Effect of a Memory Aid upon Concept Attainment: A Developmental Study

Jeanette Ellen McCarthy
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Effect of a Memory Aid upon Concept Attainment:
A Developmental Study

Jeanette Ellen McCarthy

A Dissertation Submitted to the Faculty of
the Graduate School of Loyola University in Partial Fulfillment
of the Requirements for the Degree of
Doctor of Philosophy

May, 1968
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Chapter I. Introduction

Olson's (1968) recent review of the literature in cognitive development clearly emphasizes that memory plays a critical, but currently unspecified role in accounting for conceptual development and for the influence of language on thought. Miller (1956) and Mandler (1967) have given evidence that memory is closely related to the cognitive processes through analyses based upon an information processing paradigm.

The purpose of the present study was to investigate the effect of a memory aid upon the solution of concept attainment problems of boys and girls at three different age levels. In addition, the findings were evaluated in the light of serial vs. parallel processing modes relative to current information theory.
Chapter II. Review of Relevant Literature

Memory

Dominowski's (1965) review of the role of memory in concept learning stimulated investigation into the use of memory aids as facilitating factors in the acquisition of concepts. Fishkin, Wolfgang and Rasmussen (1967) investigated the effect of one or two past instances with three age groups between 10 and 18 years. The younger Ss profited more from past information than adults, confirming the finding of Bourne, Goldstein, and Link (1964) that the availability of previously presented information reduced memory errors, especially for problems of greater complexity. However, according to recent evidence of Weir (1967), a memory aid was of no significant benefit for adults while six-year-olds were confused concerning the purpose of the device in a problem solving task. The nine-year-olds used the memory aid to adopt more effective strategies. Restle and Emmerich (1966) investigated the effect of short-term memory on concept attainment of college students. They concluded that subjects must depend upon reliable short-term memory attained by an active process of memorizing in information transmission unless they are provided with artificial memory aids.
Information Theory

A review of the literature reveals that attempts to understand the young child's limited memory capacity relative to information theory is largely unexplored. The striking difference in cognitive task performance of the six-year-old child when compared to older children has received a variety of labels: lack of conservation operationalized as over discrimination (Saltz & Sigel, 1967), memory differences (Weir, 1964) enactive representation leading to equivalence groupings based on imagery instead of linguistic structures (Bruner, Olver, & Greenfield, 1966) and centration and lack of conservation prior to the concrete operations stage (Piaget & Inhelder, 1957; Inhelder & Piaget, 1958).

Such variety of explanations for performance in cognitive tasks at different levels has led to extensive research producing useful insights. These investigations, however, have often centered upon end results instead of the actual information processing. Included in the present investigation is an attempt to analyze individual protocols with the aim of determining reasons for age differences.

Posner (1963, 1964, 1965) has extended information techniques to the study of memory and thinking in human cognition. Concept attainment studies would be classified, according to Posner, in the second mode of sequential tasks (Broadbent, 1958) wherein the subject stores the incoming stimuli and is required to produce them. (Such a procedure is in contrast to Broadbent's
first mode wherein the subject handles the stream of incoming information by giving a relatively independent response to each event such as in a reaction time experiment.) Concept attainment, however, requires a special transformation on the part of the subject which Posner (1965, p. 198) labels "information reduction": "Such transformations require the subject to produce a subset of the stimulus input. Any task in which the subject is required to map more than one stimulus point into a single response is a reduction task. The loss of information in these tasks clearly does not represent error, but rather is necessary to produce the required output."

In concept attainment studies, the basic type of information reducing transform is called "gating" (Posner, 1964). In this type, the subject is successful if he is able to ignore certain aspects of the stimulus input, called irrelevant attributes, in making the classification. He is thus able to be selective in relevant information that passes through the "gate".

Traditional performance measures in concept attainment research have stressed number of trials to criterion. Such an approach has been criticized by Bourne (1965, 1966) since the analysis of the process by which subjects approach the task is left unscrutinized. A more effective measure is an investigation of errors on individual protocols which leads to an analysis of strategies of the subject during the sequences of hypotheses (Bruner, Goodnow, & Austin, 1956; Olson, 1966).

In extending the research of Bruner, Laughlin has effectively
formulated quantitative rules for focusing strategy (1965) and both focusing and scanning strategy (Laughlin, 1966; Laughlin & Jordan, 1967) to determine selection strategies under different experimental conditions. In addition, Laughlin has devised a method for analysis of errors by listing types of untenable hypotheses for conjunctive focusing (Laughlin, 1966; Laughlin & Jordan, 1967). In the present investigation, a modified form of the Laughlin process analysis was used.

In addition to relating information input to efficiency of concept attainment of children, new insights into the perceptual-cognitive demands placed on children during such experiments may be gained from investigating serial vs. parallel information processing modes (Von Neuman, 1958; Neisser, 1963; Sperling, 1963). Nickerson (1967) recently attempted to distinguish these two modes of processing by studying categorization time in meeting conjunctive and disjunctive criteria. No attempts to extend serial vs. parallel processing modes to an understanding of children's cognition have been formulated, although the work of Piaget (Inhelder & Piaget, 1958); Piaget, 1963) on conservation and research by Bruner (1966) on iconic and symbolic functioning may be viewed as fitting the parallel processing paradigm.

As mentioned previously, Broadbent describes the first mode of handling a stream of incoming information as one of reacting relatively independently to each incoming event of a sequential series (serial processing). Pilot study work for the present experiment revealed that about half of the first-grade children
reacted to each set of four instances in a concept attainment task as if it were a separate problem. Their failure to store incoming stimuli, in order to relate one trial to the next, may be perceived as a lack of parallel processing ability. Matura-
tion of neurological structures underlying parallel processing may well be the factor in the striking difference between the behavior of first- and third-grade children but such speculations are beyond the scope of the investigation.

In the present study half of the children were given a memory aid to bridge the gap between trials. If a child is a serial processor, a memory aid, as the presence of the last card in the series, should facilitate his concept attainment. In addition, decision time should increase for the children in the first grade who use the memory aid since more information would be processed serially. However, the decision time of the older children who are functioning with a parallel processing mode would not necessarily be extended.

Additional support for the view that the older child is more efficient at filtering or "gating" with the use of parallel processing is found in the work of Olson (1966). Olson analyzed the development of strategies against the theoretical background of Bruner (1964, 1966) who postulates cognitive growth through enactive, ikonic, and symbolic representation. The most special-
ized "natural" system of symbolic activity, according to Bruner, is language. Olson notes that as the child's symbolic representation advances, the information used is less tied to
specific instances (serial processing), a decided advantage in concept-attainment tasks. Instead, the child is beginning to select distinguishing features that enable him to discriminate between a set of alternatives (parallel processing). Olson gives evidence that children do poorly in conceptual tasks by failing to combine information from previous trials. The structure for combining such information is either not yet developed or is simply not well enough managed according to Olson. Bruner (1966) describes this inclination of the child to focus on a single aspect of the situation at a time as a "one-track" tendency. In addition, Bruner gives evidence that the five- and six-year-old child often deals with single features of a problem in serial fashion rather than in hierarchies and therefore must rely upon image-matching or ikonic functioning in contrast to symbolic functioning. Since a child operating at the ikonic level relies heavily upon the immediate perceptual field, it may be proposed that he would be aided in concept attainment problems by a visible memory aid.

Sex Differences

Sigel (1965) gives the basic rationale for separate analyses of sex differences on cognitive tasks. In his investigation he poses two possible reasons for sex differences: (1) different socialisation experiences of boys and girls; (2) differential developmental rates. Recent research of Sigel and McBane (1967) on classification behavior reports sex differences but no attempt
is made to give an explanation for the results.

Wallach and Kogan (1965) list sex differences in their study of categorizing and conceptualizing but they find the bases for the differences more complicated than had been assumed. The Kagan (Kagan, Moss & Sigel, 1963; Kagan, 1966) and Witkin (Witkin et al., 1954; Witkin et al., 1962) studies have consistently confirmed the finding of the superior analytic functioning of boys relative to girls.

In a study of concept attainment of college students, (Archer, 1962) an interaction between the sex variable and two other factors is reported. Considering the findings on sex differences in cognitive studies, it seemed important to include sex as a factor in designing experiments in the area even though specific predictions relative to the variable may not be produced.

Stimulus Preference

In selecting problems for concept attainment studies, it is necessary to control for the possibility that subjects' dominance hierarchy of concepts may differ, especially among age levels. Although there is evidence that man is a "biased sorting machine" (Underwood, 1966; Wallace, 1964), predictions of dominance are difficult to make because distinctions between abstraction and conceptualization tasks have not always been made (Corah, 1964; Corah, 1966; Wohlwill, 1957).

In a study of the conceptual behavior of three-year- to eight-year-old children, Kagan and Lemkin (1961) reported that
all children strongly preferred form to either color or size, and size was rarely used as a basis for conceptual similarity. Sigel (1964, p. 232) confirms this result: "Size is less salient an organisational cue than color or form for the very young child. Abstraction of size-attributes requires the child to ignore the other potent and observable attributes of color, form and meaningfulness. The size of an object is relative to an external measure or to other objects, whereas color and form are judged by intrinsic attributes."

Suchman and Trabasso (1966a, 1966b) investigated the effect of stimulus preference of color or form on children's concept attainment. An important factor, according to their results, is whether the stimulus dimension selected for testing purposes is congruent with the child's perceptual preference.

A general finding that emerges from the expanding studies on stimulus preference is that children before the age of five or six prefer color to form while older children mainly prefer form. However, no attempt has been made to hold form constant (circles or squares always relevant) in concept attainment studies with two-attribute conjunctive problems, and varying size (large or small), number (one or two) and color (blue or red) in a random design.

Methodological Problems

Developmental studies of concept attainment have been hampered by lack of methodological procedures to cope with the
limited information-processing capacity of the young child. Yntema and Mueser (1962) emphasize that on the adult level the fewer things kept track of at one time the more restricted the processes of thought. Reitman (1965, p. 51) adds: "... at each point we have to insure that we do not overload this capacity and lose track of some key aspect of whatever we are thinking about." On the surface, a simple solution to the limited memory capacity of the child may be perceived in a simultaneous or "unlimited memory" condition as described by Cahill and Hovland (1960) in which all prior instances remain in view. However, Buttenlocher (1964) cites evidence that such a procedure is too distracting for the child with a limited memory span and poorly developed symbolic processes.

Another attempted solution when experimenting with children is the frequent use of two- or three-stimuli presentation technique in concept learning studies (Kendler & Kendler, 1962; Osler, 1962, 1966) and in probability studies (Stevenson & Weir, 1959; Stevenson & Zigler; Weir, 1967). Lewis' (1966, p. 47) recent critique centers upon the proposal that such procedures need not involve a conscious decision-making process resting on large amounts of cognitive capacity. For naive organisms, the process is essentially a conditioning phenomenon. In addition, such studies are questionable due to the strong alternation tendencies of young children and primates (Jeffrey & Cohen, 1965; Schusterman, 1963). In the present study the presentation of four instances of five attribute concepts on each trial was
labeled an incomplete selection paradigm.

Hypotheses

In summary, the present investigation studied the effects of a memory aid upon the solution of concept attainment problems of boys and girls at three different grade levels. Specifically, the following hypotheses were tested:

(a) The memory aid facilitates concept attainment at each of the three grade levels, first, third and fifth.
(b) Decision time increases for the first-grade children who used a memory aid.
(c) The number of untenable hypotheses decreases with increase in grade level.

As explained in the review of the literature, no attempts were made to make hypotheses relative to sex and problem type differences.
Chapter III. Method

Design and Subjects. A $2 \times 2 \times 3 \times 3$ repeated measures factorial design was used with the variables: (1) memory aid (present or absent); (2) sex (male or female); (3) grade (first, third, and fifth); and (4) problems (three of the conjunctive type for each child).

The subjects consisted of 144 children, forty-eight for each of the three grade levels, with the restriction of one-half of the girls and boys serving in the memory aid condition. A pool of 100 boys and 100 girls (eighty first-grade, seventy third-grade, and fifty fifth-grade) were selected by a table of random number method from the average and above-average IQ lists prepared by teachers. In the pilot study work, about half of the first-grade children and a few of the third-grade children did not solve the conjunctive problems after about 100 trials. Therefore, the criterion of 120 trials was established and the pool of 200 children was selected in order to assure randomness for replacement of $S$s who did not meet the criterion. Only 144 protocols, however, were included in the final analyses since, when this total was met, the experimental sessions were terminated. All $S$s were students attending St. John Brebeuf's, Niles, Illinois, a parochial middle-class school with an enrollment of 1,400 children.
Problems and Apparatus. Each concept instance contained five attributes of two levels each: color (red or blue), form (circle or square), size (large or small), black border (one or two) and number (one or two). Each large, 9-1/2 inch by 16 inch card was composed of four 4 inch instances with one right answer. (See Figure 1.) The large cards were mounted manually in succession by E on a wooden stand with two steel strips placed behind the top of each of the rows of two squares each. The child indicated his choice by placing a magnet marker on the large card near the top of one of the four squares. Prior to the experiment, a random order of the thirty cards in each set was determined.

Six of the twelve possible two-attribute conjunctive concepts were selected randomly. Each child was presented three problems: size dominant (large circles, small squares); color dominant (red circles, blue circles); and number dominant (one square, two squares). Borders and two other attributes were irrelevant for each problem. There were forty-eight possible orders of the six problems with size, number, and color maintained in each order. The sequential order of appearance of the three problems for each of the Ss was determined by a Latin square design such that each problem appeared equally often in every ordinal position.

Procedure. Instructions were given to each child to explain the meaning of a two-attribute conjunctive concept. First the child was shown four instances of the ten cards used
Figure 1. Sample training card of four instances.
in the training session. (See Figure 2.) The ten 4 inch square cards had five attributes of two values: color (yellow or green), form (letter A or B), size (large or small), black border (one or two). Two part answers were emphasized by indicating "lucky answers" such as "big B's" or yellow "A's". Next the child was shown a successive series of eight cards and was assisted by E to arrive at the "lucky answer" which would win each time. Essentially this was a "model" technique, for when the child made an error E asked the child to notice his last choice. For example, if "green B" had been correct on the previous trial and if the child selected "yellow A", he was shown his previous correct choice and asked to select another one of the four instances. This procedure continued until S was able to give the correct conjunctive answer.

As soon as the child stated his hypothesis, he was given immediate feedback with a marble if he selected the correct instance and a negative report if he selected the incorrect one. Therefore, the reinforcement was contingent: that is, when S made a correct response, he was informed that he was correct; when he made an incorrect response, he was not told which response was correct on that trial. The information gained depended upon S's response (Weir & Gruen, 1965). The reinforcement procedure as outlined above was used for both the training and experimental trials.

It is important to note that during these training trials no memory aid was used in the formal way as outlined below. If the
Figure 2. Sample experimental card of four instances.
child made an error, he was reminded of previous correct choices but did not receive instructions on the presence of a memory aid.

When the actual experimental trials were run, the memory aid condition consisted of leaving the previous card in view to the right of S with another magnet marker indicating the child's choice on the last trial. If the child had made the correct choice, he could have noted that the marker indicated an aid for the correct selection on the next trial. Thus, it was necessary for the child to realize that the aid could be used as a "connecting" device: that is, he had to notice the marker's placement and compare it with the next card that appeared. Therefore, there was no formal training in the use of the memory aid in that the child had to realize for himself that only by comparing with the last choice could he make a correct choice on the next trial. The child could also learn by his incorrect choices, especially if an identical, incorrect instance appeared on the next card.

The last stage of the instructions was the presentation of four 4 inch square cards which were examples of concepts used in the experiment. Differences in size, color, number, form and border were pointed out, with a review of the meaning of a two-attribute conjunctive concept. As in the training period, it was emphasized that the "lucky answer" had two parts such as "red circles" or "one square". Careful efforts were made to distinguish between the idea of a two-part, i.e., a conjunctive answer, and an answer which would be correct because of two
objects. Such an example would be the distinction between the lucky answers "red circles" and "two circles." In both examples the answer has two parts but in the former case one or two objects could be the lucky answer.

For all children the following formal instructions were given at this stage:

Now we are ready to start the real problems. You will have three problems to answer. There are two ways you can win prizes. (The experimenter pointed to the balloons, large "shooter" marbles, and plastic cowboys and Indians. The child was asked to say what prize he wanted in order to avoid delay during the experimental session.) As soon as you get the "lucky answer" that is right every time, you can have your prize. Each time you will mark one of these four squares with your magnet as we practiced a few minutes ago. As soon as you mark one, you tell why you marked it. See how fast you can get to the "lucky answer" that wins every time. Each time you pick the right one out of the four you will know, because I will give you a marble. When you have won all these marbles you may have a prize, too.

For the children in the memory aid condition, the following instructions were added:

To help you we will place the last card that you saw right here. (E demonstrates by placing card on the table to the right of S.) I will put the marker on the one out of the four that you picked.

The only verbal reports by E as trials proceeded were the following: "You win," "No, not this time" or "No, but keep trying" and "Let's see if you can get the 'lucky answer' that is right every time."

After S's report of the hypothesis for each trial, the next large card was presented after five seconds to control for the postfeedback interval (Bourne, 1966). The standard interval also
allowed time for the placement of the last trial card for the memory aid condition. When the child won four times in a row, E asked the child: "Now, what is the 'lucky answer'?" The pilot study revealed that children may be operating upon the correct hypothesis but may be reporting on individual instances. The child therefore may have to stop to reflect on the 'lucky answer' apart from what he may be verbalizing each time. If the child was not able to give the correct two-attribute answer, the experimental session continued until the child reached another criterion of four correct choices or a maximum of 120 trials. In the latter case the child was eliminated from the experiment but his protocol was kept for later analysis. The next child of the same sex and age received the condition and random order of problems of the child who was eliminated. No experimental session was over sixty minutes for any child. If necessary, an individual child was recalled on the next day to complete the three problems. No constraint was placed on the child relative to the number of attributes named unless it was time for the "lucky answer" to be given.

The entire experimental period for each child was tape recorded so that E was free during the session to record hypotheses and note individual reactions to the memory aid, that is, whether or not an individual child made use of the aid. A 60 cycle tone attachment on the tape recorder was used as a timer. When each large card was displayed, E pressed a button which recorded a buzz on the tape, unknown to S. As soon as
S marked one of the four choices, another buzz was recorded. When tapes were replayed, decision time was determined by means of a stopwatch.
Chapter IV. Results

Dependent Variables

The dependent variables for the concept attainment tasks were: (1) card choices to solution with verbalization of two-attribute concepts; (2) card choices to solution without verbalization; (3) difference scores between card choices with and without verbalization; (4) untenable hypotheses; (5) number of borders named; (6) decision time.

Each dependent variable, with the exception of the difference scores, was evaluated using a $2 \times 2 \times 3 \times 3$ repeated measures factorial design with the variables: (1) memory aid (present or absent), (2) sex (male or female), (3) grade (first, third, and fifth), (4) problems (three of the conjunctive type for each child. Therefore, the repeated measures were for the three concept attainment problems. Two analyses of variance were completed for each dependent variable with the exception of borders and difference scores: (1) the repeated measures were considered according to type of problem, i.e., color, number, and size; (2) the repeated measures were considered according to presentation order, i.e., for successive trials. The between subjects data was the same for both type of problem and successive trials of the problems since the data are obtained for between groups by summing across problems. Therefore, in the
reporting of results, repetitions are avoided by not noting significant differences again in between subjects data for type of problem and presentation order.

Card choices to solution with verbalization of two-attribute concepts (analyzed according to type of problem). Mean scores to the two-fold criteria of four correct choices with verbalization of the correct two-attribute concept are given in Table 1 and the analysis of variance is given in Table 2. The effect of the memory aid condition was significant, \( F(1,132) = 5.37, p < .05 \). The highly significant grade difference for card choices to solution, \( F(2,132) = 16.71, p < .001 \), was further analyzed by Duncan multiple-range comparisons of means at each grade level. The third and fifth-grade \( S_s \) required fewer card choices to solution than the first-grade \( S_s \) (\( p < .05 \)) with no difference between third and fifth-grade \( S_s \). There was a significant problem type (color, number, and size) effect, \( F(2,264) = 3.39, p < .05 \). Number concepts were more difficult than the color concepts (\( p < .05 \)) with no differences between the comparisons of the color and size and the size and number concepts. No significant interactions were found in the analysis of card choices to solution with verbalization.

Card choices to solution without verbalization (analyzed according to type of problem). In the second scoring procedure, only the objective behavior of four consecutive correct choices---without verbalization---was tabulated. The resulting mean scores are given in Table 3 and the analysis of variance is given in
Table 1

Means for Card Choices to Solution (Verbalization)
With Type of Problem as Repeated Measure

<table>
<thead>
<tr>
<th>Problem Type</th>
<th>Color</th>
<th>Number</th>
<th>Size</th>
<th>Total</th>
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<td><strong>First Grade</strong></td>
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<tr>
<td><strong>Boys</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Memory Aid</td>
<td>17.75</td>
<td>28.42</td>
<td>17.25</td>
<td>21.14</td>
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<tr>
<td>Non Memory Aid</td>
<td>28.08</td>
<td>48.33</td>
<td>28.58</td>
<td>35.00</td>
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<td><strong>Girls</strong></td>
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<tr>
<td>Memory Aid</td>
<td>30.25</td>
<td>23.85</td>
<td>29.75</td>
<td>27.94</td>
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<tr>
<td>Non Memory Aid</td>
<td>23.75</td>
<td>33.75</td>
<td>31.00</td>
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<td><strong>Third Grade</strong></td>
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Table 2

Analysis of Variance for Card Choices to Solution (Verbalized & Non-Verbalized) with Type of Problem as Repeated Measure

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<th>Non-Verbalized MS</th>
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<td>14.43**</td>
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* P < .05
** P < .001
Table 3

Means for Card Choices to Solution (Non-Verbalization) With Type of Problem as Repeated Measure

<table>
<thead>
<tr>
<th>Problem Type</th>
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<th>Size</th>
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<tr>
<td><strong>Boys</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memory Aid</td>
<td>16.92</td>
<td>20.00</td>
<td>14.08</td>
<td>17.00</td>
</tr>
<tr>
<td>Non Memory Aid</td>
<td>20.92</td>
<td>26.83</td>
<td>16.83</td>
<td>21.53</td>
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<tr>
<td><strong>Girls</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memory Aid</td>
<td>21.83</td>
<td>24.58</td>
<td>29.00</td>
<td>25.14</td>
</tr>
<tr>
<td>Non Memory Aid</td>
<td>23.67</td>
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<td>26.42</td>
<td>25.83</td>
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<tr>
<td><strong>Third Grade</strong></td>
<td></td>
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<tr>
<td><strong>Boys</strong></td>
<td></td>
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<tr>
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<td>14.50</td>
<td>14.14</td>
</tr>
<tr>
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<td>17.83</td>
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</tr>
<tr>
<td><strong>Girls</strong></td>
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<tr>
<td>Memory Aid</td>
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<td>20.92</td>
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<td>14.83</td>
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<td><strong>Fifth Grade</strong></td>
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<tr>
<td><strong>Boys</strong></td>
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<td></td>
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<tr>
<td>Memory Aid</td>
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<td>11.08</td>
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<tr>
<td><strong>Girls</strong></td>
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<tr>
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<td>10.83</td>
<td>12.33</td>
<td>12.83</td>
<td>12.00</td>
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</table>
Table 2. A significant difference between grades, \( F (2,132) = 14.43, p < .001 \), was revealed by the new analysis. The comparison among means indicated a significant difference in the number of card choices to solution without verbalization between first- and fifth-grade Ss \((p < .05)\) but not between first- and third-grade Ss as in the analysis under the verbalization condition. In addition, the effect of the memory aid and problems were not significant as in the previous analysis.

**Difference scores.** Subtraction of total card choices for each S across problems under the two scoring procedures (verbalization and nonverbalization) yielded difference scores. Since the main interest was in total differences across problems, the repeated measures are not given in the means in Table 4 and the analysis reported in Table 5. Significant sex, \( F (1,132) = 4.30, p < .05 \), and memory aid differences, \( F (1,132) = 6.84, p < .01 \), were obtained as given in Table 5. The grade effect was not significant. However, a "zero" difference score indicated that S was able to give the two-attribute answer on reaching the first criterion of four correct choices in a row. The fewer the "zero" difference scores that an S had was indicative of poorer performance in that he was not able to verbalize the answer when he had selected the correct instance four times in a row. Thirty-six of the 48 first-grade Ss, 32 of the third-grade Ss, and 22 of the fifth-grade Ss did not have "zero" difference scores. The total chi-square difference among grades was 22.41 \((df = 2)\) which was highly significant \((p < .001)\). Separate chi-square
Table 4

Means for Difference Scores Between Card Choices to Solution (Verbalized and Nonverbalized)

<table>
<thead>
<tr>
<th></th>
<th>Memory Aid</th>
<th></th>
<th>Non Memory Aid</th>
<th></th>
</tr>
</thead>
<tbody>
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<td></td>
<td>Boys</td>
<td>Girls</td>
<td>Total</td>
<td>Boys</td>
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<tr>
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<td>Grade 3</td>
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<td>11.00</td>
<td>26.42</td>
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<td>Grade 5</td>
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<td>3.00</td>
<td>5.34</td>
<td>11.59</td>
</tr>
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</table>
Table 5

Analysis for Difference Scores Between Card Choices to Solution (Verbalized and Nonverbalized)

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<th>MS</th>
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<tr>
<td>Memory (M)</td>
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<td>6.84**</td>
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<td>G X S</td>
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<td>2</td>
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<td>3.84</td>
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*P < .05
**P < .01
tests between grades revealed the following significant differences: first vs. third, \( \chi^2 = 8.33 (df = 1), p < .01 \); first vs. fifth, \( \chi^2 = 17.08 (df = 1), p < .001 \); and third vs. fifth, \( \chi^2 = 19.41 (df = 1), p < .001 \).

Card choices to solution with verbalization of two-attribute concepts (analyzed according to presentation order). Since a Latin square design was used (as explained in the method section) it was possible to analyze the card choices to solution to determine whether or not within subject differences would emerge across successive trials. Therefore, the investigation in this analysis was concerned with trials, i.e., first, second, or third, disregarding whether or not the problem at the trial involved color, number, or size. The means for card choices to solution with presentation order as repeated measure are given in Table 6 and the analysis of variance is given in Table 7. Between subject effects would be identical to those given in the section on the analysis according to type of problem. However, in the within subject analysis it is important to note that the \( F (2,264) = .50 \) indicates no significant improvement across trials. The significant Sex X Presentation Order interaction, \( F (2,264) = 3.19, p < .05 \) is given in Figure 3, and was further analyzed by multiple range comparisons. In Figure 3 the mean for the girls on Problem 2 is significantly greater than the mean for the boys on the same problem. \( (p < .05) \). Between trials 2 and 3 the boys' mean card choices to solution increased \( (p < .05) \) with no significant increase for the girls' choices.
Fig. 3—Sex x presentation order of problems for card choices to solution.
Table 6

Means for Card Choices to Solution with Presentation Order as Repeated Measure

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<td>12.69</td>
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<td>17.50</td>
<td>15.47</td>
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</table>
### Table 7

Analysis of Variance for Card Choices to Solution with Presentation Order as Repeated Measure

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<td>Between Ss</td>
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<td>16.80**</td>
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<td>16.80**</td>
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<td>&lt;1</td>
</tr>
<tr>
<td>Memory Aid (M)</td>
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</tr>
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<td>&lt;1</td>
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<tr>
<td>Error (w)</td>
<td>264</td>
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<td></td>
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</tbody>
</table>

* p < .05  ** p < .001
Untenable hypotheses with type of problem as repeated measure. Information processing was investigated by a modification of Laughlin’s method (1966) of scoring untenable hypotheses. The method determines the consistency of the current hypothesis with available information and was adapted for the analysis of each of the Ss’ three protocols. Untenable hypotheses were of two types: (a) a hypothesis stating the opposite of any value on the previous positive card, e.g., the hypothesis “red circle” when the previous card choice was a blue circle, (b) the repetition of the entire hypothesis on a previous negative card, e.g., the hypothesis “blue circle” when the previous negative card was the same. In this investigation untenable hypotheses were determined for only one trial back. Thus, in the memory-aid condition, the errors would be of the perceptual-inference type (Cahill & Hovland, 1960) since hypotheses would be checked for compatibility with information in instances which are available for S’s immediate inspection. Memory errors would be recorded in the nonmemory aid condition since hypotheses would be checked for compatibility with previously seen but no longer available instances.

The number of untenable hypotheses on each problem was divided by the number of card choices on that problem to determine the percentage of untenable hypotheses. Means and analysis of variance for percentage of untenable hypotheses with type of problem as repeated measure are given in Tables 8 and 9. The percentage of untenable hypotheses differed significantly for
Table 8

Means for Percentage of Untenable Hypotheses with Type of Problem as Repeated Measure

<table>
<thead>
<tr>
<th>Problem Type</th>
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Table 9

Analysis of Variance for Untenable Hypotheses with Type of Problem as Repeated Measure

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<th>F</th>
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<td>2.62</td>
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<td>223.58</td>
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</table>

*P < .05
**P < .01
the three types of problems, $F(2,264) = 8.37, p < .01$. The percentage of untenable hypotheses for the size concepts was significantly greater ($p < .01$) than for the number and color concepts with no difference between the color and number concepts. The significant Sex X Grade interaction, $F(2,132) = 3.98, p < .05$ was further analyzed to discover that the percentage of untenable hypotheses for the third-grade girls was significantly lower than for the third-grade boys ($p < .01$). The interaction is graphed in Figure 4. There was also a significant Sex X Memory Aid X Problems interaction, $F(2,264) = 4.78, p < .01$. An attempted explanation is given in the discussion below.

**Untenable hypotheses with presentation order as repeated measure.** The percentage of untenable hypotheses were reanalyzed in order to investigate changes across successive trials. The means and analysis of variance for the investigation are given in Tables 10 and 11. The between Ss analysis of variance is identical to that for percentage of untenable hypotheses with type of problem as repeated measure. The significant problems effect according to presentation order, $F(2,264) = 3.69, p < .05$, was further analyzed to reveal that the percentage of untenable hypotheses for trial one was significantly lower ($p < .05$) than for trials two and three with no difference between trials two and three.

**Number of borders named with type of problem as repeated measure.** Since borders were irrelevant for all problems, frequent mention of them impeded efficient concept attainment.
Fig. 4.—Sex x grade interaction for untenable hypotheses
Table 10

Means for Percentage of Untenable Hypotheses with Presentation Order as Repeated Measure

<table>
<thead>
<tr>
<th>Presentation Order</th>
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<tr>
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Table 11
Analysis of Variance on Untenable Hypothesis with Presentation Order as Repeated Measure

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<td>Sex (S)</td>
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<td>154.09</td>
<td>&lt;1</td>
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<td>3.28</td>
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<td>&lt;1</td>
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* p < .05
The means and analysis of variance of the number of times borders were named were analyzed with type of problem as repeated measure (Tables 12 and 13). The significant grade effect of number of borders named, $F (2, 132) = 4.39, p < .05$, was further investigated in order to determine grade differences. First-grade Ss named borders three times as often as fifth-grade Ss and almost twice as often as third-grade Ss ($p < .01$). Correlations ($r$) between number of times borders were named as an attribute and the number of card choices to solution for each of the problem types (color, .64; number, .64 and size, .73) were highly significant ($p < .001$).

**Decision time (seconds) with type of problem as repeated measure.** The means and analysis of variance for decision time with type of problem as repeated measure are given in Tables 14 and 15. The grade effect was significant, $F (2, 132) = 5.77, p < .01$. The decision time of the fifth-grade Ss was significantly faster ($p < .01$) than that of the other two grades. The decision time of the third-grade Ss did not differ significantly from the first- or fifth-grade Ss. No other main effects or interactions were significant.

**Decision time (seconds) with presentation order as repeated measure.** The means and analysis of variance for decision time according to presentation order, i.e., across successive trials, are given in Tables 16 and 17. The highly significant problem effect according to presentation order, $F (2, 264) = 60.16, p < .001$, was further analyzed by multiple range comparisons.
Table 12

Means for Number of Borders Named with Type of Problem as Repeated Measure

<table>
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<td>12.83</td>
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<td>9.00</td>
<td>8.19</td>
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Table 13

Analysis of Variance of Number of Times Borders Named with Type of Problem as Repeated Measure

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<td>Within Ss</td>
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<td>2.68</td>
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* P < .05
Table 14

Means for Decision Time (Seconds) with Type of Problem as Repeated Measure

<table>
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<th>Problem Type</th>
<th>Color</th>
<th>Number</th>
<th>Size</th>
<th>Total</th>
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</thead>
<tbody>
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<td><strong>First Grade</strong></td>
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</tr>
<tr>
<td><strong>Boys</strong> Memory Aid</td>
<td>5.24</td>
<td>4.58</td>
<td>4.85</td>
<td>4.89</td>
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Table 15

Analysis of Variance for Decision Time with Type of Problem as Repeated Measure

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*P < .01
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<tr>
<td><strong>Girls</strong></td>
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</tr>
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<td>3.75</td>
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Table 17

Analysis of Variance for Decision Time with Presentation Order as Repeated Measure

<table>
<thead>
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<th>Source</th>
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<th>F</th>
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<tr>
<td>Between Ss</td>
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<tr>
<td>Grade (G)</td>
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<td>71.63</td>
<td>5.77**</td>
</tr>
<tr>
<td>Sex (S)</td>
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<td>1.87</td>
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<td>G X S</td>
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<td>Error (b)</td>
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<td>Error (w)</td>
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* P < .05  
** P < .01  
*** P < .001
The decision time for problem one was less than for problems two and three ($p < .01$) with no significant difference between the latter. A significant Grade X Presentation Order, $F(2,264) = 2.59, p < .01$, was found and is graphed in Figure 5. Multiple range comparisons revealed that the decision time for problem one was greater at all three grade levels when compared to the other problems ($p < .05$).

Summary of major findings

In general, third- and fifth-grade Ss were markedly superior to first-grade Ss in solving the concept attainment problems. The memory aid condition was effective in increasing concept attainment ability at all three grade levels. In addition, the memory aid condition aided in the verbalization of two-attribute answers as evidenced by the analysis of difference scores between number of card choices to solution under verbalization and nonverbalization scoring procedures.

Decision time for the first-grade Ss did not increase under the memory aid condition as originally hypothesized.
Fig. 5.—Grade x presentation order of problems for decision time (seconds)
Chapter V. Discussion

The present investigation was an attempt to study the effects of a memory aid upon the solution of conjunctive concept attainment problems at the first-, third-, and fifth-grade levels incorporating sex and problem type differences. In addition, the study originated from one of the first attempts to adapt the research of Bruner, Goodnow and Austin (1956) on conjunctive concept attainment to the child's level by the use of an incomplete selection paradigm.

The procedure for the protocol analyses was adapted from the research of Laughlin (1966) on untenable hypotheses and was given theoretical foundation by an evaluation of serial vs. parallel processing modes relative to the development of cognitive abilities (Posner, 1963, 1964, 1965).

Therefore, the hypotheses for this study were derived primarily from the research of Bruner, Laughlin and Posner. However, as the analyses progressed it became evident that additional concepts relative to the relation of language to cognition had to be incorporated into a meaningful discussion of the results.

Main effects

The hypothesis that the memory aid would facilitate concept
attainment at each of the three age levels was supported by the analysis of card choices to solution. Such a finding confirms the view of Miller (1956) and Mandler (1967) that memory is closely related to the cognitive processes and that aids facilitating memory would be effective in improved concept attainment (See also Dominowski's review, 1965, pp. 276-278). It is important to note that the memory aid effect was not significant for the analysis based upon card choices to solution in the non-verbalization scoring procedure. As explained previously, this scoring procedure was added in order to determine scores that would have been obtained had the experimenter set a simple criterion of four consecutive correct card choices without the added requirement of verbalization of the two-attribute conjunctive concept. It seems, therefore, that the memory aid facilitated verbal expression as expanded in the later section on language and cognition. This assumption was also supported by the finding that the memory aid effect was significant for the analysis of the difference scores which were obtained by subtracting total card choices for each S across problems under the two scoring procedures of verbalization and nonverbalization.

In the analysis of difference scores and card choices to solution, the common finding was that the behavior of third and fifth-grade Ss in the concept attainment tasks were similar while the first-grade Ss seemed to be functioning on a different cognitive level. As was noted in the difference score analysis, the very significant chi square result in the
investigation of "zero" scores revealed that the first-grade Ss failed more often to verbalize the answer when they had selected the correct instance four times in a row. The large number of first-grade Ss, especially in the non-memory aid condition, who thus found it difficult to verbalize an objectively attained concept may have arrived at the solution by a gradual acquisition of S-R associations instead of by formulating and testing hypotheses (Osler & Pivel, 1961). It would seem that for all three grade levels, extreme deviation from the ability to verbalize the answer, and thus obtain a high difference score, indicated a different type of cognitive functioning. Sinclair (1967) emphasizes, however, that the young child's conceptual system is separate from his language system. Vygotsky (1962, p. 126) states: "The structure of speech does not simply mirror the structure of thought; that is why words cannot be put on by thought like a ready-made garment. Thought undergoes many changes as it turns into speech."

Olson (1968) in a recent review of the links between cognition and thought, clarifies the issue: "While language does not appear to influence the ability to make fine discriminations or to form any perceptual schemata, it may be employed to direct attention to some properties of the world that the culture has found to be important which otherwise may be ignored." In this way, language influences the formation of some schemata and consolidates the boundaries of some others. This is what Bruner et al., 1966, have described as 'language as an
invitation to form a concept.'

Another important grade distinction was revealed by the analysis of borders named in stating the hypothesis on each trial. High correlations were obtained between the number of trials and the mention of borders. First-grade children failed in the 'gating' operation, i.e., the screening out of irrelevant attributes, perhaps due to an inability to narrow the perceptual field. Such a finding would support the views of Piaget and Bruner relative to the high use of the perceptual "given" in attempts to solve cognitive tasks. The first-grade Ss might be labeled as too "perceptually aware" of the irrelevant attributes. Further research with constraint directions (see below) may clarify the link of language as a tool in orienting perception as an aid in solving problems at the first-grade level.

In summary, grade differences seem to be primarily due to differences in level of cognitive functioning and failure to screen out irrelevant attributes in the concept attainment tasks.

Grade differences were not found for the percentage of untenable hypotheses under repeated measures of type of problem or presentation order. Since no constraint was placed on Ss relative to the number of attributes that could be named, the analysis by the untenable hypothesis measure was not as effective as it might have been had the Ss been instructed to name only two attributes for a conjunctive answer. Another experiment has been planned which will take into account the greater
effectiveness of a constrained strategy. Olson in Bruner et al., 1966 emphasizes that externally imposed constraints lead children to improve their strategies. In a study of information processing in children, Laughlin, Moss & Miller (under editorial review) found a significant grade and model effect relative to the percentage of constraint questions asked in a modified game of "twenty questions" suggested by Bruner and his associates (1966). By the use of a constraint model, therefore, it is anticipated that not only will the scoring of untenable hypotheses be more valid, but the imposition of a constraint will cause a sharper focusing on the perceptual field which should aid in attainment of concepts.

Sex as a significant main effect appeared only in the analysis of difference scores. Except for the third-grade girls in the memory aid condition, girls had lower difference scores in the eight other groups (Table 4) indicating superior performance in the ability to verbalize the concept.

Interaction effects

The significant Sex X Presentation Order interaction may be indicative of the girls' superior ability to attain a level of solution and then to maintain it. The boys increased the number of card choices to solution between trials two and three resulting in poorer performance.

The very significant Sex X Memory Aid X Problem Type interaction in the analysis of variance for untenable hypotheses
with type of problem as repeated measure revealed irregular relationships. When the twelve means are divided at the median point it becomes apparent that the poorer performance of the boys and the difficulty of the size concepts are contributing the most weight to the interaction effect.

The significant Grade X Problems (according to presentation order) in the analysis of decision time is not surprising in that familiarity with procedure would facilitate an increase from trials one to two across grades. However, it is important to note here that although there was a highly significant decrease in decision time across trials, no significant improvement across trials occurred. Several research reports have given evidence that improvement across trials is not found in concept-attainment experiments when Ss initiate selection of instances (Bruner et al., 1956; Conant & Trabasso, 1964; Laughlin, 1966, 1968; Laughlin & Jordan, 1967). McGlynn and Laughlin (1967) postulate a social facilitating effect for their finding of improvement across trials in a selection procedure. In reception procedures (Haygood & Bourne, 1965; Neisser & Weene, 1962) improvement across trials is found. In the latter case the experimenter has greater control of information processing in that he limits the sequential presentation of instances. The present investigation contributes to the growing findings in research relative to selection vs. reception procedures since the design entailed a modified selection procedure having a major amount of experimenter preprogramming of
one correct instance out of four on each card.

Originally it was hypothesized that an interaction between memory aid and grade would emerge based upon the parallel vs. sequential processing model of information theory. First-grade Ss in the memory aid condition did not have a longer decision time. A major factor could be that the first-grade Ss in the non-memory aid condition often stopped to ask if they could see the previous card before making a choice. Some first-grade Ss in the memory-aid condition did not take time to use the memory aid to compare their previous choice with the new card. Further research should vary procedures whereby Ss would be trained in the use of a memory aid or trained to request to view the previous card.
Chapter VI. Summary

The present investigation was designed to study the effects of a memory aid upon the solution of conjunctive concept attainment problems. A $2 \times 2 \times 3 \times 3$ repeated measures factorial design was used with the variables: (1) memory aid (present or absent), (2) sex (male or female), (3) grade (first, third, and fifth), and (4) problems (three of the conjunctive type for each child).

The study originated from one of the first attempts to adapt the research of Bruner, Goodnow, and Austin on conjunctive concept attainment to the child's level by means of an incomplete selection paradigm.

The following hypotheses for the study were derived from the research of Bruner, Laughlin, and Fosner: (1) The memory aid would facilitate concept attainment at each of the three age levels; (2) Decision time would increase for the first-grade children who used the memory aid; (3) The number of untenable hypotheses would decrease with age. The first hypothesis was supported. As the analyses progressed it became evident that concepts relative to the relation of language to cognition had to be incorporated into a meaningful discussion of the results. An important finding was that the memory aid facilitated the verbalization of the two-attribute conjunctive answers.
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College of St. Teresa, Winona, Minnesota 1950-1951

B.A. Briar Cliff College, Sioux City, Iowa 1951-1954 1958-1959

M.A. Marquette University, Milwaukee 1960-1962

Ph.D. Loyola University, Chicago 1965-1968

Experience

Junior High School Teacher, Pocahontas, Iowa 1954-1958

High School Teacher, Biology, Wahlert High School, Dubuque, Iowa 1959-1960

Instructor and Assistant Professor of Psychology, Briar Cliff College, Sioux City, Iowa 1961-1965

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Harvard University, Summer 1967

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Academic scholarship to College of St. Teresa 1950-51
Graduated Maxima cum Laude, Briar Cliff College 1959
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Member, Speaker's Bureau, Briar Cliff College 1964-65
Member, Midwest Psychological Association 1963
Member, American Psychological Association 1962
Member, Psi Chi 1966
APPROVAL SHEET

The dissertation submitted by Jeanette Ellen McCarthy has been read and approved by the director of the dissertation. Furthermore, the final copies have been examined by the director and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the dissertation is now given final approval with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Date ___________________ Signature of Adviser ___________________