratories. If conducted correctly it was regarded as a process not subject to error. In fact, Wundt and his followers placed a great deal of emphasis upon training observers for the accurate description of their conscious processes.

Classical introspectionism soon boasted such members as Wundt, Kulpe, Muller, and Titchener (Boring, 1953). They shared the belief that description of consciousness reveals patterns of sensory elements which could be further broken down into more basic elements. Thus elementism and sensationism became synonymous with introspectionism. Titchener further maintained that these descriptions of consciousness should exclude statements of meaning since these were merely inferences on the part of the observer and lacked the accuracy of reports of sensations. But introspection with inference and meaning left out soon became extremely dull and without function. And psychologists began to note that examinations of the mind did not reveal stable images and sensations, but rather intentional activities directed toward an object or goal. Such shortcomings combined with the advent of Gestalt and Behavioristic psychology culminated in the downfall of classical introspectionism.

In the early 1900's Gestalt psychology, founded by Wertheimer, developed as a protest against the constraints and inadequacies of classical introspectionism. It took root particularly in the area of perception where classical introspectionism could not explain the phenomenon of seen movement. Within this theory, learning involved changes in the phenomenal field through an organization of the incoming stimuli in a way which achieved maximum simplicity. As such, the perceptions could be analyzed and studied in and of themselves using an introspective technique, but without reference to conscious mental processes, images, or sensations. The main difficulty in applying Gestalt psychology to problems of learning was that the system, while describing certain aspects of the learning process, did not indicate how the environment should be arranged in order to facilitate learning. And even though Gestalt psychology exerted extensive influence on educational thought and remained respectable, its popularity in America soon began to wane. As Boring (1953) states, "American psychology tended all along to be practical and functional and...was destined to become behavioristic."

The greatest rejection of classical introspectionism came with the advent of behaviorism. Its principal proponent, J.B. Watson, reacted against the formalism and inaccuracy of introspection and attempted successfully to replace it with a psychology of behavior. At the same time, studies of conditioning by Pavlov helped spread this behavioristic position in American psychology. In brief, behaviorism espoused the doctrine that psychological

theory should be based on data recorded from observable actions of subjects (Ss). These data were to be collected under controlled experimental conditions in which the experimenter (E) manipulated various properties of the stimulus materials presented. Subjects in these tasks were to be naive, rather than trained, and introspective references to consciousness were to be excluded.

Watson, in attacking introspection was not objecting to the use of words by the subject, but rather to trusting the subject to place correct and interpretable meanings into his words. He thus criticized this method as being extremely unreliable. Introspective reports lacked consensual validity, since several persons viewing the same material often gave different interpretations as to its content. Because of these factors psychologists became very leary about obtaining verbal reports from Ss in psychological studies. It was assumed the experimenter could not believe the subject or accurately interpret what he said. Most studies, therefore, dealt just with the quantitative aspects of learning and recall and with modes of presentation of the material. This operationism further tended to prevent psychologists from speculating about processes inside the memorizer and emphasized what the experimenter, rather than the memorizer, was doing. Such data were seldom supplemented by reports of how the learner represented the material to himself.

Certain psychologists took an extreme position in the condemnation of introspectionism and denied that a person's conscious mediational processes had any necessary connection at all with the

learning process. One such investigator was E.L. Thorndike. Throughout the 1930's Thorndike accumulated evidence which showed that a great many Ss who performed well in learning situations could not verbalize how they had learned. He maintained that conscious awareness of what one is doing is not necessary for learning to take place. Any relationship between introspective reports of awareness and performance merely shows that awareness depends on how much learning there is of which to be aware (Thorndike, 1935; Farber, 1963). In other words, awareness may be a consequence of learning rather than a prerequisite. More recently, B.F. Skinner expressed the view, "The private event is at best no more than a link in a casual chain and it is usually not even that (Farber, 1963).

But even the behaviorists could not afford to deny completely that such processes were going on. Comprehensive theories of learning, postulated by such noted men as Hull, Tolman, Levin, and others, acknowledge the central processes involved in learning. But their theories, according to Travers (1963), made little provision for the measurement of the mediating processes which their systems discussed. Various studies of mediation were conducted, but usually within some sort of transfer paradigm. Subjects were typically asked to learn several similar lists of paired-associates, and mediation was indirectly inferred by E from the changes in Ss performance from one list to the next. As Barclay (1961) has suggested, however, transfer paradigms are not the most effective designs for studying mediation. He concluded that within such

designs mediation either has no effect or its effect is so closely interwoven with general transfer that it cannot be distinguished. An introspective technique, when considered with respect to other variables, might minimize this problem and provide valuable information about mediational processes.

Recently there has been a resurgence of interest in conscious mediational processes. A number of psychologists have argued that not only do private experiences exist, but also they may to some extent explain a person's behavior in a learning situation (Miller, Galanter, & Pribram, 1960). Among these investigators there is a growing acceptance that learning is not accomplished in simple rote fashion as formerly thought.

This matter is related to the classical controversy in psychology concerning the nominal vs. effective stimulus. The nominal stimulus refers to the measured properties of the stimulus material as presented. The effective stimulus refers to the psychological consequences of stimulation and cannot be directly observed. How the two are related is complex and difficult to determine, but investigations of this relationship are crucial in developing comprehensive models of behavior. This is particularly true in learning verbal materials because of the complete degree to which effective stimulation depends on the activities of the experimental subject (Rothkopf, 1965).

Miller (1956) has written extensively on coding processes used by Ss in transforming the nominal into the effective stimulus. Underwood and Keppel (1963) call this process encoding. They

maintain that there is a transposition process in memory which may involve associational aids or mneumonic devices. In addition, if a subject in fact encodes the material he must necessarily decode it to produce the original stimulus. More specifically, the effectiveness of a person's encoding-decoding procedures will be ultimately related to learning. Thus, in opposition to the noncognitive argument of investigators such as Thorndike, these cognitive theorists support the position that conscious recognition of the relational aspects of the material to be learned is directly related to performance. They furthermore state that, "If it were not for an unreasonable prejudice against questioning subjects psychologists would long ago have discovered...that one can usually understand a person's behavior much better (Farber, 1963).

Several experimenters have recently discussed the feasibility of questioning Ss and using their verbal reports to study how people learn (Epstein, Rock, & Zuckerman, 1960; Miller, Galanter, & Pribram, 1960; Underwood & Schulz, 1960; Farber, 1963; Eagle & Leiter, 1964). Generally these investigators are in agreement that verbal reports may provide valid information on how people learn, but relatively few systematic and extensive investigations have been undertaken to support their conjectures. Some recent research by Martin, Boersma, & Cox (1965) has attempted to systematically analyze and classify Ss verbal reports. These experimenters gave Ss a PA learning task after which they were to state in writing how they had attempted to make each association. In brief, Martin et al. were able to classify verbal reports into seven

categories: (1) No association, (2) Repetition, (3) Single letter cue, (4) Multiple letter cue, (5) Word formation, (6) Superordinate, and (7) Syntactical. These categories are rank ordered along an apparent continuum of cue complexity. A description of the classification scheme is given in Table 1. Plotting mean correct responses for each pair as a function of strategy level resulted in a monotonically increasing relationship from strategy levels one through seven. In addition, each subject was assigned a total strategy level score based on the sum of his strategy ratings for all eight pairs. A Spearman rank order correlation coefficient between total strategy level score and total correct responses on the task was .62 indicating the higher the strategy level the greater the number correct. They found this scheme to be very reliable and to have predictive value. With this approach, Martin et al. (1965) have shown that it is possible to classify a widely varying collection of idiosyncratic verbal reports into relatively few categories. Furthermore, rank ordering these categories made possible a certain level of quantification which yielded a positive relationship between verbal reports and performance.

Since actively searching for cues, or coding the material, has been shown to be part of the learning process it may be reasoned that giving strategy aids would effectively reduce the time required to learn. As expected, such studies have shown that when Ss are given instructions specifically designed to increase the probability of mediational links in PA learning, or when the links themselves are provided by E, the results are often striking. In

TABLE 1

Classification and Rank Order of Associative Strategies

Associative Strategy	Type of Cue Subject Reported Using	Example of Verbal Report
1. No Reported Associations	S was not able to state how he managed to make the association.	Sagrole-Polef: "Don't know how I learned this pair."
2. Repetition	S reported rehearsing the pair.	Volvap-Nares: "Just kept repeating these words to myself."
3. Single Letter Cues	S reported using a single letter in each of the paralogs in making the association.	Tarop-Gojey: "Noticed that each word contained an O."
4. Multiple Letter Cues	S reported using multiple letters in each of the paralogs.	Sagrole-Polef: "Each word contains an OLE."
5. Word Formation	S reported that an actual word was embedded in one or both of the paralogs and made use of these words in making the association.	Meardon-Zumap: "The word EAR is contained in Meardon and learned that EAR goes with Zumap."
6. Superordinate	S reported selecting elements from each of the two paralogs that had some relationship to each other.	Sagrole-Polef: "Sagrole begins with S and Polef with P - thought of State Police."
7. Syntactical	S reported selecting elements from each of the two paralogs and embedding these elements into a sentence, phrase, or clause.	Rennet-Quipson: "Changed Rennet to Bennet and saw Quips in Quipson - thought Bennet Cerf Quips on TV."

every case the number of trials, number of errors, or time to criterion were significantly reduced, both for normal and retarded Ss (Spiker, 1960; Cramer, 1962; Jensen & Rohwer, 1963; Kitao, 1963). Merely naming the stimulus items has produced facilitation of learning (Jensen, 1963). This effect has also been shown to occur when only one word provides the mediating link (Epstein, Rock, & Zuckerman, 1960; Glanzer, 1962). But studies in which the experimenter provides the link in the form of a syntactical or thematic strategy in general may be expected to have the greatest facilitating effect (Jensen & Rohwer, 1963; Bruner & Oliver, 1963; Davidson, 1964; Martin, Boersma, & Cox, 1965). The facilitating effect of mediational cues has also been illustrated in long term retention. Wallace, Turner, & Perkins (1957) showed that when Ss were instructed to form a visual image connecting two words on a PA task they could remember up to 700 pairs with 95% accuracy.

In general these studies illustrate the increase in learning and retention when Ss are provided associational cues or are instructed to provide their own. But no studies could be found which systematically investigated these effects with respect to age. More specifically, no studies were revealed which examined the effects of giving the same syntactical mediational cues at various age levels.

No studies were disclosed which investigated the extent to which mediational cues should be given. Providing aids on only part of the material to be learned may provide the subject with enough information to formulate his own on the unaided material.

Giving aids on all the material may be too much to assimilate and interfere with maximum performance. On the other hand, any transfer from the aided items may not be as beneficial as if E provided cues on all the material to be learned.

These effects also have not been studied with respect to slow and fast learners. Studies comparing the mediational activities of slow and fast learners seldom show consistent or clear results (Scheible, 1954; Underwood & Schulz, 1960). An investigation of these problems utilizing the Martin et al. (1965) strategy classification scheme may contribute valuable information to the study of the learning process.

The present study was designed to determine whether the methods for collecting strategy information from college students employed by Martin et al. (1965) could be utilized for 4th, 6th, and 8th graders. More specifically, it was designed to determine whether children in elementary grades could effectively verbalize about cues which they used to form associations. If so, it may be possible to employ Martin's classification system to study the formation of associative strategies developmentally. It was reasoned that one important factor involved in a person's increasing learning ability may be an increase in the use of high level strategies. It was also of interest to determine if there were any sex differences in performance and/or strategies used and to investigate such differences developmentally.

Another purpose of this study was to investigate whether strategy aids given by E would facilitate performance of Ss in the

elementary grades. Furthermore, if provision were made for aiding a different number of items for the various groups, it might be expected that the more items given a strategy aid the better the performance of the group. In addition, Ss may be expected to perform better on the unaided items within a list which has other items aided. It was reasoned that providing strategy cues for some items within a list may help Ss to formulate their own strategies on the unaided items. This in turn may facilitate performance on these items relative to a control group which had the same pairs, but none of which were given strategy aids.

Another aspect of this experiment which has been little investigated is the relationship between strategies employed during learning and long term retention of the material. It was reasoned that given strategy aids would increase retention on the aided pairs, and perhaps on those unaided pairs within a list which contained aided items.

For the present study it was also conjectured that one of the differences between fast and slow learners may be that the latter have not developed the habit of searching for cues in material to be learned. On this grounds one might expect that the administration of strategy aids by E would facilitate the performance of slow learners more than the fast learners.

DESIGN AND METHODOLOGY

Subjects

Two hundred forty-two students, 130 males and 112 females, served as Ss in this experiment. The students were from three 4th, 6th, and 8th grade classes in a suburban community. Subjects were tested in their classrooms as a group. Table 2 presents characteristics of the classes at each grade level. Subjects were eliminated from the analysis if in the opinion of the teacher they had severe emotional problems or were retarded. All Ss were naive with respect to paired-associate (PA) learning tasks.

Materials

Sixteen low meaningful (L-M) and sixteen high meaningful (H-M) disyllables were selected from Noble's (1952) list. The L-M items were used as stimuli and H-M items as responses. These low-high pairs were divided into two lists of eight pairs, one designated the practice task list and the other the criterion task list. An effort was made during the construction of pairs, and during the assigning of pairs to lists, to avoid any obvious association between the items in a pair or among the pairs of a list. The mean value of the stimulus and response items were, respectively, 1.91 (s^2 = .58) and 7.44 (s^2 = 1.93) for the practice task items and 1.23 (s^2 = .02) and 7.48 (s^2 = 1.41) for the criterion task items. The criterion list is presented in Table 3. Each stimulus-response pair and each stimulus (without the response) was photographed on separate slides for visual presentation. A Kodac 700

TABLE 2

Sample Characteristics and Treatment Designations for the Nine Classes

Grade Level	n	Males	Females	Mean Age	Age s^2	Treatment Condition	
	27	16	11	9.7	.38	4-C	Control
4	24	12	12	9.6	.33	4-E-4	Aid on 4 pairs
	34	21	13	9.6	.25	4-E-8	Aid on 8 pairs
	28	12	16	11.6	.47	6-C	Control
6	26	15	11	11.8	.24	6-E-4	Aid on 4 pairs
	28	14	14	11.7	.29	6-E-8	Aid on 8 pairs
	28	19	9	13.5	.33	8-C	Control
8	22	9	14	13.7	.42	8-E-4	Aid on 4 pairs
	25	13	12	13.6	.41	8-E-8	Aid on 8 pairs

TABLE 3

Paired-Associate List and Strategy Aids for Criterion Task

Criterion Task		Strategy Aid
NEGLAN	LEADER	"Negro leader"
MEARDON	INSECT	"Meadow insect"
SAGROLE	MONEY	"Role of money"
VOLVAP	JEWEL	"Valuable jewel"
LATUK	OFFICE	"Late to office"
BODKIN	WAGON	"Book in wagon"
TAROP	DINNER	"Tar for dinner"
ZUMAP	KENNEL	"Zoos have kennels"

carousel projector with a Lafayette T-2K automatic timer was used for presentation of the slides.

Procedure

Measures on four separate tasks were obtained from each individual: (1) a practice task, (2) a criterion task, (3) a strategy report task, and (4) a retention task. The practice task was administered 24 hours before the criterion task. Strategy information was collected immediately after the criterion task, while retention data were obtained 48 hours later. All Ss were naive with respect to the testing schedule.

The practice task was given to insure that everyone understood the nature of the criterion task and to control for warm-up and learning to learn effects, which have been shown to confound the results of similar studies (e.g. Mattson, 1965). Another purpose of the practice task was to assess comparability of groups. This was necessary to insure that differences on the criterion task could be attributed to treatments and not to an initial difference in the ability of the groups. The task also served as an instrument for defining slow and fast learners for the criterion task. Thus E was able to determine the differential effect of treatments on slow and fast learners. Finally, the practice task gave Ss an opportunity to become acquainted with the concept of strategies before the collection of strategy information. A pilot study showed that 4th grade students had difficulty interpreting the question, "What tricks, if any, did you use while trying to learn

these pairs?" Consequently, a great deal of individual attention was required if Ss were to adequately express in writing how they had attempted to form an association. It was reasoned that acquainting Ss with the concept of strategies or tricks would reduce the amount of individual attention required and increase the validity and reliability of their reports on the criterion task.

At the beginning of the practice task Ss were given test booklets and instructed to fill in the face sheet. Immediately following the face sheet a sample test page appeared. The E read the instructions and used this sample to help explain the task. Subjects were told to study the pairs of items as they appeared on the screen during each learning trial, and on test trials to circle the word in their test booklet they thought went with the stimulus item. Complete instructions are given in Appendix A. For the practice task, learning trials were presented at a 4 second rate with a 5 second intertrial interval. For the test trials, however, the timer was switched to manual control so that all Ss had sufficient time to respond. Exposure time for each test item was approximately 10 seconds. Four learning trials were alternated with four test trials. Each of the eight pairs were presented separately for learning trials, as were the individual stimulus items for test trials. Duplicate copies of each slide enabled E to randomize slides on every learning and test trial and thus avoid possible serial position effects.

A recognition procedure was used for test trials. The test booklets contained 32 pages with the eight responses randomly

presented on each page. Odd numbered pages were on yellow paper, and even numbered pages on white paper so that E could call out the number and color of the page for every test item. A quick glance around the room insured that every subject was on the right page.

At the conclusion of the task Ss were shown each pair separately and asked if they had used any tricks while attempting to learn the pairs. Three different students were selected to respond for each item. This procedure acquainted Ss with the concept of strategies for the purpose of improving the collection of strategy information on the criterion task.

The criterion task was presented 24 hours after the practice task. The procedure was similar to that of the practice task with the following exceptions: (1) a different PA list was used, (2) subjects were run for five trials, (3) exposure time per item indicated that the task was somewhat easier than expected, and (4) specific instructions were given for the respective treatment conditions.

Criterion treatments were randomly assigned to the three classes at each grade level. Table 2 presents the respective treatment assignments. No strategy aids were given for the control treatment. Thus, performance of these groups provided a standard against which to judge treatment effects. For the E-4 treatment, however, E gave strategy aids on 4 of the 8 pairs. The aided pairs are the first 4 pairs presented in Table 3. Aid was given simply by having E verbally state the strategy for each pair on learning trials one and two. For the E-8 treatment, aid was presented

verbally on all eight pairs on trials one and two. These strategy aids are presented in Table 3. The aids employed in this study were selected from those shown to be effective in the pilot study. Instructions for each treatment are presented in Appendix B.

In brief, the control groups were told that they were going to do the same kind of task they did the day before, but with different pairs. The E-4 groups were told the same thing. In addition, they were told E would give them a trick on 4 of the 8 pairs which might help them learn those pairs. The E-8 groups were instructed similarly except that E said he would give a trick for all 8 pairs. Ss were told they could use these tricks or not as they pleased.

A recognition procedure was employed for the criterion task. The test booklets contained 40 pages with the 8 responses randomized on each page to avoid possible serial position effects. Again yellow and white pages were alternated to aid in the administration of the task.

After completion of the criterion task, E passed out a booklet which had each pair printed on a separate page. Ss were instructed to write down, to the best of their ability, how they had attempted to form each association. If they used a trick they were to state what it was. If Ss in the aided groups used E's tricks they were to write these down as given. Subjects were given approximately 90 seconds per pair to report a strategy. Complete instructions for this task are presented in Appendix C.

Using a recall method, retention data were collected 48 hours after the criterion task. Ss had not been told there would be a

retention test on the criterion pairs. Each stimulus word was presented separately on a blackboard for 15 seconds. Subjects were instructed to write down both the stimulus and the word they thought went with it. Complete instructions for the retention task are presented in Appendix D.

Three experimenters conducted the testing for all experimental procedures. The pilot study revealed that this number could adequately handle the group testing procedures.

Developmental Analysis

To investigate performance on the PA task developmentally, several analyses were performed. The 4th grade control (4-C), 6th grade control (6-C), and 8th grade control (8-C) groups in the criterion task were selected for study, since these groups were not confounded by treatment effects. Figure 1 presents the criterion task acquisition curves for these groups. Mean total correct responses and variances for 4-C, 6-C, and 8-C groups were, respectively, 20.93 (s^2 = 75.23), 27.43 (s^2 = 67.51), and 29.04 (s^2 = 50.63). A one-way analysis of variance among total correct responses for the three control groups yielded a statistically significant F ratio ($F = 7.842$; $df = 2,80$; $p < .01$). Individual comparisons showed that 8-C and 6-C were significantly different than 4-C ($p < .01$), but not significantly different from each other. In short, ability to perform on the task increases at a decreasing rate among elementary school children at these ages.

To investigate the hypothesis that associative strategies may be related to this increase in performance with age, four judges independently rated the verbal reports of the 4-C group. Each subject was then assigned a total strategy score based on the sum of strategy ranks for all 8 pairs. The Kendall coefficient of concordance (W) among all four raters on total strategy score was .98 (see Siegel, 1956, pp. 229-238). Since inter-rater reliability was extremely high only one rater was selected to rate 6th and 8th

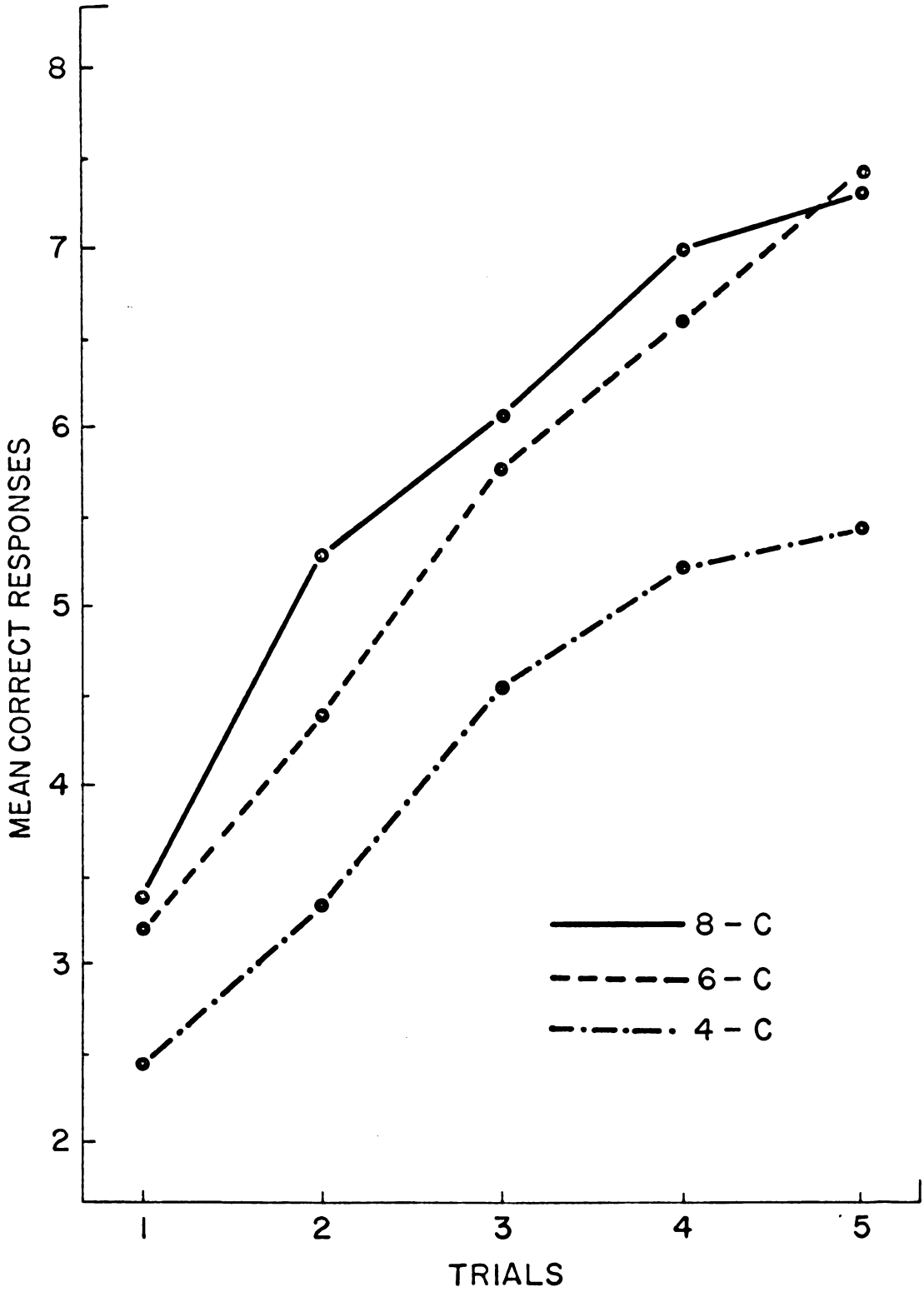


Fig. 1. Acquisition curves for 4, 6, and 8th grade control groups on criterion task.

grade verbal reports. Total strategy level scores were subsequently computed for Ss in each of these groups.

Table 4 shows percent frequency of strategy level use for each control group. It reveals an increase in high level strategies as age increases. Mean total strategy scores and variances for 4-C, 6-C, and 8-C groups were, respectively, 28.48 (s^2 = 170.33), 39.96 (s^2 = 52.63), and 43.36 (s^2 = 116.37). A one-way analysis of variance on total strategy scores for these groups yielded a significant F ratio ($F = 18.458$; $df = 2,80$; $p < .01$). Individual comparisons revealed that 8-C and 6-C were significantly different than 4-C ($p < .01$), but were not significantly different from each other. Thus, these data show that frequency of high level strategies and total strategy scores increase with an increase in age.

To assess the relationship between strategy used and performance on individual pairs, mean correct responses for each strategy level were computed. These means are plotted for each group in Figure 2. In general, the figure shows the higher the strategy level the better the performance. In order to determine whether this positive relationship held for total strategy scores, Spearman rank order correlations between total strategy scores and total number correct responses were computed. The correlations for 4-C, 6-C, and 8-C were, respectively, .54, .61, and .45 ($p < .01$). In short, these results indicate that a significant amount of variance in Ss performance on the PA task can be accounted for by their verbal reports.

TABLE 4

Percent Frequency of Strategy Level Use
for 4, 6, and 8th Grade Control Groups

	Strategy Classification						
Grade Level	1	2	3	4	5	6	7
4	29	19	7	9	3	14	19
6	4	19	5	9	6	24	33
8	5	6	11	3	6	35	34

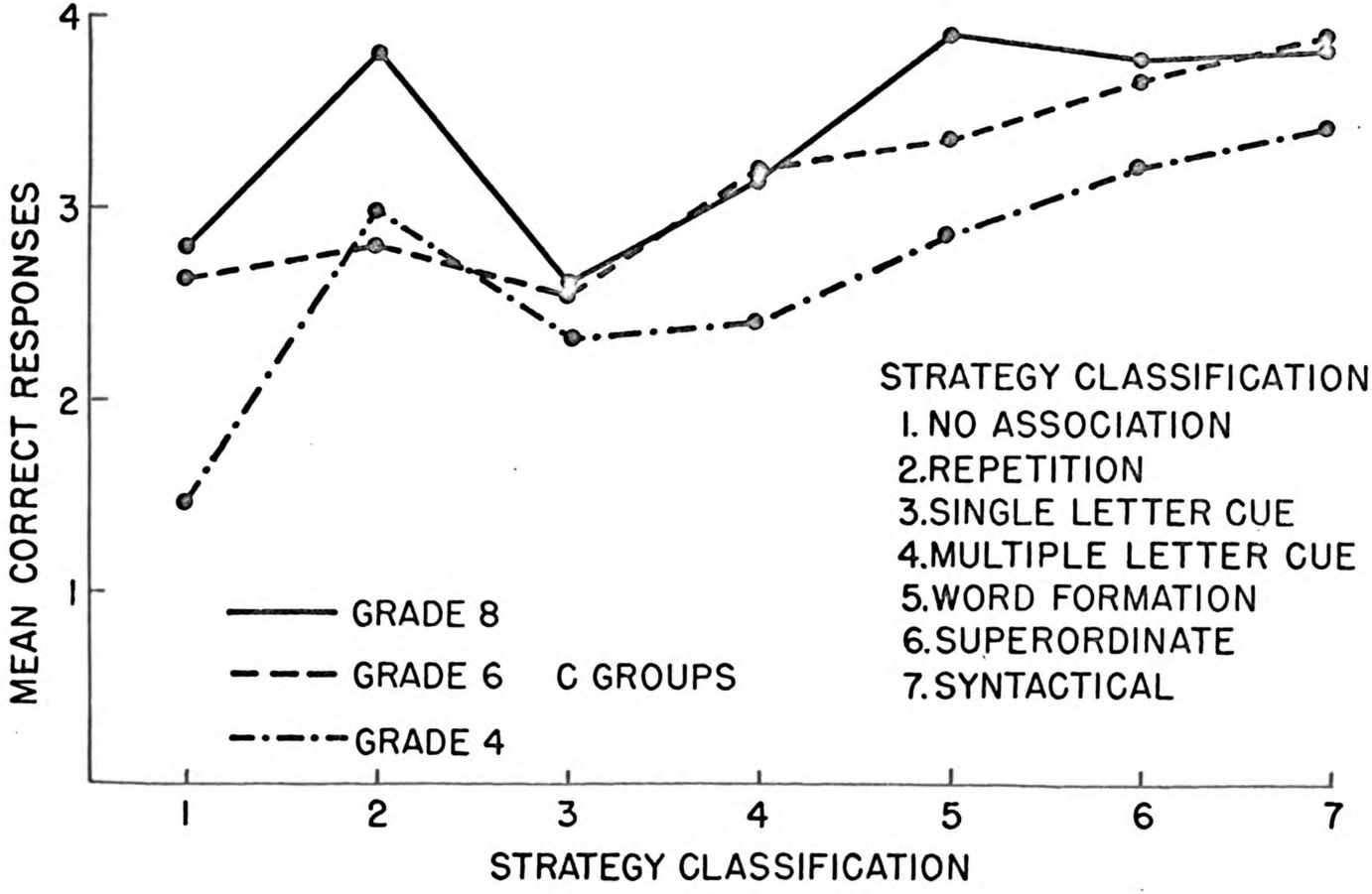


Fig. 2. Mean number correct responses by strategy for control groups on criterion task.

It was also of interest to determine whether there was a sex effect in performance and/or strategies used in the task with respect to grade level. First, a sex by grade level analysis of variance on total correct responses was performed. For this analysis both main effects were significant ($p < .01$), and the interaction was negligible (see Table 5). Mean correct responses and variances for males and females in the three control groups are presented in Table 6. This table shows females performed better than males at every grade level. Second, a sex by grade level analysis of variance on total strategy scores was performed. Again, both main effects were significant (sex, $p < .05$; grade level, $p < .01$), and the interaction was negligible (see Table 7). Mean strategy scores and variances for males and females in the three control groups are presented in Table 8. This table shows females had higher total strategy scores than males at every grade level.

If it can be shown that long term retention of the material increases with the use of high level strategies, the previously observed positive relationship between levels of strategy used and acquisition becomes especially important. Therefore percent correct responses on the retention task as a function of strategy level used on the criterion task was plotted (see Figure 3). Examination of this figure reveals, in general, that higher level strategies are associated with better retention. The reversals in the middle range of strategy levels may be attributed, in part, to

TABLE 5

Analysis of Variance on Total Correct Responses on Criterion Task for 4, 6, and 8th Grade Control Groups

Source	DF	F
Sex	1	23.85**
Grade Level	2	10.43**
Sex X Grade Level	2	.55
Residual MS	77	(50.96)

** $p < .01$

TABLE 6

Mean Correct Responses and Variances for Males and Females in 4, 6, and 8th Grade Control Groups

Grade Level		Sex	
		Males	Females
4	$\bar{X}_2$	17.25	26.27
	s	42.73	78.42
6	$\bar{X}_2$	24.33	29.75
	s	77.88	51.00
8	$\bar{X}_2$	26.16	35.11
	s	45.25	7.86

TABLE 7

Analysis of Variance on Total Strategy Scores for 4, 6, and 8th Grade Control Groups

Source	DF	F
Sex	1	6.15*
Grade Level	2	13.72**
Sex X Grade Level	2	1.29
Residual MS	77	(100.04)

* $p < .05$

** $p < .01$

TABLE 8

Mean Strategy Scores and Variances for Males and Females in 4, 6, and 8th Grade Control Groups

Grade Level		Sex	
		Males	Females
4	$\bar{X}_2$	24.69	34.00
	s	137.56	180.00
6	$\bar{X}_2$	39.25	40.50
	s^2	54.75	53.87
8	$\bar{X}_2$	38.89	47.22
	s^2	130.99	8.95

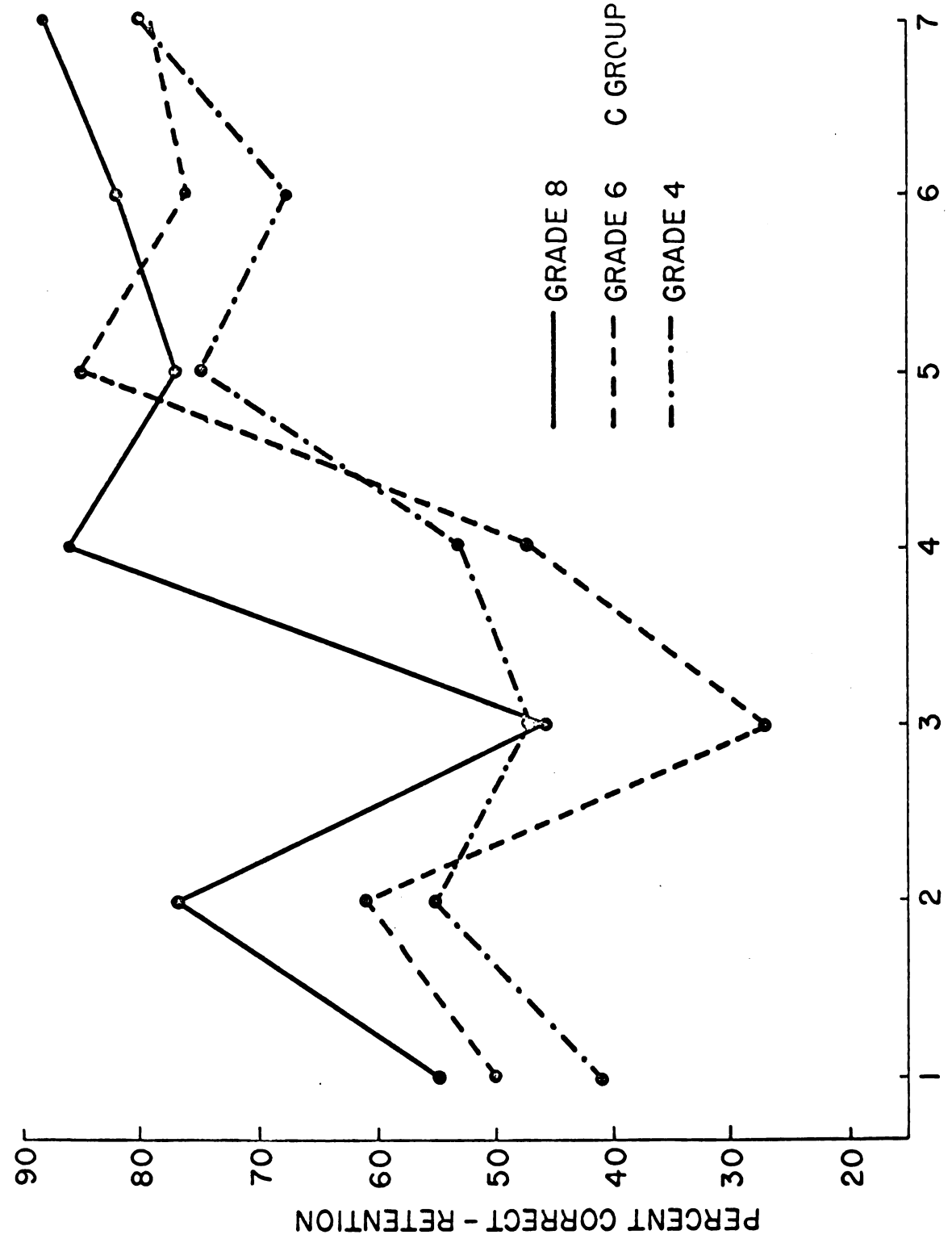


Fig. 3. Percent correct responses on retention as a function of strategy level used on criterion task for control groups.

the relatively small frequency of strategy use at these levels, and to the restricted range of retention scores.

A one-way analysis of variance on total retention scores for the three control groups yielded a significant F ratio ($F = 7.213$; $df = 2,80$; $p < .01$). Individual comparisons revealed that 6-C was significantly different than 4-C ($p < .05$), 8-C was significantly different than 4-C ($p < .01$), but 8-C and 6-C were not significantly different from each other. Mean correct responses and variances on the retention task for groups 4-C, 6-C, and 8-C were, respectively, 3.93 ($s^2 = 6.76$), 5.50 ($s^2 = 4.70$), and 6.29 ($s^2 = 7.99$). The 8-C group retained the most, while 6-C retained more than 4-C. Rank order correlations were also computed between total strategy scores and total correct responses on retention. The correlations for groups 4-C, 6-C, and 8-C were, respectively, .57 ($p < .01$), .59 ($p < .01$), and .32 ($p < .05$). Thus, it appears that a significant amount of variance in retention of PA material can be accounted for by verbal reports on acquisition.

To summarize, the results of the developmental analysis showed that elementary school children could effectively verbalize about cues which they used to form associations. In addition, the data revealed that acquisition and retention scores increase with age as do total strategy scores, and that better performers used higher level strategies at each grade level. Moreover, females performed better than males at every grade level and used consistently higher level strategies on the PA task.

Analysis of Treatment Effects

Another aspect of this study was to determine whether strategy aids given by E would facilitate performance of Ss in the elementary grades. To establish initial comparability of groups at each grade level, a grade level by treatment analysis of variance on total correct responses on the practice task was performed. (Treatment designation refers to that which the group received on the criterion task.) This analysis, summarized in Table 9, revealed a significant grade level effect ($p < .01$) and an insignificant treatment effect. There was, however, a significant interaction ($p < .05$). Table 10 presents mean correct responses and variances for all groups on the practice task. Examination of this table shows the performance of the 4th grade E-4 group (4-E-4) was superior to the other two 4th grade groups on the practice task. A one-way analysis of variance and individual comparisons on performance at the 4th grade level established this group as the source of interaction. At this level the E-4 group was significantly different than both the C and E-8 groups ($p < .01$). A geometric interpretation of this interaction is presented in Figure 4. Thus, with the exception of group 4-E-4, all groups proved to be comparable at each grade level.

To assess the effects of giving different amounts of aid, a grade level by treatment analysis of variance on total correct responses on the criterion task was performed. This analysis, summarized in Table 11, showed that both main effects were significant ($p < .01$). The interaction was also significant ($p < .01$), which may be attributed to the initial superiority of the 4-E-4 group.

TABLE 9

Analysis of Variance on Practice Task Scores

Source	DF	F
Grade Level	2	19.55**
Treatment	2	1.79
Grade Level X Treatment	4	2.81*
Residual MS	233	(42.53)

* $p < .05$

** $p < .01$

TABLE 10

Mean Correct Responses and Variances
for Practice Task

Grade Level		Treatment Condition		
		C	E-4	E-8
4	$\bar{X}_2$	16.52	22.42	16.76
	s^2	33.95	42.43	48.31
6	$\bar{X}_2$	20.46	20.50	21.75
	s^2	44.04	52.42	71.01
8	$\bar{X}_2$	25.18	24.77	24.80
	s^2	24.97	37.90	23.75

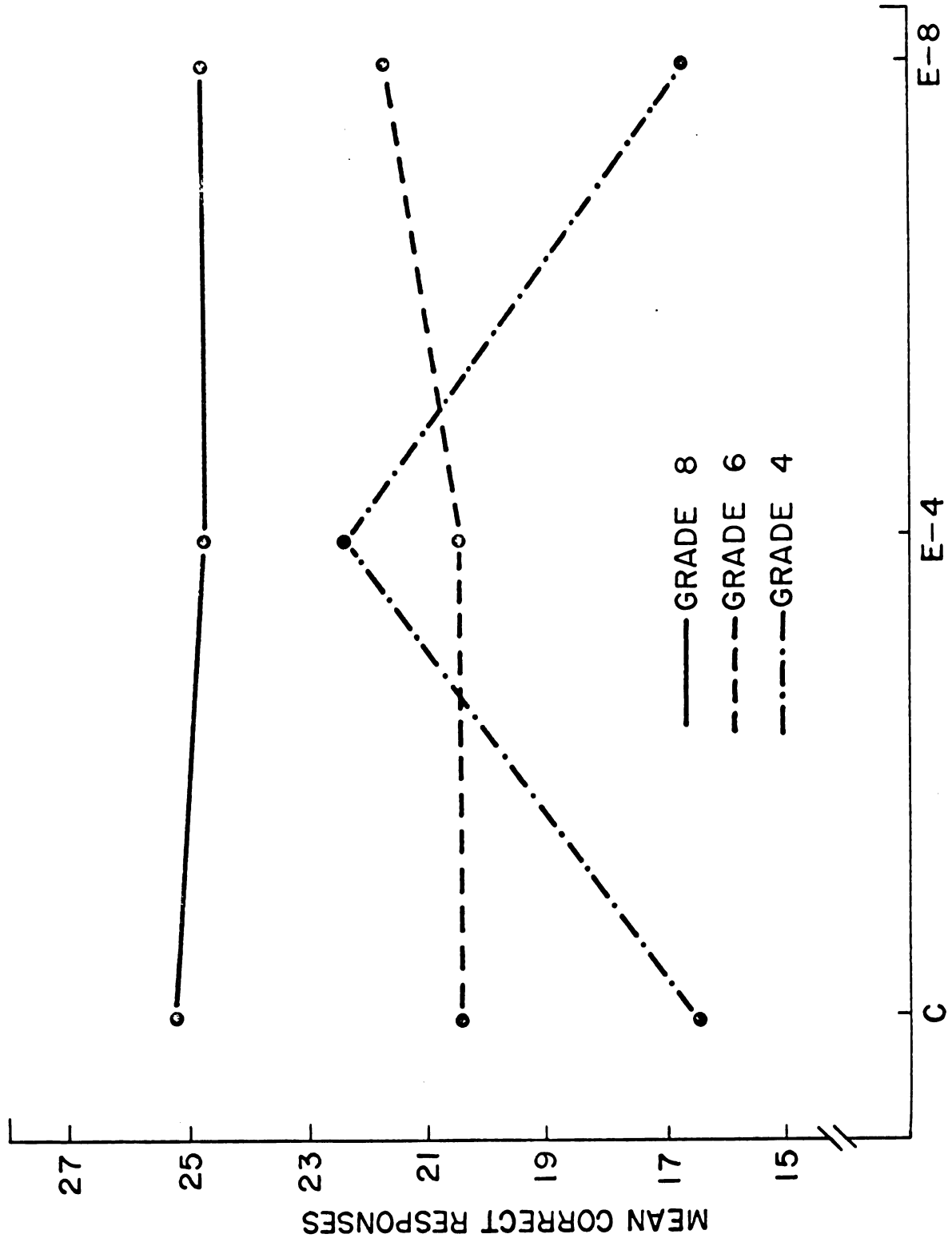


Fig. 4. A geometric interpretation of interaction of grade level with treatment condition on the practice task.

TABLE 11

Analysis of Variance on Criterion Task Scores

Source	DF	F
Grade Level	2	7.90**
Treatment	2	84.26**
Grade Level X Treatment	4	5.03**
Residual MS	233	(36.19)

** $p < .01$

Table 12 presents mean correct responses and variances for all groups on the criterion task. These means are plotted in Figure 5 which presents a geometric interpretation of the interaction on the criterion task.

The effect on acquisition of giving different amounts of aid can be readily seen in Figures 6, 7, and 8 which present, respectively, the 4th, 6th, and 8th grade acquisition curves for all treatments. In general, the E-8 groups performed the best, while the E-4 groups were superior to the C groups. Consequently, mean correct responses increased as aid increased at each grade level (see Table 12). Analyses of variance and individual comparisons were performed at each grade level to establish the statistical significance of the various differences in mean performance. At the 4th and 8th grade levels, groups E-4 and E-8 were significantly different than group C ($p < .01$), but not significantly different from each other. At the 6th grade level group E-4 was significantly different than group C ($p < .05$), group E-8 was significantly different than group C ($p < .01$), but E-4 and E-8 were not significantly different from each other. Although the E-4 groups were not significantly different than the E-8 groups at any grade level, the differences were always in the predicted direction. Furthermore, giving aid on the task produced a ceiling effect which may have minimized the differences between the E-4 and E-8 groups. In general, performance of the E-4 groups was near asymptote by approximately the third trial and any improvement by the E-8 groups was not apt to be statistically significant. In short, these results clearly illustrate

TABLE 12

Mean Correct Responses and Variances
for Criterion Task

Grade Level		Treatment Condition		
		C	E-4	E-8
4	$\bar{X}_2$	20.93	34.29	37.50
	s^2	75.23	31.61	3.89
6	$\bar{X}_2$	27.43	32.19	37.61
	s^2	67.51	58.00	9.95
8	$\bar{X}_2$	29.04	36.95	37.96
	s^2	50.63	8.14	22.54

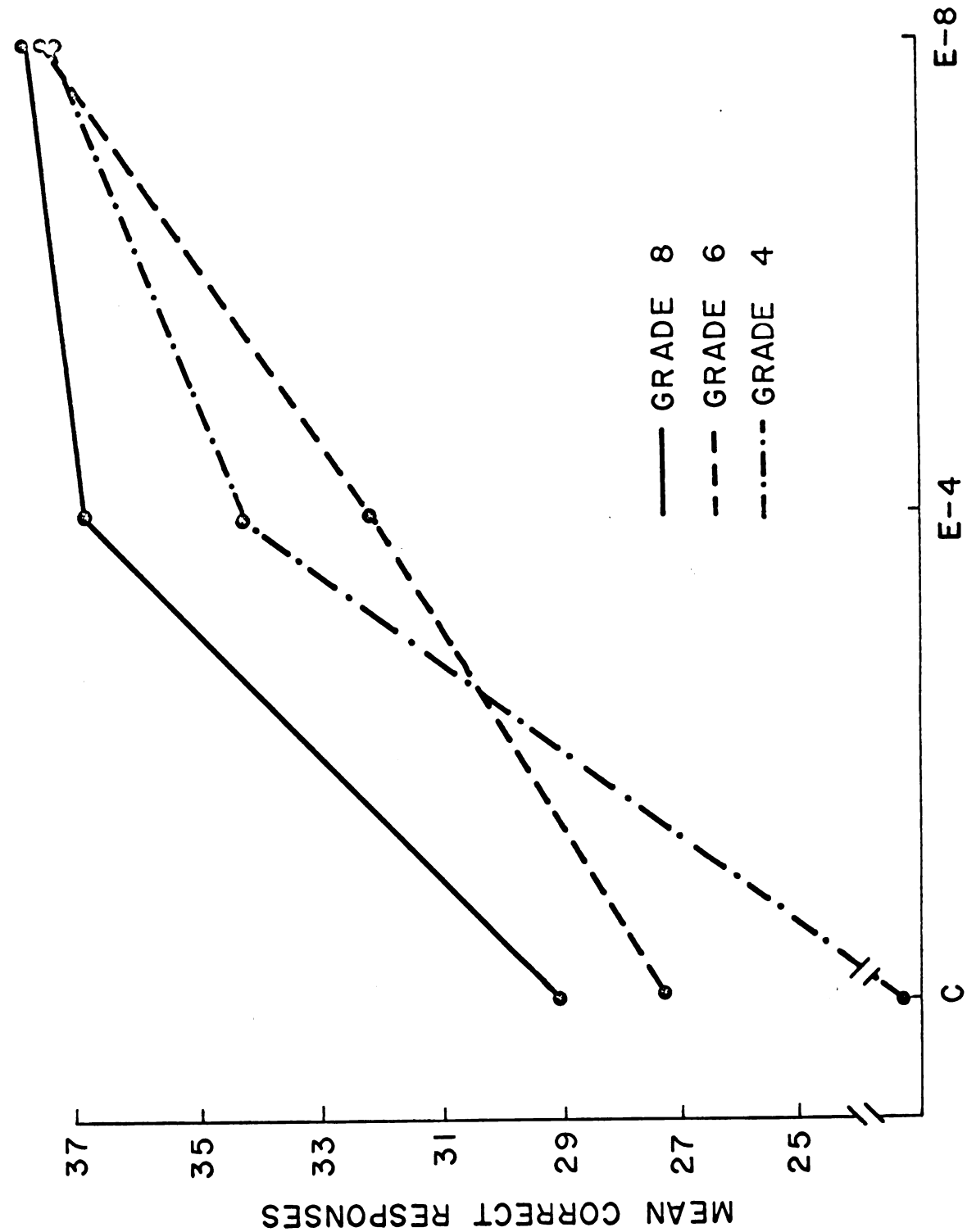


Fig. 5. A geometric interpretation of interaction of grade level with treatment on the criterion task.

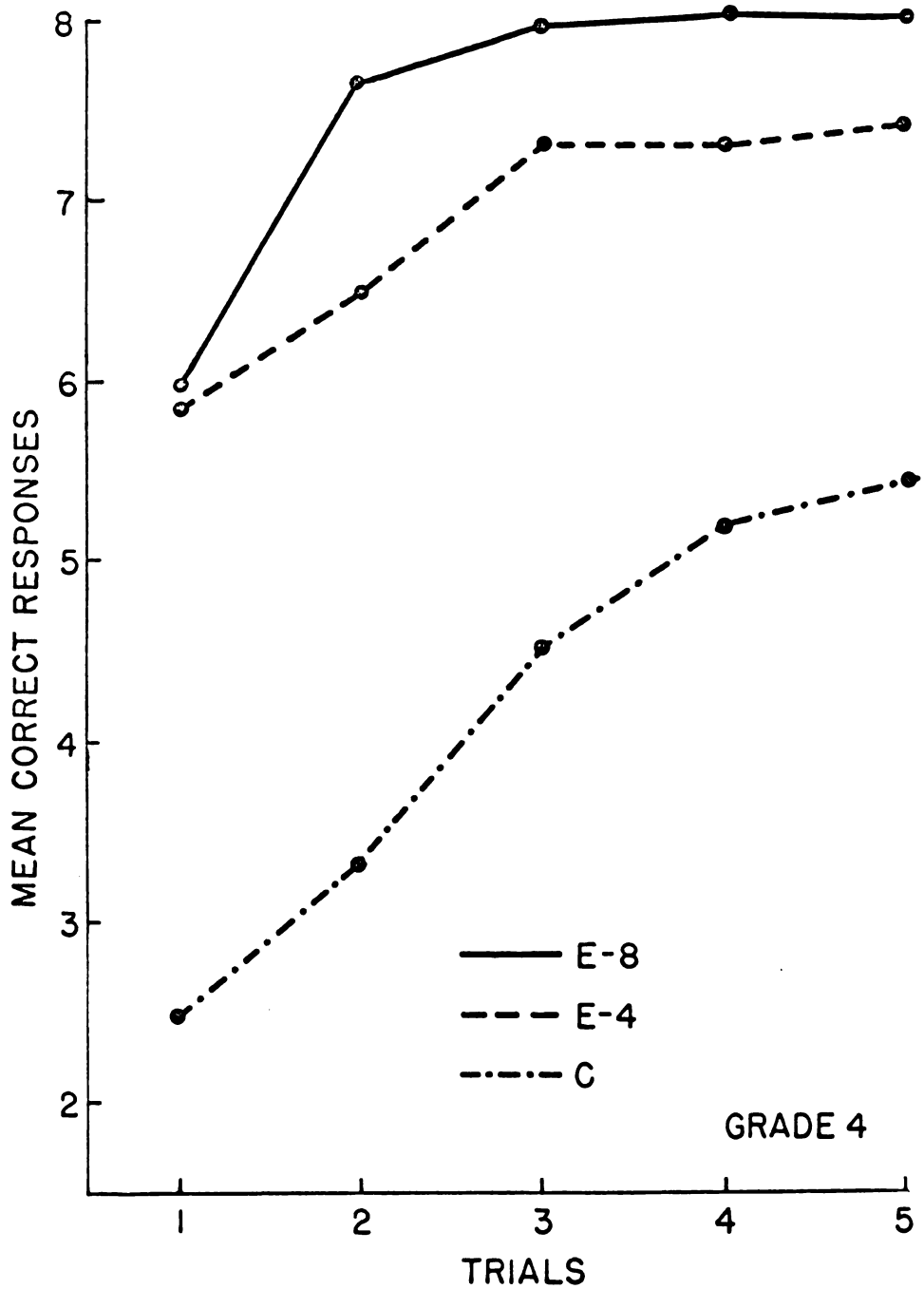


Fig. 6. Fourth grade acquisition curves on criterion task for E-8, E-4, and C treatments.

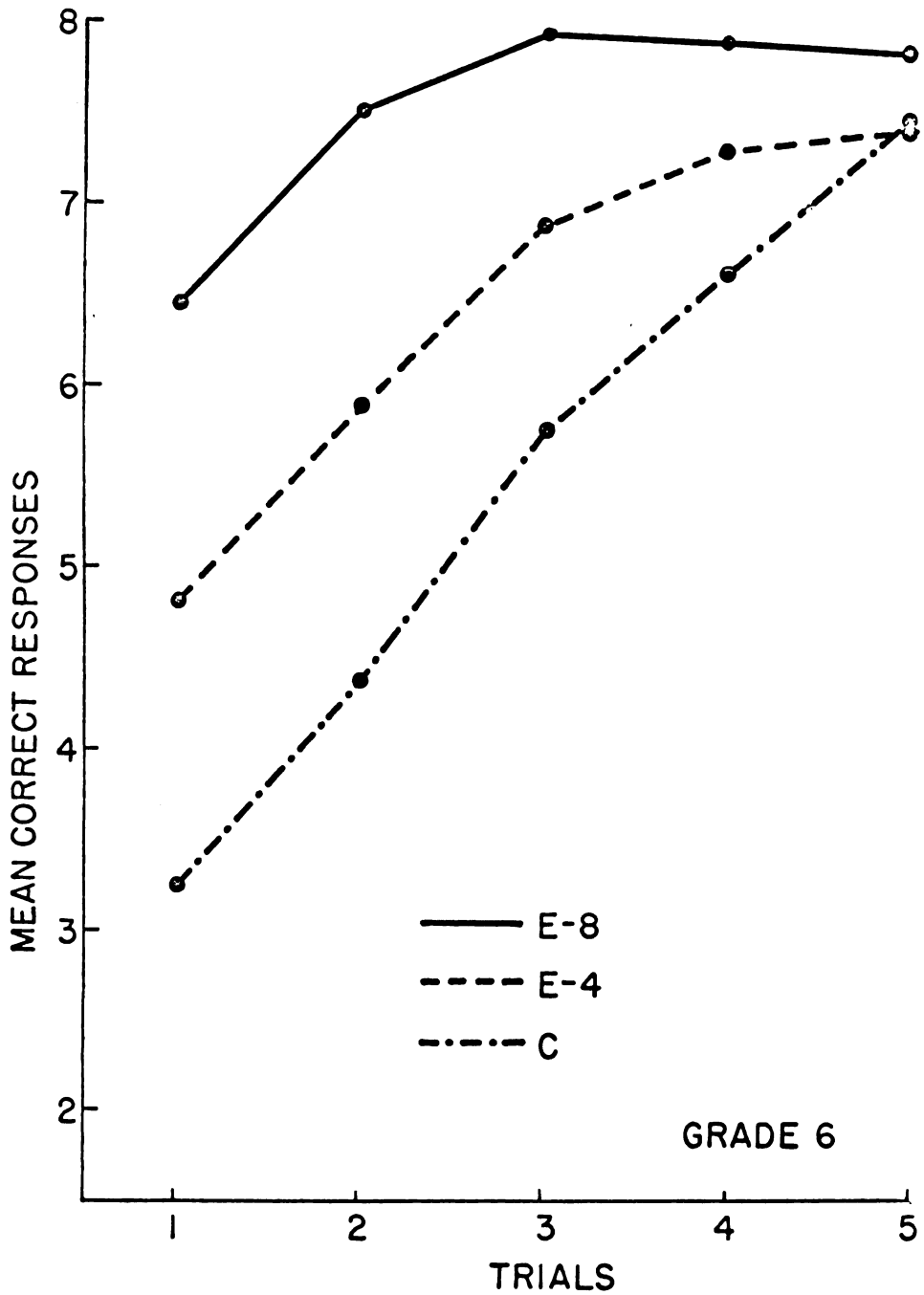


Fig. 7. Sixth grade acquisition curves on criterion task for E-8, E-4, and C treatments.

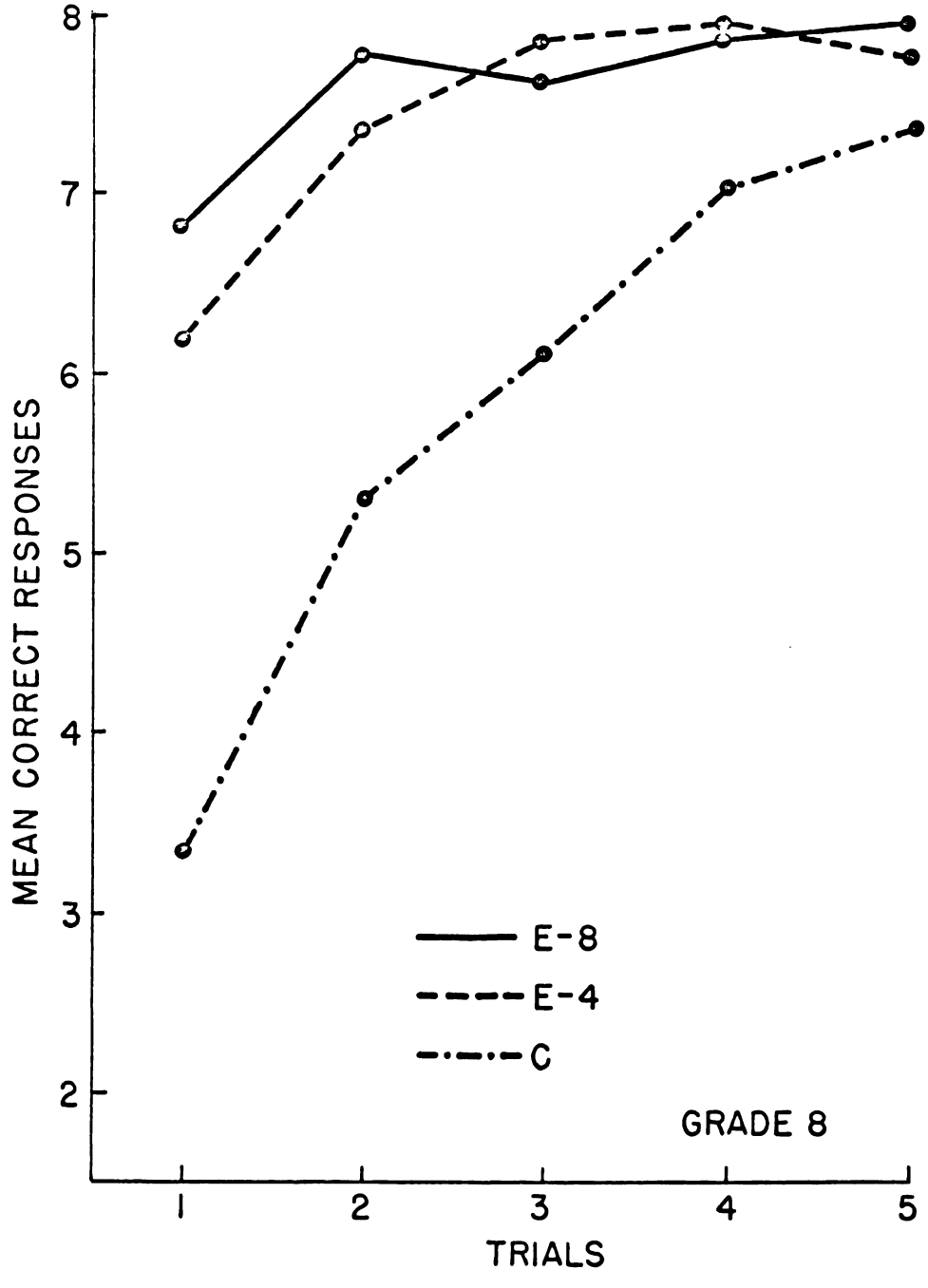


Fig. 8. Eighth grade acquisition curves on criterion task for E-8, E-4, and C treatments.

the facilitating effect on acquisition of providing associational cues for Ss, and there is some indication that giving aid on all 8 pairs was more beneficial than giving aid on only 4 pairs.

It was hypothesized Ss may be expected to perform better on the unaided items within a list which has other items aided. To investigate this hypothesis, performance on the unaided (B pairs) in the E-4 groups was compared with performance on those same four pairs (B pairs) in the C groups. This comparison was made with a two-way analysis of variance on total correct responses on B pairs for C and E-4 groups over all grade levels. The analysis, summarized in Table 13, showed both main effects and the interaction were significant (grade level, $p < .05$; treatment, $p < .01$; interaction, $p < .05$). Performance on B pairs was significantly better in the E-4 groups. The interaction, due to group 4-E-4, may be seen in Table 14 which presents mean correct responses and variances on B pairs for each group. To investigate the possibility that the significant treatment effect may be due to the initial superiority of the 4-E-4 group, the same analysis of variance was performed on B pairs for 6th and 8th grade levels only. The treatment effect showed that performance on B pairs was still significantly better in the E-4 groups ($F = 11.374$; $df = 1,100$; $p < .01$).

It was reasoned that providing strategy cues for half the items may have helped Ss to formulate their own strategies on the unaided items. To investigate this hypothesis, verbal reports for B pairs in the E-4 groups were rated as before. Table 15 presents the collapsed frequency of strategy level use on B pairs for 4th, 6th,

TABLE 13

Analysis of Variance on Total Correct Responses on B Pairs for C and E-4 Treatment Conditions

Source	DF	F
Grade Level	2	4.714*
Treatment	1	25.934**
Grade Level X Treatment	2	3.717*
Residual MS	149	(17.089)

* $p < .05$

** $p < .01$

TABLE 14

Mean Correct Responses and Variances on B Pairs for C and E-4 Treatment Conditions

Grade Level		Treatment Condition C	Treatment Condition E-4
4	$\bar{X}_2$	10.74	15.88
	s	21.89	18.11
6	$\bar{X}_2$	13.04	14.85
	s	20.33	19.90
8	$\bar{X}_2$	14.29	17.73
	s	14.58	5.73

TABLE 15

Collapsed Percent Frequency of Strategy Level Use on B Pairs for 4, 6, and 8th Grade C and E-4 Treatment Conditions

Grade Level		Collapsed Strategy Classification		
		1-2	3-4-5	6-7
4	C	50	18	32
	E-4	32	13	55
6	C	30	20	50
	E-4	25	14	61
8	C	12	21	67
	E-4	17	12	71

and 8th grade groups for C and E-4 treatment conditions. Examination of this table shows an increase in the percentage of high level strategies used in the E-4 groups on B pairs.

To determine whether this increase held for total strategy scores, a two-way analysis of variance was performed on total strategy scores on B pairs for C and E-4 groups over all grade levels. The analysis, summarized in Table 16, revealed that both main effects were significant (grade level, $p < .01$; treatment, $p < .05$), and the interaction was not significant. Mean correct responses and variances for these groups are presented in Table 17. Total strategy scores for the B pairs were significantly higher in the E-4 groups. Although the interaction was not significant there exists the possibility that the treatment effect may be exaggerated by the initial superior ability of the 4-E-4 group.

To investigate this possibility the same analysis of variance was performed on total strategy scores for B pairs for 6th and 8th grade levels only. The treatment effect was not significant ($F = .821$; $df = 1,100$) which indicates the difference between mean strategy scores for the C and E-4 groups at the 4th grade level contributed much of the variance to the previously significant treatment effect. It may be noted, however, that Ss in the 6th and 8th grades are approaching asymptote in total strategy score which may account for the lack of significance.

In general, it can be concluded there was positive transfer from the aided pairs to the unaided pairs in the E-4 groups. Furthermore, there is some indication that one of the variables related

TABLE 16

Analysis of Variance on Total Strategy Scores on B Pairs for C and E-4 Treatment Conditions

Source	DF	F
Grade Level	2	11.542**
Treatment	1	6.021*
Grade Level X Treatment	2	1.697
Residual MS	149	(32.786)

* $p < .05$

** $p < .01$

TABLE 17

Mean Strategy Scores and Variances on B Pairs for C and E-4 Treatment Conditions

Grade Level		Treatment Condition C	Treatment Condition E-4
4	$\bar{X}_2$	13.82	18.50
	s^2	44.46	40.61
6	$\bar{X}_2$	18.75	20.12
	s^2	17.45	43.87
8	$\bar{X}_2$	21.25	21.77
	s^2	20.71	31.80

to this positive transfer was an increase in the use of higher level strategies on B pairs in the E-4 groups.

To illustrate the relationship between aided (A pairs) and unaided (B pairs) in the E-4 treatment condition, Figures 9, 10, 11 present, respectively, the 4th, 6th, and 8th grade acquisition curves for A and B pairs in all treatment conditions. It would be expected that acquisition of A and B pairs for the E-8 conditions, and A pairs in the E-4 conditions, would be the highest, since all pairs were aided in these conditions. Acquisition of A and B pairs for C conditions should be the lowest since no pairs were aided in this condition. If there is transfer from the A to the B items in the E-4 condition, the acquisition curves for E-4 B pairs should fall between the curves for the E-8 condition and the curves for the C condition. In general, Figures 9, 10, and 11 support all of the above expectations at each grade level.

Table 18 presents mean total correct responses and variances of A and B pairs for each treatment condition. To determine the statistical significance of the various differences in performance, individual comparisons were made between treatments at each grade level for A and B pairs separately. For A pairs at all grade levels, E-4 and E-8 were significantly different than C ($p < .01$), but not significantly different from each other. This is as predicted. For B pairs at the 4th grade level the C, E-4, and E-8 groups were all significantly different from each other ($p < .01$). At the 6th grade level the E-8 group was significantly different than both the E-4 and C groups ($p < .01$), but the difference between E-4 and C was not

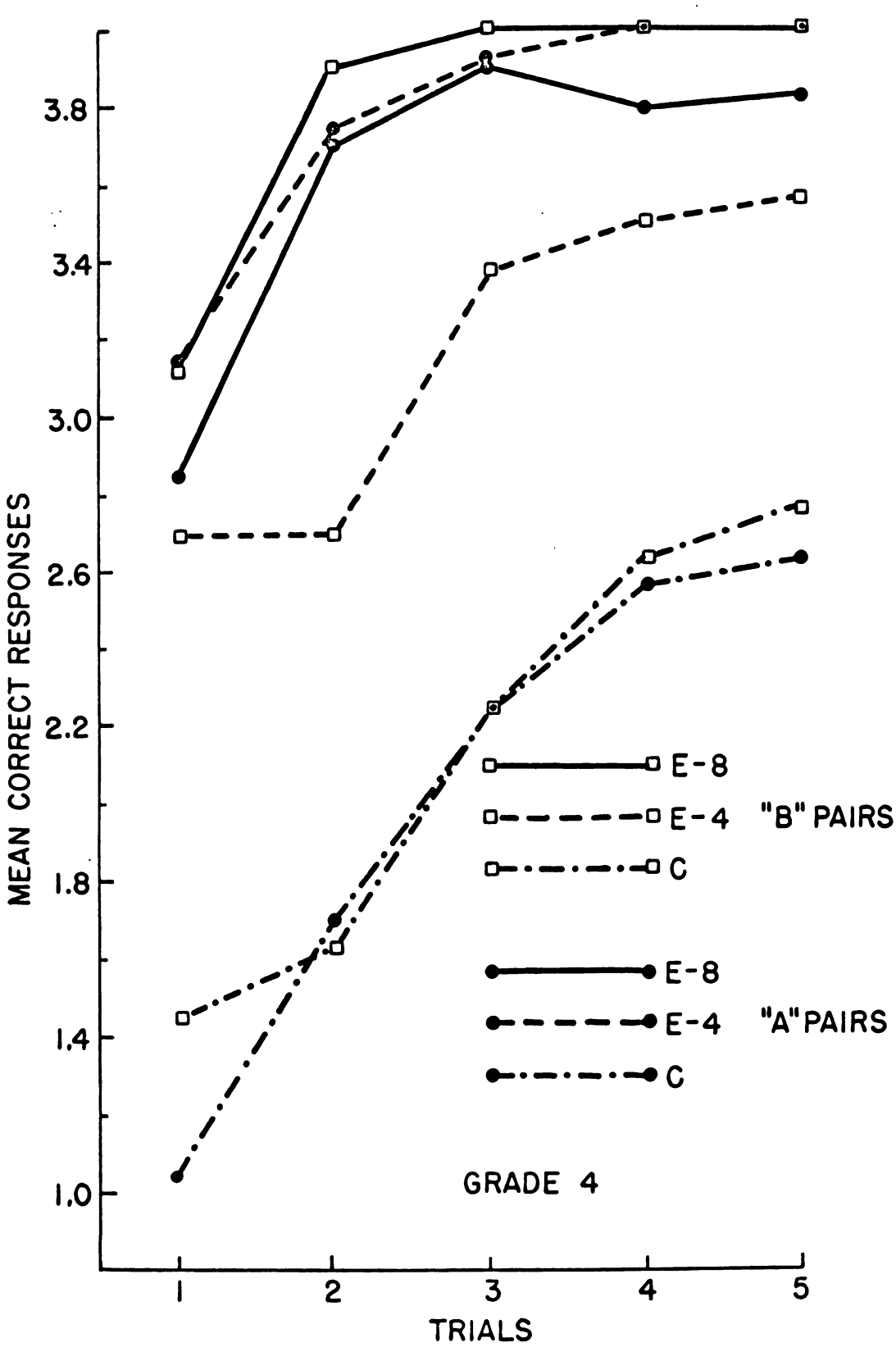


Fig. 9. Fourth grade acquisition curves for A and B pairs. The A and B pairs refer respectively to the four aided and unaided pairs in the E-4 condition.

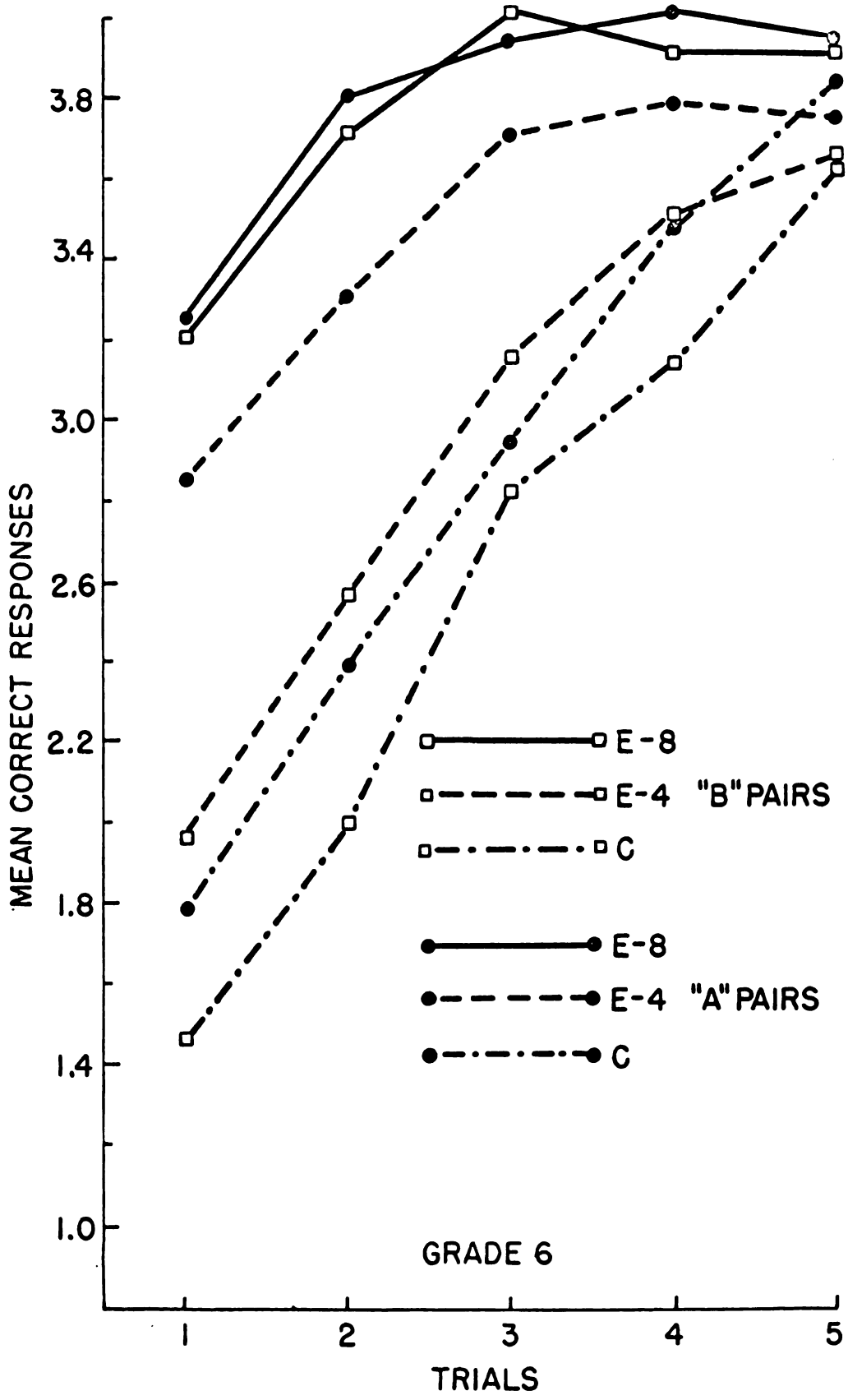


Fig. 10. Sixth grade acquisition curves for A and B pairs. The A and B pairs refer respectively to the four aided and unaided pairs in the E-4 condition.

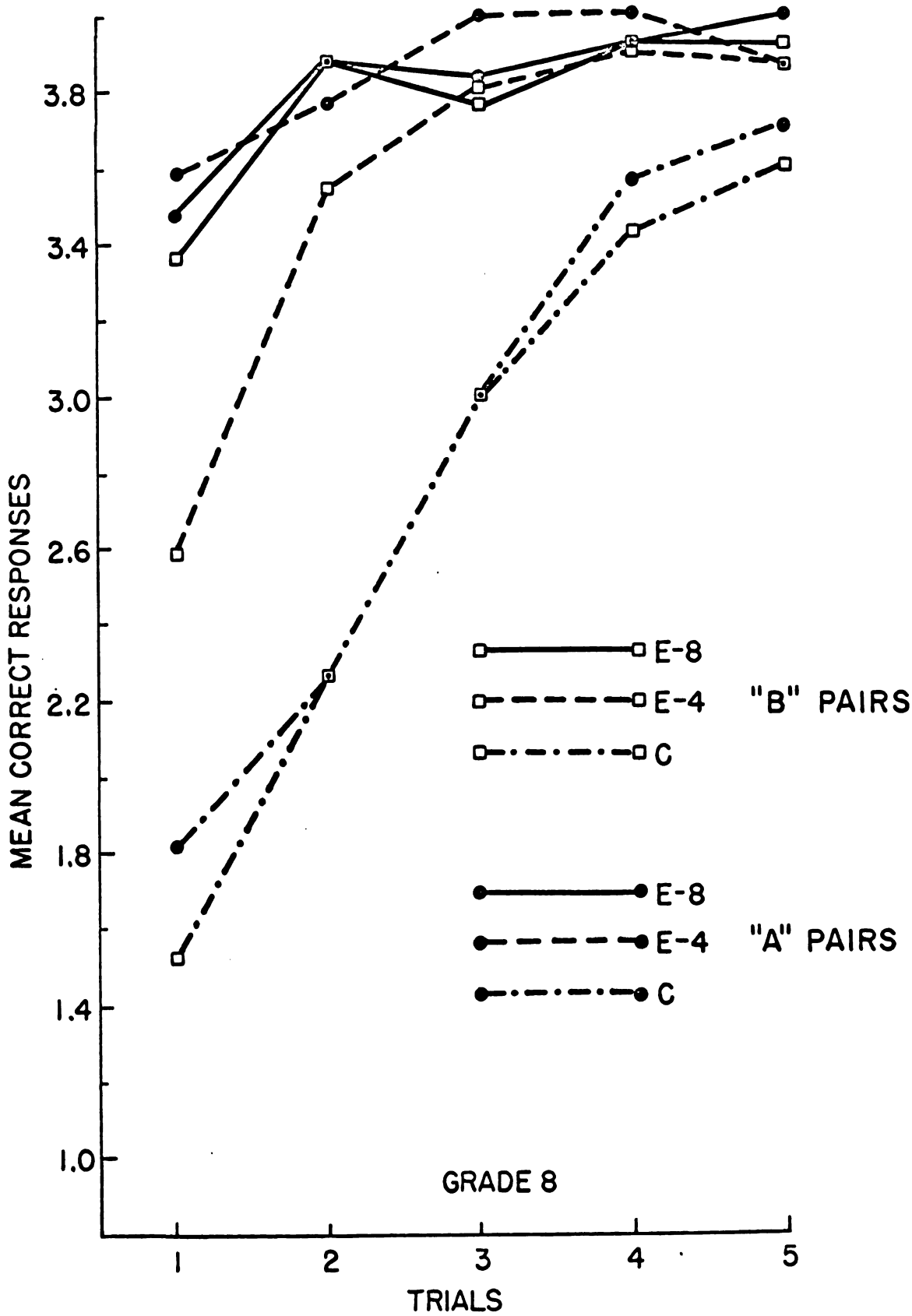


Fig. 11. Eighth grade acquisition curves for A and B pairs. The A and B pairs refer respectively to the four aided and unaided pairs in the E-4 condition.

TABLE 18

Mean Correct Responses and Variances on A and B Pairs for Criterion Task

Grade Level		Treatment Condition					
		C		E-4		E-8	
		A	B	A	B	A	B
4	$\bar{X}_2$	10.19	10.74	18.42	15.88	18.47	19.03
	s^2	22.54	21.89	4.95	18.11	2.68	1.18
6	$\bar{X}_2$	14.39	13.04	17.35	14.85	18.89	18.71
	s^2	16.03	20.33	13.84	19.90	3.73	2.66
8	$\bar{X}_2$	14.75	14.29	19.23	17.73	19.12	18.84
	s^2	13.82	14.58	1.04	5.73	4.94	6.81

significant ($p < .10$). At the 8th grade level the E-4 and E-8 groups were significantly different than the C group ($p < .01$), but were not significantly different from each other. The failure of the latter to reach significance may be partly due to the ceiling effect which is most prominent at the 8th grade level. In general, the results of the individual comparisons between B pair performance at each grade level support the hypothesis of positive transfer from the aided items in the E-4 groups.

To investigate the possibility that A pairs were easier to learn than the B pairs, or vice versa, a t test was performed at each grade level between mean correct responses on A and B pairs in the C group, in which there was no treatment effect. The resulting t scores for the 4th, 6th, and 8th grade groups were, respectively, .433, -1.191, and -.461, none of which were significant. Thus, it appears that A and B pairs were of approximately equal difficulty.

Since no significant differences were found for item difficulty, the comparative effectiveness of strategy aids could be estimated by t tests at each grade level between mean correct responses on A and B pairs in the E-8 groups, in which all pairs were aided. The resulting t scores for these 4th, 6th, and 8th grade groups were, respectively, 1.656, -.374, and -.408, none of which were significant. Thus, it appears that A and B strategy aids were of approximately equal effectiveness.

Retention Analysis

To investigate the hypothesis that giving strategy aids would increase retention of the aided pairs, a two-way analysis of variance

on total retention scores was performed. The analysis, summarized in Table 19, showed both main effects were significant ($p < .01$), and the interaction was not significant. Mean correct responses and variances on retention for all treatment conditions are presented in Table 20. Examination of these means, and the significant treatment effect, indicate that administration of strategy aids significantly increased long term retention of PA material.

To determine whether performance on unaided pairs improved within a list which contained aided pairs, retention of A and B pairs was analyzed separately. Mean correct responses and variances on retention for A and B pairs are presented in Table 21. As in the acquisition analysis, individual comparisons were made between the three treatment conditions at each grade level for both A and B pairs. For A pairs at the 4th and 8th grade levels retention for the E-4 and E-8 groups was significantly better than retention for the C groups ($p < .01$), but not significantly different from each other. For the 6th grade level, group E-4 was significantly different than group C on retention ($p < .01$), group E-8 was significantly different than group C ($p < .05$), but groups E-4 and E-8 were not significantly different from each other. These results confirmed the expectation that aided pairs would be retained significantly better than unaided pairs.

Individual comparisons for the B pairs showed, at the 4th grade level, group E-8 was significantly different than both the E-4 and C groups. At the 8th grade level group E-8 was significantly different than group C. All other comparisons at each grade level were

TABLE 19

Analysis of Variance on Total Retention Scores

Source	DF	F
Grade Level	2	12.55**
Treatment	2	20.92**
Grade Level X Treatment	4	1.81
Residual MS	230	(4.05)

** $p < .01$

TABLE 20

Mean Correct Responses and Variances
for Retention Task

Grade Level		Treatment Condition C	E-4	E-8
4	$\bar{X}_2$	3.93	5.50	7.15
	s^2	6.76	6.26	1.40
6	$\bar{X}_2$	5.50	6.54	7.04
	s^2	4.70	4.02	3.67
8	$\bar{X}_2$	6.29	7.41	7.68
	s^2	7.99	.82	.32

TABLE 21

Mean Correct Responses and Variances for A and B Pairs on Retention Task

Grade Level		Treatment Condition					
		C		E-4		E-8	
		A	B	A	B	A	B
4	$\bar{X}_2$	2.00	1.93	3.04	2.46	3.44	3.71
	s^2	2.08	1.92	1.43	2.17	.62	.28
6	$\bar{X}_2$	2.61	2.89	3.38	3.15	3.43	3.61
	s^2	1.14	1.58	1.05	1.50	1.22	.91
8	$\bar{X}_2$	3.11	3.18	3.77	3.64	3.86	3.82
	s^2	1.29	1.49	.28	.43	.12	.25

not significant. Although Table 21 shows B pairs in the E-4 condition were retained better than the same pairs in the C groups, these differences were in no case statistically significant. Thus, it appears that the positive transfer from the aided to the unaided items in the E-4 condition during acquisition tended to drop out in long term retention.

Analysis of Fast and Slow Learners

For the present study it was conjectured that one of the differences between fast and slow learners may be the latter have not developed the habit of searching for cues in material to be learned. On this grounds the administration of strategy aids would be expected to facilitate the performance of slow learners more than the fast learners. To investigate these conjectures, several analyses were performed.

Rank order correlations were computed between Ss practice and criterion task acquisition scores for all treatment conditions. Examination of Table 22 reveals that the correlations between practice and criterion task scores are highly significant for C groups at each grade level ($p < .01$). Intercorrelations for the E-4 groups are lower but still significant ($p < .01$). For the E-8 groups, however, the correlations at each grade level are low and not significant. Thus as aid increased the correlations between practice and criterion task acquisition decreased.

An explanation of these results may be seen in Table 12. This table shows the variance of scores on the criterion task was less in

TABLE 22

Intercorrelations Between Acquisition Scores on Practice and Criterion Tasks

	Treatment Condition		
Grade Level	C	E-4	E-8
4	.79**	.62**	.11
6	.51**	.52**	.27
8	.74**	.51**	.18

** $p < .01$

the aided groups, which indicates the difference between performance of fast and slow learners was diminished. And the more homogeneous the groups were, the lower the correlations between practice and criterion task scores. These findings support the hypothesis that slow learners would benefit more from strategy aids than fast learners.

To contrast the performance of fast and slow learners, Ss from the top and bottom one-third of each group in total correct responses on the practice task were selected for study. Acquisition curves for fast (F) and slow (S) learners on the practice task are presented in Figures 12, 13, and 14 for the 4th, 6th, and 8th grade groups, respectively, for all treatment conditions. It will be noted acquisition for F learners was considerably greater than for S learners.

To determine comparability of these groups, individual comparisons between treatment conditions at each grade level were performed separately for F and S learners. Mean correct responses for F and S learners on the practice task are given in Table 23. At the 4th grade level group E-4 was significantly different than the C and E-8 groups ($p < .01$) for both F and S learners. This was due to the initial superiority of the 4-E-4 group as a whole. The 6th grade E-8 group was significantly different than group C ($p < .05$) for F learners. All other comparisons were not significant. Thus, with these exceptions, all groups proved comparable at each grade level.

In contrast to the practice task acquisition, Figures 15, 16, and 17 present criterion task acquisition curves for these same F

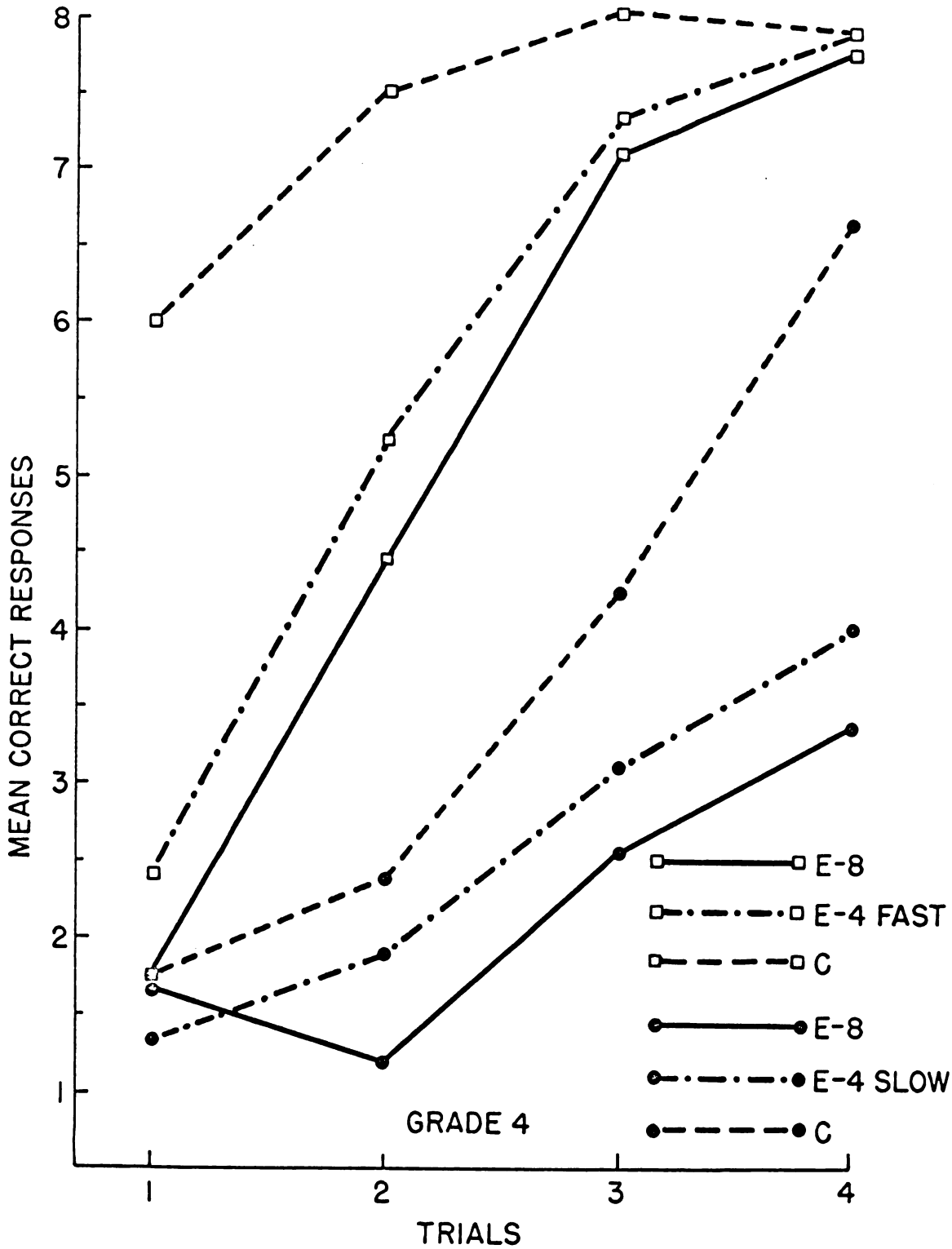


Fig. 12. Fourth grade acquisition curves for fast and slow learners on practice task.

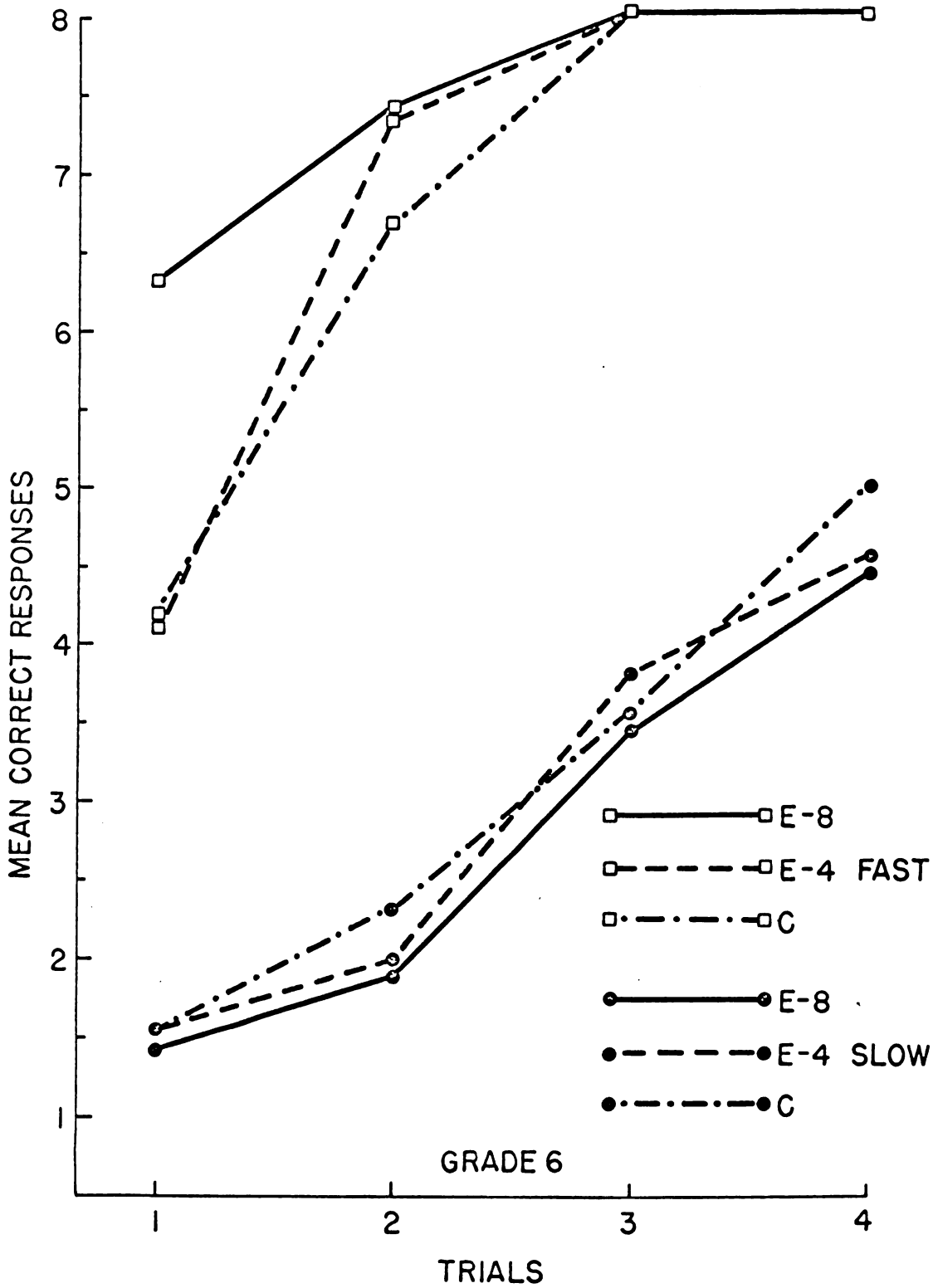


Fig. 13. Sixth grade acquisition curves for fast and slow learners on practice task.

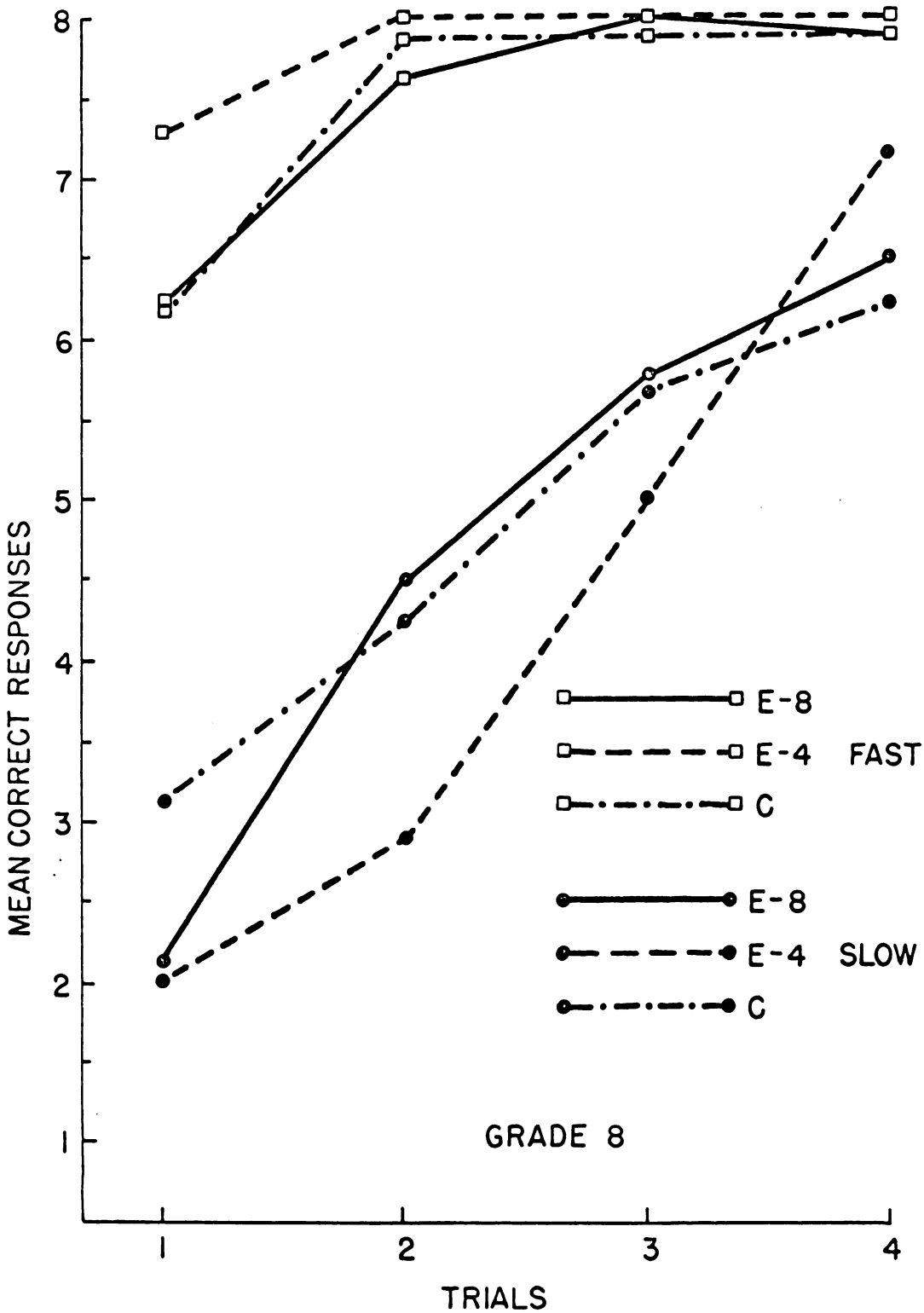


Figure 14. Eighth grade acquisition curves for fast and slow learners on practice task.

TABLE 23

Mean Correct Responses for Fast and Slow Learners on Practice Task

Grade Level		Treatment Condition		
		C	E-4	E-8
4	F	22.89	29.38	21.00
	S	10.33	15.00	8.73
6	F	26.89	27.44	29.78
	S	12.44	11.89	11.22
8	F	29.89	31.29	29.75
	S	19.22	17.00	18.88

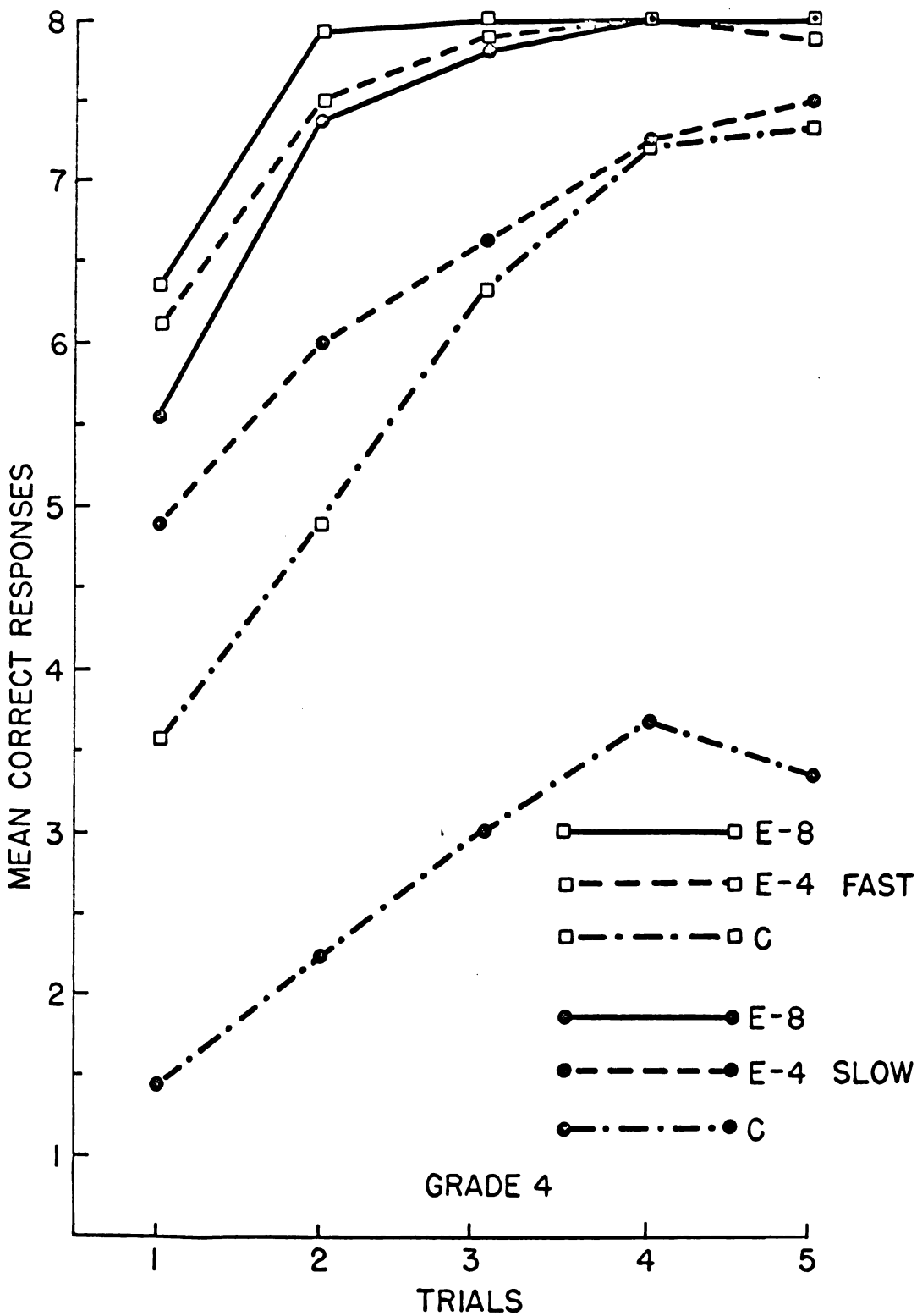


Fig. 15. Fourth grade acquisition curves for fast and slow learners (as defined by practice task) on criterion task.

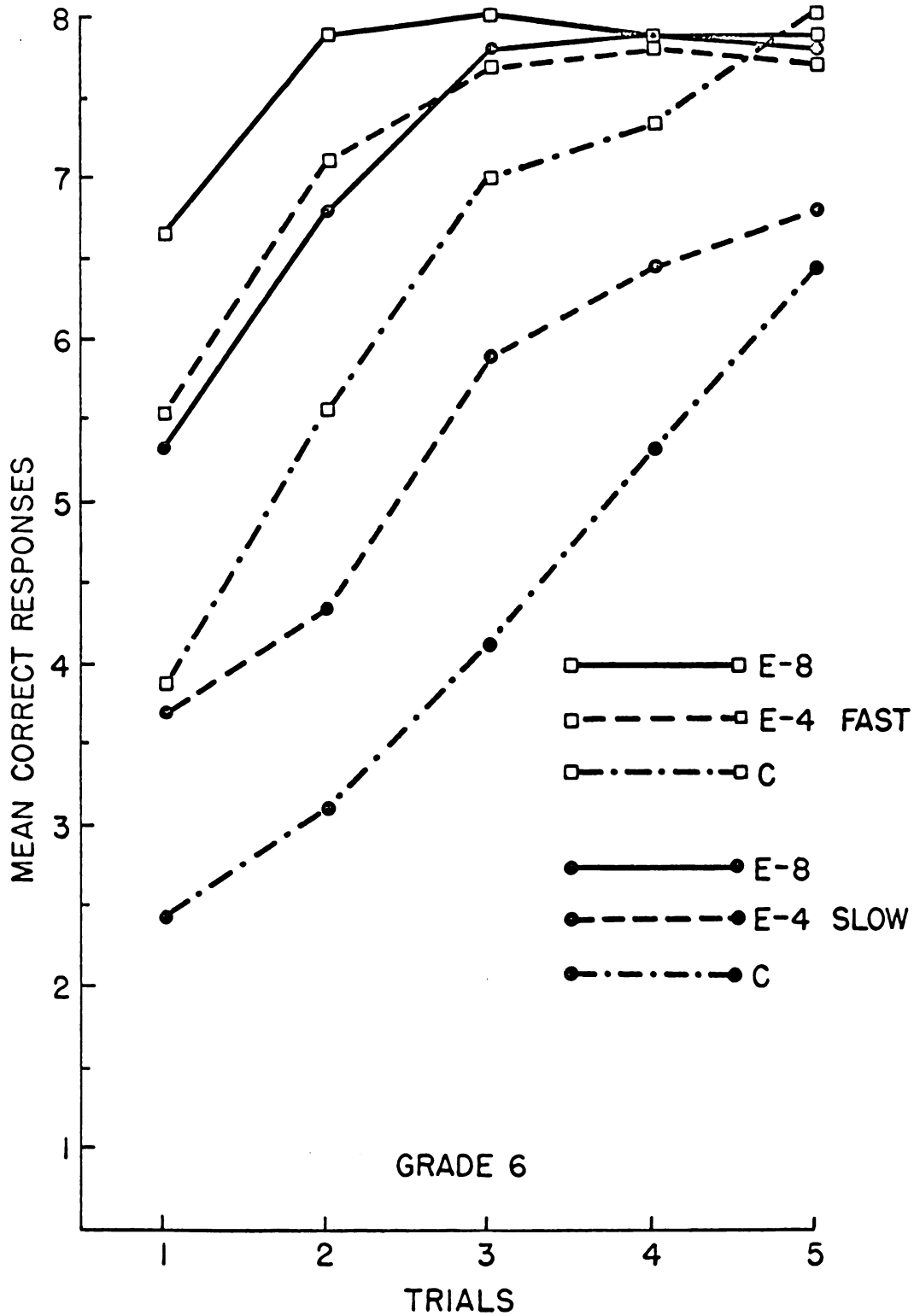


Fig. 16. Sixth grade acquisition curves for fast and slow learners (as defined by practice task) on criterion task.

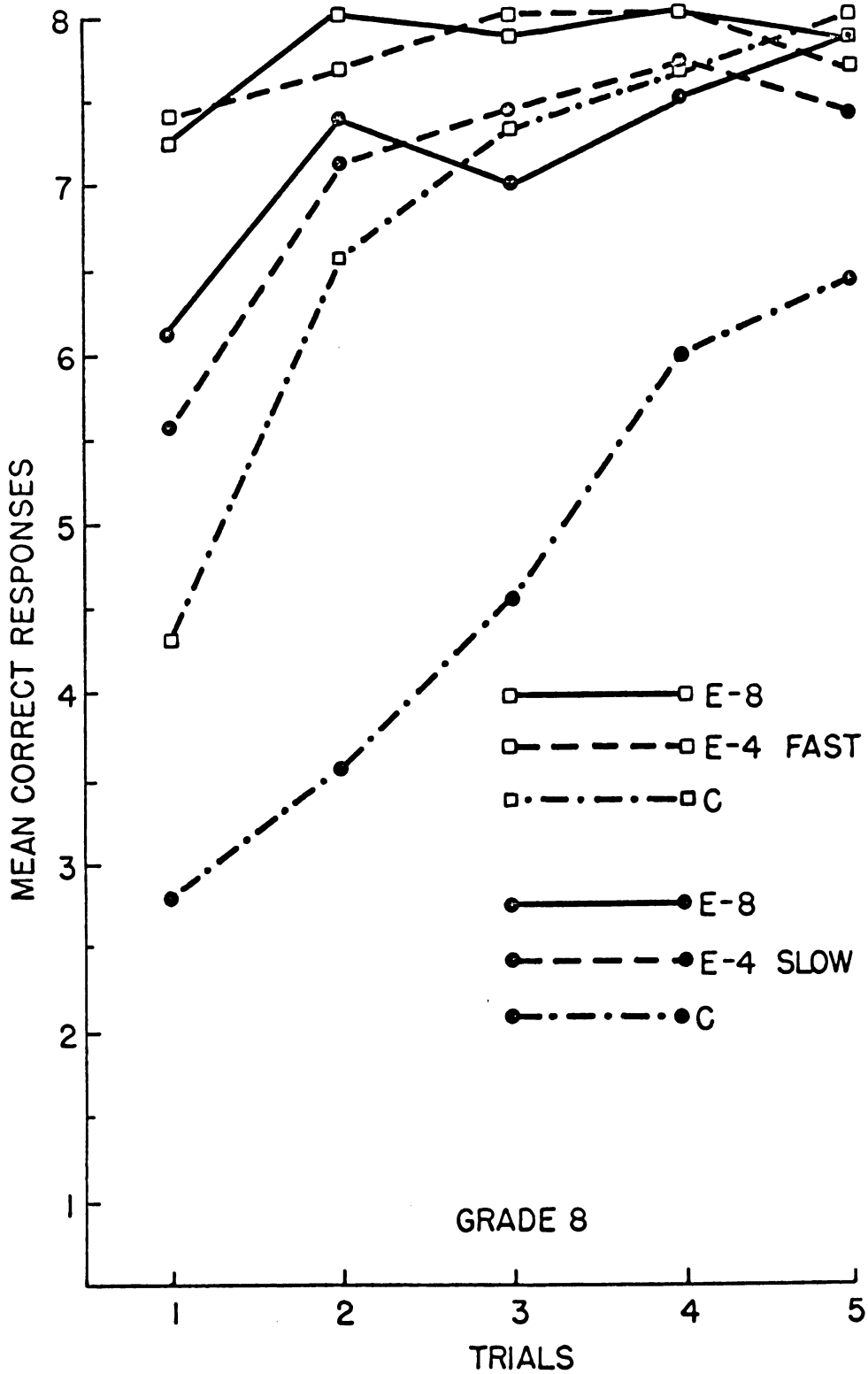


Fig. 17. Eighth grade acquisition curves for fast and slow learners (as defined by practice task) on criterion task.

and S learners at the 4th, 6th, and 8th grade levels, respectively, for all treatment conditions. It will be noted not only did S learners improve when given strategy aids, but, in general, their performance was superior to F learners in the unaided C groups.

To determine the effects of giving strategy aids on performance of F and S learners, individual comparisons between treatment conditions at each grade level were performed. Mean correct responses for F and S learners on the criterion task are presented in Table 24. At the 4th grade level groups E-8 and E-4 were significantly different than group C ($p < .01$) for both F and S learners. At the 6th grade level group E-8 was significantly different than group C for both F and S learners ($p < .05$ and $p < .01$, respectively). And at the 8th grade level group E-4 and E-8 were both significantly different than group C ($p < .01$) for both F and S learners. In general, these results show the significant improvement in performance for both F and S learners as aid increased.

It is of interest to note, however, the difference between mean performance of F and S learners in the aided and unaided groups. Compared to C groups, the E-4 and E-8 groups for S learners showed greater gains than the E-4 and E-8 groups for F learners. This supports the hypothesis that strategy aids may facilitate performance of S learners more than F learners.

It was hypothesized there may be a difference between levels of strategy used by F and S learners. Therefore, an attempt was made to categorize all verbal reports on the criterion task. Classification of the aided pairs, however, did not prove profitable. On

TABLE 24

Mean Correct Responses for Fast and Slow Learners on Criterion Task

Grade Level		Treatment Condition		
		C	E-4	E-8
4	F	29.33	37.38	38.27
	S	13.67	32.25	36.73
6	F	31.78	35.78	38.33
	S	21.44	27.11	35.56
8	F	33.89	38.86	39.00
	S	23.33	35.29	35.88

approximately 70% of these pairs Ss reported using the strategy aids suggested by E. On the remaining 30%, Ss reported formulating their own associations. Computation of mean correct responses as a function of strategy level revealed no differences since performance on all aided pairs was nearly perfect for both F and S learners. Moreover, there was no difference between F and S groups in frequency of different levels of strategy used on aided items. Nor was there any difference between these groups in frequency of using the strategies suggested by E, or in formulating their own associations. To investigate the difference between F and S learners with respect to strategies used, therefore, only the unaided control groups were selected for study.

Table 25 presents the collapsed percent frequency of strategy level use for F and S learners in the C groups. Examination of this table reveals that F learners used more high level strategies at each grade level. Table 26 emphasizes this difference by presenting the same data collapsed over 4th, 6th, and 8th grade levels. In short, analysis of strategies used on the aided pairs revealed no differences between F and S learners. But for the unaided pairs, F learners at each grade level consistently used more high level strategies than S learners.

TABLE 25

Collapsed Percent Frequency of Strategy Level Use for Fast and Slow Learners on Control Groups

Grade Level		Collapsed Strategy Classification		
		1-2	3-4-5	6-7
4	F	33	7	60
	S	62	15	23
6	F	19	21	60
	S	25	23	52
8	F	11	19	70
	S	6	32	62

TABLE 26

Collapsed Percent Frequency of Strategy Level Use for Fast and Slow Learners on Control Groups When Collapsed Over Grades

Combined Grades		Collapsed Strategy Classification		
		1-2	3-4-5	6-7
4, 6, 8	F	21	16	63
	S	31	23	46

DISCUSSION AND CONCLUSIONS

The results of this experiment strongly support the research hypothesis that the formation of strategies (coding) is an integral part of paired associate learning. Observers frequently perceive this task as a rote learning situation which involves little or no high level mental activity on the part of the learner. The data have shown, however, this task is closer to a problem solving situation in which the learner consciously seeks a solution to the problem of how to associate one word with another.

The developmental analysis revealed that elementary school children not only formulate associative strategies, but can effectively verbalize about the cues which they use to form these associations. Moreover, using the Martin et al. (1965) classification scheme, the cues reported in each control group were easily rank ordered along a continuum of complexity, and quantified.

As can be seen in Table 4, the frequency of use of higher level strategies (those ranked 6 and 7) increased markedly with grade level for the control groups. The percentage of high level strategies were 33%, 57%, and 69% for groups 4-C, 6-C, and 8-C, respectively. The data also revealed that performance on the PA task improved markedly with grade level. Mean correct responses on the task were 20.93, 27.43, and 29.04 for 4-C, 6-C, and 8-C, respectively (see Table 12).

The fact that frequency usage of high level strategies and number correct on the PA task both increase with age does not prove

that one is directly related to the other. In fact, two interpretations of this concurrent increase may be offered:

I. Children actually use the same strategies at each grade level. The increase in high level strategies reported with age is due simply to an increase in the ability to verbalize about these strategies. The observed positive relationship between strategy level and performance, therefore, is merely an artifact and does not indicate cause and effect.

II. Children as they grow older learn to use more sophisticated strategies of learning. These higher level learning strategies directly result in increasing performance with age on the PA task. Moreover, at any grade level, the better an individual is at formulating efficient strategies the better will be his performance. The following findings will show the results of this study strongly support the latter interpretation.

The results of the developmental analysis revealed that within each grade level, the higher the strategy level reported for a particular pair the greater the acquisition of that pair. Figure 2, which presents mean correct responses for each strategy level, shows, in general, the higher the strategy level the better the performance. It may be noticed the curves are not monotonically increasing from strategy levels one to seven. The reversals at strategy level two may be partly explained by the fact that several subjects at each grade level, who made nearly perfect scores, reported using simple repetition to make each association. This may, in fact, be an efficient learning technique for a relatively small

proportion of the population. But a more plausible explanation is that these Ss did initially use high level strategies to help associate the pairs, and when the strategies were no longer needed they were forgotten. There is evidence that as learning proceeds in a PA task, the mediators drop out and the associations become direct (Underwood & Schulz, 1960). Regardless, if these few Ss were omitted from the present analysis, the reversals in Figure 2 would be practically eliminated.

Within the control groups at each grade level the better performers were also shown by various analyses to use more high level strategies. The significant rank order correlations between individuals' total strategy scores and total correct responses at each grade level is one example ($r = .54$, $.61$, and $.45$ for 4-C, 6-C, and 8-C, respectively; in all cases $p < .01$). Another example is the fact that females, who generally were better performers at each grade level (see Table 6), also tended to use higher level strategies than males at each grade level (see Table 8). It is possible that one of the main factors accounting for a female's superiority in many verbal tasks is the ability to formulate more efficient strategies of learning.

The developmental analysis also revealed that within each grade level, the higher the strategy level reported for each pair, the better the retention of that pair. Figure 3, which presents percent correct responses on retention as a function of strategy level used on the criterion task, shows, in general, that higher strategy levels are associated with better retention. The reversals

in the middle range of strategy levels may be attributed to the relatively small frequency of strategy use at these levels and to the restricted range of retention scores. The significant rank order correlations between individuals' total strategy scores and total correct responses on retention show that better performers on the retention task used higher level strategies on acquisition. The correlations for groups 4-C, 6-C, and 8-C were, respectively, .57 ($p < .01$), .59 ($p < .01$), and .32 ($p < .05$).

Numerous important findings in support of the position that more efficient strategies result in increased learning were revealed in the analysis of treatment effects. When these elementary school children were given high level strategy aids at the beginning of the PA task, learning was greatly improved. Figures 6, 7, and 8, which present the 4th, 6th, and 8th grade acquisition curves for all groups on the criterion task, show the dramatic improvement when strategy aids were administered. In general, the more items aided, the better the acquisition, though the differences between mean performances of the E-4 and E-8 groups were not significant at any grade level. This may be partly due to the fact that giving strategy aids increased the acquisition of the E-4 groups so dramatically that Ss nearly reached asymptote in performance. Further improvement by the E-8 groups was not apt to be statistically significant. In spite of the lack of significant differences, however, Table 12 shows that learning was greatly facilitated by treatments 2 and 3 at all grade levels.

The analysis also revealed that unaided items tended to be learned faster within a list which had other items aided. The analysis of variance, summarized in Table 13, shows that unaided (B pairs) were learned significantly faster in the E-4 groups ($p < .01$). The individual comparisons between treatments at each grade level for A and B pairs further illustrate the superior performance on the B pairs (see Table 18). There are at least two possible interpretations of these results:

(1) Giving aid on half the pairs essentially reduced the size of the list by rendering the aided items much easier to learn. Subjects consequently had more time to concentrate on mastering the unaided pairs.

(2) Giving high level strategy aids on half the pairs provided examples for the Ss as to how to formulate efficient learning strategies for the unaided pairs. For many Ss, giving examples of efficient associational cues may have broken a set to rehearse or repeat the pairs in an attempt to form the associations.

The first interpretation is undoubtedly relevant but the data also lend support to the latter. Analysis of the strategies reported for the B pairs supports the position that the improvement in performance resulted from positive transfer from the aided items in formulating more efficient strategies. Table 15 shows an increase in the percentage of high level strategies used for B pairs in the E-4 groups at all grade levels. For group 4-E-4, 55% of the strategies reported for B pairs were ranked either 6 or 7, as compared to only 32% for group 4-C. Group 6-E-4 reported using 61%

high level strategies on B pairs as compared to 50% for group 6-C. And group 8-E-4 reported 71% high level strategies, compared to 67% for group 8-C on these same pairs. These findings suggest that administering strategy aids on half the pairs may have stimulated the formation of high level strategies for, and consequently the acquisition of, the unaided pairs.

Perhaps the findings of greatest importance in this study were revealed in the retention analysis. If the administration of associational cues is to have any real value, it must be shown that this technique results in increased long term retention as well as short term acquisition of the material.

The results of the retention analysis supported the hypothesis that giving strategy aids would effectively increase long term retention of the PA material. The analysis of variance summarized in Table 19 shows that the treatments resulted in a significant improvement in retention of the aided groups ($p < .01$). Analysis of A and B pairs separately (see Table 21) confirmed the expectation that aided pairs would be retained better than unaided pairs. In addition, retention for B pairs was better in the E-4 groups than the C groups at each grade level, but these differences were in no case statistically significant. Thus the hypothesized positive transfer from the aided to the unaided items in the E-4 treatment condition during acquisition appears to decrease during long term retention.

At this point the criticism might be leveled that it is misleading to maintain that giving strategy aids increases long term

retention. Retention very likely is greater on the aided pairs because there was a greater degree of learning for these pairs. In fact, acquisition of the aided pairs was so rapid that there was time for overlearning on these pairs, which would further improve retention. It was, however, the administration of strategy aids which produced this increased rate of learning. Thus, the end result of giving associational cues during the learning process is an increase in long term retention of the material.

As final support to the position that more sophisticated strategies of learning resulted in greater performance on this task, one may cite the analysis of fast vs. slow learners. Fast (F) and slow (S) learners were determined by selecting the top and bottom one-third of each group in total correct responses on the practice task. As can be seen in Table 23, there are very large differences in performance of F and S learners on this task. Figures 12, 13, and 14, which present, respectively, the 4th, 6th, and 8th grade acquisition curves on the practice task, further illustrate these differences.

For the criterion task control groups (which received no aid) F and S learners improved little more than would be expected as a result of having had previous exposure to a PA task (see Table 24). Note also there were five trials instead of four which would result in a slight increase in the scores of the criterion groups relative to the practice task.

For those groups which were administered strategy aids, however, the change in performance of F and S learners is striking.

Table 24 shows the performance of both of these groups as aid increases. Figures 15, 16, and 17 graphically present the differences in performance of F and S learners for all treatment conditions for the 4th, 6th, and 8th grade groups, respectively. Examination of these figures reveals that not only do S learners improve greatly when given strategy aids, but in general their performance is superior to the F learners in the unaided control groups! Although F learners also show great improvement, it is not as pronounced as that of the S learner.

The results of these analyses strongly support the hypothesis that one of the differences between F and S learners is that the latter are not as efficient in searching for cues in the material to be learned. Since the administration of strategy aids improved the performance of S learners more than F learners, this suggests that the former may not have as many high level strategies available for application. Examination of the strategies used by F and S performers in the control groups confirmed this expectation. For the fourth grade 60% of the F learners' strategies were rated 6 or 7 as compared to 23% for S learners. For the sixth grade, percent of high level strategies reported was 60% to 52% in favor of F learners. This same comparison was 70% to 52% for eighth graders (see Table 25). When collapsed over grade levels 63% of the F learners used 6 or 7 level strategies as compared to 46% for S learners. Moreover, the frequency of low level repetition strategies is greater for S than F learners (see Table 26).

These analyses illustrate that S learners do not use as sophisticated strategies as F learners. Moreover when given strategy aids on the PA task slow learners improved more than the fast learners, indicating that many, possibly for the first time, were using something more than mere repetition to link the pairs. In fact, in the E-8 groups the performance of S and F learners was almost equal. The decrease in the variance of scores of the criterion task groups as aid increases indicates these groups were becoming more homogeneous. In other words, the difference between the F and S learners was diminished as a result of the administration of strategy aids.

It may be suggested here that this interaction was due to the apparent ceiling effect for the fast learners in the aided groups (see Figures 15, 16, and 17). One might argue, however, that this ceiling effect was produced by the treatment, as evidenced by the fact that F learners in the control groups did not reach asymptote. In addition, most learning situations typically have a ceiling, specifically, that point at which the task is mastered. And it is a curious criticism which questions, when S learners have mastered the task along with the F learners, "What would have been the result if the F learners had still had room to improve?" In other words, what if the task had been made harder? The point is, the task was hard enough - giving strategy aids made it easy. In fact, some evidence previously cited indicates the task literally could not have been made hard enough if mediational aids were given for every pair (Wallace, Turner, and Perkins, 1957). Future research,

however, might avoid the apparent ceiling effect and subsequent problems with interpretation by reducing the proportion of aided items, increasing the number of items in the list, and/or reducing the exposure time of these items during acquisition.

The implications of this research bear serious consideration on the part of the educator. The present experiment has shown it is possible to enhance the learning of paired associate type material by suggesting the application of high level strategies. It might, therefore, be possible to teach students "how to learn" by utilizing this technique themselves in appropriate learning situations.

Certain kinds of teaching materials might also be developed which have these more effective strategies built into them. Material to be learned in the classroom, for example, might be structured in such a way as to highlight the various cues which are embedded in the material itself. This experiment has presented conclusive evidence that superior learners will discover and utilize such cues on their own. Teaching this technique as a method of learning to all students, and structuring classroom materials to facilitate this method may result in substantial increases in learning.

Not only could the material be structured differently, but the method of presentation could be varied. Many classroom tasks which are commonly viewed as rote learning situations might profit from a PA type of presentation, during which cues in the material are highlighted for faster acquisition. Spelling tests, definition

learning, and foreign language vocabularly are but three examples. Textbook outlines and summaries may even be written in this manner.

This experiment has also shown that by suggesting the use of high level strategies it is possible to minimize individual differences in performance on a PA task. It further suggests that many poor learners are not inherently slow. Rather, they have not learned how to search for cues in the material to be learned. In short, they simply have not learned "how to learn." The analyses have shown that S learners do not use as many high level strategies as F learners. But when S learners are given strategy aids on the PA task, their performance is practically as good as the F learners! For this type of task, therefore, it may be possible to structure teaching materials and methods of presentation for different levels of intellect so that end performance of F and S learners is the same.

If the method under discussion could dramatically improve the performance of S learners, it might tend to obviate the present trend toward classroom grouping of students according to their abilities. The psychological advantages gained by poorer students who are able to maintain a classroom association with the brighter individuals cannot be minimized.

In developing a teaching method which utilizes the formation of coding devices to enhance learning, one may question whether it is more advantageous for the learner to search for and discover his own cues, or to have these cues presented to him. Some educators may advance the argument that there is virtue in the student

struggling on his own to discover the principles of learning. The present study has shown this to be false, at least for this type of task. Subjects in the aided groups, who reported using the high level cues supplied by the experimenter, exhibited performance superior to that of Ss in the unaided groups, who reported finding their own high level strategies. In addition, the items aided by the experimenter were retained significantly longer. Moreover, for all E-4 groups, retention of the unaided pairs was not as great as that of the aided pairs even though these subjects were directly exposed to the high level strategies of the aided items.

The previous discussion does not suggest that all learning materials could feasibly be supplied with cues and strategies, either by the instructor, or by embedding the strategies in the material itself. For many kinds of learning this approach may not be practical. What is practical is to teach the student a general method of searching for and associating the available cues in material to be learned. In today's productive society in which the fund of knowledge is increasing so rapidly, great value would be placed on a technique which increases both the rate and the amount of learning in the limited time available to the learner.

In conclusion, this experiment has shown that the formation and use of associational strategies is an integral part of certain types of learning. Further research in this area may result in advances in teaching methods and in the structuring of teaching materials. Moreover, the introspective technique used in this study has been shown to be a fruitful and revealing approach to the study of complex mediational processes.

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A P P E N D I C E S

APPENDIX A

INSTRUCTIONS FOR THE PRACTICE TASK

"Everyone fill out the information requested on the cover. Do not look inside the booklet until I tell you to. This task should be fun for you. I simply want you to learn several pairs of words. I will now give you an example. (The pair GOKEM VILLAGE was projected on the screen in front of the group.) This is called a learning trial. Everyone knows what this word is (pointing to VILLAGE). But how many of you know what this word is (pointing to GOKEM)? This is called a nonsense word. It isn't a real word.

I want you to study this pair of words together so that when I show you the nonsense word by itself you can remember what went with it. (The stimulus word GOKEM was then presented by itself.) This is called a test trial. Please turn to the first page in your booklet. It should have the word SAMPLE written at the top. You will see a list of words written on this page. Hunt down through this list until you find the word that went with GOKEM and draw a circle around it. Did you all circle VILLAGE? That was just a sample. That pair will not be on the task.

For the main task I want you to learn eight such pairs. You will have a learning trial just as in the example, but this time you will be shown eight pairs, one at a time. They will be presented rapidly so pay close attention. Then you will have a test trial. Just the words on the left, the nonsense words, will be shown, one at a time. Each time a word comes on the screen you are to hunt through the list of words in your booklet and circle the

word you think went with it on the learning trial. Each time you circle a word turn the page. Then another word will be shown. Select the word that went with it, circle it, and turn the page. Then another word will be shown, and so on until all eight words have been shown. Then you will have another learning trial, another chance to learn the pairs. They will be the same pairs but in a different order. In fact, you will have several learning trials and several test trials. Please circle a word for every slide on the test trials, even if you have to guess. But do not turn back in your booklet once you have turned the page. If you think that you have made a mistake you can get it right on the next trial. If, however, you would like to make a change on the particular page you are on at the moment, cross out the incorrect response and circle the one you think is right.

It will not be easy to learn eight pairs all at once, but don't get discouraged. Please do not talk to your neighbor or look at his answers. It is very important that you do your <u>own</u> work. This will not affect your grade in this class but please do the best you can. Remember to circle a word for every slide on the test trials and turn the page after you have made your guess. Are there any questions? O.K., put your pencils down and just study the pairs as I present them to you."

(At the completion of the test the experimenter asked the following.)

"Did any of you use any tricks to help you learn the pairs? Please raise your hand if you did, and I will call on you. Please

tell the class what trick you used on this pair." (Each S-R pair was shown one at a time and the experimenter called on three different students to give their strategies for each pair.)

APPENDIX B

INSTRUCTIONS FOR THE CRITERION TASK

"Please fill in the information requested on the cover of your booklet. You all remember what the object of the task was yesterday. You studied several pairs of words on the screen. When I presented just the nonsense word on the left you circled the word in your booklet that you thought went with it. Today you will perform the same task, but with eight different pairs, of course." Instructions now varied slightly for each treatment group as follows: Control - "Are there any questions?" E-4: "There will be something added, however, On the first two learning trials I will give you a trick for each of four pairs which might help you learn them. I will give you the same tricks on both trials. But I will state each trick out loud only once while the pair is on the screen so pay close attention. You may use these tricks or not as you please. Are there any questions?" E-8: "There will be something added, however. On the first two learning trials I will give you a trick for each of the eight pairs which might help you learn them. I will give you the same tricks on both trials. But I will state each trick out loud only once while the pair is on the screen so pay close attention. You may use these tricks or not as you please. Are there any questions?"

APPENDIX C

INSTRUCTIONS FOR STRATEGY COLLECTION TASK

"Please fill in the information requested on the cover. You will remember yesterday I asked if anyone had used any tricks to help them during the learning task. Several of you told the class what your tricks were. Today I want each of you to tell me in writing if you used any tricks on this task. You will notice that your booklet contains eight pages. Each page has one of the pairs at the top. Please write down to the best of your ability how you attempted to learn each pair. If you did not use a trick, say so in writing. If you did use a trick make sure you write down what it was. If you repeated a pair to yourself, write that down." (For the E-4 and E-8 groups the following instructions were added here: "If you used the tricks I gave you make sure you write down what they were. Do not write, 'I used yours', without explaining what they were.") "Do not select something that is easy to write and copy it on every page of your booklet. And do not make something up just to please me. Think about each pair individually and write as much or as little as necessary to explain what you used. If you used more than one trick write them both down. Do not borrow your neighbor's tricks. It is very important that you do your own work. If anyone needs any help with spelling or expressing themselves in writing raise your hand and I will help you. Do not turn the page to the next pair until I tell you to. Remember, tell me the best you can in writing how you tried to learn each pair. Are there any questions?"

APPENDIX D

INSTRUCTIONS FOR RETENTION TASK

"Please fill in the information requested at the top of your sheet. Today I am going to see how many of the pairs you can remember from the second test you took. I will write each nonsense word on the board for a few seconds, one at a time. Please write down this nonsense word and the word you think goes with it. Do this in the same order in which I present them. Again it is very important that you do your own work. Do not say the words out loud. It will spoil the task. Remember, write down <u>both</u> the nonsense word and the word that you think goes with it. Are there any questions?"