Childrens [sic!] multiple cue learning and sampling strategies in concept identification.

CHILDRENS MULTIPLE CUE LEARNING AND SAMPLING STRATEGIES IN CONCEPT IDÉNTIFICATION

A Dissertation Presented

by

Marc A. Clement

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Abstract

The present study examined the multiple-cue learning and sampling strategies of 180 kindergarten and 180 fourth grade children in a concept identification problem with two redundant relevant dimensions and one irrelevant dimension. The major results indicated that 1) most subjects who learn about both relevant cues learn them one-at-a-time rather than "focusing" in on both simultaneously; 2) two-cue learners take longer to respond than do one-cue learners; and 3) kindergarteners take longer to respond than do fourth graders, make more errors, and are less likely to learn about both relevant dimensions.

Introduction

Psychologists have long been interested in the study of concept identification or concept learning: the process by which individuals learn to classify objects, events, and abstractions. The psychological study of concept learning is rooted in the seventeenth century philosophical doctrine of associationism. According to John Locke, a major proponent of associationism, once two ideas become associated, when one of them comes to mind it would tend to evoke the other. Other basic principles of associationism included: contiguity - ideas that occur close together in time tend to become associated; similarity - ideas that are similar are more likely to be associated than dissimilar ones; and repetition - the more frequently ideas occur together the more strongly they become associated. Associationism emphasized experience in learning, as embodied in Locke's assertion that a man's mind at birth was a "blank slate" (tabula rasa) and all that a person learned was from the impressions that the environment made upon his senses. Associationism, thus, was primarily a doctrine of passive learning in which associations were formed with no conscious planning or forming as part of the learning process.

The more recent view is that concept learning is an active process. Bruner and his associates (1956) published the first major work from this perspective. They were interested in the processes that occurred as subjects learned to categorize stimuli. What they found was that subjects showed evidence of consciously planned, and highly organized strategies for learning rules of classification. Since the publication of Bruner's work, much of the concept learning research has been concerned with identifying the strategies that subjects use in attempting to solve a concept identification problem.

In the typical concept identification problem, subjects are presented with dimensional stimuli with binary values, examples of which are: color - red or blue, size - large or small. These dimensions are incorporated into stimuli which are ordinarily printed on cards or rear projected onto a screen, and the subject's task is to classify these stimuli according to two or more arbitrarily designated categories. As a measure of learning, the subjects are run to a criterion performance (such as 10 consecutive correct responses), after which they are quizzed on their rule of classification.

Researchers have studied the problem solving strategies of subjects within the context of a multidimensional concept identification problem with more than one potential solution. In a problem with two potential solutions some subjects will learn one of the solutions, some will learn the other solution, and still others will learn both solutions. The redundant relevant cues paradigm thus provides an ideal experimental paradigm for studying selectivity during learning and the breadth of learning. Researchers have focused on the reasons for one- and two-cue learning and any differences between one- and two-cue learners in terms of: problem solving strategy, total errors for problem solving, latency of responses, and any developmental differences in the probability of a two-cue solution.

Multiple Cue Learning. The fact that some adult subjects learn both relevant solutions in a redundant relevant cues concept identification problem is a well established experimental finding (e.g., Clement & Anderson, 1975; Trabasso & Bower, 1968). Multiple cue learning by children has not been as extensively studied.

House & Zeaman (1963) did the first work in this area. Their procedure, with retarded children (MA - 4 to 8 years), involved giving children a series of two- and three-trial discrimination learning problems from which it was possible to derive estimates of the extent to which compound cues (e.g., the unitary pattern of 'blank triangle') were used by the children. This procedure is very different from the learning to criterion procedure typically employed in concept identification problems. The differences notwithstanding, the results of their series of experiments indicated that retarded children could use the components (e.g., black or triangle) and the compounds (e.g., black triangle) in solving a simple simultaneous discrimination problem. Further, they found that the ability to utilize compound information was an increasing function of mental age. Using a similar procedure, Eimas, who received his training in Zeaman's lab, replicated this finding with retarded children (1964) and normal children (1965).

Eimas (1969) followed up these findings using a somewhat different procedure. Using either 2, 3, or 4 relevant dimensions he attempted to ascertain how many cues children employ in a problem solution and what effect developmental level had on the use of multiple cues. The results indicated that kindergarteners were able to learn something about two relevant cues but very little about three or four relevant cues. Second and fourth graders were able to learn about three, and in some individual cases four relevant cues. After reaching criterion on a simultaneous discrimination problem, the subjects were given a series of test trials with one and then the other relevant cue (or cues) neutralized. From this Eimas derived a percentage of how much was learned about each of the relevant dimensions. Thus, it was not possible to say, for example, that there were 10 three-cue learners among the second graders, but rather that when classifying dimensions during the test trials on three relevant dimensions the second graders were correct 69% of the time on color, 88% correct on form, and correct 87% of the time when classifying size.

Anderson (1972) found multiple cue learning by second grade children in both an incidental learning and a relevant redundant cue task. Children trained with one dimension relevant were able to learn something about a previously irrelevant dimension made relevant in overtraining. Incidental learning by children is a well established experimental finding (e.g., Siegel, 1968; Siegel & Stevenson, 1966).

These are the only studies that have looked at multiple cue learning by children in the context of a concept identification problem. As noted, the procedures were somewhat different than the typical concept identification procedure employed with adult subjects. Yet there does seem to be some indication that children are able to learn about multiple relevant cues, and that this ability increases with age (Eimas, 1969).

Sampling Strategies. A question that has been studied more extensively concerns the strategies that children typically employ in solving a multidimensional concept identification problem.

How a subject solves a multidimensional concept identification problem with more than one potential solution is a question that has intrigued researchers for at least the past ten years. Two models of concept identification have been given serious consideration in attempting to account for a subject's performance: a random-sample-of-strategies model (multiple-look) and a one-hypothesis-at-a-time model (one-look).

A number of experimental findings have provided evidence for a multiple-look strategy by adults. Tests of relevant redundant cue learning (Trabasso & Bower, 1968), blank trial probes (Levine, 1970), and latency data (Levine, 1969) have been presented as major support for a multiple-look strategy. Very simply, this multiple-look model supposes that on the first trial and after each error the subject draws a random sample of all hypotheses. If correct, the subject eliminates irrelevant hypotheses, finally focusing in on the relevant cue or cues.

A one-look model supposes that the subject samples only one dimension per trial, sampling with replacement after an error and retaining the sampled dimension after a correct response. When Trabasso & Bower (1968) found evidence of multiple cue learning by subjects, they felt that this required a multiple-look strategy and thus abandoned their own one-look model (Bower & Trabasso, 1964). Zeaman & House's (1963) one-look attentional model was similarly thought to be inadequate in explaining multiple cue learning. Yet, by making a small extension of this model, Shepp, Kemler, & Anderson (1972) have shown that a one-look model can predict and account for two-cue learning. More importantly for one-look interpretations, Kemler & Anderson (1972) have shown that a one-look model can predict most of the data that Trabasso & Bower (1968) have presented to support their multiple-look model.

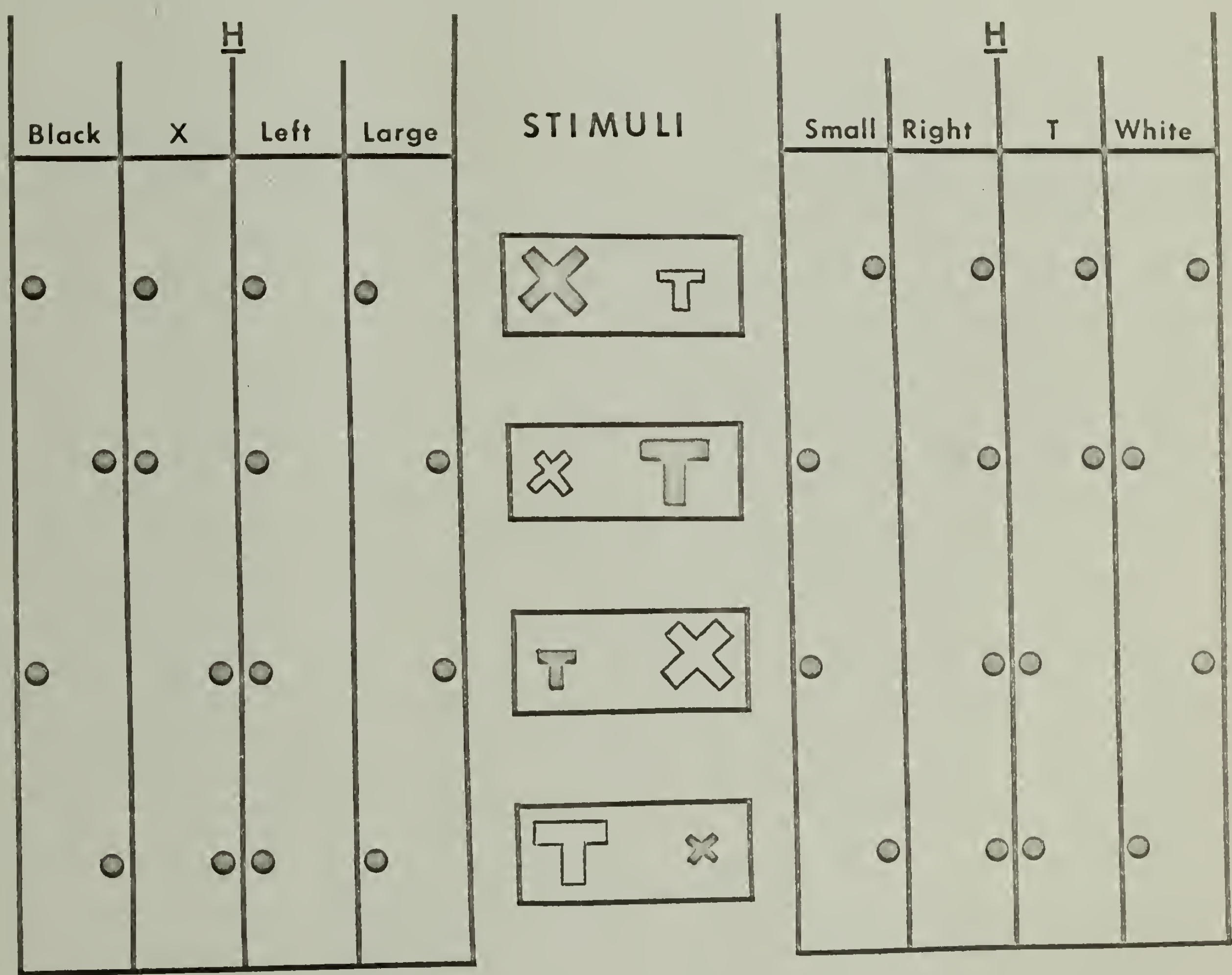
A number of studies using the blank trials procedure (Eimas, 1969b; 1970) have attempted to ascertain the strategy that children use in solving a concept identification problem. The blank trial procedure was developed by Levine (1963, 1966) to study the hypothesis behavior and focusing strategies of adult subjects in the context of a discrimination learning problem. Levine (1970) began with three assumptions: 1) the subject begins with one hypothesis which determines his response, 2) if the subject is told nothing about the correctness or incorrectness of his response he will retain the hypothesis, and 3) by training the subject, the experimenter knows the set of hypotheses from which the subject is sampling. To infer a subject's hypothesis, Levine used a series of blank trial probes. That is, reinforcement was given on trial 1 followed by a series of four trials without reinforcement, followed by a feedback trial, four more blank trials, and so on. Levine used stimuli similar to those shown in Figure 1. Since the hypotheses from which the subject is sampling are finite and

Insert Figure 1 About Here

known to the experimenter, Levine was able to ascertain which of the eight simple hypotheses the subject was sampling during the four blank trials. If at any point in the problem the experimenter wishes to know the subject's hypothesis, he simply presents the four blank trial probes. Also, since there are 16 possible response patterns (the eight simple patterns plus eight other random patterns), if the subjects are not using a hypothesis strategy they would follow the single hypothesis pattern only 50% of the time.

Levine (1970) found that 92% of the probes showed hypothesis patterns, that 95% of the subjects repeated a hypothesis after a correct response, and that only 2% repeated a hypothesis after an incorrect response. Further, Levine found

Figure 1



that contrary to his first assumption, the subjects were sampling a subset of hypothesis, taking one as the working hypothesis and using that as the basis of their response. Following a correct response the same working hypothesis is retained, and inconsistent hypotheses in the subset are discarded. Following an incorrect response, the working hypothesis is discarded and the subject chooses a new working hypothesis (either one from his subset or if the subset has gone to zero, he chooses a new subset and a new working hypothesis from that subset).

Eimas (1969b), using this same blank trial procedure, studied the hypothesis behavior and focusing ability of children. He found that at all the grade levels he studied (2nd, 4th, 6th, and 8th) children formulated and used hypotheses, and that the extent of hypothesis behavior increased significantly with developmental level. Eimas further found that at all ages, subjects were to some extent able to focus; but, as with hypotheses behavior, the extent of focusing increased with developmental level. Eimas felt that this focusing deficiency in younger children was due to either an inability to code information after a correct response, recode after an incorrect response, or an inability to remember any coded or recoded information.

In a subsequent study, Eimas (1970) found that if the memory requirement was minimized, children at the second grade level were able to focus nearly perfectly. By making the relevant information available to the child, logical information processing (focusing) was possible. To make this relevant information available to the child, Eimas used a number of different techniques. One group of subjects was able to refer back to the outcome trial stimulus during the blank trials. If the outcome was positive, a plus sign was placed over the positive cues. If the outcome was negative, a minus sign was placed over the negative cues. This was a memory aid group. A second group always had the positive cues available whether they had made a positive or negative response. This was a memory and recoding group. Finally, there was a memory, recoding, and attention aid group. Only the plus sign was used and this sign was positioned so as to cover the negative cues. All these groups exhibited nearly perfect focusing ability: a perfect focuser has four hypotheses at outcome trial 1, two at outcome trial 2, and one hypothesis at outcome trial 3. Eimas' second graders had approximately 4.5 hypotheses at outcome trial 1, and were able to focus down to approximately 2 hypotheses at outcome trial 3.

Training has also been shown to be an important variable in altering a child's approach to a concept identification problem. Gholson, Levine, and Phillips (1972), using a blank trial procedure, found that kindergarten children exhibited stereotypic behavior in a concept identification problem. The most common stereotypes were position alternation and position perserveration, with none of the kindergarteners exhibiting a focusing strategy. By adding training on stimulus differentiation, Gholson and McConville (1973) were able to get kindergarteners to manifest response patterns consistent with simple hypotheses. A control group in this study without this training continued to exhibit these stereotypic patterns of responding.

Latency. Latency data has also been presented as further evidence for a random-sample-of-strategies model which, of course, implies a focusing strategy. According to the single hypothesis assumptions, the subject is in two states; he has an incorrect hypothesis and makes correct responses by chance, or he has the correct hypothesis and he is consistently correct. The trial of last error marks this transition point between the two states. Latencies should reflect this demarcation point. The one-trial single hypothesis assumption would thus predict that after the trial of last error latencies should be constant. Yet as Erikson, Zajkowski, and Ehman (1966) pointed out, this does not hold. Latencies continued to decrease for a few trials after the trial of last error before reaching their lower asymptote. Following this up, Levine (1969, employing in a concept identification problem, had his subjects ring a bell when they felt that they had solved the problem. This identified what Levine called the 'solution trial', and he predicted and confirmed that from the trial of last error to the solution trial latencies should decrease; beyond the solution trial the latencies should be constant. Levine says that this follows from the random-sample-of-strategies model in which the trial of last error is that trial at which the subject first takes the correct hypothesis as his working hypothesis. During the next few trials, the subject is reducing his subset until none but the working hypothesis remains. If the reasonable assumption is made that latency is a function of the number of hypotheses in the subset to be evaluated, there should be a decrease in latencies from the trial of last error to the solution trial.

It may be as equally reasonable to assume that the subject at the trial of last error, though only sampling one dimension, is not completely confident of his solution. If so, one can explain this latency decline within the framework of a one-look model. The subject becomes more and more confident as he tests his solution on trials subsequent to the trial of last error, and his increasing confidence is manifested in shorter latencies. Finally, at the solution trial when the subject is completely confident of his solution, his latencies level out at their lower asymptote. Falmagne (1970) gives this interpretation to latency decline in her hypothesis model for concept identification. She says that it is natural to postulate that the latency of a response is inversely related to the strength of the current hypothesis. She goes on to say that the decrease in latencies during a sequence of correct responses (e.g., from the trial of last error to the solution trial) would result from the increment in the strength of that hypothesis under positive reinforcement.

<u>Conclusions from the data</u>. The data on children's

multiple cue learning and performance in concept identification problems can be summarized as follows: 1) children, from kindergarten age and older, can learn multiple relevant cues, but the studies purporting to show this may not be giving a true indication of the performance of a typical subject. The House and Zeamon (1963) study, for example, required subjects to extract as much information as possible from the stimuli (i.e., learn compounds) in order to be reinforced. In the Eimas study (1969), subjects were reinforced during the single cue test trials and thus may have learned about the relevance of a cue at this time. 2) with training and the use of various memory and recoding aids, children were able to employ a focusing strategy. This says nothing though about the typical strategy employed by children. It should also be noted that the subjects in the above mentioned studies were all well practiced (4 to 8 practice problems each) and thus they may develop or be lead to a focusing strategy during these practice problems. 3) finally, there are no studies that looked at the child's latency of response.

Research on children's multiple cue learning and sampling strategies thus provide conflicting data, particularly on the performance of kindergarteners and fourth graders. Kindergarteners were found to employ, almost exclusively, stereotypic behavior in attempting to solve the problem (Gholson, et al., 1972). These stereotypic behaviors do not lead to problem solution, yet Eimas (1969) found that kindergartners could learn about two relevant cues. Approximately 5% of the fourth graders studied by Gholson, et al., (1972) employed a focusing strategy. Over half used a dimension checking strategy; that is, a strategy of systematically checking one dimension at a time. Without resampling after solving the problem, fourth graders would not learn about relevant redundant cues; yet, Eimas (1969) found that fourth graders learned about two, sometimes three, and often four relevant redundant cues. Taking these results to a logical conclusion, it would be expected that kindergarten and fourth grade children who learn about multiple relevant cues would have to be learning them in a serial fashion because Gholson, et al., (1972) found that a focusing strategy is not the strategy typically (or at all) employed by these age subjects.

Clement and Anderson (1975) provide a methodology which can be extended to examine multiple cue learning, sampling strategies, and latency data in a concept identification problem with children. Their study utilized the solution trial procedure developed by Levine (1969). Adult subjects were given a concept identification problem with two relevant and redundant dimensions and two irrelevant dimensions. One group of subjects were run to a criterion of 15 consecutive correct responses and then quizzed on their solution. A second group was asked to press a button when they felt that they had solved the problem (the solution trial). Their results indicated that the two-cue learners predominately learned about one of the relevant dimensions by the solution trial and then learned about the second relevant cue during the remainder of the criterion run. These data are consistent with the hypothesis that subjects were using a one-look strategy which involved resampling, without error, after solving the problem on the basis of one of the relevant cues. Further, Clement and Anderson (1975) found that two-cue learners took longer to respond than one-cue learners both during the criterion run and on the pre-criterion trials.

A concept identification study with kindergarten and fourth grade children as subjects, using the methodology of the Clement and Anderson (1975) study, would add significantly to the research in this area. First, it would clear up some of the questions concerning children's multiple cue learning that were left unanswered by the Eimas (1969) study. The Eimas study provides no individual data on multiple cue learning or data on how children arrive at a multiple cue solution. By using a solution trial procedure this study would give an indication on whether children arrive at a multiple cue solution in a serial or "focusing" fashion. Finally, data would be provided on the child's latency of response, an area in which at present there are few data. For these reasons, the study would be important and should add valuable data to the area of children's concept identification.

Method

<u>Subjects</u>. Three hundred eighty subjects participated: 180 kindergarten, 180 fourth graders, and 20 University of

Massachusetts undergraduate volunteers. An almost equal number of the kindergarteners and fourth graders were taken from the following schools: Belchertown Elementary School, Ware Elementary School, and the Three Rivers School. The kindergarteners and fourth graders were randomly assigned to each of three equal sized groups. The undergraduates were assigned to each of two equal sized groups.

Apparatus and Stimuli. The stimuli consisted of fifteen identical 30 cm. tall 'Barbie dolls'. Eight of the dolls wore white dresses which varied on three bivalued dimensions: number of blue pockets - one or two, shape of the red 'ric-rac' on the hem of the dress - straight or wavy, and type of gold belt - chained or solid. All possible combinations of the three dimensions were used. Six of the remaining dolls each had one of the six possible cues on their white dresses. These dolls will be referred to as the single dimension dolls. The one remaining doll had on just a plain white dress.

The subject was seated in front of a mock-up of a school house. The front of the school house, facing the subject, was 60 cm. wide and 45 cm. high. Directly in front of the subject was a 10 cm. x 15 cm. sliding door. When the door was opened, a doll came into view and the opening of the door activated a Hunter model 120A KLOCKOUNTER. The KLOCKOUNTER stopped when the sliding door was closed.

Procedure. All subjects were given a concept identification problem with two redundant relevant dimensions and one irrelevant dimension. All three combinations of relevant dimensions were used and each subject was given a unique random order of presentation of the dolls.

Each child was taken individually from his classroom to play the 'twin game'. One group of subjects (CR group) was run to a criterion of 15 consecutive correct responses. They were instructed that after a fairly large number of consecutive correct responses the experimenter would signal the end of the problem. A second group (ST group) was instructed to tell the experimenter when they felt that they had solved the problem. They stated their solution and then continued on to the criterion of 15 consecutive correct responses, including the correct trials before they stated their solution. If the subject stated an incorrect solution, the problem continued until the subject either reached criterion or stated another solution. The third group (MOD ST) was run in a manner the same as the ST group with one exception: when the subjects stated their solution at the solution trial they were asked to classify the single dimension dolls. At the end of the criterion run all subjects were quizzed on their solution and then asked to classify the single dimension dolls. The college students were assigned to either the ST or CR groups.

The subjects (with the exception of the college students) were first given a practice problem with one relevant dimension and no irrelevant dimensions. The following instructions were given:

"We are going to play a game with two dolls. One's name is Susan and the other's name is Jane. These girls are twins. Do you know what a twin is? (If the child does not know, he will be given a simple explanation). In order to help the teacher tell Susan and Jane apart their mother bought them two different sized hats. One of the girls has a great big hat just like this one. (the door to the school house was opened showing the doll with the plain white dress with a big hat) The other girl has a little hat just like this one. (the door to the school house is again opened, this time showing the same doll but with a small hat)

I'm now going to show you some dolls and I want you to tell me whether you think that I'm showing you Jane or Susan. Try to be correct every time."

For the ST and MOD ST groups, the instructions continued:

"Tell me as soon as you know how to tell the girls apart."

After these instructions the experimenter showed one of the dolls and asked the subject what the doll's name was. Whatever name the child gave was arbitrarily designated correct and he was told, "Very good. That's correct." On the next trial, the subject was shown a doll with the opposite relevant dimension and again asked to name the doll. If incorrect the subject was told, "No, that is incorrect." All subjects completed a criterion run of 10 consecutive correct responses and were quizzed on their solution. If after 20 trials the subject was not able to verbalize a solution or had not entered the criterion run, he was told the solution and given another practice problem with a different relevant dimension. The relevant dimension was color of scarf - red or blue. If the subject was not able to solve the second practice problem he was given a prize, classified as a nonlearner, and dropped from the experiment.

Once the subject solved the practice problem, he was instructed:

"You did very well in that game. We're going to play another game now. Do you remember the dress that the girls had on in the last game? (the child is shown a doll with just a plain white dress) It was just a plain white dress with nothing on it. In order to help the teacher tell Susan and Jane apart their mother bought some things to put on their dresses. One of the things that the mother put on the dresses was either one pocket or two pockets. (the child is shown the two dolls) Another thing that the mother put on the dresses was either a chained belt or a straight belt. (the child is shown these two dolls) The mother also put either a wavy or straight design on the bottom of the dresses (these two dolls were shown).

Now I'm going to show you some dolls and I want you to tell me whether I'm showing you Susan or Jane.

Remember to try and be correct every time."

For the ST and MOD ST groups, the instructions continued:

"Just like you did in the last game, you tell me as soon as you know how to tell the girls apart."

If the subjects in the CR group had not entered the criterion run by trial 60 they were classified as nonlearners. Subjects in the ST and MOD ST groups were classified as nonlearners if they either had not verbalized a solution or had not entered the criterion run by trial 60.

After stating their solution, at the solution trial, the MOD ST group subjects were asked to classify the single dimension dolls. They were instructed:

"I'm now going to show you the dolls that I showed you in the beginning of the game. Remember the dolls with just one thing on their dresses? I want you to tell me whether you think that I'm showing you Susan or Jane. If you're not sure which doll it is, you just tell me that you're not sure."

The subjects were not reinforced on these trials. After classifying the dolls, the subjects continued on to the remainder of the criterion of 15 consecutive correct responses. The ST group subjects after stating their solution, at the solution trial, continued on to completion of the remainder of the 15 consecutive correct responses.

At the end of the criterion run and after stating their solution, all groups were asked to classify the single dimension dolls. Their instructions were the same as those given to the MOD ST group at the solution trial and as before, subjects were not reinforced on these trials.

After completion of the series, the subject was thanked for his participation, told he did a very good job, and given a prize. Subjects were not given a detailed explanation of the problem so as not to bias future subjects. As a further control in insuring that the subjects were as naive as possible to the problem, the names of the girls were changed for different children (e.g., Cindy and Mary, Cathy and Judy).

Latencies were taken and recorded on all trials, including the trials on which the subjects classified the single dimension dolls.

The CR and ST group college students were run exactly the same way as were the younger subjects. The instructions were prefaced with a statement that this was a game intended for younger children but in order to make the results comparable, the instructions would have to be read verbatim.

Results

Solution Type. The major dependent variable of the present study, the number of one- and two-cue learners in the kindergarten and fourth grades at criterion and the solution trial, is shown in Table 1. These one- and two-cue learners

Insert Table 1 About Here

are classified according to their stated solution. The sub-

Table 1

Number of One- and Two-Cue Learners

Group		Solution Type			
		At Criterion		At Solution Trial	
		One-Cue Learners	Two-Cue Learners	One-Cue Learners	Two-Cue Learners
K	CR	39	21	--	--
	ST	41	19	55	5
	MOD ST	39	21	55	5
4th	CR	26	34	--	--
	ST	26	34	50	10
	MOD ST	30	30	51	9

ject's verbal classification of the relevant dimensions was compared to the single dimension doll classification at criterion and solution trial. The correspondence between the two is shown in Table 2, from which it can be seen that the greatest deviation between the two methods involves subjects stating one solution but classifying both relevant dimensions correctly.

Insert Table 2 About Here

A X^2 was computed, and no significant differences were found between the methods of classification either at criterion or solution trial. It is interesting to note that the greatest deviation (9%) involves the kindergarten one-cue learners stating one solution but classifying both relevant dimensions correctly. This may indicate that the kindergarteners are somewhat more hesitant in stating multiple solutions.

No significant differences were found between the number of one- and two-cue learners in the CR, ST, and MOD ST groups at criterion within the kindergarten and fourth graders. There was however, a significant difference between the total number of one- and two-cue learners in the kindergarten and fourth graders, ($X^2(1) = 15.40$, $p < .001$). Thirty-four percent of the kindergarteners and fifty-five percent of the fourth graders learned about both relevant dimensions indicating that fourth graders are more likely to learn both solutions in a redundant relevant cues problem. There is also a significant difference between the number of one- and two-cue learners in both the

Table 2

Agreement between the verbal solution and the single dimension doll classification

Verbal Solution

Single Dimension Classification	At Criterion	K one-cue	K two-cue	4 one-cue	4 two-cue
K	one-cue	109	2	-	-
	two-cue	10	59	-	-
4	one-cue	-	-	77	1
	two-cue	-	-	5	97

MOD ST at Solution Trial

Verbal Solution

Single Dimension Classification		K one-cue	K two-cue	4 one-cue	4 two-cue
K	one-cue	53	0	-	-
	two-cue	2	5	-	-
4	one-cue	-	-	48	0
	two-cue	-	-	3	9

kindergarten and fourth grade ST subjects at criterion and solution trial, ($X^2(1) = 10.20$, $p < .01$; $X^2(1) = 20.64$, $p < .001$). For kindergarteners the number of two-cue learners from solution trial to criterion increased from 5 two-cue learners at solution trial to 19 at criterion. For the fourth graders the number of two-cue learners increased from 10 to 34. This indicates that at these ages, subjects were predominately learning the second relevant cue after having stated one solution trial. There was a similar difference for both the kindergarten and fourth grade MOD ST subjects, ($X^2(1) = 12.56$, $p < .001$; $X^2(1) = 16.77$, $p < .001$). As with the ST group, this result indicates that these subjects predominately learn the multiple relevant cues in a serial fashion over the trials of the criterion run. The difference between the number of two-cue learners at the solution trial in the kindergarten and fourth grade subjects was not significant.

The subject's solution type was further broken down on the basis of the relevant dimension combination that was presented to the subject. The number of one- and two-cue learners in each of these groups is shown in Table 3. There were no significant differences in the number of one- and two-cue learners in

Insert Table 3 About Here

the kindergarten and fourth graders for the pocket-belt combination. There was, however, a significant difference in the belt-hem combination and the pocket-hem combination between the

Table 3

Number of one- and two-cue kindergarteners and fourth graders in each of the relevant dimension combinations

	Pocket Hem		Pocket Belt		Belt Hem	
	one-cue	two-cue	one-cue	two-cue	one-cue	two-cue
Kindergarteners	47	13	30	30	42	18
Fourth	36	24	24	36	23	37

kindergarteners and fourth graders, ($X^2(1) = 12.10$, $p < .001$; $X^2(1) = 4.70$, $p < .05$). Within the kindergarten subjects, there were significant differences in the number of one- and two-cue learners in both the pocket-hem/pocket-belt comparison and the pocket-belt/belt-hem comparison, ($X^2(1) = 9.36$, $p < .01$; $X^2(1) = 5.00$, $p < .01$). In the fourth graders, the pocket-hem/pocket-belt comparison and the pocket-hem/belt-hem comparisom were both significantly different in terms of the number of one- and two-cue learners, ($X^2(1) = 4.80$, $p < .05$; $X^2(1) = 5.62$, $p < .05$). Overall there are more two-cue learners than one-cue learners in the pocket-belt combination, whereas the opposite holds true for the other two combinations.

The one-cue learners were examined further in terms of the relevant dimension that they used in solving the problem. These data are presented in Table 4. Significantly more subjects in the pocket-hem combination solve the problem on the basis of

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Insert Table 4 About Here

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pocket ($X^2(1) = 50.69$, $p < .001$). In the pocket-belt combination significantly more subjects solve the problem on the basis of pocket, ($X^2(1) = 24.02$, $p < .001$). In the belt-hem combination, belt is used significantly more often than hem as a basis of solution, ($X^2(1) = 12.00$, $p < .001$). Interestingly though, when the number of hem solutions in the pocket-hem combination is compared to the number of belt solutions in the pocket-belt combination the difference is not significant.

Table 4

Relevant dimension used by the one-cue learners in problem solution

		Grade K	Grade 4
Pocket-Hem Combination	Pocket	42	34
	Hem	5	5
Pocket-Belt Combination	Pocket	28	15
	Belt	2	9
Belt-Hem Combination	Belt	28	18
	Hem	14	5

The subjects who solved the problem on the basis of one of the relevant dimensions at the solution trial but both at criterion were examined in terms of the relevant dimension learned by the solution trial. These data are shown in Table 5. In the pocket-belt combination, significantly more subjects first learned pocket, ($X^2(1) = 10.02$, $p < .01$). Similarly in the pocket-hem combination, significantly more subjects first learned pocket, ($X^2(1) = 8.10$, $p < .01$). The difference in the belt-hem combination was not significant.

Insert Table 5 About Here

These data indicate that pocket is consistently more salient in terms of both one-cue solutions and solution stated at the solution trial. Belt is somewhat more salient than hem but only in terms of one-cue solutions.

There were 19 subjects (5% of the total) who were unable to solve the problem. All but one were kindergarteners. Three of the subjects refused to continue after three or four trials of the practice problem. Three of the non-learners exhibited an alternation strategy and two consistently attempted to solve the problem on the basis of pocket even though it was irrelevant. No consistent pattern of responding was discernable for the remaining 11 non-learners (including the one fourth grader).

Of the 20 undergraduate subjects, 10 each were assigned to an ST and CR group. All the CR group subjects solved the problem on the basis of both relevant dimensions. All but one

Table 5

Relevant dimension learned by solution trial
for serial two-cue learners

Relevant Dimensions Combination

	Pocket/Belt		Belt/Hem		Pocket/Hem	
	Pocket	Belt	Belt	Hem	Pocket	Hem
4	12	5	9	9	8	2
K	12	2	6	3	7	1

of the ST group subjects solved on the basis of both relevant dimensions at the solution trial. That one subject eventually learned the second relevant dimension. It was very apparent that a prohibitively large number of subjects would have to be run to get enough one-cue learners to make comparisons with the younger subjects. The college students solved the problem very rapidly - an average of .7 errors. The problem was apparently too easy for the college students and since this would make their data of little value, no further subjects of this age were run.

Acquisition. The mean total errors, trial of last error, and solution trial for the various groups are shown in Table 6. A 3(groups) x 2(grade) x 2(solution type) x 3(relevant dimension combination) analysis of variance for total errors

Insert Table 6 About Here

was computed. This analysis and all subsequent analyses were computed using the method of unweighted means (Myers, 1966, p. 106). The Analysis of Variance Table is shown in Appendix A. There was a main effect of grade due to the kindergarteners making significantly more total errors than the fourth graders, $F(1,328) = 20.46$, $p < .001$. There was also a main effect of relevant dimension combination, $F(2,328) = 27.85$, $p < .001$. Subjects with the belt-hem combination made significantly more errors than both the pocket- hem and pocket-belt combinations (all comparisons are computed by Scheffe's method

Table 6

Mean Total Errors, Trial of Last Error and Solution Trial

		K		4th	
		1 Cue	2 Cue	1 Cue	2 Cue
Total Errors	Pocket/Hem	3.81	5.23	2.70	2.84
	Pocket/Belt	1.58	2.00	2.70	.82
	Belt/Hem	7.40	8.05	4.37	4.00
Trial of Last Error	Pocket/Hem	5.85	8.69	4..0	5.15
	Pocket/Belt	3.42	4.22	5.70	1.51
	Belt/Hem	14.11	14.16	8.00	7.86
Solution Trial	Pocket/Hem	4.61	4.44	4.50	4.64
	Pocket/Belt	4.81	5.38	4.26	3.88
	Belt/Hem	6.07	5.84	4.46	4.40

Group	Mean Total Errors	Mean Trial of Last Error	Mean Solution Trial
K	4.47	8.56	5.58
4th	2.86	5.21	4.32
CR	3.90	7.59	--
ST	3.88	7.10	4.60
MOD ST	3.21	6.08	4.93
1 Cue	3.89	7.39	4.85
2 Cue	3.38	6.32	4.66
Pocket Hem	3.13	5.62	4.56
Pocket Belt	1.97	4.13	4.53
Belt Hem	5.87	11.02	5.21

for post-hoc comparisons). Subjects with the pocket-hem combination made significantly more errors than those with the belt-pocket combination. A significant grade X solution type interactions is illustrated in Figure 2, $\underline{F}(1,328) = 4.13$, $p < .05$. Kindergarten two-cue learners made more errors than kindergarten one-cue learners yet the fourth grade one-cue learners made more errors. The difference within each grade for the different solution types is not significant. Figure 3 illustrates the interaction of grade X relevant dimension, $\underline{F}(2,328) = 3.68$, $p < .05$. The kindergarteners made more errors at each relevant dimension combination but the difference is particularly large with the belt-hem combination.

Insert Figures 2 & 3 About Here

A 3(groups) x 2(solution type) x 2(grade) x 3(relevant dimension combination) analysis of variance for trial of last error was computed. The Analysis of Variance Table is shown in Appendix B. As with total errors, there was a main effect of grade with the kindergarteners having a significantly later trial of last error, $\underline{F}(1,328) = 26.17$, $p < .001$. There was also a main effect of relevant dimension combination, $\underline{F}(2,328) = 31.97$, $p < .001$. Subjects with the belt-hem combination had a significantly later trial of last error than both the pocket-hem and pocket-belt combinations. Also subjects with the pocket-hem combination had a significantly later trial of last

Figure 2

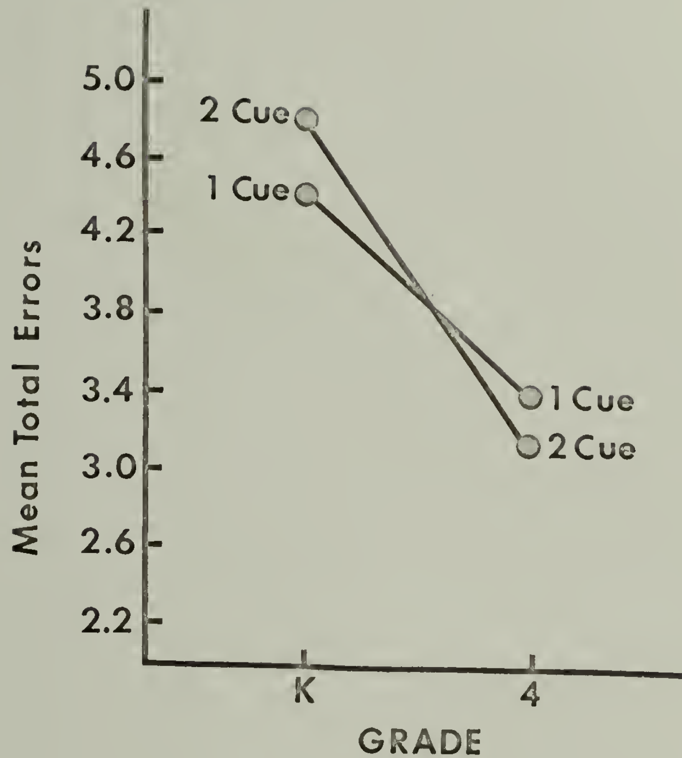
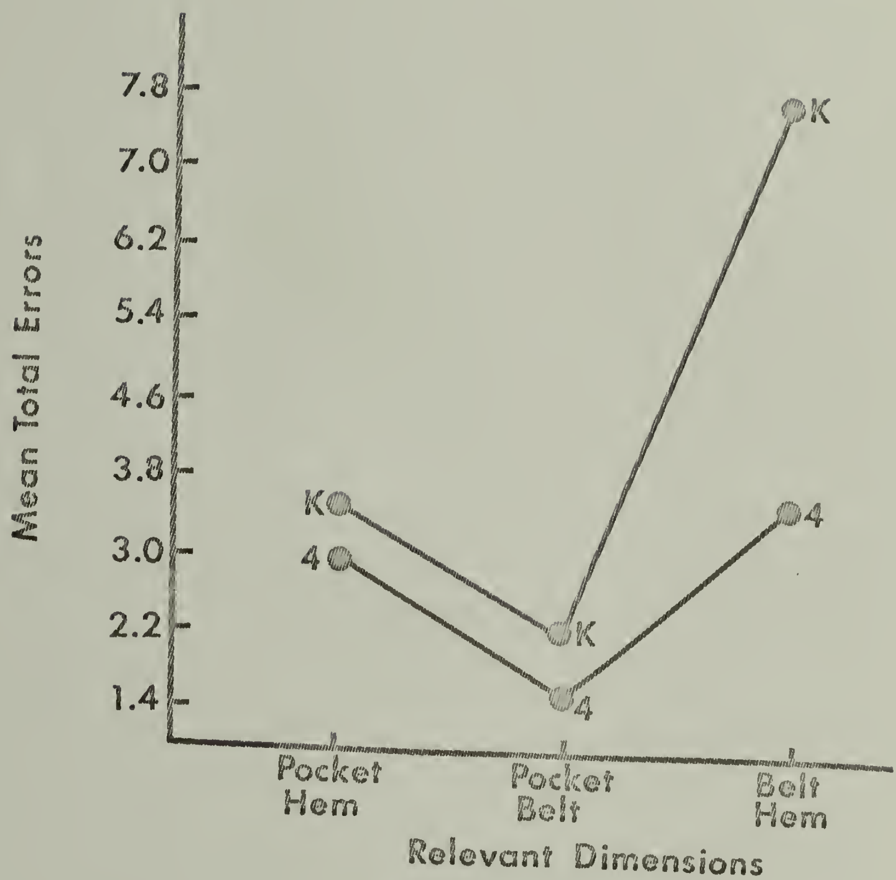

5.0
4.6
4.2
3.8
3.4
3.0
2.6
2.2
Mean Total Errors
2 Cue
1 Cue
1 Cue
2 Cue
K
4
GRADE

Figure 3


7.8
7.0
6.2
5.4
4.6
3.8
3.0
2.2
1.4
Mean Total Errors
K
4
K
4
K
4
Pocket
Hem
Pocket
Belt
Belt
Hem
Relevant Dimensions

error than those with the pocket-belt combination. Figure 4 illustrates the grade X relevant dimension combination interaction, $F(2,328) = 3.89$, $p < .05$. Again, as with total errors, kindergarten subjects had a significantly later trial of last error within each relevant dimension combination but the difference is especially great in the belt-hem combination.

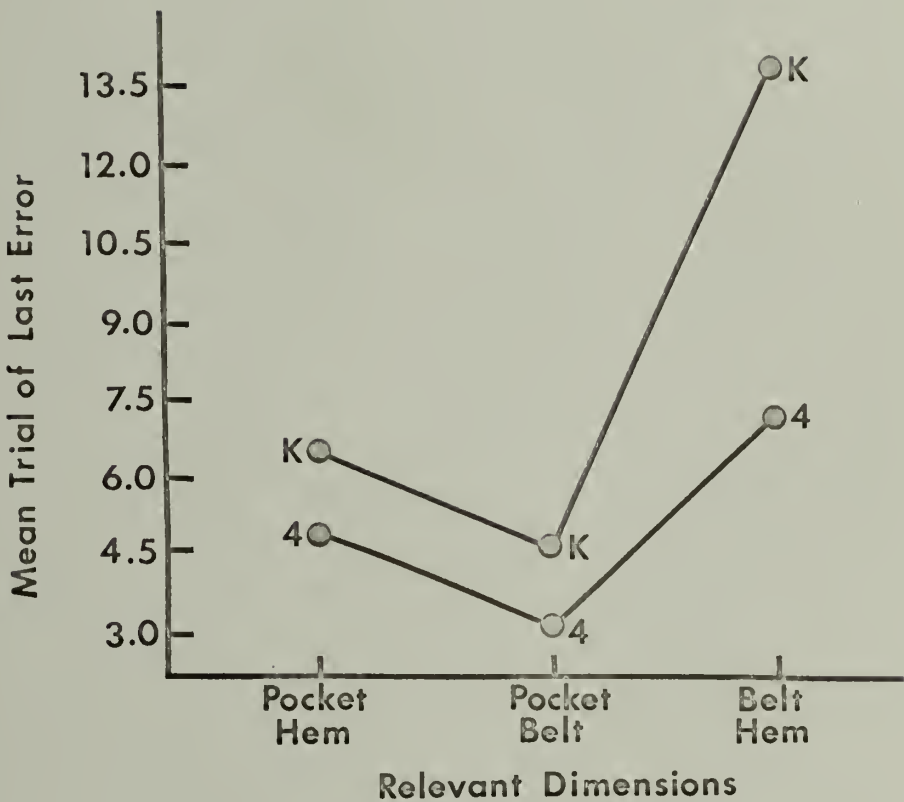
Insert Figure 4 About Here

A 2(groups) x 2(solution type) x 2(grade) x 3(relevant dimension combination) analysis of variance for solution trial was computed. The Analysis of Variance Table is shown in Appendix C. There was a main effect of grade due to a later solution trial in the kindergarten group, $F(1,218) = 19.80$, $p < .001$. There was also a main effect of relevant dimension combination, $F(2,218) = 6.70$, $p < .01$. Subjects in the belt-hem combination had a significantly later solution trial than both the pocket-hem and pocket-belt subjects. The age X relevant dimension interaction is illustrated in Figure 5, $F(2,218) = 6.75$, $p < .01$. In the pocket-hem combination the

Insert Figure 5 About Here

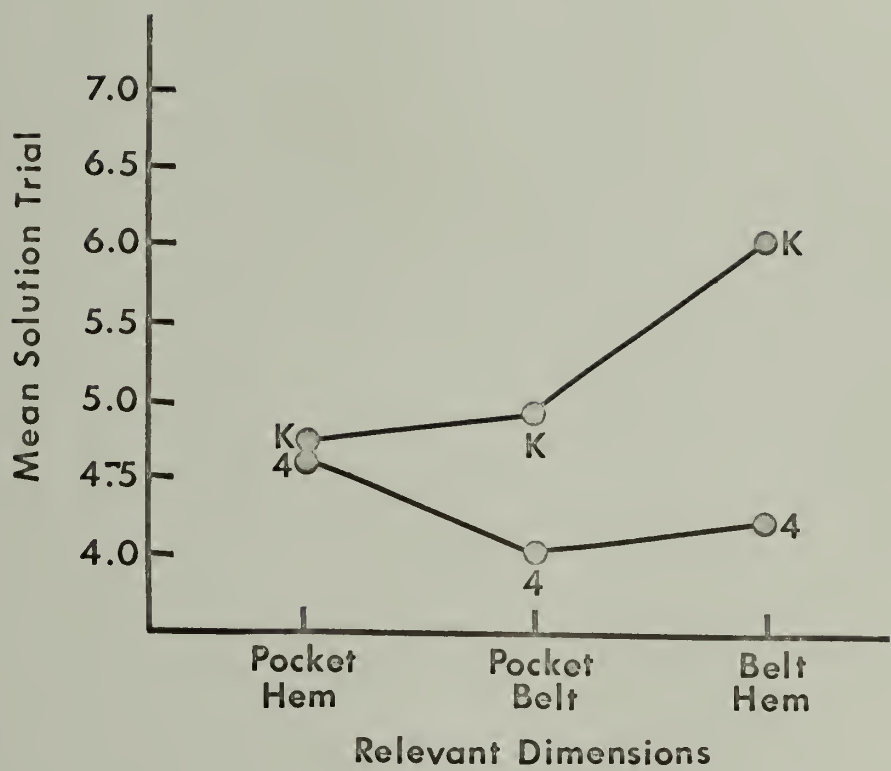
difference between the kindergarteners and fourth graders is not significant. In both the pocket-belt and belt-hem combinations the kindergarteners have a significantly later solution trial with the difference more pronounced in the belt-hem combination.

Figure 4



13.5
12.0
10.5
9.0
7.5
6.0
4.5
3.0
Mean Trial of Last Error
K
4
K
4
K
4
Pocket
Hem
Pocket
Belt
Belt
Hem
Relevant Dimensions

Figure 5


Mean Solution Trial
7.0
6.5
6.0
5.5
5.0
4.75
4.0
K
4
K
4
K
4
Pocket
Hem
Pocket
Belt
Belt
Hem
Relevant Dimensions

Total errors, trial of last error, and solution trial for the practice problem were also examined. All subjects were able to solve the first practice problem and with such rapidity that the data were not analyzable. For example, fourth grade subjects in the MOD ST group (60 subjects) made a total of only one error. Kindergarten subjects in the ST group made a total of only 25 errors on the practice problem. The total number for trial of last error and solution trial were also too small to analyze.

Latencies. Criterion run latencies were analyzed in a 3(groups) x 2(solution type) x 2(grade) x 15(criterion trials) analysis of variance. The Analysis of Variance Table is shown in Appendix D. Figure 6 illustrates the significant solution type main effect, $F(1,348) = 16.10$, $p < .001$, due to longer latencies of two-cue learners, and the significant main effect

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Insert Figure 6 About Here

---

of criterion trials, $F(14,4872) = 40.25$, $p < .001$, due to decreasing latencies with increasing trials. The significant main effect of grade, $F(1,348) = 15.75$, $p < .001$, due to longer latencies of the kindergarten children is shown in Figure 7. A significant grade X solution type interaction, $F(1,348) = 10.16$, $p < .01$, is illustrated in Figure 8. The

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Insert Figures 7 & 8 About Here

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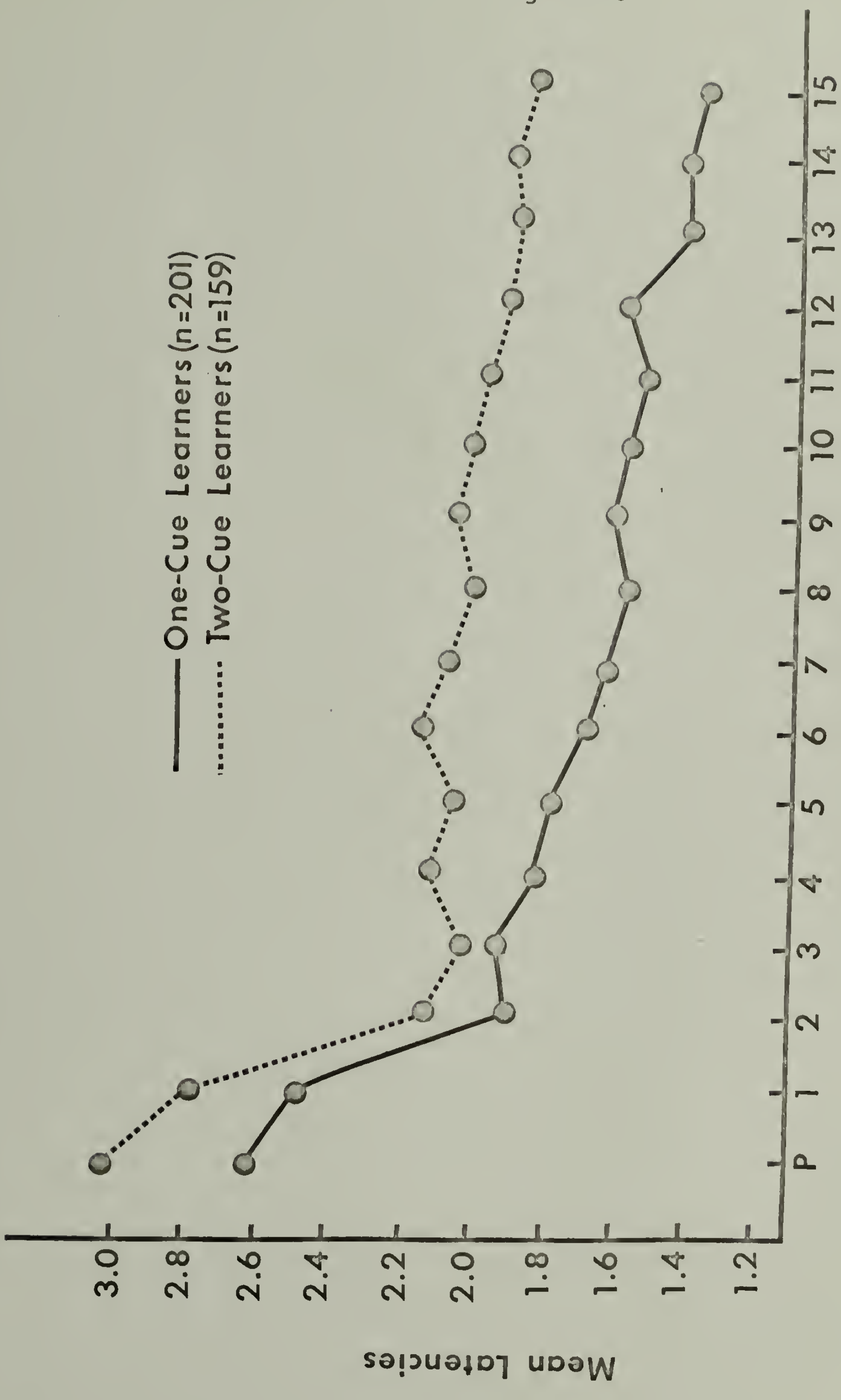
kindergarten two-cue learners are significantly slower than

Figure 6



One-Cue Learners (n=201)
Two-Cue Learners (n=159)
Mean Latencies
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
TRIALS
P
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Figure 7

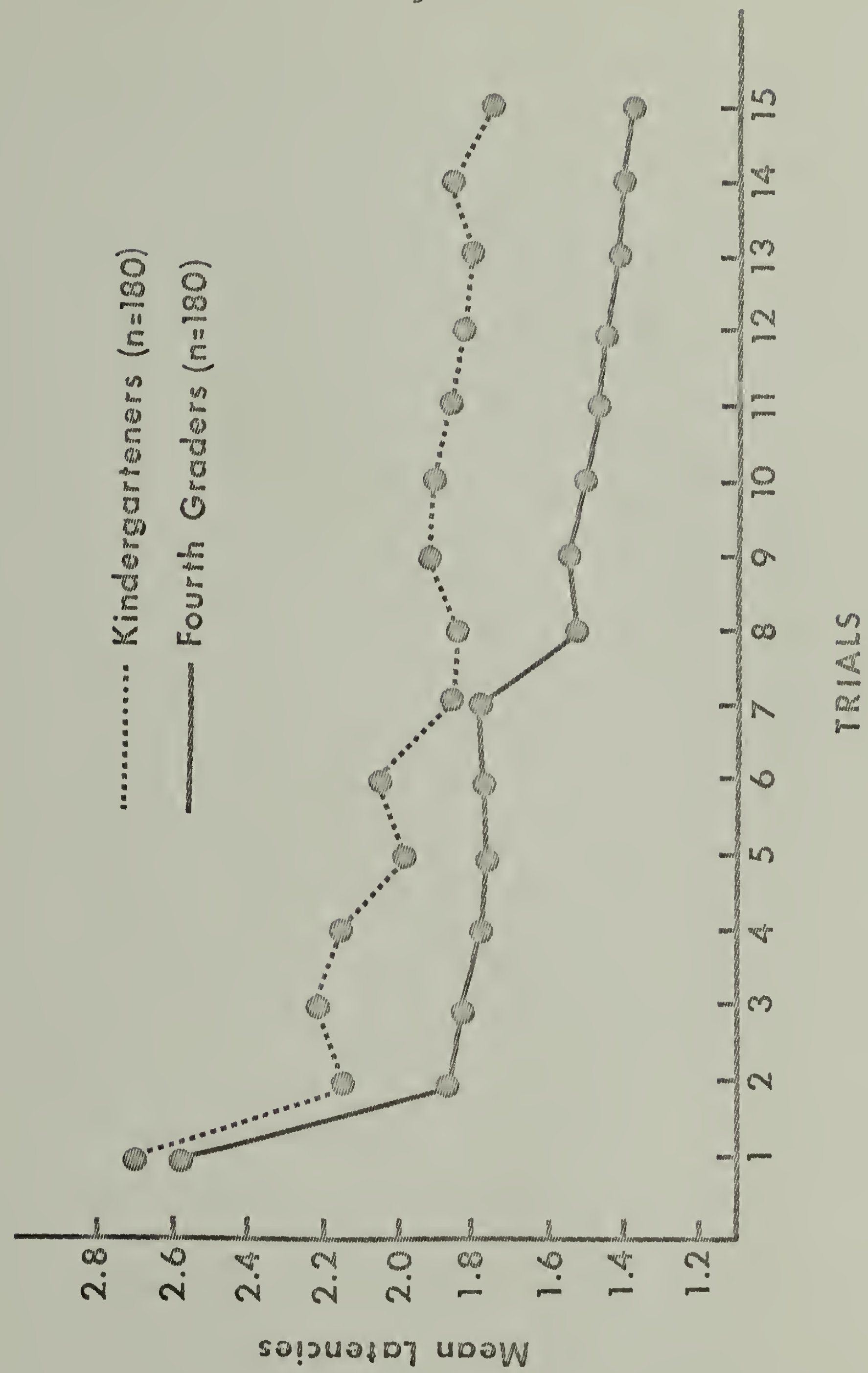
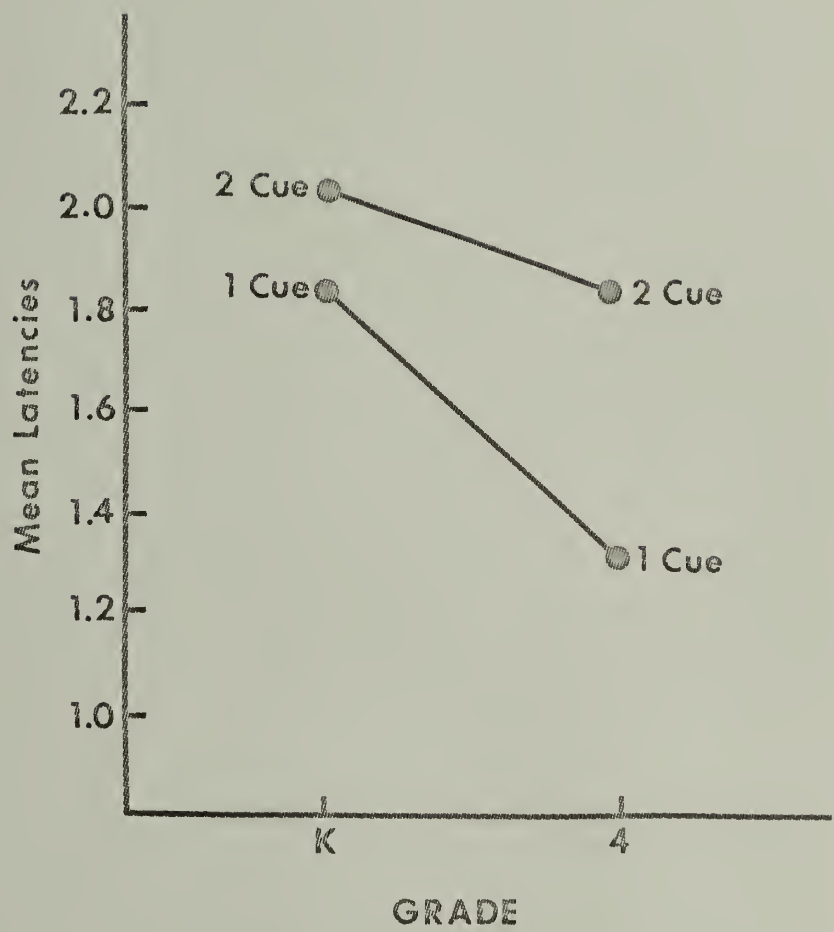

Kindergarteners (n=180)
Fourth Graders (n=180)
Mean Latencies
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
TRIALS

Figure 8


2.2
2.0
1.8
1.6
1.4
1.2
1.0
Mean Latencies
2 Cue
1 Cue
2 Cue
1 Cue
K
4
GRADE

all other groups. Fourth grade one-cue learners are significantly faster than all other groups, and there is no difference between the kindergarten one-cue and fourth grade two-cue learners

Average pre-solution latencies for those subjects making at least one error were submitted to a 2(grade) x 2(solution type) analysis of variance. The Analysis of Variance Table is shown in Appendix E. Only the main effect of solution type was significant, $\underline{F}(1,281) = 8.60$, $p < .01$, due to two-cue learners taking longer to respond than one-cue learners. These average pre-solution latencies are indicated as trial $\underline{P}$ in Figure 6.

Criterion run latencies for the practice problem were analyzed in a 2(solution type in main problem) x 2(grade) x 10(criterion trials) analysis of variance. The Analysis of Variance Table is shown in Appendix F. Figure 9 illustrates

Insert Figure 9 About Here

the significant grade effect, $\underline{F}(1,356) = 14.18$, $p < .001$, due to longer latencies of the kindergarteners and the significant main effect of criterion trials, $\underline{F}(9,3204) = 15.57$, $p < .001$, due to decreasing latencies with increasing trials. The significant grade x solution type interaction, $\underline{F}(1,356) = 5.69$, $p < .01$, is illustrated in Figure 10. The fourth grade one- and two-cue learners are responding at about the same rate,

Insert Figure 10 About Here

Figure 9

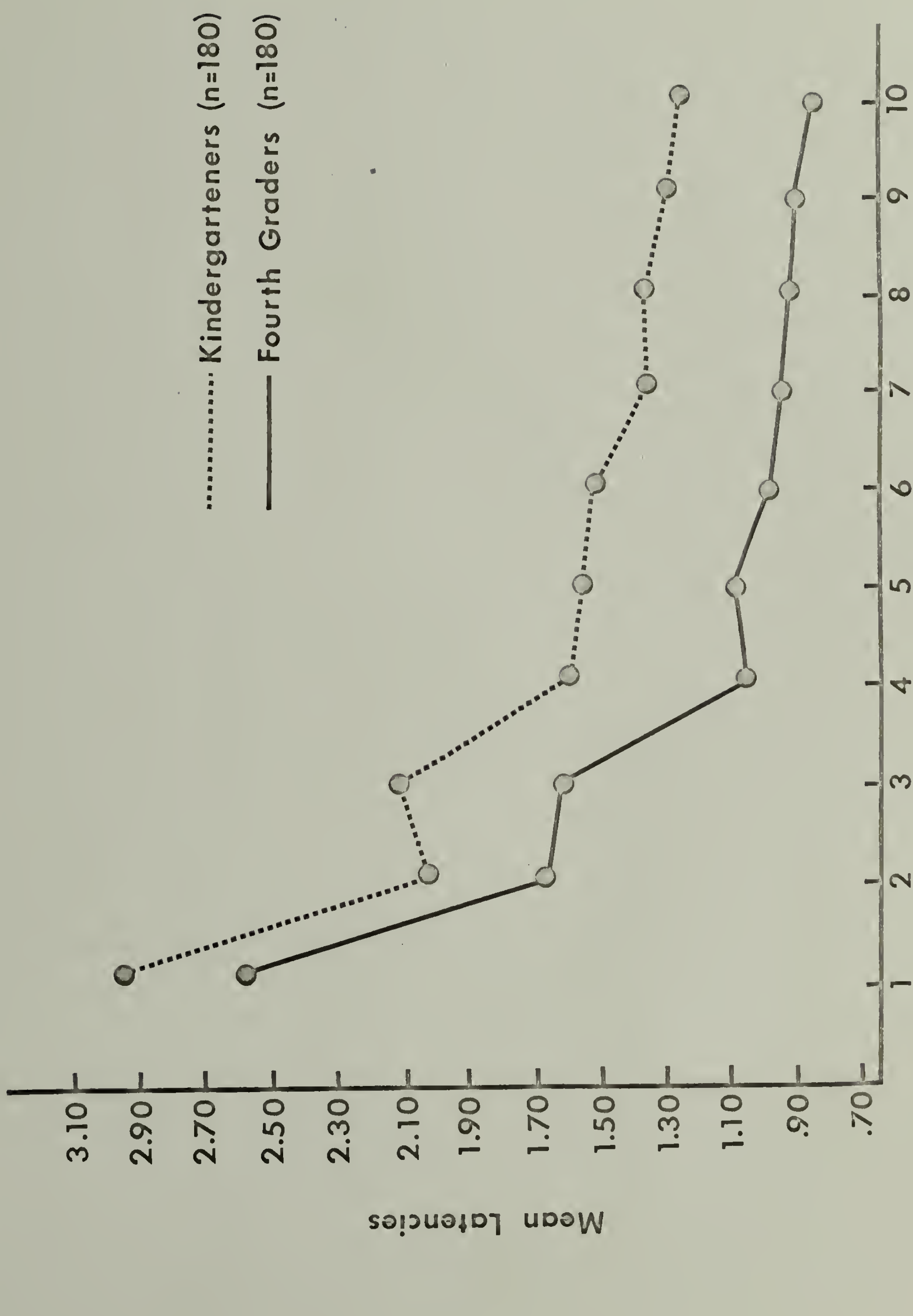
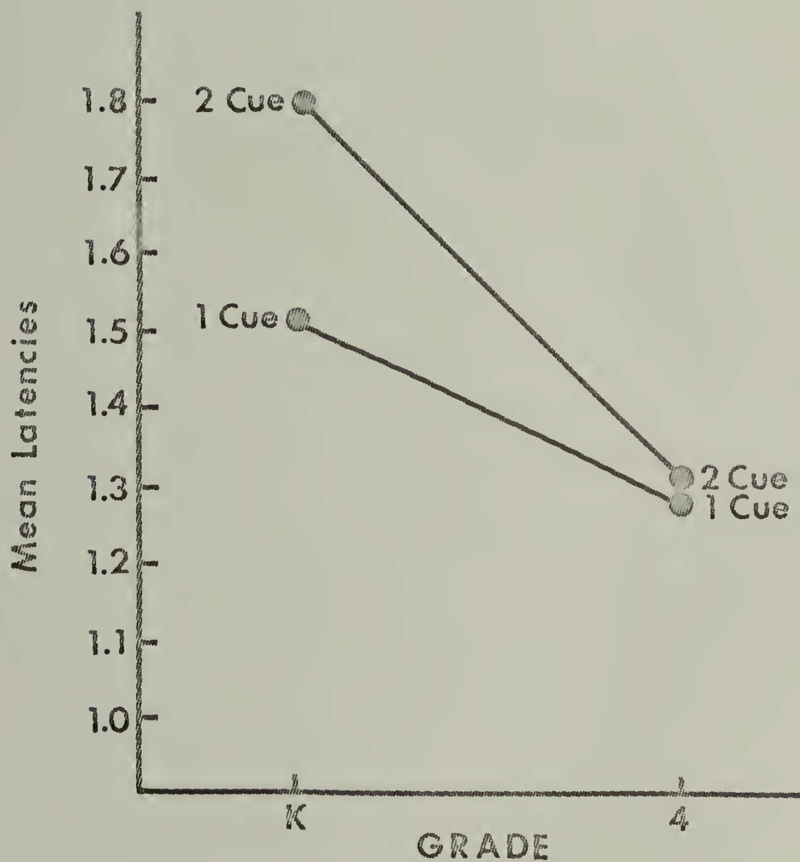

Kindergarteners (n=180)
Fourth Graders (n=180)
Mean Latencies
3.10
2.90
2.70
2.50
2.30
2.10
1.90
1.70
1.50
1.30
1.10
.90
.70
TRIALS
1
2
3
4
5
6
7
8
9
10

Figure 10


1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
Mean Latencies
2 Cue
1 Cue
2 Cue
1 Cue
K
4
GRADE

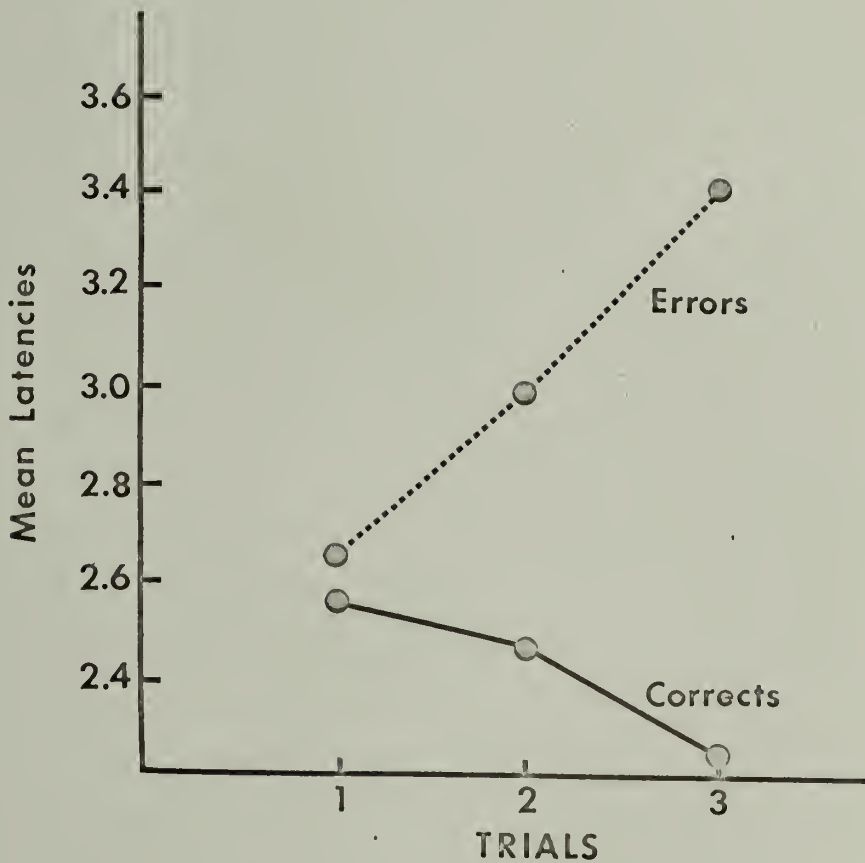
whereas the kindergarten one-cue learners are responding much more rapidly than the kindergarten two-cue learners.

Analyses of variance were also computed on latencies for subjects making 3 correct responses in a row during the pre-criterion trials and for those making 3 error responses during the pre-criterion trials. For both, a 2(grade) x 3(trials) analysis of variance was computed. The Analysis of Variance Table for 3 corrects is shown in Appendix G; for 3 errors in a row, Appendix H. For both groups the only significant effect was a trials effect; 3 correct, $\underline{F}(2,248) = 4.00$, $p < .05$; for 3 errors, $\underline{F}(2,242) = 5.69$, $p < .05$. These main effects are illustrated in Figure 11. On the first error and first correct, latencies are about equal but in subsequent consecutive error trials, latencies increase whereas in subsequent correct trials, latencies decrease.

Insert Figure 11 About Here

Single Dimension Classification. As previously pointed out, the single dimension doll classification was not significantly different from the subject's verbal solution. A 2(grade) x 3(type of classification) analysis of variance of latency was computed with respect to the subject's classification of the single dimension dolls at the end of the criterion run. The subjects could classify the dolls correctly, incorrectly, or state that they weren't sure of the classification. The Analysis of Variance Table is shown in Appendix I. There was

Figure 11


3.6
3.4
3.2
3.0
2.8
2.6
2.4
Mean Latencies
Errors
Corrects
1
2
3
TRIALS

a significant main effect of grade, $\underline{F}(1,470) = 6.81$, $p < .01$, due to longer response latencies for the kindergarteners. Figure 12 illustrates the significant main effect of type of classification and the main effect of grade. The main effect

Insert Figure 12 About Here

of type of classification, $\underline{F}(2,470) = 43.27$, $p < .001$, is due to the more rapid responding when the subject responds correctly.

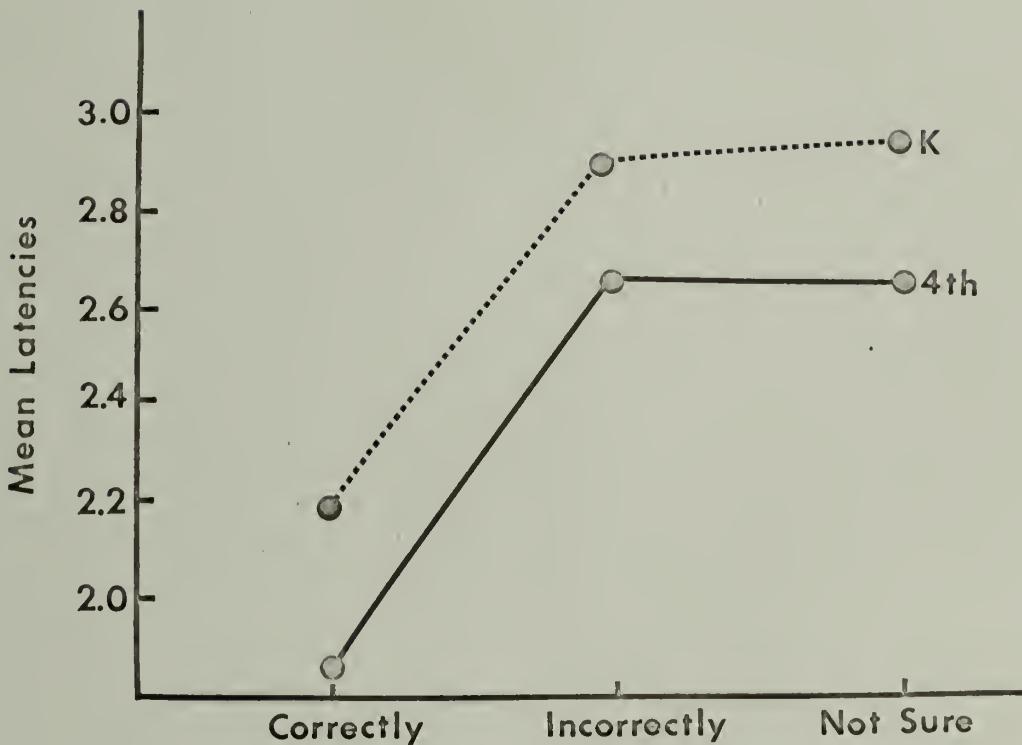
The final analysis examined the one-cue learners response latencies on the single dimension dolls for the unlearned relevant dimension and the irrelevant dimension. The Analysis of Variance Table is shown in Appendix J and as can be seen, the difference was not significant.

Discussion

The major results of the present study indicate that 1) the kindergarten and fourth grade children who learn about both relevant dimensions learn them in a serial fashion rather than "focusing" in on both simultaneously; 2) kindergarteners are less likely than fourth graders to learn about both relevant dimensions; 3) kindergarteners take longer to respond than fourth graders, make more errors, have a later solution trial and trial of last error; and 4) two-cue learners take longer to respond both during the criterion trials and the pre-criterian trials.

The results are very clear that both the kindergarten and

Figure 12


3.0
2.8
2.6
2.4
2.2
2.0
Mean Latencies
K
4th
Correctly
Incorrectly
Not Sure

fourth grade subjects learn the relevant redundant cues in a serial fashion over the trials of the criterion run. That is, they resample, without error, after learning one of the solutions. This finding is consistent with the hypothesis stated in the introduction. Eimas (1969) had found that children of these ages can learn about multiple relevant cues, yet Gholson et. al. (1972) found that these same aged children are not likely to employ a "focusing" strategy. Thus one would expect that kindergarten and fourth grade two-cue learners would have to learn these cues in a serial fashion. This result was obtained.

A modified one-look model can account for the data of the present study. Shepp, Kemler, and Anderson (1972) and Kemler and Anderson (1972) have shown that a one-look model can predict the account for two-cue learning. With this formulation and the fact that the Zeaman and House (1963) model does not require the subject to attend to the same dimensions on each trial, it is possible for a one-look interpretation to predict and account for these data.

Interestingly enough, the difference between the number of two-cue learners at solution trial in the kindergarten and fourth graders was not significant. Of particular interest is the fact that the percentage of two-cue learners who state both solutions at solution trial is similar for the kindergarten and fourth graders as well to the adult data of the Clement and Anderson (1975) study. Twenty-five percent of the kindergarten two-cue learners, twenty-nine percent of the fourth grade two-cue learners, and twenty-seven percent of the adult two-cue learners stated both solutions at the solution trial. For all these groups, approximately one quarter of the two-cue learners are multiple-cue solvers by the solution trial. There are two possible explanations for why this percentage is fairly constant: either a certain percentage of two-cue learners use a "focusing" strategy or this percentage of Ss are not stating a solution until testing all dimensions. The latter suggestion is probably not the case. The solution trial for these two-cue learners (K - 5.20; 4th - 4.32) is not significantly later than for serial two-cue learners or one-cue learners. Further, they do not have a significantly later trial of last error or make more errors. Concerning the first possible explanation, a multiple-look strategy does not, of course, guarantee that a subject will learn both relevant dimensions by the solution trial. For this to happen the subject must have both relevant dimensions in the focus sample and efficiently focus down to both. The data suggest that a group of potential two-cue solvers, who are relatively unpracticed, may well consist of approximately 25% multiple-lookers and 75% one-lookers. Age differences are obtained in the size of the potential group of two-cue solvers. This should be examined in future research for as Shepp et al. (1972), and Clement and Anderson (1975) point out, there may be subjects and situations for which one-look models apply and others for which multiple-look models apply.

The second major result is that the kindergarteners are less likely than the fourth graders to learn about both relevant dimensions. There are two interesting developmental differences in terms of solution type within the different relevant dimension combinations which help explain this difference. The first is the fact that the difference between the number of two-cue learners in the pocket-belt combination in the kindergarten and fourth grade subjects is not significantly different. In the pocket-hem and belt-hem combinations the difference is significant. An examination of Table 3 reveals that the reason for the non-significance in the pocket-belt combination is due to the greater number of two-cue learners in the kindergarten group as compared with the other two combinations. This is most likely due to the higher salience of belt as compared with hem, thus making it more likely for the kindergarteners to sample belt than hem after solving on the basis of pocket. Belt is more salient than hem in terms of the solution of the kindergarten one-cue learners in the belt-hem combinations (Table 4) and in terms of the relevant dimension learned by the solution trial for the serial two-cue learners (Table 5). On all comparisons, pocket is without question the most salient dimension and is probably the first dimension sampled by the kindergarteners. Once having learned, or disconfirmed, pocket, they then switch to belt and test that. Hem, being the least salient is more likely to be the last dimension sampled. The subject may simply have completed the criterion run by the time he either begins to sample hem or has had enough trials to learn of the relevance of hem. It may also be that hem is so low in salience that it is never tested by some kindergarteners. Therefore, a major source of difference between the number of one- and two-cue learners of the two age groups may be the difficulty the younger subjects have in testing a non-salient relevant redundant cue. Trabasso and Bower (1968, Chap. 6) argue that the proportion of two-cue learners should increase as the salience of the relevant dimensions converge. If pocket is more salient than belt, and belt more salient than hem, as seems to be the case from the data, then these results are in agreement with Trabasso and Bower's contention. Conversely, if one cue dominates the stimulus pattern this should decrease the number of two-cue learners. In the pocket-hem combination this seems to be the case.

The second interesting finding is that for the pocket-hem combination for the fourth graders, there are more one-cue than two-cue learners. In each of the other combinations for the fourth graders, there are more two-cue learners. The reason for this follows from the salience of the respective dimensions. Pocket is so salient in comparison with hem, that the fourth graders may be less likely to sample hem after solving on the basis of pocket (Table 5). Supporting this argument is the fact that the smallest number of two-cue learners in the kindergarten group is also in the pocket-hem combination. Thus, salience seems to play an important role in determining whether a subject will be a one- or two-cue learners. It may also play a role in the selection of the strategy that the subject employs. In the present study there wasn't enough two-cue learners at solution trial to statistically examine this, but salience of cues may turn out to be highly significant in terms of strategy selection. A further indication of the salience of pocket is the high percentage of subjects who classified pocket on the single dimension trials when it was irrelevant. At solution trial, 80% of the kindergarten MOD ST subjects and 54% of the fourth graders attempted to classify pocket even though it was irrelevant. At criterion, the percentages were: kindergarteners - 83%, fourth grade - 54%.

In summary, the solution trial data seem very clear and concise and can be accounted for by a modified one-look model. Salience of the dimensions plays an important role in two-cue learning and it may be one of the major factors in the difference in the number of one- and two-cue learners in the two age groups studied. It is possible that it may also affect the subjects strategy that he uses in attempting to solve the problem.

The finding that kindergarteners had more total errors and a later trial of last error was expected. What was surprising was that the difference was so small. Kindergarteners, on the average made only about two more errors than the fourth graders and in general solved the problem with relative ease (averaging only about four and a half errors). This is probably because the setting of the problem and the use of the dolls made the problem "relevant" and meaningful for the child. This may also account for the relatively low number of non-learners. Most concept identification studies using children as subjects either give a number of progressively more difficult practice problems or special training to those unable to solve the first problem. Neither of these tactics were necessary in this study.

The finding that the belt-hem combination was the most difficult for the subjects (in terms of total errors and trial of last error) and the pocket-belt the easiest follows from the solution type data. The fact that the belt-hem combination was exceedingly difficult for the kindergarteners is due to the fact that they were more likely to sample pocket first and to continue sampling even after repeated disconfirmations. This is evident from their patterns of response and also from the fact that they persisted in classifying pocket on the single dimension classification trials even though it was irrelevant.

The solution trial analysis provides two important pieces of data related to the subject's confidence in their solution. The solution trial is defined as the point in the problem at which the subject is completely confident of his solution. Kindergarteners had a significantly later solution trial, indicating that they require more confirmations of a correct response before they are convinced that it is the correct solution. Kindergarteners had an especially later solution trial in the belt-hem combination. If the kindergarteners in this combination feel that pocket should be part of the solution, then either they require more confirmations of the correct response or more disconfirmations of pocket before they are convinced that they have the correct solution. A more salient relevant dimension may make the subject more confident of his solution, whereas a less salient one may require many more confirmations before the subject is convinced that it is really the solution. This would be easy to test. If this study had included confidence ratings (as in Coltheart's 1973 study), the subjects in the belt-hem combination may not be "certain that response is correct" even through to the end of the criterion run. There is some support for this contention in the latency data. The mean criterion run latency for the fourth grade subjects in each relevant dimension combination was: pocket-belt - 1.67 secs, pocket-hem - 1.61 sec, and belt-hem - 1.65 sec. For the kindergarteners it was: pocket-belt - 1.75 sec, pocket-hem - 1.75 sec, and belt-hem - 2.09 sec. Kindergarteners in the belt-hem combination took an especially long time to respond as compared to the other relevant dimension combinations. These subjects may be testing pocket on each trial even though basing their response on either belt or hem and this would account for the extra time.

The final key finding of this study is that two-cue learners take longer to respond than one-cue learners. This extends a similar finding of Clement and Anderson (1974) with adult subjects. The finding is especially interesting because two-cue learners are consistently slower, that is, even prior to the trial of last error. It may be that two-cue learners reflect longer before responding, whereas one-cue learners are more impulsive. Kagan (1964, 1965 & 1966) has found that many children can be classified as impulsive or reflective on the basis of how they respond in a number of situations. For example, reflective children delay longer in answering a question put to them by an adult, make fewer errors in inductive reasoning tasks, and wait longer before describing a picture. Lacking data on the impulsiveness and reflectiveness of the present children, it is not possible to make a statement of a relationship between that variable and one- and two-cue learning. It should be noted that there is no significant difference in total errors for the different solution types as would be expected if there were a relationship between reflectiveness/impulsiveness and solution type.

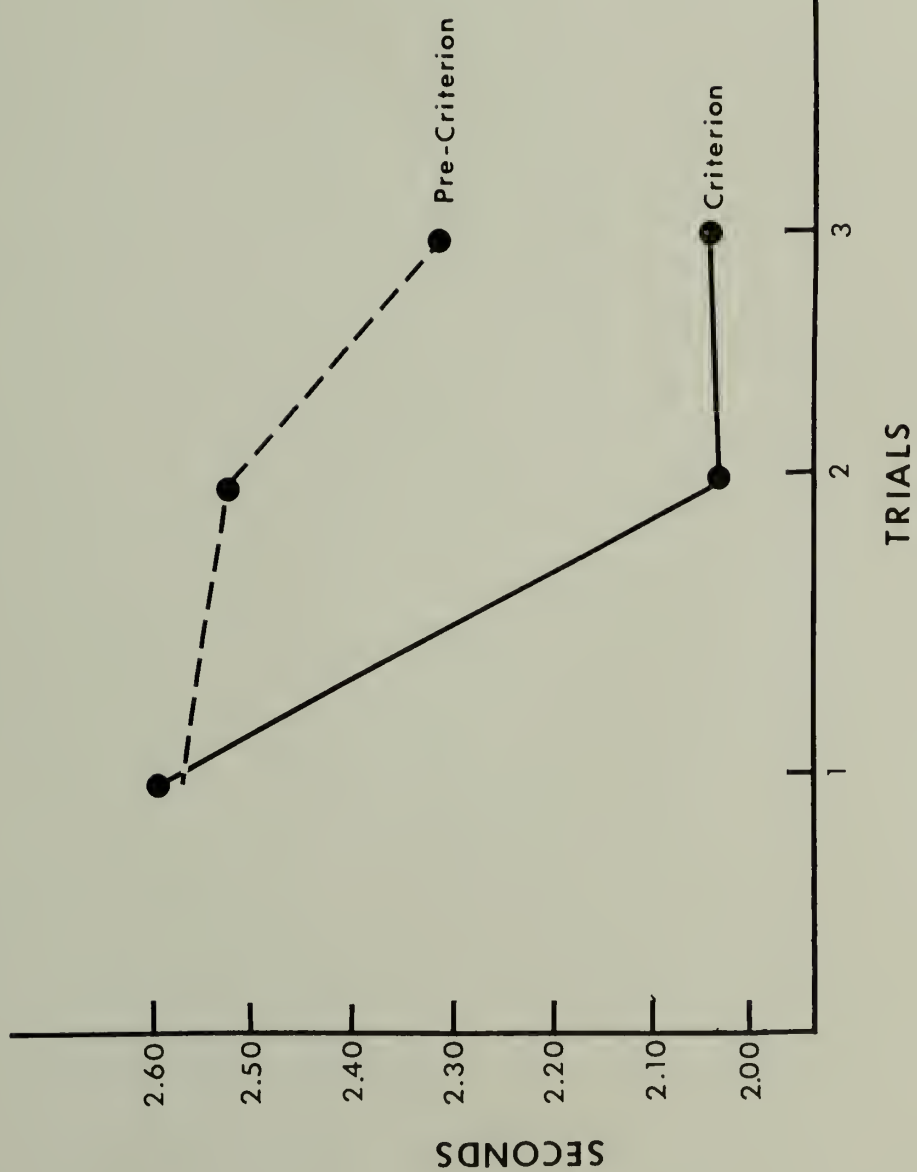
It could be asked whether the difference in response latency is more a symptom or cause of individual differences between one- and two-cue learners. With adult subjects, it seems to be at least partly the cause of these differences. Clement and Anderson (1975; Exp. 2) found that there were significantly more two-cue learners in a group of subjects who could view the stimulus for four seconds before responding, compared to a group that had only one second to view the stimulus.

The decline of latencies over the trials of the criterion run was expected from the findings of Clement and Anderson (1975), Erikson et al. (1966) and Levine (1969). This has been consistently found in the adult concept identification studies and this study extends this finding to children. Levine explains this decline from the trial of last error to the solution trial in terms of the subset sampling assumptions.

Though this study does not provide a direct test of a subject's strategy, it does seem to indicate that the decline in latencies is not the result of a multiple-look strategy. Over 75% of the two-cue learners in the ST and MOD ST groups stated only one solution at the solution trial and this high a percentage would not be expected if subjects were using a multiple-look strategy. A likely interpretation is that the decline in latency is due to increased confidence on the part of the subject in the correctness of his solution. Coltheart's (1973) curve of confidence ratings during the criterion run is analogous to the latency decline curve of the present study. Her subjects expressed increasing confidence until approximately trial 6 of the criterion run when they were "certain that response is correct". Solution trial in the present study was approximately trial 5. It may be argued, of course, from a multiple-look view that a reduction in the size of the subset results in increased confidence. If this is in fact the cause of latency decline, then one would expect that during a string of consecutive correct response in pre-criterion there should be a latency decline similar to the first few trials of the criterion run. In fact there is a decline but it is not as great a decline as the first few trials of the criterion run. The difference was not statistically examined but as can be seen from Figure 13, the decline is not as great as in the pre-criterion trials. This is suggestive that something very

Insert Figure 13 About Here

different is happening during a string of consecutive correct responses in pre-criterion as compared to the first three trials of the criterion run. If a subject were using a multiple-look strategy, the decline in latencies in both cases should be similar. This is not the case. As further evidence for a relationship between latency decline and confidence, Coltheart (1973) found that although there is an increase in confidence during a string of three consecutive correct responses in pre-criterion, the increase is not as great and at all points higher (less confidence) than the confidence rating of the first three trials of the criterion run. For whatever reasons, subjects during the pre-criterion trials, even though having a string of consecutive correct responses, are not as confident of their response, as when they enter the criterion run. This is analogous to the latency finding of the present study. Latencies decline during a string of consecutive correct response, prior to the trial of last error, but not as much as the first few trials of the criterion run. This re-


Pre-Criterion
Criterion
TRIALS
1
2
3
SECONDS
2.60
2.50
2.40
2.30
2.20
2.10
2.00

sult lends support to the assumption that the latency decline is a function of the confidence that the subject has in his response.

The grade X solution type interaction for latencies is a particularly perplexing interaction. This interaction is illustrated in Figure 8. Two-cue learners take longer to respond than one-cue learners for each grade level, but the difference is greater for the fourth graders. A possible explanation for this is that, regardless of solution type, kindergarteners will wait a minimum amount of time before responding. That is, there may be a hesitancy on the part of the kindergarteners to respond. One of the possible reasons that they become two-cue learners may be due to this extra time that they take before responding. If we make the assumption that kindergarten two-cue learners are using this minimum response time to become two-cue learners, whereas the one-cue learners do not utilize this minimum time, we can see why the difference in response time between kindergarten one- and two-cue learners would not be very great. Since there is no hesitancy on the part of the fourth graders in responding, we see the more typical ones and two-cue learners latency separation.

The analysis of the practice problem latencies showed that, as with the main problem, the fourth graders responded more rapidly than the kindergarteners. A main effect of solution type, however, was not obtained. What that means is that the latency of response for the fourth graders in the practice problem could not be used to predict whether a subject would be a one- or two-cue learner in the main problem. The practice problem latency however, was still predictive for the younger subjects. This lack of solution type interaction illustrated in Figure 10. This grade X solution type interaction is opposite to the interaction obtained in the main problem. The fourth graders show almost no difference between one- and two-cue learners. In the practice problem all the fourth graders are responding at what seems to be a minimum response time. The problem may simply be too easy for the fourth graders. That is, the stimuli may not be complex enough to require any reflection on the part of the fourth graders. Whereas, the problem may be difficult enough to differentiate between potential one- and two-cue learners in the kindergarten group.

The latency of response in the single dimension dolls classification provides some supportive data for the system used (verbal statement) in classifying a subject as a one- or two-cue learner. When classifying the dols correctly (that is, the same as their verbal statement) subjects responded significantly faster than when classifying them incorrectly or when stating that they weren't sure. The speed of classification for the last two were in fact almost equal (figure 12). This and the fact that there was no difference in response latency when one-cue subjects were classifying the unlearned relevant dimension lends support to the statement of the subject that he in fact only learned about one of the relevant dimensions.

If subjects had responded faster on the unlearned (in terms of their verbal statement) relevant dimension we could assume that there may be some learning on this relevant dimension.

This study provides three major pieces of data. The first is the finding that two-cue learners predominately learn about the relevant redundant cues in a serial fashion over the trials of the criterion run. This confirms and extends the findings of the Clement and Anderson (1975) study with adults and the observations that in paired associate tasks subjects attend to stimuli in a selective manner during learning (James and Greeno, 1967). As previously discussed, this finding has important implications for theories attempting to account for a subject's performance in a concept identification problem.

A second major finding is that two-cue learners take longer to respond than one-cue learners. This is a novel finding in children's concept identification, but has been previously found with adult subjects (Clement and Anderson, 1975). Clement and Anderson further found that if the subject was required to wait four seconds before responding the likelihood was increased that the subject would employ a multiple-look strategy. Studies are needed to determine the generality of this finding, particularly in terms of children's learning and whether or not a child's strategy can be manipulated by controlling the amount of time available for viewing the stimuli. Forcing the younger child (kindergarten age) to wait before responding may enable the child to overcome the salience problem previously discussed.

The final significant piece of information, and perhaps potentially the most important, involves the methodology employed in this study. Concept identification studies with children have traditionally used a number of different tactics to assure that the child understands and can solve the problem. These tactics range from giving a large number of progressively more difficult (or progressively closer approximations to the main problem) practice problems, to giving non-learners special instructions or training. This study used a procedure and stimuli which eliminate the necessity for a large number of practice problems or special instructions or training. Providing the children with a problem that is "relevant" and understandable without a great deal of experimental manuevering, and at the same time providing a methodology that effectively answers the questions asked about children's concept identification is a contribution of this investigation.

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Appendix A

Analysis of Variance for a 3 X 2 X 2 X 3 factorial design for total errors

A (three levels) = CR, ST, and MOD ST groups
B (two levels) = One and Two cue learners
C (two levels) = Kindergarteners and Fourth graders
D (three levels) = Combinations of relevant dimensions

SV	df	SS	MS	F	
Total	359				
A	2	8.02	4.01	2.50	Not significant
B	1	.40	.40	.25	Not significant
C	1	32.75	32.75	20.46	$p < .001$
D	2	89.13	44.56	27.85	$p < .001$
AB	2	9.53	4.76	2.98	Not significant
AC	2	9.28	4.64	2.90	Not significant
AD	4	2.16	.54	.34	Not significant
BC	1	6.62	6.62	4.13	$p < .05$
BD	2	7.76	3.88	2.42	Not significant
CD	2	11.79	5.89	3.68	$p < .05$
ABC	2	7.14	3.57	2.23	Not significant
ABD	4	7.07	1.76	1.10	Not significant
BCD	2	1.46	.73	.45	Not significant
ABCD	4	12.78	3.19	1.98	Not significant
S/ABCD	328	526.39	1.60		

Appendix B

Analysis of Variance for a 3 X 2 X 2 X 3 factorial design for the trial of last error

A (three levels) = CR, ST, and MOD ST groups
B (two levels) = One and Two cue learners
C (two levels) = Kindergarteners and Fourth graders
D (three levels) = Combination of relevant dimensions

SV	df	SS	MS	F
Total	359			
A	2	27.33	13.66	2.98 Not significant
B	1	.16	.16	.03 Not significant
C	1	119.62	119.62	26.17 $p < .001$
D	2	293.24	146.12	31.97 $p < .001$
AB	2	24.26	12.13	2.65 Not significant
AC	2	18.50	9.25	2.02 Not significant
AD	2	4.53	1.13	.24 Not significant
BC	1	12.88	12.88	2.81 Not significant
BD	2	19.31	9.66	2.11 Not significant
CD	2	35.63	17.81	3.89 $p < .05$
ABC	2	21.76	10.88	2.38 Not significant
ABD	4	13.97	3.49	.76 Not significant
BCD	2	11.98	5.99	1.31 Not significant
ABCD	4	55.90	12.23	2.67 Not significant
S/ABCD	328	1498.96	4.57	

Appendix C

Analysis of Variance for a 2 X 2 X 2 X 3 factorial design for the solution trial data

A (two levels) = ST and MOD ST groups
B (two levels) = One and Two cue learners
C (two levels) = Kindergarteners and Fourth graders
D (three levels) = Combination of relevant dimensions

SV	df	SS	MS	F	
Total	239				
A	1	.47	.47	2.35	Not significant
B	1	.01	.01	.05	Not significant
C	1	3.96	3.96	19.80	$p < .001$
D	2	2.68	1.34	6.70	$p < .01$
AB	1	.02	.02	.10	Not significant
AC	1	.76	.76	3.80	Not significant
AD	2	.12	.06	.30	Not significant
BC	1	.05	.05	.25	Not significant
BD	2	.09	.05	.25	Not significant
CD	2	2.70	1.35	6.75	$p < .01$
ABC	1	.01	.01	.05	Not significant
ABD	2	1.05	.53	2.65	Not significant
BCD	2	.39	.20	1.00	Not significant
ABCD	2	.66	.33	1.65	Not significant
S/ABCD	218	43.85	.20		

Appendix D

Analysis of Variance for a 3 X 2 X 2 X 15 factorial design for the latency data

A (three levels) = CR, ST, and MOD ST groups
B (two levels) = One and Two cue learners
C (two levels) = Kindergarteners and Fourth graders
D (fifteen levels) = Trials of the criterion run

SV	df	SS	MS	F
Total	5399	6374.00		
Between S	359	1941.00		
A	2	28.45	14.23	2.94 Not significant
B	1	77.81	77.81	16.10 $p < .001$
C	1	76.09	76.09	15.75 $p < .001$
AB	2	3.74	1.87	.38 Not significant
BC	1	49.10	49.10	10.16 $p < .05$
AC	2	4.46	2.23	.46 Not significant
ABC	2	27.35	13.67	2.83 Not significant
S/ABC	348	1674.00	4.82	
Within S	5040	4433.00		
D	14	439.64	31.40	40.25 $p < .001$
AD	28	21.91	.78	1.00 Not significant
BD	14	6.36	.45	.57 Not significant
CD	14	5.27	.37	.47 Not significant
ABD	28	42.89	1.53	1.96 Not significant
ACD	28	13.41	.47	.60 Not significant
BCD	14	15.73	1.12	1.42 Not significant
ABCD	28	48.79	1.74	2.23 Not significant
SD/ABC	4872	3839.00	.78	

Appendix E

Analysis of Variance for a 2 X 2 factorial design for pre-criterion latencies

A (two levels) = Kindergarteners and Fourth graders
B (two levels) = One and Two cue learners

SV	df	SS	MS	F
Total	284	437.31		
A	1	1.06	1.06	.70 Not significant
B	1	12.91	12.91	8.60 $p < .01$
AB	1	.82	.82	.54 Not significant
S/AB	281	422.52	1.50	

Appendix F

Analysis of Variance for a 2 X 2 X 10 factorial design
for latencies in the practice problem

A (two levels) = One and Two cue learners in the non-practice problem
B (two levels) = Kindergarteners and Fourth graders
C (ten levels) = Trials of the criterion run

SV	df	SS	MS	F
Total	3599	4528.31		
Between S	359	1221.00		
A	1	.14	.14	.04 Not significant
B	1	158.76	158.76	54.18 $p < .001$
AB	1	16.70	16.70	5.69 $p < .05$
S/AB	356	1045.40	2.93	
Within S	3240	3307.31		
C	9	981.43	109.04	153.57 $p < .001$
AC	9	9.10	1.01	1.42 Not significant
BC	9	7.23	.80	1.12 Not significant
ABC	9	3.30	.36	.50 Not significant
SC/AB	3204	2306.25	.71	

Appendix G

Analysis of Variance for a 2 X 3 factorial design for subjects making 3 corrects in a row prior to the trial of last error

A (two levels) = Kindergarteners and Fourth graders
B (three levels) = Trials

SV	df	SS	MS	F
Total	377	927.89		
Between S	125	431.35		
A	1	1.41	1.41	.40 Not significant
S/A	124	429.94	3.46	
Within S	252	496.54		
B	2	15.36	7.68	4.00 $p < .05$
AB	2	4.31	2.16	1.12 Not significant
SB/A	248	476.87	1.92	

Appendix H

Analysis of Variance for a 2 X 3 factorial design for subjects making 3 errors in a row prior to the trial of last error

A (two levels) = Kindergarteners and Fourth graders
B (three levels) = Trials

SV	df	SS	MS	F
Total	368	1459.08		
Between S	122	766.14		
A	1	15.17	15.17	2.44 Not significant
S/A	121	750.97	6.20	
Within S	246	692.94		
B	2	30.65	15.38	5.69 $p < .05$
AB	2	7.64	3.82	1.41
SB/A	242	654.65	2.70	

Appendix I

Analysis of Variance for a 2 X 3 factorial design for latency of single dimension classification

A (two levels) = Kindergarteners and Fourth graders
B (three levels) = Classified correctly, incorrectly, or as not sure

SV	df	SS	MS	F
Total	475	564.99		
A	1	6.81	6.81	6.81 $p < .01$
B	2	86.45	43.27	43.27 $p < .001$
AB	2	.48	.48	.48 Not significant
S/AB	470	471.25	1.00	

Appendix J

Analysis of Variance for a one-factor design for latency of single dimension classification

A (two levels) = Unrelated relevant dimension and Irrelevant dimension

SV	df	SS	MS	F
Total	257	485.50		
A	1	3.78	3.78	2.01 Not significant
S/A	256	481.72	1.88	