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ATTENTION AND MEMORY IN CONCEPT LEARNING AS A FUNCTION OF TASK COMPLEXITY AND AGE

APPROVED BY

DISSERTATION COMMITTEE

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CHAPTER I

INTRODUCTION

The majority of the theorizing and research directed toward the study of cognitive and conceptual development has emphasized the premise that there are basic changes occurring in the thinking processes of the child as he matures. Some of these approaches stress the role of the development of symbolic processes. For example, Piaget (e.g., Flavell, 1963) emphasizes the operations that carry out the symbolic processes and the rules by which the child brings these operations together to form logical systems of cognition. The mediational approaches also place high value on the symbolization process. Pavlov's "second signal system" has been concerned with that part of behavior that depends on verbal stimuli and verbal responses. In 1934 Vygotsky (1962) presented a theory of conceptual development, dealing with the relationship between thought and language, which considered the child capable of thinking when he was able to use his own verbal processes to control his behavior. Closely related to these two Russian mediational views is that of Kendler and Kendler (1962) who stress the role of internal mediating links in the form of internal or implicit verbal responses.

These views have all concentrated on changes in cognitive functioning with age that are associated with the course of language development and functional differences in the role of verbalization. Though Piaget does not appear to fall within this category, he is placed here as he relied heavily on children's verbalizations and ability to verbalize for the development of his theory. The Kendler approach was not originally associated with the verbalization process; the subject was seen as having two tasks in a conceptual situation: 1) orienting himself toward a particular dimension of the stimulus material and 2) combining responses to particular values of that dimension (Kendler, Glucksberg, and Keston, 1961). However, with studies finding an association between verbalization and performance on these tasks (Kendler and Kendler, 1962) and with support from the language relativity hypothesis (Whorf, 1956), this view is generally interpreted in terms of a <u>verbal</u> mediational hypothesis.

In recent years there has been dissatisfaction with the emphasis on the role of verbalization and language development per se as being the primary or only underlying process connected with changes in conceptual and cognitive performance. Attention has been shifting to the possible role of other processes which may or may not be interrelated to the verbalization process, but which are related to overall changes in cognitive development.

One of the primary tools used to study the development of conceptual processes has been the reversal and nonreversal shift paradigm as developed by the Kendlers (e.g. 1962). In there concept shift studies the subject is presented stimuli varying in several dimensions (such as color and size). Each dimension has two or more levels (e.g., color - red or blue). The subject is typically required to respond to, or identify the levels in one of the dimensions. At some point in the training of the problem the feedback changes and the subject has to reverse his responses or respond to other aspects of the stimuli. Interest is generally directed toward the subject's performance in this second phase of task performance. In the reversal shift situation, the subject is required to respond to the same dimension as before but the overt choices are reversed (i.e., if "large" was the correct response in the first phase, "small" is the correct response in the shift phase). In the nonreversal shift, a previously irrelevant dimension becomes relevant (i.e., if size was the relevant dimension in phase 1, color might become the relevant dimension in phase 2).

Single unit S-R theory would predict that the nonreversal shift task should be easier than the reversal shift task (i.e., in the reversal shift the former responses are incorrect 100% of the time, while in the nonreversal shift the former responses are incorrect only 50% of the time as "large" and "small" occur equally often with each color). This single unit S-R prediction was found to hold for preschool subjects but not for college subjects (Kendler and Kendler, 1962; Kendler and D'Amato, 1955). Further, it was found that in the vicinity of 5- to 7-years-of-age, a change occurred from the reversal to nonreversal shift.

The Kendlers felt that these results could adequately be accounted for by incorporating a mediational link into the S-R unit (i.e., an interval r-s unit between the S and the R). In terms of mediational theory, the inner-connecting links for the two situations (reversal and nonreversal shifts) differ considerably. In the reversal shift situation, the subject would use the same mediational hypothesis that he used in the pretraining session; he just has to change his overt response. For the nonreversal situation the subject has to acquire a new mediational hypothesis in addition to changing his overt response. In such a situation, mediational theory would predict that the reversal shift is the easiest, while the single unit S-R approach would predict that the nonreversal shift is easier. Thus the Kendler approach explains the changes in performance as a function of age in terms of the development of the mediational mechanism.

In regard to the concept-shift paradigm, the outgrowth of Kendler's reversal non-reversal shift which has received the majority of emphasis in this country, at least two other hypotheses have been offered to explain what is occurring. Tighe and Tighe (1966) postulate the importance of the role of perceptual factors. According to their view, the young child cannot analyze the stimuli into stimulus dimensions; his analysis is characterized by less well differentiated complexes or stimulus compounds. Zeaman and House (1963), with the dimensional-observing response hypothesis, propose that the factors operating in the Kendler shift situation are primarily attentional in nature. A recent review by Wolff (1967) concludes that attentional factors are the primary forces operating in the shift situation; that the verbalization and perceptual-differentiation hypotheses are not, in general, the crucial factors. Wolff feels that studies that are supposedly demonstrating the role of the effects of verbalization are limited to the cases in which overt verbalization was utilized to direct attention to specific aspects of the stimulus material.

Some other recent theorizing efforts stress processes other than the verbalization process per se. Bruner (1964) emphasizes the role of memory functions in his conception of changes in cognitive growth as being a function of reliance on different types of "representations." In his view, past events are first represented to the child through appropriate motor responses (enactive representation). Past events are then represented by the perceptual qualities of the field, i.e., through images (iconic representation). Finally, symbolic representation comes into play in which the child is able to make inferences beyond the information given in the immediate situation. Wohlwill (1962) also highlights changes in the mental processes as a function of decreasing dependence on information in the immediate stimulus field.

Some of the current Russian investigators relate the developmental cognitive changes to the role of the orienting response, steming from the work of Sokolov (e.g. 1963). The orienting response is associated with both physiological arousal and a conscious attentive process (Sokolov, 1963; Lynn, 1966; Zaporozhets, 1960). For example, developmental studies by Zaporozhets (1960, cited in Berlyne, 1963) place priority on both orienting reactions and feedback, with emphasis placed on the organization of the orienting response. This emphasis is related to renewed interest in the role of attention in this country (e.g., Trabasso and Bower, 1968; Wachtel, 1967).

Recent considerations of the course of cognitive development have thus, at least momentarily, turned away from the emphasis on language growth and are considering other processes. The two processes which are now being given a great deal of consideration are attention and memory. This growing interest in the developmental area, along with the findings in concept identification research (covered in Chapter II), gives impetus to the purpose of the present study, to investigate the roles of attention and memory in concept learning with children.

CHAPTER II

NATURE OF CONCEPT IDENTIFICATION RESEARCH AND MATHEMATICAL MODELS

Concept identification has served as a useful paradigm for the investigation of the effects of many types of experimental variables on cognitive performance. These include such variables as: the effects of drugs and induced stress (Pishkin, Wolfgang and Bradshaw, 1963; Pishkin, Shurley and Wolfgang, 1967), the influence of social cues and social interaction (Pishkin and Blanchard, 1963; Wolfgang, 1967a), stimulus redundancy (Bourne and Haygood, 1959), auditory cues (Bulgarella and Archer, 1962; Lordahl, 1961), and misinformation feedback (Pishkin, 1960). In the concept identification paradigm the subject is presented geometric patterned stimuli that may vary in a number of dimensions (e.g., shape, color, size, number, horizontal or vertical position, border, background, etc.) with typically one or two of the dimensions being relevant (i.e., necessary) for task solution, while the other dimensions are either irrelevant (i.e., have no relationship to solution), or are invariant (i.e., appears at only one of their levels). Task complexity is generally varied quantitatively by changing the proportion of the number of relevant dimensions in relation to the total number of relevant and irrelevant dimensions. Many studies have found a positive linear relationship between this proportion and problem solving efficiency (i.e., time to solution, number of errors made, trials to reach solution) (e.g., Archer, Bourne and Brown, 1955; Bourne, 1957; Lordahl, 1961; Bulgarella and Archer, 1962; Bourne and Haygood, 1959; Pishkin, 1960).

One of the earliest studies in the general area of concept formation (the precursor of concept identification) was conducted by Hull (1920) in which subjects learned to anticipate nonsense syllables with a series of Chinese radicals. Those radicals which were similar in some specified way had the same nonsense syllable associated with them. Hull found that many of his subjects could learn the appropriate association but could not say why the association was correct. Other early experiments in the area also used this paired-associate type of paradigm. A series of studies by Heidbreder and associates (Heidbreder, 1946a; Heidbreder, 1946b; Heidbreder, 1948; Heidbreder, 1949; Heidbreder, Bensley and Ivy, 1948; Heidbreder and Overstreet, 1948) were designed primarily to test the relative difficulty of different types of concepts and used materials composed of pictorial sketches of objects.

Early studies in concept formation ability as a function of age were also primarily concerned with the types of concepts that children were able to handle. A series of studies by Welch and Long (Welch, 1940a; Welch, 1940b; Welch and Long, 1940a; Welch and Long, 1940b; Welch and Long, 1943) concluded that the conceptualizing ability of children develops in a hierachial level, from simple to more complex, or from concrete to abstract, with more generalization occurring at the higher levels. For example, some of the earliest concepts grasped were that "men" and "women" were "people." Later concepts such as: 1) "potatoes" are "vegetables," 2) "apples" are "fruit," and 3) both "vegetables" and "fruit" are "food," are understood. Reichard, Schneider and Rapaport (1944), using sorting tasks, described three levels of conceptual development. The first was the concrete level in which nonessential incidental features of objects are used for classification; the second was the functional level, in which classification is based on the use or value of the objects. In their third level, the conceptual level, classifications are made on the basis of abstract properties or relationships of the objects.

Other studies were also concerned with the age level at which certain types of concepts were formed. A variety of concepts were investigated including triangularity (Gellerman, 1933; Munn and Stiening, 1931), roundness (Long, 1940), magnitude (Thrum, 1935; Welch, 1939), time (Ames, 1946; Friedman, 1944), cause-effect relationships (Lacey and Dallenbach, 1949), contradictory relations (Dixon, 1949), and social concepts (Ordan, 1945).

The early studies in concept learning were criticized because of the problem of not being able to quantify the complexity of the stimuli independently of the subject's responses. Such a variety of types of stimulus objects and procedures were used that it was difficult to make comparisons among studies. Also, some of the studies, especially those with adults, used a paired-associate paradigm with the subjects having to learn nonsense syllables as well as learning or identifying the concepts involved. Richardson and Bergum (1954), in an analysis of the experiments up to that time, indicated that 70-80% of the time involved in these tasks was devoted to the learning of the nonsense syllables themselves. In 1952, Underwood advocated the need to develop a better method for control on complexity of the stimuli.

In 1955, Archer, Bourne and Brown, using the information theory analysis advocated by Hovland (1952), developed a procedure that would allow the experimenter to directly measure the amount of information contained in the stimulus material independently of the subject's response. In information theory, the basic unit delineating the amount of information contained in the stimulus set is called a bit, the abbreviated form of "binary digit." A bit is defined as $\log_2 x$, where x is the number of different stimuli in the set to be classified. When the set consists of several dichotomous stimulus dimensions, the amount of information (in bits) is equal to the number of stimulus dimensions. Each time another dichotomous dimension is added to the stimulus set, the amount of information increases by 1 bit (Miller, 1953; Miller, 1956; Shannon and Weaver, 1959). By specifying the bits of relevant and irrelevant information in the stimulus set, task complexity is equal to the number of irrelevant bits of information provided. Archer, Bourne and Brown (1955) and a number of other investigators (e.g., Bourne, 1957; Lordahl, 1961; Bulgarella and Archer, 1962; Bourne and Haygood, 1959; Pishkin, 1960) have used this procedure to vary task complexity by systematically increasing the amount of irrelevant information along different binary (bi-leveled) stimulus dimensions. The general finding in these studies has been that increases in amount (bits) of irrelevant information makes the task progressively more difficult and resulted in a linear increase in the number of errors made before arriving at the solution.

One of the first studies to use this systematic procedure with geometric patterns (the standard stimulus material for most studies with college students and adults) with young children is relatively recent. Osler and Kofsky (1965) tested 4-, 6- and 8-year-olds and found that concept learning was influenced by both age and task complexity. Using the concept identification paradigm with 1 relevant dimension and 0, 1 or 2 irrelevant dimensions, it was found that for any one age group the number of errors increased with task complexity (in a linear fashion as in the studies with college <u>S</u>s previously mentioned), and that with any one complexity level the task became easier with an increase in age. With 1 irrelevant dimension, for example, Osler and Kofsky found that 40% of the 4-year-olds and 60% of the 6-year-olds could solve the task; with 2 irrelevant dimensions, 40% of the 6-year-olds and 70% of the 8-year-olds could solve the problem. With these age groups and the complexity levels used, the relationship between performance and complexity appeared to be linear, i.e., an asymptote of the children's performance limits had not been reached.

Following the results of the early research using the information theory approach, Bourne and Restle (1959) developed a mathematical model of concept identification. In this model, difficulty of concept identification tasks is directly related to the amount of irrelevant information and inversely related to the amount of redundant relevant information. (When two or more dimensions are perfectly correlated they are redundant. When the redundant information occurs with the relevant dimension(s), the subject can use any one or any combination of the redundant relevant cues to solve the problem.) The probability of a correct response on any one trial in the Bourne and Restle model is seen as a combination of conditioning of the relevant (reinforced) cue and adaptation to the irrelevant (non-reinforced) cues. Thus the main assumption of this model is the additivity of cues, i.e. addition of irrelevant information increases task difficulty. However, research efforts soon demonstrated that the mere process of adding another irrelevant dimension, without considering the saliency of the dimension for the subject (i.e., the attentional value of the dimension) was inadequate. For example, Brown and Archer (1956) found that positional variations were more difficult for most subjects than were the other dimensions that they used. Wolfgang (1967b) found that some dimensions lead to differential performance for males and females. Archer (1962) showed that not only did differential effects of cue saliency of dimensions occur for the two sexes, but also that the stimulus variation within a dimension (what Archer called the obviousness of the levels of the dimension) affected task difficulty. These studies point out that the additivity of cues assumption in the Bourne and Restle model does not hold on the basis of the mere physical addition of stimulus dimensions; that it will hold only if the saliency of the cues can be equated. Thus the Bourne and Restle model and some of the research it has generated serve to emphasize part of the role attentional processes have in concept identification tasks.

Other studies in concept learning also point to the role of attentional factors by the use of experimental manipulations of attentional variables or by prior determination of dimensional preferences. For example, Trabasso (1963) used emphasizers to draw more attention to specific aspects of the stimuli. The use of verbal label pretraining for certain aspects of the stimulus material has also been shown to effect the ease of subsequent concept learning (Rasmussen and Archer, 1961; Stephens, 1967; Tulving and Pearlstone, 1966). Studies using redundant relevant cues have also shown that many subjects are aware of only one of the possible relevant dimensions; that they don't notice or attend to the others (Trabasso and Bower, 1968). Suchman and Trabasso (1966a; 1966b) found that for young children performance was related to the child's preference for the relevant dimension. In these studies, prior to the discrimination problem, the child's preference for color or form was determined. On one task the children had to learn discriminations with color relevant and form irrelevant, or vice versa. An interaction occurred between dimension preference and problem difficulty. That is, children assessed as preferring color over form learned the color problem quickly but the form problem slowly; children preferring form over color gave the opposite pattern of results.

The possible role of attentional factors in concept identification experiments with children is supported by other studies. Inglis, Ankus and Sykes (1968) conclude that children between 5- and 10-years-of-age show a progressive improvement in selective attention.

Ginsburg (1967) found that, with an increase in age, there is an increase in the amount of information that can be effectively attended to and that the more specifically a problem can be communicated to a child the more effective will be the child's performance. Related to this, Osler and Weiss (1962) found that specificity of instructions concerning a conceptual task erased earlier differences found between children at two levels of intelligence (Osler and Trautman, 1961; Osler and Fivel, 1961).

A few years following the Bourne and Restle model, a new model of concept identification was set forth by Restle (1961; 1962). This model assumes that the subject approaches the task with a set of strategies or hypotheses. For each instance or stimulus complex that is presented to the subject, he is said to select one of the strategies to test, and if it doesn't work, he rejects this particular strategy and selects another. The subject continues to select hypotheses until he finds one which works. The rejected strategies go back into the subject's pool or set of strategies and, according to the Restle model, have an equal chance of being selected again with all the rest of the strategies in the set (both tested and untested). Because of this sampling with replacement assumption the Restle model is often called the "no-memory" model since it assumes that the subject cannot recall or remember what strategies he has previously tested. Most of the subsequent research with this model has been directed primarily toward disproving the "no-memory" aspect of concept identification and thus to emphasize the role of memory factors.

One direction of this research has been to experimentally change the memory requirements of the task by systematically varying the number of previously exposed stimulus patterns that are left available for the subject to view. The use of simultaneous presentation, or even a limited number of specific past instances, has been demonstrated to improve concept identification performance in college students (Cahill and Hovland, 1960; Bourne, Goldstein and Link, 1964; Hunt, 1961; Trabasso and Bower, 1964; Pishkin and Wolfgang, 1965). A recent study by Pishkin, Wolfgang and Rasmussen (1967) with 4th through 12th grade children, found that the use of available past instances improved concept learning performance as a function of age. Presenting 0, 1 or 2 past instances to the subjects, the most improvement in performance as a function of amount of past instances available was seen in the youngest age group (composed of 4th, 5th and 6th graders). As age increased, the differential improvement was less, allowing the interpretation that the older subjects could make more efficient use of their own memory of the situation and thus the presence of memory aids adds little additional information for them. Conversely, the interpretation could be that the younger subjects have more difficulty recalling past information and thus visible memory aids improve their performance more noticeably. For example, Inglis, Ankus and Sykes (1968) found a progressive improvement in short-term memory from age 5 through age 20, using the dichotic listening device.

While many of the studies that have been mentioned are not concerned with sex differences in memory functions, there is some indication that some differences do exist. For example, Tyler (1965) summarizes studies on memory (recall of digits and reproduction of geometric forms) in which females are superior to males. Osler and Kofsky (1965), however, found no significant main effects due to sex in their study of concept learning with 4-, 6- and 8-year-olds. But significant interactions with sex were found in the Pishkin, Wolfgang and Rasmussen (1967) study with 9 through 17 year olds. Females were superior to males with zero and two specific past instances available and also when only negative feedback was used (i.e., only past errors were available). In a developmental study of auditory concept identification (Pishkin and Rosenbluh, 1966), both sexes showed an increase in errors in the 7th, 8th and 9th grade grouping as compared to the performance of the 4th, 5th and 6th graders, and also found a significant decrease in response rate for the older subjects. In addition, a significant difference between the sexes on the time to solution occurred with the males showing superior performance. Considered together, these results indicate differential age and sex effects in the role of memory and perhaps also in attentional factors, especially in the young adolescent age group.

A third mathematical model of concept identification has been proposed by Bower and Trabasso (1964). This model distinguishes between two processes operating in concept learning. The first process to occur, according to this model, is that of stimulus selection, i.e., attending to, and selecting particular aspects of, the variation or properties of the stimuli. The second process is that of associating a response to a specific value of the relevant dimension. The second process can't occur until the subject starts attending to the appropriate dimensions. The Bower and Trabasso model, in a sense, combines relevant aspects of both the Bourne and Restle (1959) and the Restle (1961, 1962) models by incorporating the attentional aspects of the task (i.e., stimulus selection) and the memory aspects of the task (encoding the appropriate dimensions and the conditioning based on reinforced responses). These two processes are similar to the rule learning and attribute identification aspects of concept learning as identified by Haygood and Bourne (1965). Their rule learning process is defined in the given way: Given the relevant attributes what is the rule for class assignment? For attribute identification: Given the rule for class assignment what are the relevant attributes? Both the Bower and Trabasso model and the Haygood and Bourne analysis emphasize two major processes in concept learning, that of discovering the relevant dimension and of associating the values of the relevant dimension with the appropriate response.

Thus, recent research in concept identification and the testing of mathematical models that have been developed for this area, point to the importance of the roles of attentional and memory processes in conceptual tasks. In none of the research to date has the possible interrelationship of these processes been considered, particularly in relation to performance of children of different ages on concept learning tasks.

CHAPTER III

STATEMENT OF PROBLEM

From cognitive development theorizing and from research growing out of mathematical models of concept identification has come some speculation and evidence on the roles of attention and memory processes in conceptual task performance. There has been little evidence in the developmental area to support these recent contentions. In the concept identification area there have been only meager efforts to identify the roles of these processes in children. The overall purpose of the present study was to start closing this gap by investigating the roles of attentional and memory aids as a function of varying levels of task complexity in the concept learning performance of children ranging in educational grade level from four-year-old preschool through the ninth grade.

The attentional and memory aids (cues) used in the present study followed manipulations that have been utilized in other concept learning experiments. The memory aid used was the presence of a specific past correct instance (specific instance cue) within each sorting category as used by Pishkin and Wolfgang (1965) and Pishkin, Wolfgang and Rasmussen (1967). The experimental manipulation of attention followed that used in the rule learning task of Haygood and Bourne (1965) in which the S's attention was focused on the levels of the relevant dimension by visual presentation of these stimulus attributes to the S prior to and during the task (here called the general focusing cue). A condition in which no cues were available was also used to provide a control condition for the comparison of the effects of the attentional and memory aids. This no cue condition was comparable to the typical concept learning situation.

One particularly important goal of the present study was the investigation of the possible interrelationship between the attentional and memory functions. Most of the theoretical discussions and research that have been presented thus far have generally considered these two processes as separate entities. A hypothesis advanced here is that these two functions are, in fact, closely related processes. For example, manipulations that emphasize certain aspects of the stimuli, such as the focusing or attending cue, also seems to enable the S to encode those aspects of the stimuli more readily and would thus facilitate the S's encoding and memory processes. Manipulations providing memory aids for the S, such as the availability of specific past instances, could also provide attending or focusing cues by aiding S to discover the relevant dimension and its levels, especially after S has been exposed to, and had available to him, a certain number of the specific instances. Thus it was assumed that both the specific instance cue and the general focusing cue have "attentional" and "memory" components, and it was hypothesized that:

1. The use of a specific instance cue condition and of a general focusing cue condition will both lead to more efficient

performance (i.e., fewer errors and faster time to solution) on a concept learning task than the use of a condition in which no such cues are available to the Ss.

While both the specific instance cue and the general focusing cue were assumed to have memory and attention components, the general focusing cue was expected to be particularly important in the early phases of the concept learning task performance. Both Bower and Trabasso (1964) and Haygood and Bourne (1965) have emphasized the role of the stimulus selection process or the discovery phase in concept learning. The general focusing cue condition provides this type of information to the S prior to the task while the specific instance cue provides this type of information only after S has begun working on the task. It is thus hypothesized that:

2. In the beginning trials of performance on the concept learning task, Ss in the general focusing cue condition will show significantly more efficient performance than the Ss in the specific instance cue condition, and that this initial advantage for the general focusing cue condition Ss will lead to somewhat better overall performance for the general focusing cue condition than for the specific instance cue condition performance.

It was also expected that the roles of the memory and attentional aids would change with variation in task complexity. This is, tasks of low complexity would not impose much of a demand on the memory and attentional capabilities of the S, and, thus, neither attentional nor memory aids would be expected to improve performance substantially compared to the condition of no cues available. However, as task complexity is increased it would be expected that both types of aids would considerably improve performance levels in contrast to the no cues available condition, since it was assumed that the attentional and memory requirements of the concept learning task were also increasing. It was thus expected that:

3. _On tasks of low stimulus complexity, the specific instance cue and general focusing cue conditions will not substantially improve concept learning performance compared to the no cues available condition. However, with increasing stimulus complexity the specific instance cue and general cue conditions will elicit progressively more efficient performance levels than the no cue condition._

Also, in regard to changes in stimulus complexity, it was speculated that the traditional result of increased difficulty with increased complexity, used as support for the Bourne and Restle model of concept identification (1959), is primarily due to the effects of the changing attentional and memory requirements of the concept learning task. That is, the common finding of more inefficient performance (i.e., more errors, longer time to solution) with increased stimulus complexity is associated with the increased load or demand placed on the _S_'s memory and attentional processes. It was hypothesized that:

4. _In the no cues available condition, more inefficient performance will occur with increases in stimulus complexity, following the Bourne and Restle prediction (1959). However, with the specific instance cue and general focusing cue conditions this trend of increasingly more inefficient performance with increased stimulus complexity will be eliminated or considerably lessened._

Another major purpose of the present study was to investigate the relationship of memory and attentional aids to *S*'s educational grade level. While there is evidence that general conceptual development improved with age (e.g., Osler and Kofsky, 1965) and that memory abilities and the ability to focus or selectively attend improve with age (e.g., Inglis, Ankus and Sykes, 1968; Ginsburg, 1967), the relationship between attention, memory and conceptual performance in regard to age differences has not received adequate research attention. Following the general trend of improvement in conceptual abilities with age it was predicted that:

5. *For tasks of equal complexity levels, performance on the concept learning task will improve with grade level; and, for Ss within the same grade level, performance will become more inefficient with increases in task complexity.*

Also, as the older *Ss* have been noted to have the advantage over the younger *Ss* in memory and attentional abilities, it was suggested that the use of cues representing these functions would not offer as much additional information to the older *Ss* as these cues would for the younger *Ss*. It was thus expected that:

6. *The use of the specific instance cue and general focusing cue conditions will improve the performance of the lower grade level Ss more than that of the higher grade level Ss on concept learning tasks of comparable complexity levels. That is, the difference in the performance levels of the no cue condition and the two cues-available conditions will be greater for the younger Ss than for the older Ss.*

It was hypothesized earlier that both the specific instance cue and general focusing cue conditions would lead to better performance than the no cues available condition (Hypothesis 1) and that the general focusing cue condition would offer an initial advantage over the specific instance cue condition and thus lead to somewhat better overall performance (Hypothesis 2). In relation to any possible age or grade level differences with these two types of cues, the author is not aware of any evidence indicating that there would be any change in the interrelationship of these cues as a function of grade, and thus it was hypothesized that:

7. The general focusing cue condition will elicit more efficient performance than the specific instance cue condition for all grade level groups.

A few of the studies that were previously mentioned (Pishkin, Wolfgang and Rasmussen, 1967; Pishkin and Rosenbluh, 1966; Tyler, 1965; Archer, 1962; Wolfgang, 1967b) found some interactions of their experimental variables with sex in concept identification performance which could possibly be interpreted in terms of differential abilities of the two sexes in memory and attentional functions. As a supplementary and exploratory part of the present study, the oldest grade group (7th through 9th grades) was replicated for both sexes.

Most studies in concept learning have used only one dependent variable, that of number of errors made prior to solution. The present study looked at performance in terms of three dependent variables: 1) number of errors made prior to solution, 2) time required to reach solution, and 3) rate of responding, a derived measure of the average number of responses (correct and incorrect) made per minute. The purpose of obtaining these three measures was to determine their interrelationship and to investigate any possible differential sensitivities of these measures to the utilization of memory and attentional cues.

CHAPTER IV

METHOD

Subjects

The subjects for this study were 180 males from the four-year-old preschool through the ninth grade classes, and 45 females from the seventh through ninth grade classes at Casady School in Oklahoma City, Oklahoma. The Ss were divided into four grade level groups, such that the first group consisted of 45 students from the four-year-old preschool and kindergarten classes (called Group P hereafter); the second group was composed of 45 students from grades 1, 2 or 3 (Group 2); the third group consisted of 45 students from grades 4, 5 and 6 (Group 5); and the fourth group was composed of students from grades 7, 8 and 9 (Group 8). Group 8 had 45 males (Group 8M) and 45 females (Group 8F); the female Ss were part of the supplementary study. With the restriction that an equal number of Ss from each grade level be assigned to each complexity and cue condition, the Ss were randomly assigned to the cells of the design with five Ss per cell.

Design

The experiment was basically a 4 x 3 x 3 factorial design with a replication for sex in Group 8. The variables were: the four grade level groupings, three conditions of cue availability, and three levels of stimulus complexity within each grade group. In addition, two problems were used to aid in eliminating the effect of spread of information about the task among the Ss. The three conditions of cue availability (CA) were: 1) last specific correct instance left exposed within each category (the specific cue condition or SC condition), 2) the levels of the relevant dimension were shown to the S and left exposed throughout the task (the general focusing cue condition or GC condition), and 3) no cues available for the S (the NC condition). Within each grade level group, problems of three stimulus complexity levels were presented to the Ss. Because of the grade range within each group and the trends of improvement in concept learning with age (Osler and Kofsky, 1965) the stimulus complexity levels overlapped the grade groups. In the design these levels are labeled low, middle, and high complexity, but, as can be seen in Table 1, the specific stimulus complexity levels varied with the grade grouping. The two problems used were shape as the relevant dimension and color as the relevant dimension; approximately one-half of the Ss within each cell of the design worked on each problem type.

Table 1

Stimulus Complexity Levels Within Grade Groups
(Number of Irrelevant Dimensions)

	Pooled Complexity Level		
Grade Group	Low	Middle	High
P	1	2	3
2	2	3	4
5	3	4	5
8	4	5	6
Median Complexity	2.5	3.5	4.5

Materials and Procedure

The subject's task was to sort geometric patterns on white 3 x 5 inch cards into two slots of a wood sorting tray placed in front of the subject. A separate deck of 96 cards was used for each stimulus complexity level. The cards within each deck were arranged in a random order with the restriction that the same pattern could not immediately follow itself. All the dimensions of the stimuli were binary. The relevant dimension was shape (square and triangle) for one-half of the Ss and color (red and blue) for the other half of the Ss. The other five dimensions, added progressively as the complexity level increased were: size (1" and 1/2" in vertical height), number (one or two patterns on the card), horizontal position (pattern on left or right side of the card with the center of the pattern being 1 1/2" from the corresponding edge), vertical position (pattern on top or bottom of the card with the center of the pattern being 1" from the corresponding edge), and orientation (pattern tilted or in its normal position; in the tilted position the squares were rotated 45° thus appearing as diamonds and the triangles were rotated 180° thus appearing as inverted triangles).

The Ss sat at a table opposite from the experimenter with the 2-slot card-sorting tray in front of S. A card file containing the deck of cards was next to the tray. The Ss were instructed that their task was to sort the cards into the two slots and that the E would tell them whether they were right or wrong after each choice (See Appendix I for the verbatim instructions). The Ss were further instructed that when they were wrong, they were to place the card in the correct slot before continuing (i.e., corrective feedback). Ss in the no cue (NC) condition were told to place the cards face down (pattern not showing) in the correct slot; Ss in the specific instance cue (SC) condition were told to place the cards face up (pattern showing) in the correct slot. Each new card placed in the slots covered the past cards so that only one past correct instance was visible within each category. In the general cue (GC) condition, the Ss were instructed to place the cards face down in the correct slot; in addition, at the end of the instructions, these Ss were shown cards depicting the levels of the relevant dimension (for shape relevant, cards with a black outline of a square and a black outline of a triangle were presented; for color relevant, cards covered with red and blue construction paper were presented). The GC condition Ss were informed only that this was one of the ways in which the cards he would see would differ from each other. No verbal labels were given to these cards by E. The cards remained face up on the table near the wood tray throughout the task.

The Ss worked on the task until they had made 16 consecutive correct responses or until they had gone through all 96 cards in the deck. The Ss worked on the task at their own pace.

CHAPTER V

RESULTS

Upon inspection of the cell variances of the error and time to solution scores for the four grade groups, it was noted that there was a large discrepancy between two indices of homogeneity of variance. The Hartley F_{max} test (Winer, 1962) showed generally large heterogenity of variance while the Cochran C test (Winer, 1962) did not. The comparisons between these two indices were comparable for the rate of response measure, generally showing homogeneity of variance. The values and probability levels for these tests are reported in Table 2.

Closer inspection of the data indicated that this discrepancy was probably due more to the presence of positive skewness of the score distributions than to heterogeneity of variance. Both of these tests are considered to be oversensitive to departures from normality, but the Hartley F_{max} test would be particularly sensitive to skewed distributions as it uses range of sample variances as its index of homogeneity (Winer, 1962). While there is evidence that the F test is relatively insensitive to moderate departures from normality of distribution (Box, 1953), the above discrepancies led to the decision that a transformation of the scores would be advantageous because it was apparent that some of the cell distributions were skewed and others were not. Winer (1962)

Table 2

Heterogeneity of Variance Tests for Error, Time, and Rate of Responding Scores for each Grade Group

Grade Group	F_{max} test	p^a	Cochran C test	p^a
Error Scores				
P	835.9	.01	.2612	
2	664.3	.01	.299	
5	363.3	.01	.3385	
8 (M)	1162.3	.01	.6351	.01
8 (F)	40.7		.2306	
Time Scores				
P	371.6	.01	.3353	
2	525.5	.01	.3077	
5	530.13	.01	.6517	.01
8 (M)	1628.53	.01	.5264	.01
8 (F)	79.76	.05	.2233	
Rate of Responding				
P	8.06		.2163	
2	3.58		.2174	
5	11.30		.2587	
8 (M)	48.99	.05	.2016	
8 (F)	31.10		.5636	.01

[a] based on $k = 9$, $df = 4$.

has suggested that a log transformation of scores is appropriate when positive skewness exists. Thus, a log (x + 1) transformation was made on the error and time scores. The values of the homogeneity of variance tests computed on these scores are presented in Table 3. The comparisons between the Hartley F_{max} test and Cochran C test demonstrated reasonably close agreement for the transformed scores. This led to the conclusion that the assumption of homogeneity of variance was tenable as well as that of equality of the shape of the score distributions.

Table 3

Heterogeneity of Variance Test of Log Error and Log Time Scores for Each Grade Group

Grade Group	F_{max} test	p^a	Cochran C test	p^a
Log Error Scores				
P	14.28		.2311	
2	23.44		.2005	
5	9.49		.2602	
8 (M)	31.47		.2282	
8 (F)	5.07		.1824	
Log Time Scores				
P	46.94	.05	.2689	
2	69.66	.05	.3133	
5	26.57		.3857	
8 (M)	13.14		.3881	
8 (F)	36.68		.2060	

[a] based on k = 9, *df* = 4.

Analysis of Log Error Scores

To obtain an overall picture of the effect of the cue availability conditions across the age groups, the three complexity levels which increased in amount of irrelevant information with age were pooled into low, middle, and high complexity levels (Table 1). Only the data on the male subjects are considered in these first sections. The data for the supplementary study on possible sex differences are presented separately at the end of this chapter. A repeated measures analysis of variance on log (x + 1) errors disclosed that all of the main effects and several of the interactions were significant. The summary of this analysis is presented in Table 4.

In order to determine if the specific problem type (i.e, shape-relevant versus color-relevant) produced a significant source of variation in the study, *t*-tests were performed on the log error scores of the two problems within each grade group. The *t*-test results were: Group P, *t* = 0.22, 43 *df*; Group 2, *t* = 0.788, 43 *df*; Group 5, *t* = 0.106, 43 *df*; Group 8M, *t* = 0.628, 43 *df*. None of these *t* values approached significance. It can be stated that the two types of problems were not significant sources of variation and that *Ss* performed equally well on either type of problem. Therefore, all subsequent analyses are based on the pooled data of both problems.

In spite of the increasing complexity levels with grade groups, the mean log errors decreased significantly with grade (*F* = 3.61, 3/144 *df*, $p<.025$). The means for groups P through 8M were 2.22, 1.48, 1.39, and 0.96 respectively. This trend was essentially linear and

Table 4

Repeated Measures Analysis of Variance of Log (x + 1) Errors with Pooled Complexity Levels

Source	df	MS	F	p
Between Subjects				
Grade Level (G)	3	1.5499	3.61	.025
Linear	1	4.2324	9.86	.005
Quadratic	1	0.1319	0.31	
Cubic	1	0.2852	0.66	
Complexity (C)	2	2.4745	5.76	.005
Linear	1	4.9383	11.50	.005
Quadratic	1	0.0107	0.02	
Cue Availability (CA)	2	3.3681	7.84	.005
G x C	6	0.7703	1.79	
G x CA	6	0.3733	0.87	
C x CA	4	1.1044	2.57	.05
Linear	2	1.4026	3.27	.05
Quadratic	2	0.8063	1.88	
G x C x CA	12	0.4431	1.03	
Subjects within groups (Between subjects error term)	144	0.4295		
Within Subjects				
Blocks of Trials (B)	7	3.2580	130.22	.001
Linear	1	16.0115	201.15	.001
Quadratic	1	4.7025	139.91	.001

Table 4 (Continued)

Source	*df*	MS	*F*	*p*
Blocks of Trials (B)				
Cubic	1	1.4726	48.76	.001
Sum of other deviations	4	0.0610	7.82	.001
B x G	21	0.0447	1.79	.025
Linear	3	0.1222	1.54	
Quadratic	3	0.1457	4.21	.01
Cubic	3	0.0153	0.51	
Sum of other deviations	12	0.0074	0.95	
B x C	14	0.0259	1.03	
B x CA	14	0.0762	3.05	.005
Linear	2	0.2652	3.33	.05
Quadratic	2	0.1806	5.22	.01
Cubic	2	0.0739	2.45	
Sum of other deviations	8	0.0035	0.45	
B x G x C	42	0.0119	0.48	
B x G x CA	42	0.9247	0.98	
B x C x CA	28	0.0252	1.01	
B x G x C x CA	84	0.0193	0.77	
B/Subjects within groups (Within subjects error term)	1008	0.0250		
Linear	144	0.0796		
Quadratic	144	0.0346		
Cubic	144	0.0302		
Sum of other deviations	566	0.0078		

the slope significantly different from zero as shown by the significance of the linear components of the trend (F = 9.86, 1/144 df, $p<.005$), and in Figure 1. Applying Duncan's multiple range test (Duncan, 1955), the difference between groups 2 and 5 was not significant but all other comparisons among the grade groups were significant at .005 (144 df). Thus, group P had a significantly higher error rate than the other three groups, and Group 8M had a significantly lower error rate than Groups P, 2 and 5.

The main effect of Complexity was significant (F = 5.76, 2/144 df, $p<.005$), with mean log errors increasing with an increase in amount of stimulus complexity (0.92, 1.54 and 2.07 respectively for low, middle and high pooled complexity levels). This trend was also essentially linear and its slope significantly different from zero (F = 11.50, 1/144 df, $p<.005$). Subsequent testing with Duncan's multiple range test showed that all three levels of complexity were significantly different at the .001 level (144 df) (Figure 2).

The Cue Availability main effect was also significant (F = 7.84, 2/144 df, $p<.005$). The error rate was significantly reduced by the introduction of the specific instance cues ($\bar{x} = 1.20$) and the general focusing cues ($\bar{x} = 1.06$) as compared to the no cue condition ($\bar{x} = 2.28$) at the .001 level (Duncan's test, 144 df). The overall difference between the SC and GC conditions was not significant. These means are shown in Figure 3.

With the Complexity x Cue Availability interaction being significant (F = 2.57, 4/144 df, $p<.05$), the main effect of Complexity and main effect of Cue Availability need to be interpreted with caution.

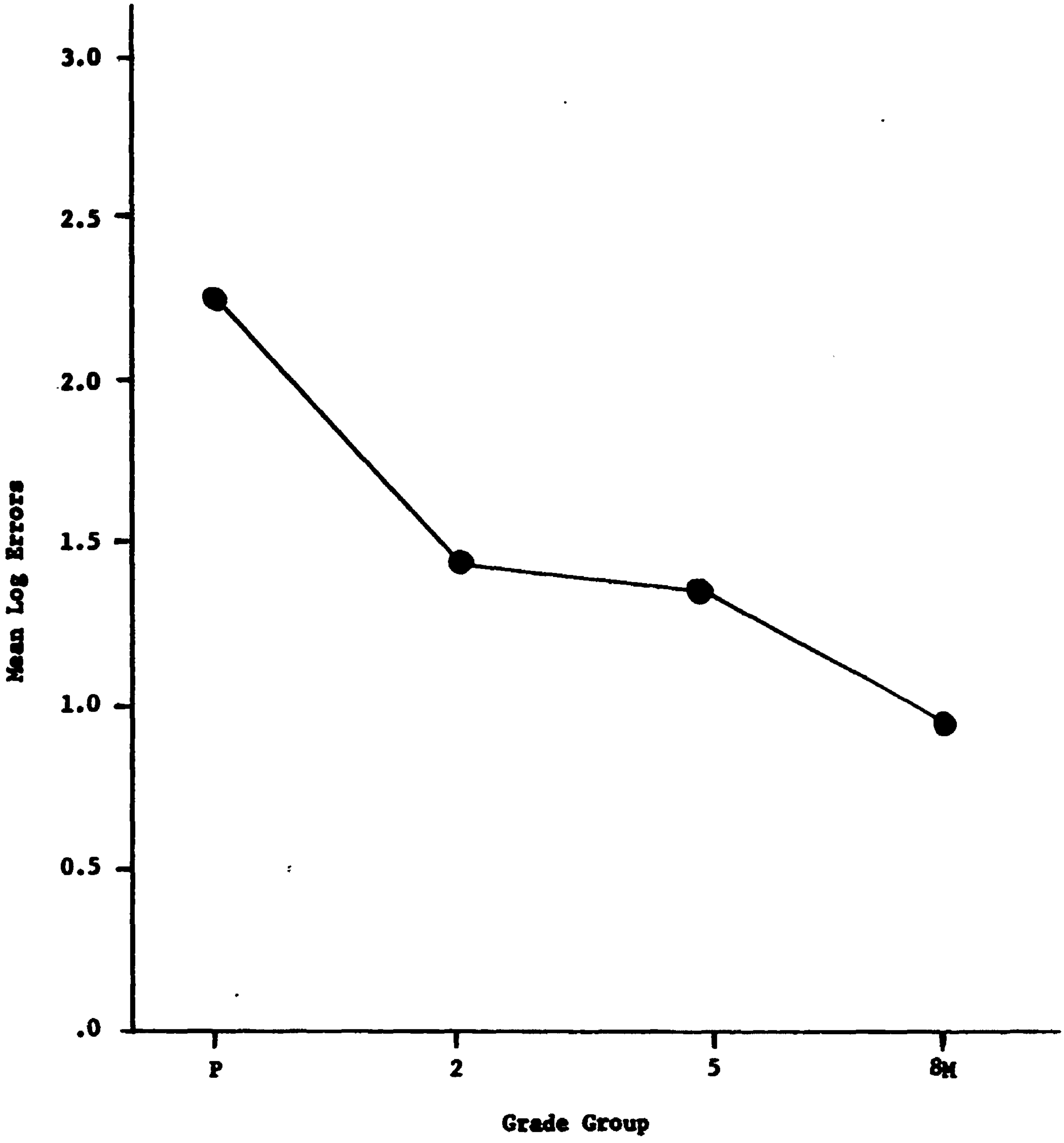


Fig. 1.--Mean log errors for the four grade groups.

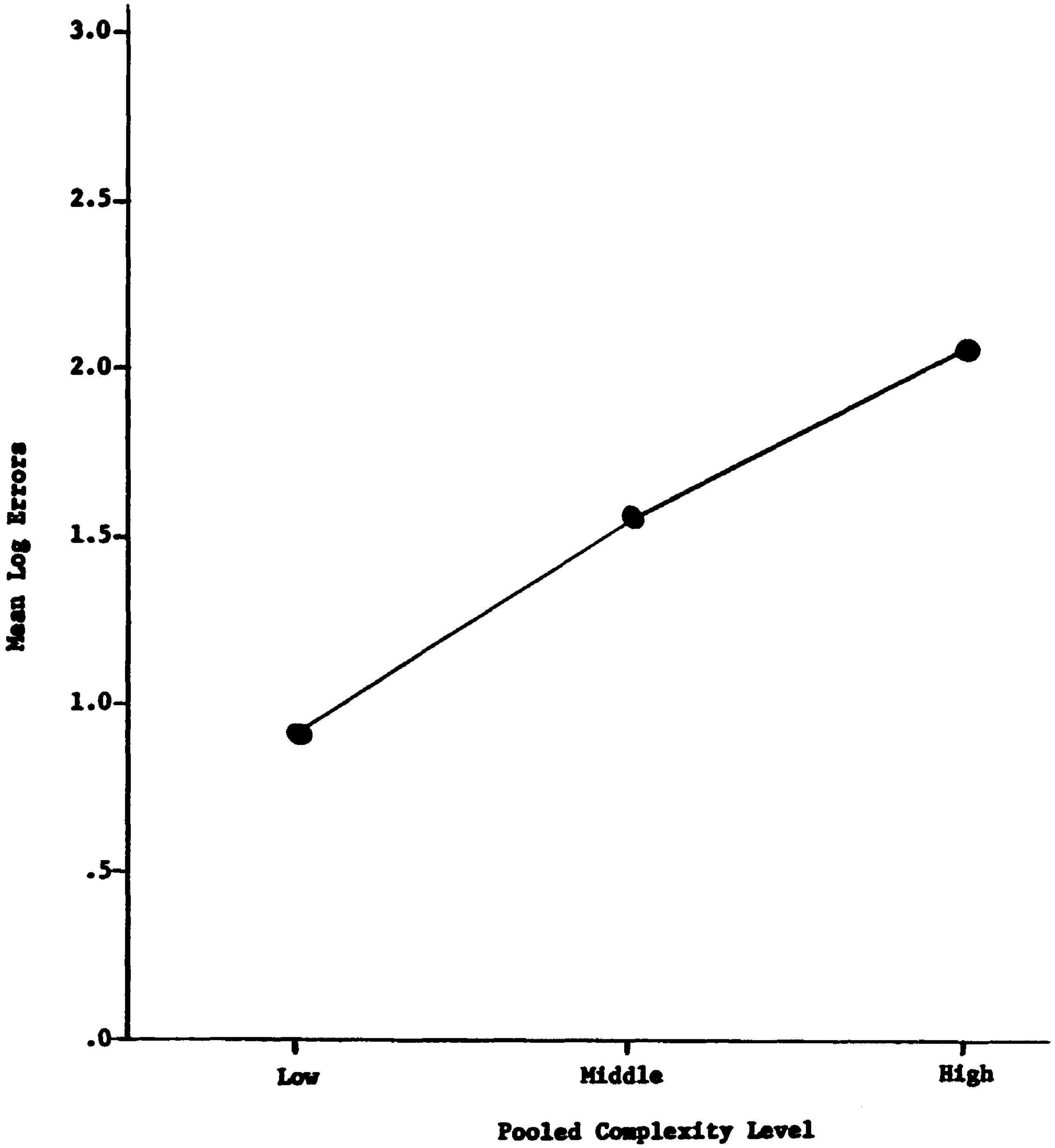


Fig. 2.--Mean log errors for the three pooled complexity levels.

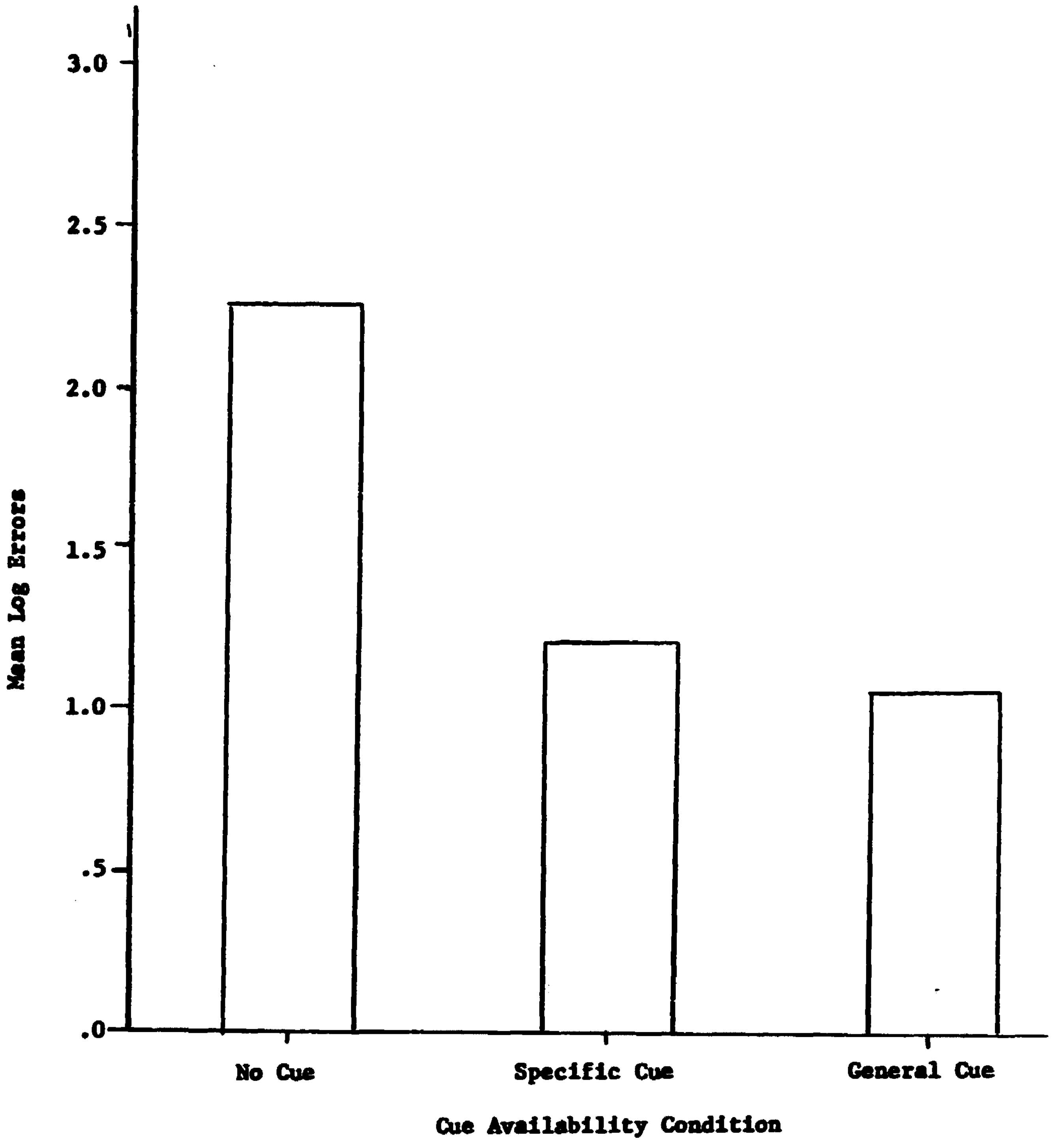


Fig. 3.--Mean log errors for the three cue availability conditions.

This interaction is shown in Figure 4. To clarify what occurred within this interaction, simple effects analyses of variance (Winer, 1962) were performed (Tables 5 and 6).

The simple effects analysis of Cue Availability (Table 5) shows that the cue availability conditions were not a significant source of variation for low complexity levels ($\underline{F}$ = 0.06, 2/144 $\underline{df}$, $\underline{p}$>10), but that the cue availability conditions were a significant source of variation for the middle and high complexity levels. This is further borne out by Duncan's test which showed no significant differences among cue conditions at low complexity ($\underline{p}$ = .05, 144 $\underline{df}$); at the middle complexity level the GC and SC conditions were not significantly different from each other, but both produced significantly fewer mean log errors than the NC condition ($\underline{p}$ = .001, 144 $\underline{df}$). At the high complexity level, all three cue availability conditions were significantly different at the .01 level with the highest error rate occurring in the NC condition and the lowest error rate occurring in the GC condition. Thus, at the middle and high complexity levels significantly fewer errors (i.e., better performance) were elicited by the use of either the SC or GC condition as compared to the condition of no cues available; however, in the highest complexity levels used in this study, the general focusing cue became more effective (i.e. fewer errors) than the specific cue condition (Figure 4).

Looking at the Cue Availability x Complexity interaction in another way, the simple effects analysis of variance for Stimulus Complexity (Table 6) shows that the effect of variation in complexity level was a significant factor only for the NC condition ($\underline{F}$ = 8.86,

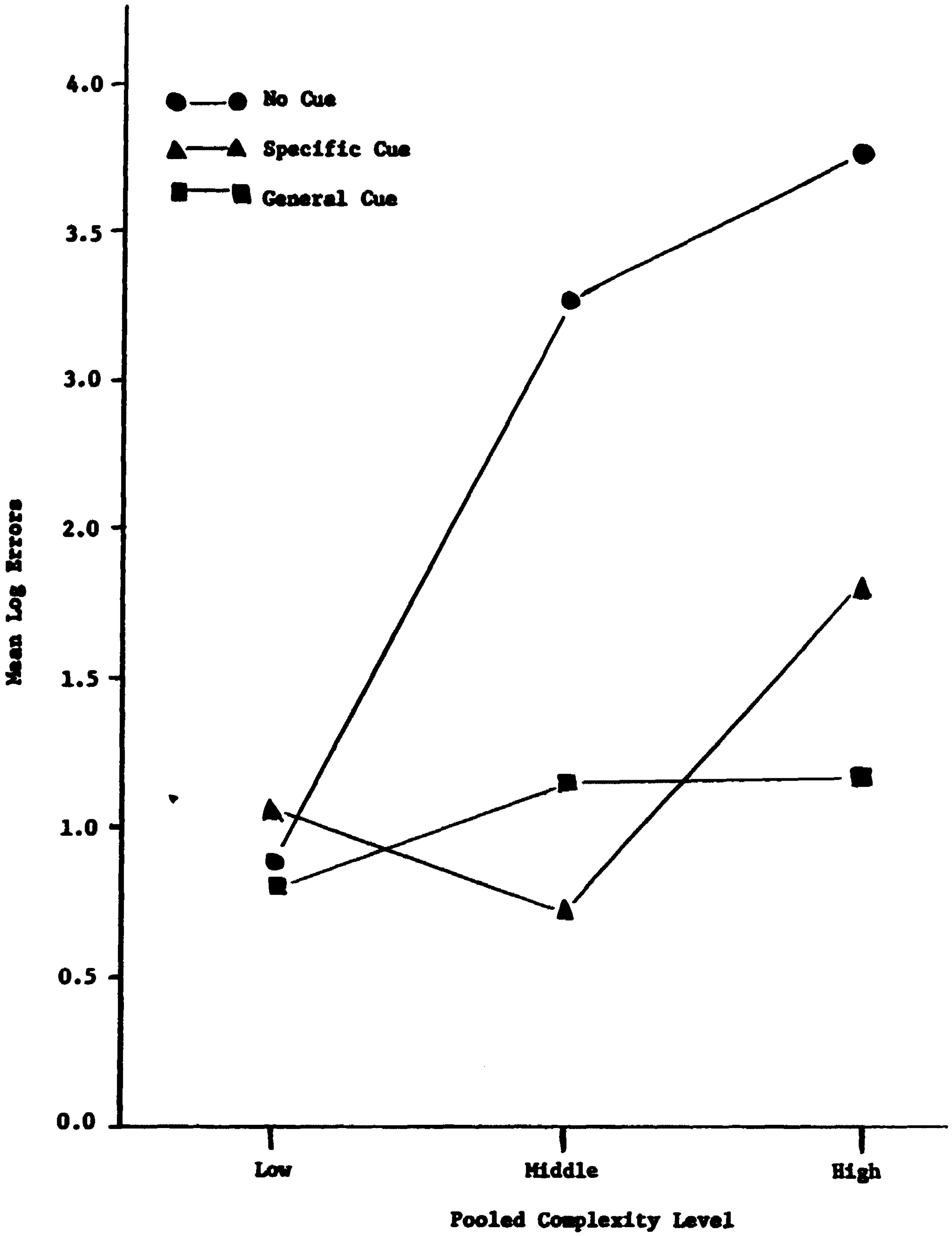


Fig. 4.--Mean log errors for the cue availability conditions as a function of pooled complexity level.

Table 5

Log Errors Simple Effects Analysis of Variance on Cue Availability (CA)

Source	df	MS	F	p
CA for Low Complexity	2	0.0273	0.06	
CA for Middle Complexity	2	2.7667	6.44	.005
CA for High Complexity	2	2.7830	6.48	.005
Within (Error)	144	0.4205		

Table 6

Log Errors Simple Effects Analysis of Variance on Stimulus Complexity (SC)

Source	df	MS	F	p
Complexity for NC	2	3.8056	8.86	.005
Complexity for SC	2	0.7890	1.84	
Complexity for GC	2	0.1182	0.28	
Within (Error)	144	0.4295		

2/144 df, $p < .005$). Complexity level did not significantly change the overall performance levels when the SC and GC conditions were used. Duncan's test disclosed that, for the NC condition, the performance levels at low and middle complexity levels were significantly different at .01 but not at .001; high complexity level performance was significantly different from low and middle complexity performance at .001 (144 df). While the overall effect of complexity on SC condition performance was not significant ($F = 1.84$, 2/144 df, $p < .10$), Duncan's test revealed that there were significantly more log errors in the high complexity condition than in the middle complexity condition ($p = .01$, 144 df). In the GC condition there were no significant differences between complexity levels. These simple effects analyses of variance were also supported by the significance of the linear trend component in the Complexity x Cue Availability interaction ($F = 3.27$, 2/144 df, $p < .05$), showing significant differences in the slopes of the trends for the cue availability conditions across complexity levels (Table 4, Figure 4).

Hypothesis 1 (p. 19) stated that a Grade Group x Cue Availability interaction would occur, i.e. that the difference in performance levels for the different types of cues would decrease with increasing grade group. In other words, the prediction was that the largest difference in performance on the different cue condition would occur in the lowest grade group, and that in the highest grade group only small differences would exist among the cue conditions. This interaction was not significant ($F = 0.87$, 6/144 df, $p > .10$, Table 4). The results are shown in Figure 5. Subsequent t-tests between pairs of cue conditions within each grade group were performed and are presented in Table 7. These

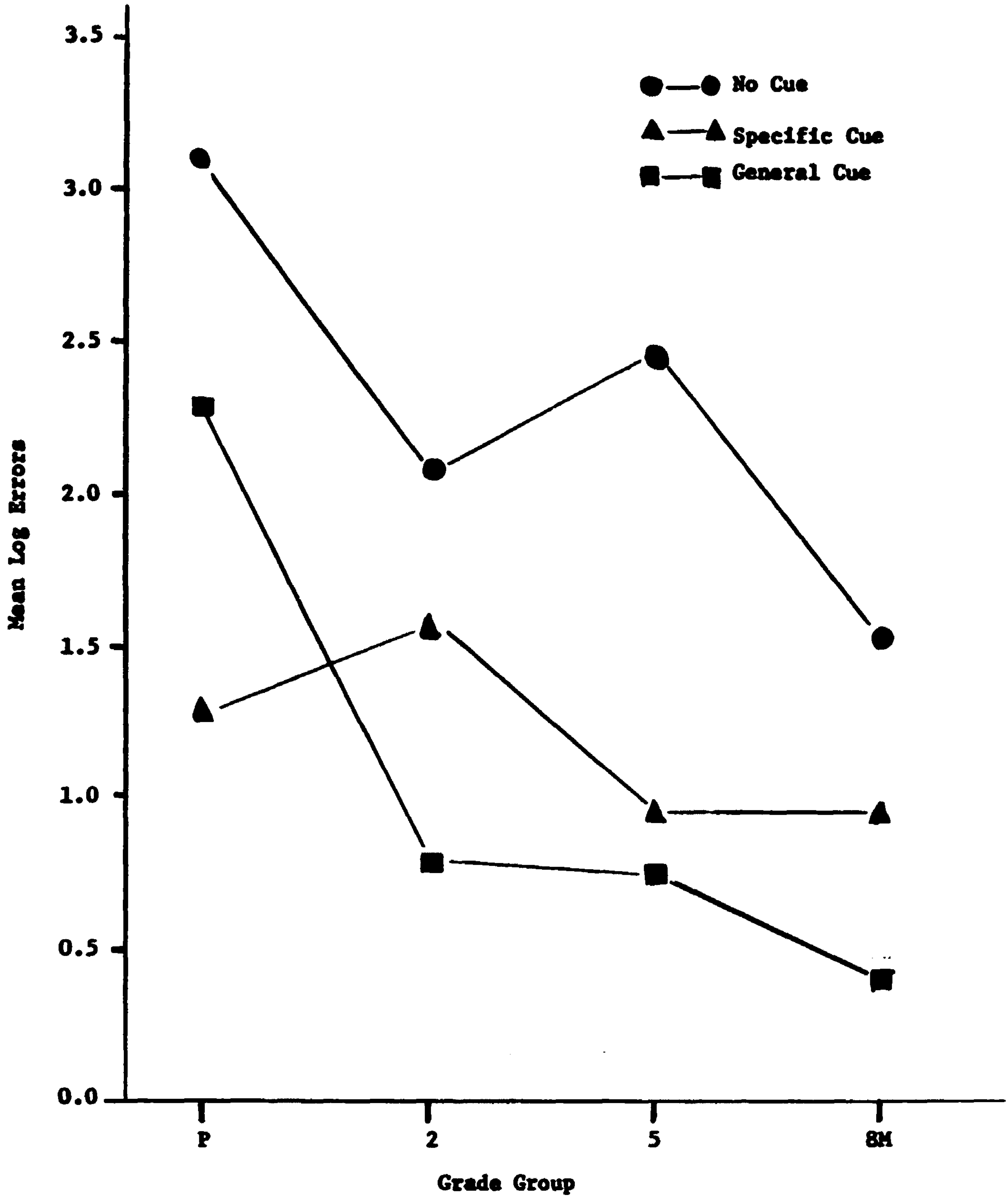


Fig. 5.--Mean log errors for cue availability conditions for each grade group.

Table 7

Summary of t Tests between Cue Availability Conditions Within Each Grade Group for Log Error Scores

Cue Availability Comparisons	Grade Group	t	p^a
No Cue vs. Specific Cue	P	2.178	.025
	2	0.569	
	5	1.92	.05
	8M	1.188	
No Cue vs. General Cue	P	0.769	
	2	1.813	.05
	5	2.00	.05
	8M	2.427	.025
Specific Cue vs. General Cue	P	-1.148	
	2	1.230	
	5	0.440	
	8M	3.005	.005

[a] $df = 28$; all probability levels are based on one-tailed tests.

tests showed that for grade groups 2, 5 and 8M the GC condition elicited significantly fewer log errors than did the NC condition ($t = 1.813$, $p < .05$; $t = 2.00$, $p < .05$; $t = 2.427$, $p < .025$, all 28 df). For group P the SC condition was easier than the NC condition ($t = 2.178$, 28 df, $p < .025$). Only in grade group 8M did the difference between the SC and GC conditions become significant ($t = 3.005$, 28 df, $p < .005$). Thus contrary to expectations, the cue conditions, particularly the GC condition, continued to facilitate performance with increasing grade group. It is of special interest to note here that for the lowest grade group the specific instance cue, not the general focusing cue, was the most facilitative (Figure 5).

The main effect of Blocks of trials (based on units of 12 successive trials) was highly significant as expected (F = 130.22, 7/1008 df, $p<.001$) with mean log errors decreasing as a function of blocks of trials (Figure 6). The largest decrease in mean log errors occurred between the first and second blocks of trials, with the decrease then becoming more gradual. The linear, quadratic and cubic components of this main effect were significant (Table 4), indicating that the decrease in error rate across blocks of trials becomes less with each block, as described above.

The Blocks of trials x Grade Group interaction was also significant (F = 1.79,, 21/1008 df, $p<.025$). This is presented in Figure 7. It should be recalled that the specific complexity levels increased with grade groups. While all four grade groups performed at about the same level on block 1, the distinction among the grade groups became noticeable on blocks 2 and 3, with group P eliciting the highest error rate across blocks, and group 8M showing the lowest error rate. Groups 2 and 5 performed about equally across blocks of trials intermediate to grade P and 8M. The linear slopes of the trends for the four grade groups were not significantly different as indicated by the non-significance of the linear component of this interaction (F = 1.54, 3/144 df). However, the curves for the grade groups were different in the quadratic trend (F = 4.21, 3/144 df, $p<.01$) indicating that the rate of decrease in mean log errors across blocks of trials became more gradual at different points and at different rates for the four groups. In Figure 7 this is shown by the rapid decrease in errors of group 8M and by the

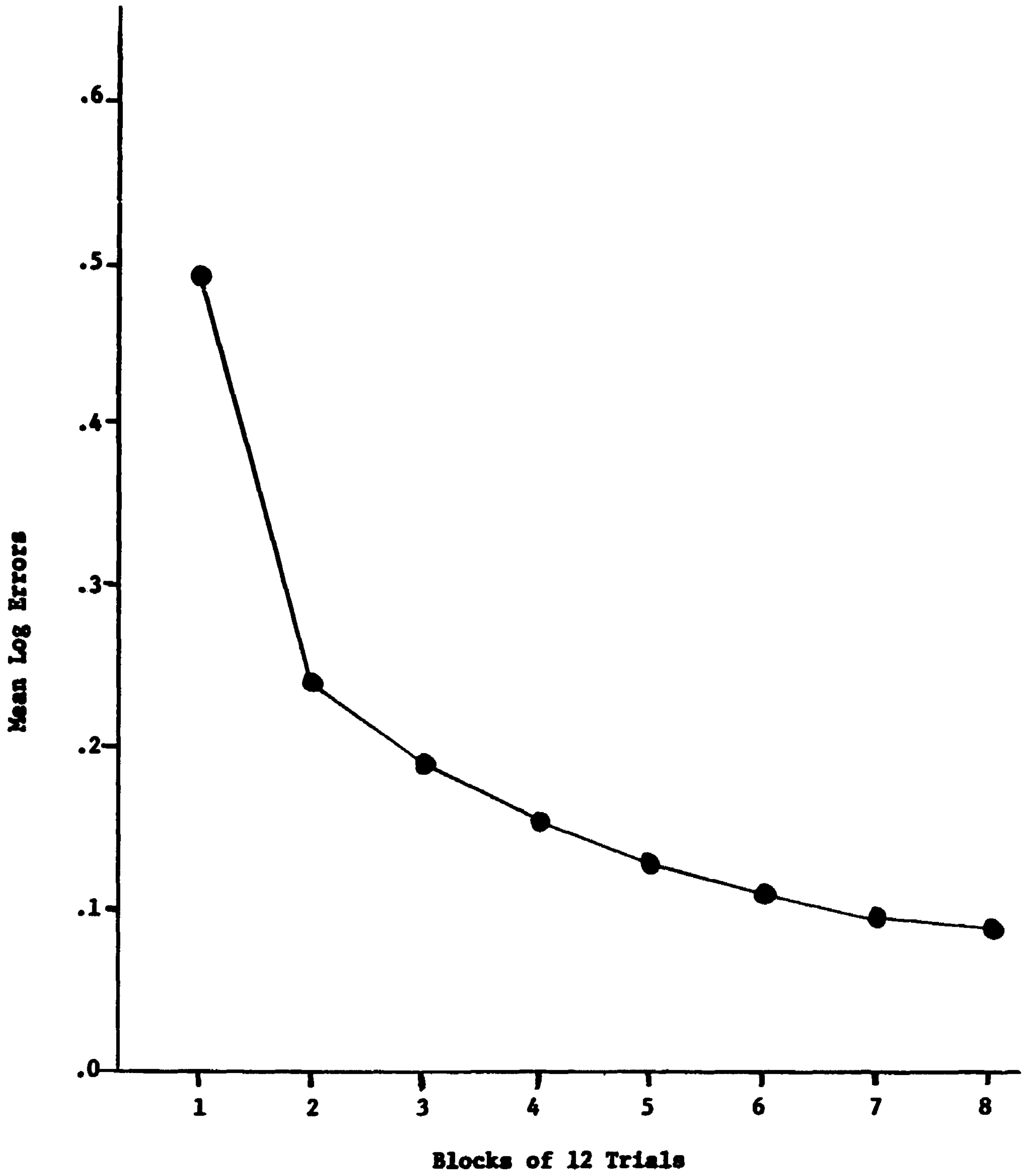


Fig. 6.—Mean log errors for each block of 12 trials.

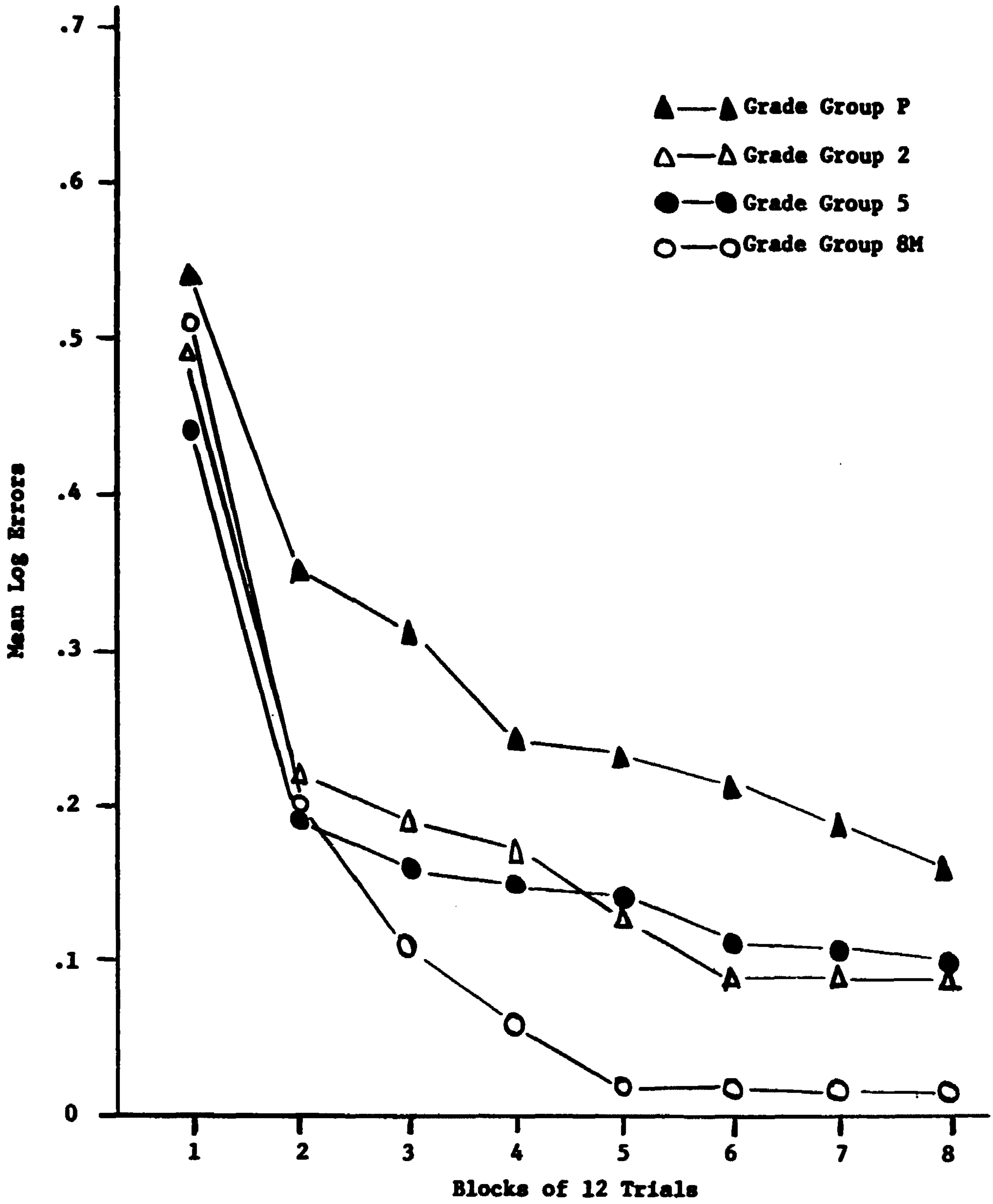


Fig. 7.—Mean log errors across blocks of 12 trials for the four grade groups.

slower decrease in errors by group P across blocks of trials.

The significance of the Blocks of trials x Cue Availability interaction ($\underline{F} = 3.05$, 14/1008 $\underline{df}$, $\underline{p} < .005$) showed the effectiveness of the SC and GC conditions in reducing error rate across blocks of trials. This interaction is shown in Figure 8. The comparison among the cue conditions on the first 2 blocks of trials is of particular interest. Subsequent tests on this interaction (Duncan's multiple range test) indicated that on the first block of 12 trials the NC and SC conditions did not lead to differences in performance but that both of these cue conditions produced a significantly higher error rate than did the GC condition ($\underline{p} = .001$, 1008 $\underline{df}$). Thus the GC condition showed a more immediate facilitative effect, in terms of a lower error rate, than the SC condition. On the second block of trials, however, the SC and GC were equally effective with no significant difference in these two performance levels. Both the GC and SC conditions led to significantly fewer errors than the NC condition on the second block ($\underline{p} = .001$, 1008 $\underline{df}$). The trends across blocks of trials for the three cue availability conditions differed in both slope of linear trend ($\underline{F} = 3.33$, 2/144 $\underline{df}$, $\underline{p} < .05$) and in quadratic curvature ($\underline{F} = 5.22$, 2/144 $\underline{df}$, $\underline{p} < .01$) thus supporting the above results that the three cue availability conditions elicited different amounts of initial error (block 1), and that the amount of decrease in errors following block 2 was different for the three cue availability conditions.

The analysis that has just been presented on log error scores was obtained by pooling the complexity levels across grade groups. To obtain a clearer picture of what happened in terms of

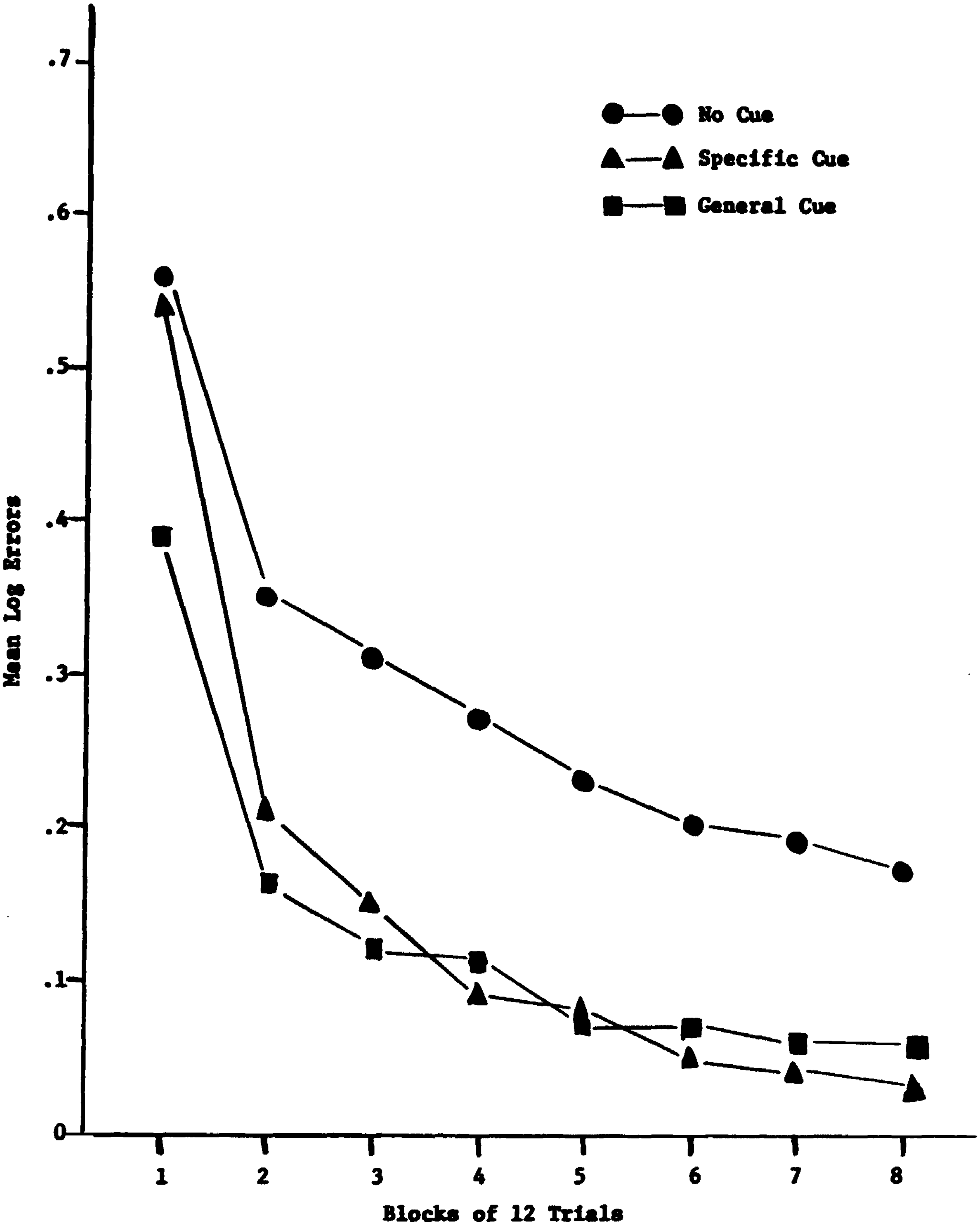


Fig. 8.—Mean log errors across blocks of 12 trials for the three cue availability conditions.

specific complexity levels, additional analyses were needed. These are presented in two ways: analysis on the individual grade groups and analysis on the individual specific complexity levels.

The summaries of the analyses of variance on the individual grade groups are presented in Tables 8, 9, 10 and 11. The main effect of Complexity reached significance only for group P ($F = 4.27$, 2/30 df, $p > .05$) and approached significance in group 5 ($F = 3.00$, 2/36 df, $p < .10$). What happened as a function of specific complexity levels for all grade groups is shown graphically in Figure 9. For group P (preschool kindergarten children) the difference between the one and three irrelevant dimensions problems was significant at the .05 level, but the differences between the one and two irrelevant dimensions and two and three irrelevant dimensions problems were not significant (Duncan's multiple range test, 36 df). For group 2, while the expected trend with complexity occurred, the overall effect of Complexity was not significant ($F = 1.22$, 2/36 df, $p > .10$) there was little difference between the two and three irrelevant dimensions problems while the four irrelevant dimensions problems was more difficult. For group 5, the expected trend of complexity approached significance ($F = 3.00$ 2/36 df, $p < .10$). The trend for group 8M was in the opposite direction than expected (i.e. decrease in error rate with increased complexity), but this effect was not significant ($F = 0.73$, 2/36 df). However, this trend indicates that the additivity of cue assumption (i.e., more stimulus cues make the task more difficult) is either not operating for this grade group or that the particular dimensions added as irrelevant cues for this group do not act as distracting irrelevant cues. It is suspected that the latter is the case.

Table 8

Grade Group P: Analysis of Variance on Log Errors

Source	*df*	MS	*F*	*p*
Between Subjects				
Complexity (C)	2	2.7903	4.27	.05
Cue Availability (CA)	2	1.5051	2.31	
C x CA	4	0.6939	1.06	
Within (Error between *S*s)	36	0.6527		
Within Subjects				
Blocks of Trials (B)	7	0.6817	2.75	.01
B x C	14	0.0243	0.98	
B x CA	14	0.0157	0.63	
B x C x CA	28	0.9323	1.30	
Within (Error within *S*s)	252	0.0248		

Table 9

Grade Group 2: Analysis of Variance on Log Errors

Source	*df*	MS	*F*	*p*
Between Subjects				
Complexity (C)	2	0.5878	1.22	
Cue Availability (CA)	2	0.7884	1.64	
C x CA	4	0.8798	1.83	
Within (Error between *S*s)	36	0.4805		
Within Subjects				
Blocks of Trials (B)	7	0.8937	2.80	.01
B x C	14	0.0119	0.41	
B x C	14	0.0037	0.01	
B x C x CA	28	0.0216	0.75	
Within (Error within *S*s)	252	0.0287		

Table 10

Grade Group 5: Analysis of Variance on Log Errors

Source	*df*	MS	*F*	*p*
Between Subjects				
Complexity (C)	2	1.2962	3.00	(.10)
Cue Availability (CA)	2	1.6366	3.79	.05
C x CA	4	0.7442	1.72	
Within (Error between *S*s)	36	0.4321		
Within Subject				
Blocks of Trials (B)	7	0.5787	25.76	.001
B x C	14	0.0176	0.78	
B x CA	14	0.0789	3.51	.01
B x C x CA	28	0.0149	0.66	
Within (Error within *S*s)	252	0.0225		

Table 11

Grade Group 8M: Analysis of Variance on Log Errors

Source	*df*	MS	*F*	*p*
Between Subjects				
Complexity (C)	2	0.1114	0.73	
Cue Availability (CA)	2	0.5579	3.66	.025
C x CA	4	0.1158	0.76	
Within (Error between *S*s)	36	0.1526		
Within Subjects				
Blocks of Trials (B)	7	1.3281	55.12	.001
B x C	14	0.0078	0.32	
B x CA	14	0.0518	2.15	.01
B x C x CA	28	0.0142	0.59	
Within (Error within *S*s)	252	0.0241		

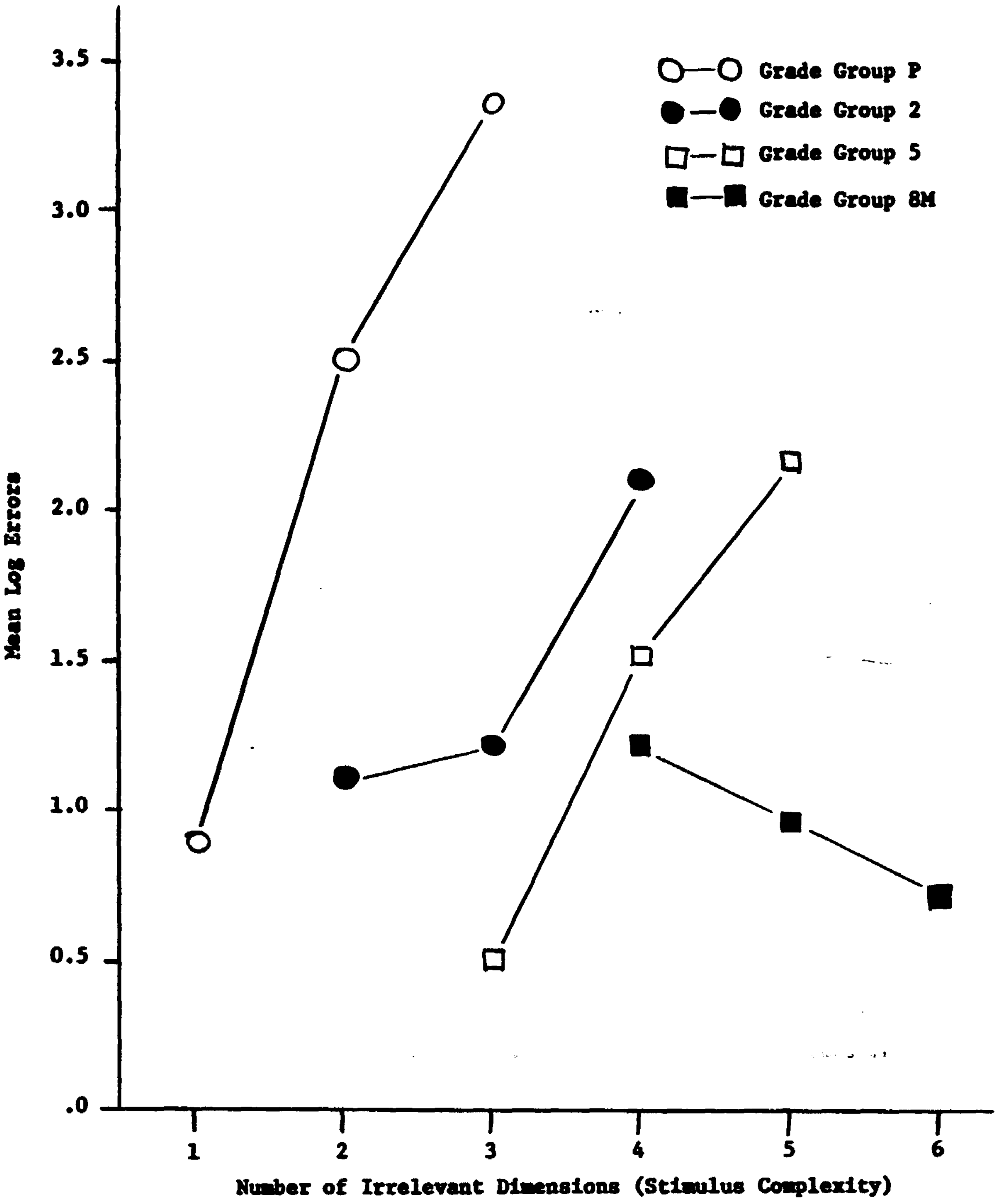


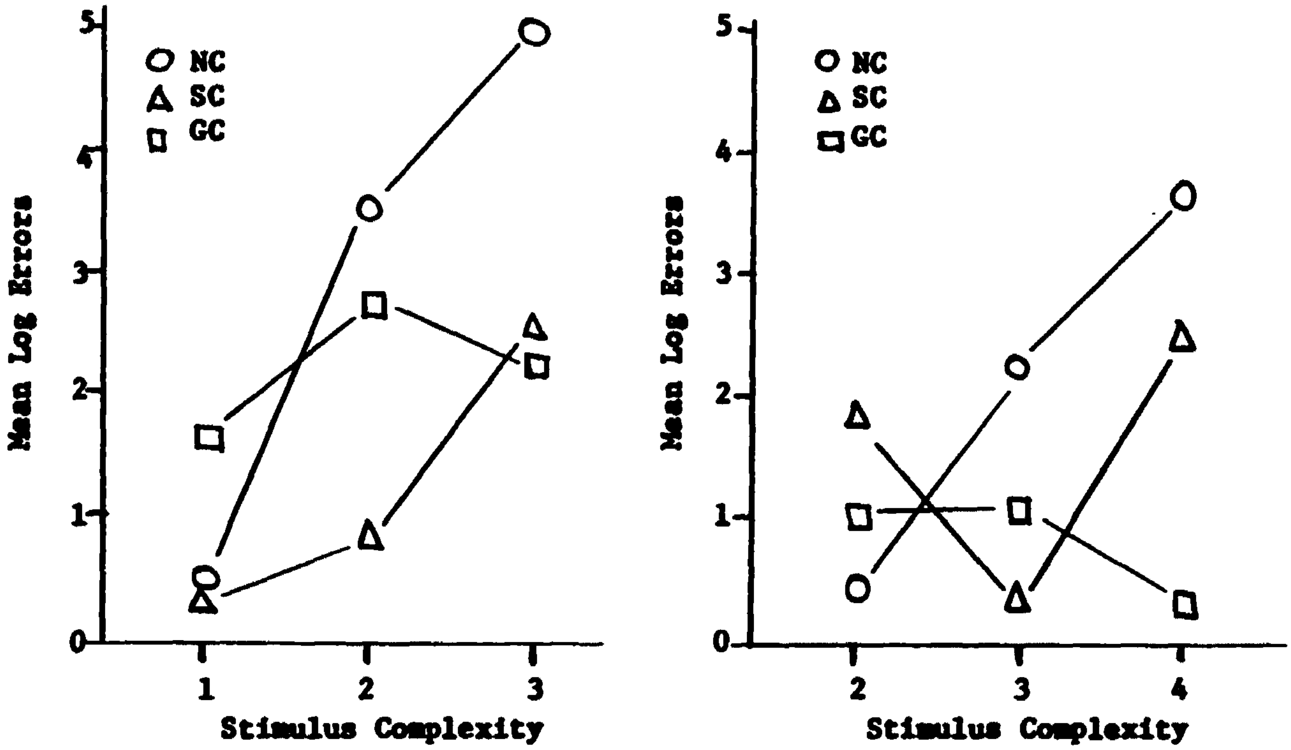
Fig. 9.--Mean log errors for specific complexity level problems for all grade groups.

The effect of the cue availability conditions for the individual grade groups has already been presented in terms of the Grade x Cue Availability interaction of the overall log errors analysis (Figure 5 and Table 7). While those results showed that the GC condition elicited the best performance for grade groups 2, 5, and 8M, and the SC condition gave the best performance for grade group P, the individual grade group analyses showed that the main effect of Cue Availability was significant only for grade groups 5 ($\underline{F} = 3.79$, 2/36 df, $\underline{p}<.05$) and 8M ($\underline{F} = 3.66$, 2/36 df, $\underline{p}<.025$). Thus, contrary to expectations (Hypothesis 6, p. 22), the cue availability conditions produced more distinct patterns of performance (i.e., less variability in amount of error) for the higher grade groups than for the lower grade groups.

The Complexity x Cue Availability interactions were not significant for any of the individual grade groups. The interaction for each grade group is shown in Figure 10.

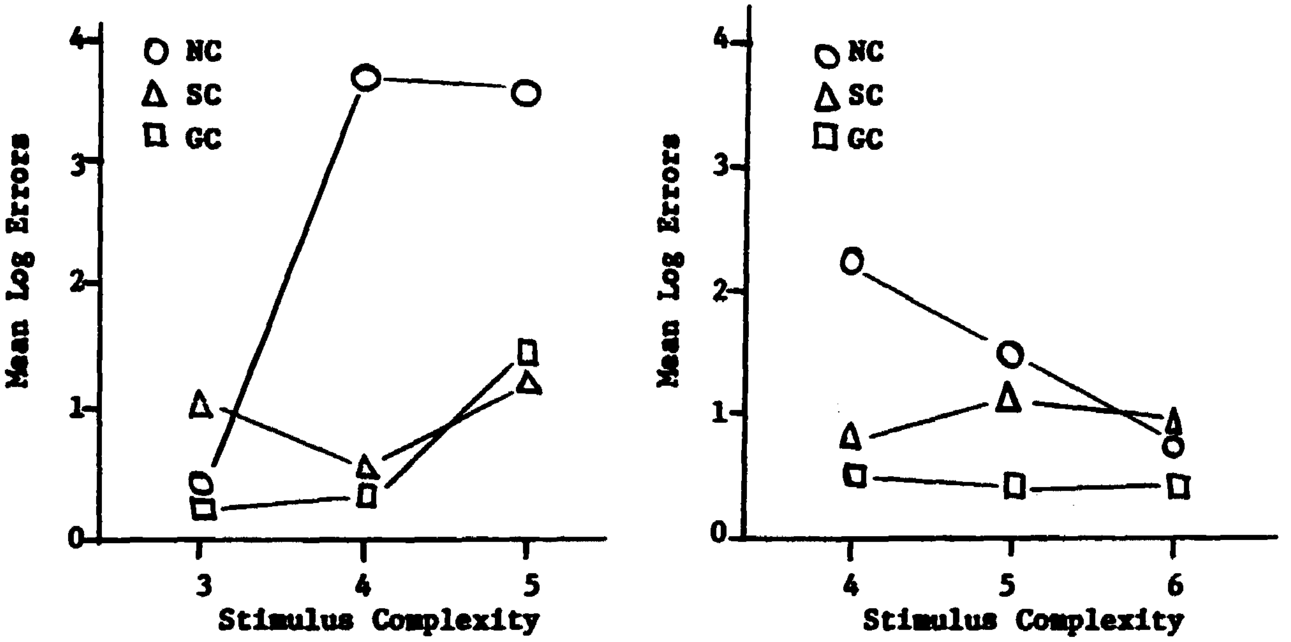
The Blocks of trials main effect was significant for all grade groups ($\underline{F}$'s = 2.75, 2.80, 25.76, 55.12; all 7/252 df, $\underline{p}<.01$), reflecting the significant grade x Blocks interaction in the overall analysis (Figure 7). Thus for all grade groups there was a significant decrease in error rate across blocks of trials.

For grade groups 5 and 8M the Blocks of trials x Cue Availability interactions were significant ($\underline{F}$'s = 3.51 and 2.15 respectively, both 14/252 df, $\underline{p}<.01$). The trends in these interactions follow those in the Blocks of trials x Cue Availability interaction in the overall analysis, in that the GC condition initially elicited a lower number of mean log errors and that the NC condition elicited a more gradual



A. Grade Group P

B. Grade Group 2



C. Grade Group 5

D. Grade Group 8M

Fig. 10.--Mean log errors for each complexity and cue availability condition for each grade group (NC = No Cue; SC = Specific Cue; GC = General Cue).

decrease in error rate than did the other two cue availability conditions.

Thus, in terms of the individual grade groups, the overall trends of the pooled complexity analysis are supported but not always at a significant level. In terms of specific complexity levels, performance differences were significant only for grade group P, with the trends in grade groups 2 and 5 in the expected direction. For grade group 8M, the trend was opposite to the trends in the other groups. The main effect of Cue Availability became significant for grade groups 5 and 8M, but not for grade groups P and 2.

To complete the picture of what occurred in terms of the specific complexity levels, analyses were performed on each specific complexity level. These appear in Tables 12, 13, 14 and 15. The influence of grade grouping on specific complexity level performance was significant only for the three irrelevant dimensions problem ($\underline{F} = 9.50$, 2/36 $\underline{df}$, $\underline{p}<.005$) and approached significance for the two irrelevant dimensions problem ($\underline{F} = 3.14$, 1/24 $\underline{df}$, $\underline{p}<.10$). These differences can be seen in Figure 9. For all the specific complexity level problems the hypothesized trend is seen (Hypothesis 5, p. 22), with the higher grade groups working on each problem showing better performance (decreased error rate) than the lower grade groups.

The main effect of Cue Availability was significant only for the four irrelevant dimensions problem ($\underline{F} = 7.52$, 2/36 $\underline{df}$, $\underline{p}<.005$) with the NC condition eliciting the highest error rate (mean = 3.21) followed by the SC condition (mean = 1.27) and the GC condition (mean = 0.42). For none of the specific complexity level problems was the Grade x Cue Availability interaction significant, but these

Table 12

Two Irrelevant Dimensions: Analysis of Variance on Log Errors

Source	*df*	MS	*F*	*p*
Between Subjects				
Grade (G)	1	1.7618	3.14	(.10)
Cue Availability (CA)	2	0.1403	0.25	
G x CA	2	1.3889	2.47	
Within (Error between *S*s)	24	0.5617		
Within Subjects				
Blocks of Trials (B)	7	0.6042	28.87	.001
B x G	7	0.0100	0.48	
B x CA	14	0.0182	0.87	
B x G x CA	14	0.0424	2.02	.05
Within (Error within *S*s)	168	0.0209		

Table 13

Three Irrelevant Dimensions: Analysis of Variance on Log Errors

Source	*df*	MS	*F*	*p*
Between Subjects				
Grade (G)	2	3.9574	9.50	.005
Cue Availability (CA)	2	0.9498	2.28	
G x CA	4	0.5622	1.35	
Within (Error between *S*s)	36	0.4164		
Within Subjects				
Blocks of Trials (B)	7	0.6485	23.64	.001
B x G	14	0.0394	1.44	
B x CA	14	0.0154	0.56	
B x G x CA	28	0.0234	0.85	
Within (Error within *S*s)	252	0.0274		

Table 14

Four Irrelevant Dimensions: Analysis of Variance on Log Errors

Source	*df*	MS	*F*	*p*
Between Subjects				
Grade (G)	2	0.4115	0.85	
Cue Availability (CA)	2	3.6362	7.52	.005
G x CA	4	0.3206	0.66	
Within (Error between *Ss*)	36	0.4833		
Within Subjects				
Blocks of Trials (B)	7	0.7354	24.81	.001
B x G	14	0.0193	0.65	
B x CA	14	0.0326	1.10	
B x G x CA	28	0.0150	0.51	
Within (Error within *Ss*)	252	0.0296		

Table 15

Five Irrelevant Dimensions: Analysis of Variance on Log Errors

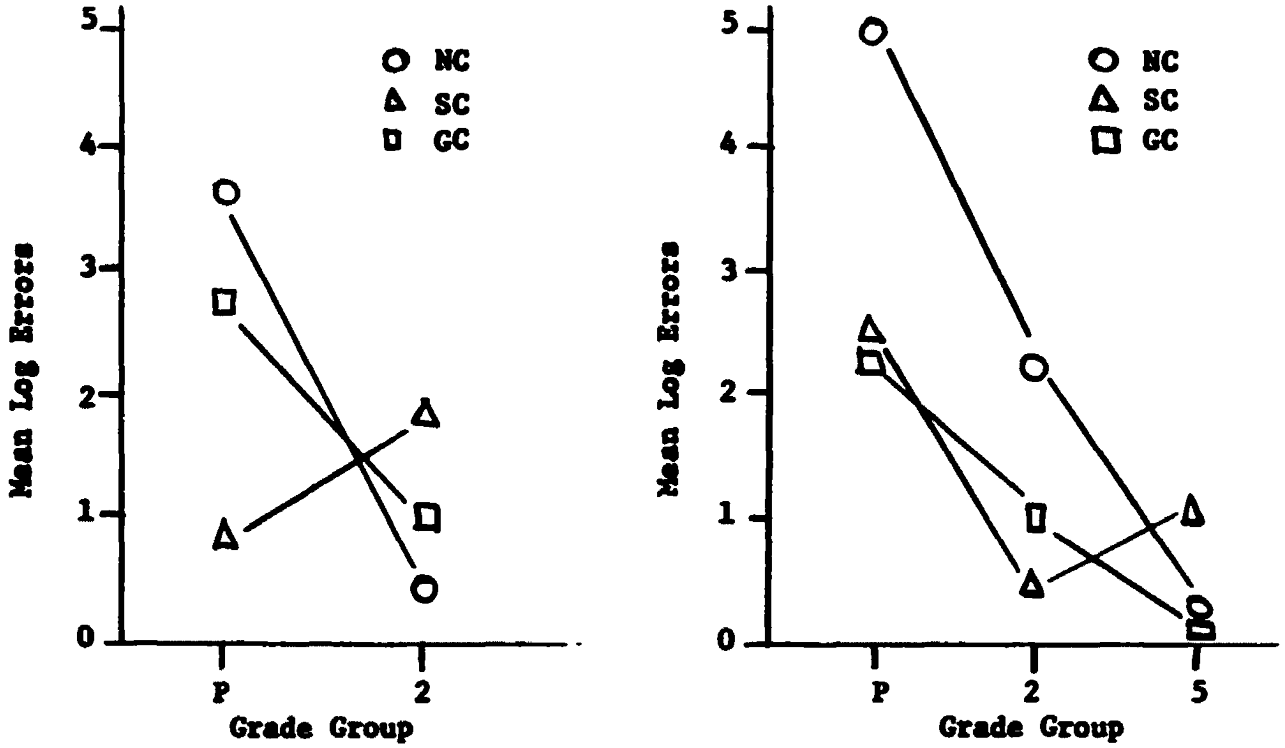
Source	*df*	MS	*F*	*p*
Between Subjects				
Grade (G)	1	1.3231	2.87	
Cue Availability (CA)	2	0.9387	1.82	
G x CA	2	0.2684	0.58	
Within (Error between *Ss*)	24	0.4613		
Within Subjects				
Blocks of Trials (B)	7	0.7219	24.31	.001
B x G	7	0.0405	1.36	
B x CA	14	0.0724	2.44	.005
B x G x CA	14	0.0234	0.79	
Within (Error within *Ss*)	168	0.0297		

interactions are presented in Figure 11 and show mean performance levels for all conditions. On examining the individual grade groups, it is seen that the general trends from the pooled complexity levels analysis give an incomplete picture of the results; that there are differences occurring that do not follow the overall trends and thus are hidden in the overall analysis.

The Blocks of trials main effect was significant for all problems, indicating a drop in error rate across trials. For the two irrelevant dimensions problem the Blocks x Grade x Cue Availability interaction was significant ($\underline{F} = 2.02$; 14/168 $\underline{df}$; $\underline{p} < .05$) emphasizing that for age group F the NC and GC conditions elicit a high (but decreasing) error rate across blocks with the SC condition yielding to a much faster decrease in error rate. For grade group 2 there was an immediate drop in errors for the NC condition ($\bar{x} = 0$ by block 2) with the SC and GC conditions eliciting a slower decrease in error rate.

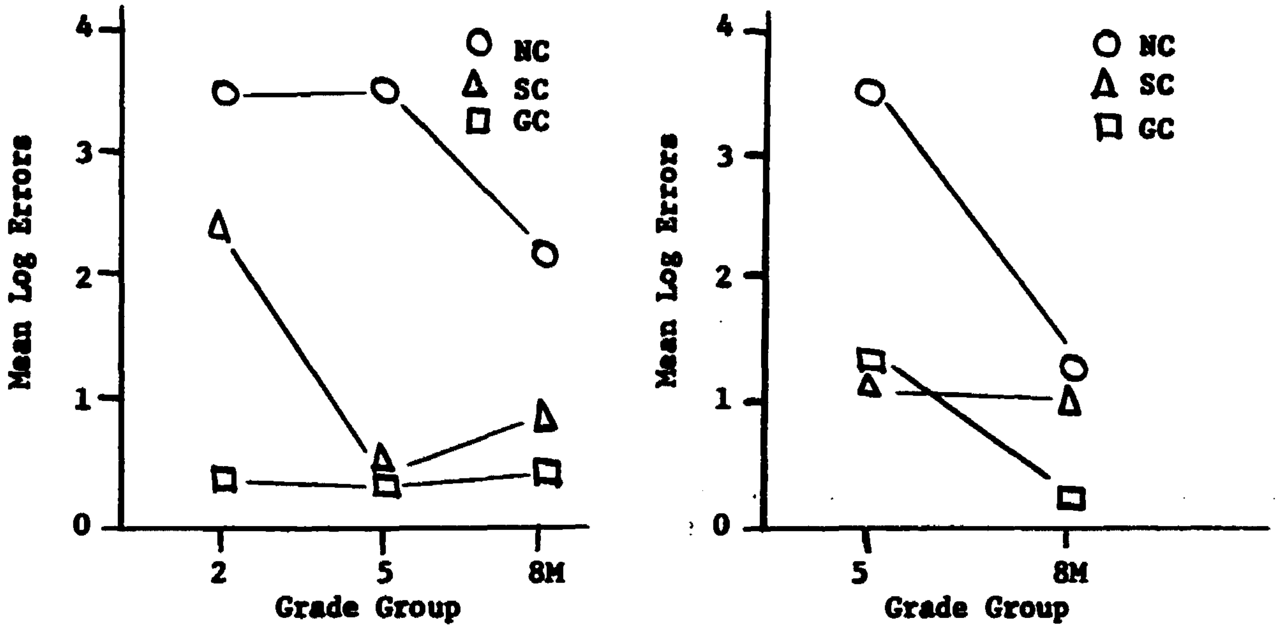
The Blocks of trials x Cue Availability interaction was significant for the five irrelevant dimensions problem emphasizing the overall trend which occurred in the overall analysis (Figure 8).

Thus, looking at the performance levels in terms of specific problems, the main effect of Grade was significant only for the lower complexity problems (two and three irrelevant dimensions) on which the lower grade groups worked, although the trend of improved performance with increasing grade was also seen on the other problems. The main effect of Cue Availability was significant only in the problem with four irrelevant dimensions. While the pooled complexity analysis of



A. Two Irrelevant Dimensions

B. Three Irrelevant Dimensions



C. Four Irrelevant Dimensions

D. Five Irrelevant Dimensions

Fig. 11.--Mean log errors for each grade and cue availability condition for specific complexity level problems.

log errors and the analysis of individual grade groups indicated the superiority of the SC in age group P, and the superiority of the GC in age groups 2, 5, and 8M (Figure 5 and Figure 10), the analysis in terms of specific problems indicates that perhaps the effectiveness of cues depends upon a combination of grade group and the difficulty of the problem for that grade group (Figure 11). That is, for grade group P, the SC condition elicited better performance than the NC condition on the two irrelevant dimensions problem. The SC condition elicited better performance than the NC condition for grade groups 2 and 5 on the four irrelevant dimensions problem. The GC condition, in terms of this analysis, showed superiority over the NC condition performance on the four irrelevant dimensions problem with grade group 5 and on the five irrelevant dimensions problem with age group 8M.

Analysis of Log Time to Solution Scores

While most studies in concept learning only use errors made prior to solution as the dependent variable, it is quite possible, especially for different grade groups, that errors and time to solution may be influenced by different factors. For this reason, the data were also analyzed in terms of time required to reach criterion. While the Pearson product-moment correlations between log time to solution and log errors were high (all significant at the .005 level, each 43 df), it can be noted in Table 16 that this relationship varies somewhat from grade group to grade group.

As with the log error scores, the log time to solution scores were first analyzed in terms of overall trends in the data, with the complexity levels being pooled across grade groups. The analysis of variance for pooled complexity levels on log time to solution is presented in Table 17. The summary table indicates that the three main effects are significant and one interaction approaches significance.

To determine if any differences occurred on the log time measure for the problems of shape-relevant versus color-relevant, *t*-tests were performed within each grade grouping. The results were: Group P, *t* = 1.28; Group 2, *t* = 0.89; Group 5, *t* = 0.26; and Group 8M, *t* = 0.94 (all 43 *df* and *p*>.10). Thus, there were no differences between the two problem types in regard to the time measure, and the problem types were pooled in the subsequent analyses.

In spite of the increasing complexity levels with grade, the log time to solution decreased significantly with grade (*F* = 8.45, 3/144 *df*, *p*<.01). The decrease in time was primarily linear as indicated by the significance of the linear component (*F* = 24.86, 1/144 *df*, *p*<.001), and as seen in Figure 12. Duncan's multiple range test showed that the differences between the adjacent grade groups were not significant, but that the mean log time to solution for grade group P was significantly longer than that of groups 5 and 8M; the mean log time for age group 2 was significantly longer than group 8M, group 5 was significantly faster than age group P, and group 8M was significantly faster than groups P and 2 (*p* = .01, 144 *df*).

As with log errors, the effect of Complexity on log time was significant (*F* = 5.64, 2/144 *df*, *p*<.01), with log time linearly increasing with Complexity (*F* = 11.27, 1/144 *df*, *p*<.01, Figure 13). Duncan's test showed that the differences between adjacent pooled complexity levels were not significant at the .01 level. The difference

Table 16

Pearson Product-Moment Correlations Between Log Errors and Log Time to Solution

	Grade Group P	2	5	8(M)	8(F)
R	.867	.929	.916	.791	.925

Table 17

Analysis of Variance of Log Time to Solution with Pooled Complexity Levels

Source	*df*	MS	*F*	*p*
Grade (G)	3	0.5082	88.45	.01
Linear	1	1.4941	24.86	.001
Quadratic	1	0.0231	0.38	
Cubic	1	0.0073	0.01	
Complexity (C)	2	0.3393	5.64	.01
Linear	1	0.6778	11.27	.01
Quadratic	1	0.0008	0.00	
Cue Availability (CA)	2	0.5231	8.70	.01
G x C	6	0.1097	1.83	(.10)
G x CA	6	0.0433	0.72	
C x CA	4	0.1165	1.94	
G x C x CA	12	0.0653	1.09	
Within (Error between *Ss*)	144	0.0601		

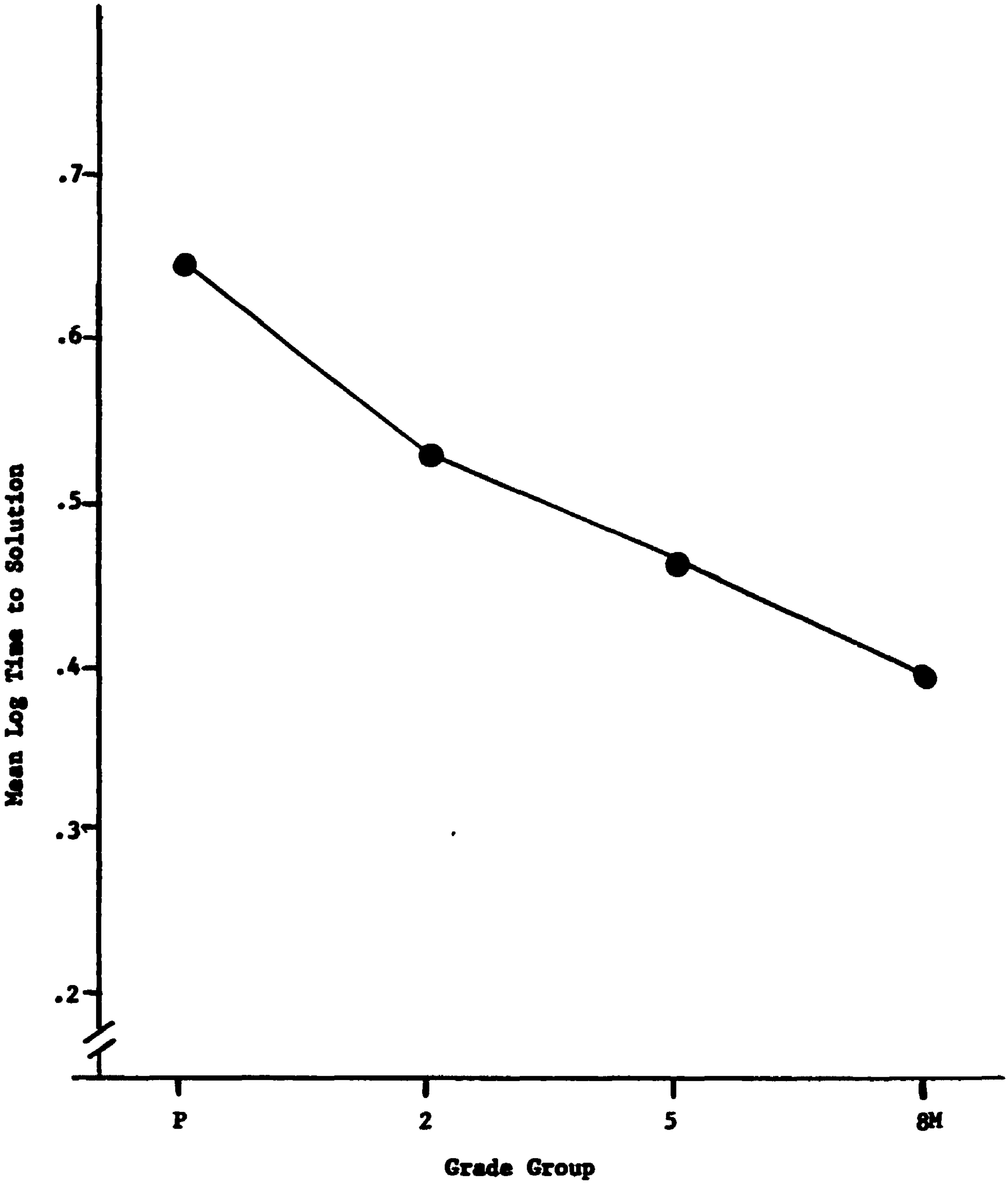


Fig. 12.--Mean log time to solution for each grade group.

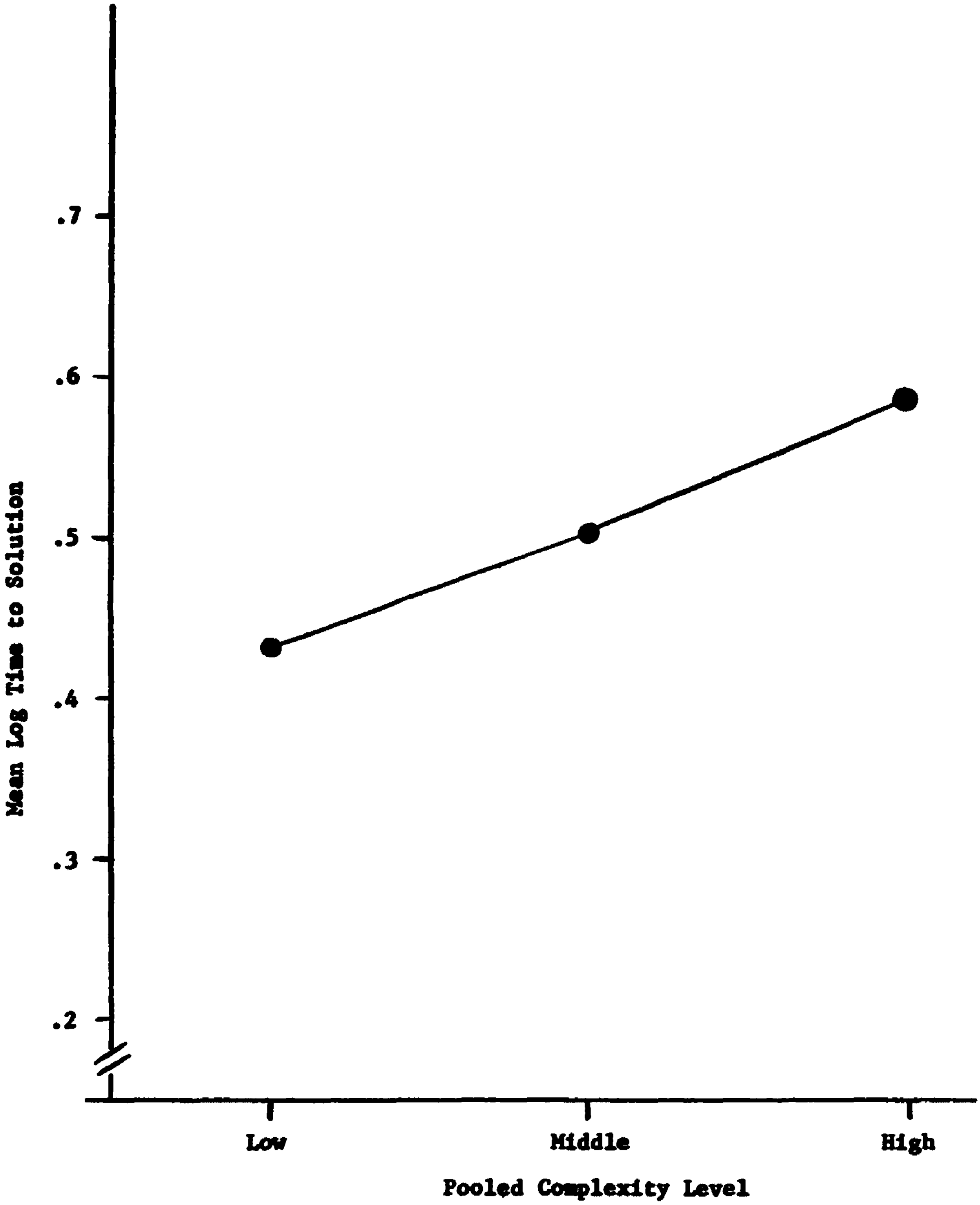


Fig. 13.—Mean log time to solution for each pooled complexity level.

between low and high pooled complexity levels was significant (p = .01, 144 df).

The relationship between the Cue Availability conditions in the log time analysis (F = 8.70, 2/144 df, $p<.01$) was the same as in the log errors analysis with the NC condition requiring the most time (mean log time = .6135) and the SC condition (mean = .4801) and GC condition (mean = .4337) requiring less time (Figure 14). The difference between the SC and GC conditions was not significant at the .01 level, but the NC condition required significantly more time to solution (Duncan's test, 144 df).

The Grade x Complexity interaction approached significance (F = 1.83, 6/144 df, $p<.10$) in which the trend of increased difficulty (in terms of log time to solution) with increased stimulus complexity was seen only for grade groups P and 5. In groups 2 and 8M there was little difference among the complexity levels (See Figure 15). This interaction did not approach significance in the errors analysis, perhaps indicating a slight differential sensitivity of these two dependent variables to the experimental variables of the concept learning task.

The analyses based on the individual grade groups are summarized in Table 18. The means for the conditions are portrayed in Figure 16.

Complexity was a significant main effect for grade groups P and 5 (F's = 4.84 and 3.75 respectively, both 2/36 df and $p<.05$). In group 2 the traditional result of more inefficient performance with increased complexity (here increased time to solution) held for

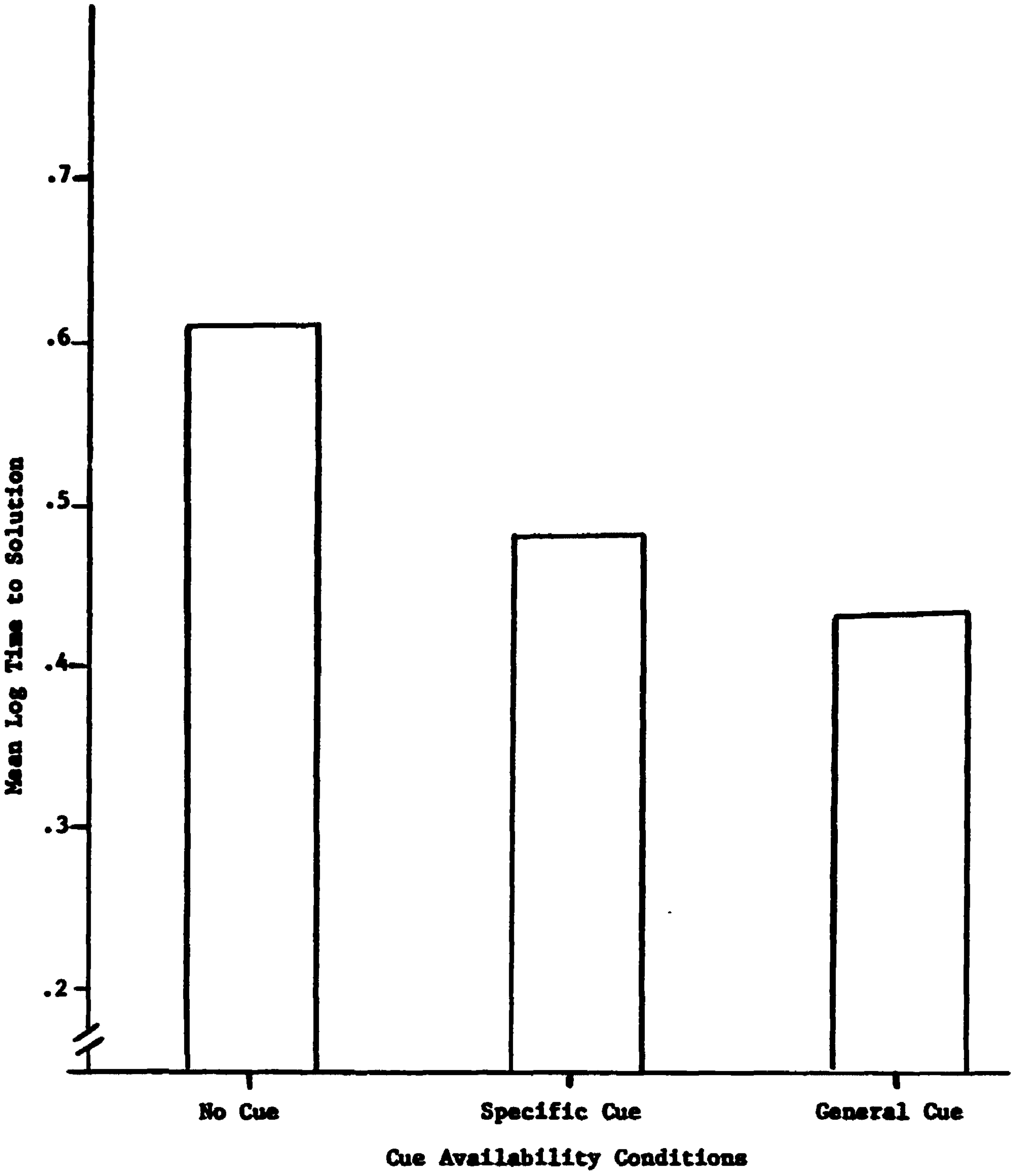


Fig. 14.--Mean log time to solution for the three cue availability conditions.

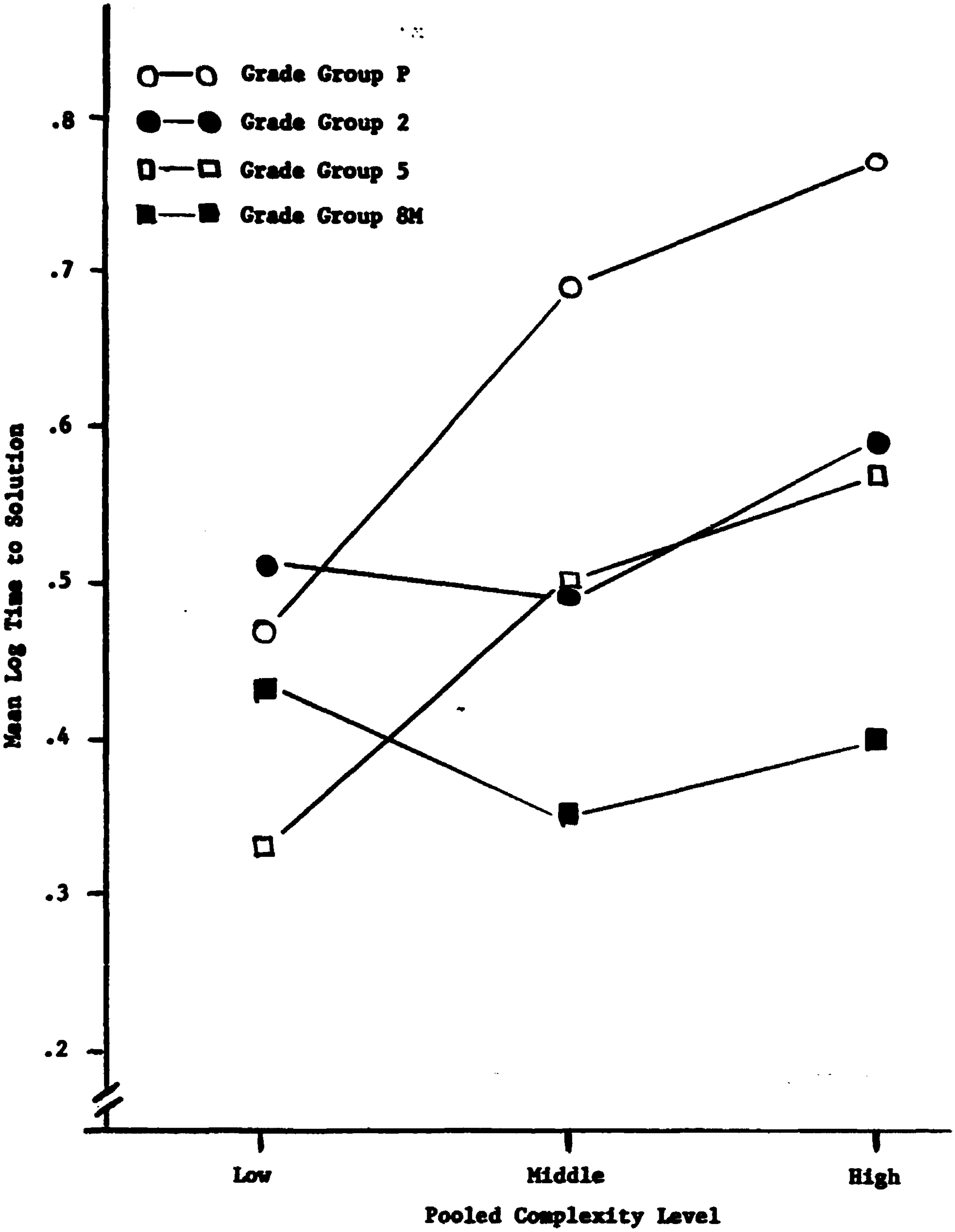
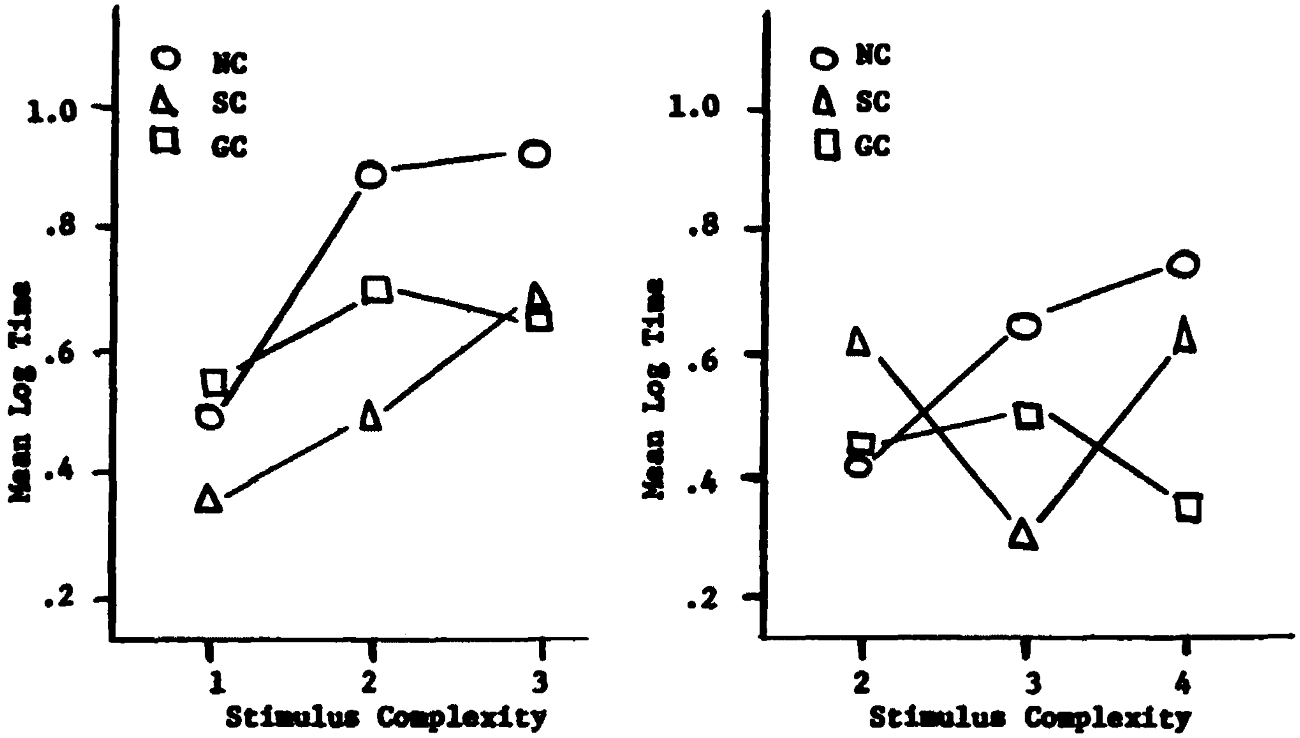


Fig. 15.--Mean log time to solution as a function of grade and pooled complexity level

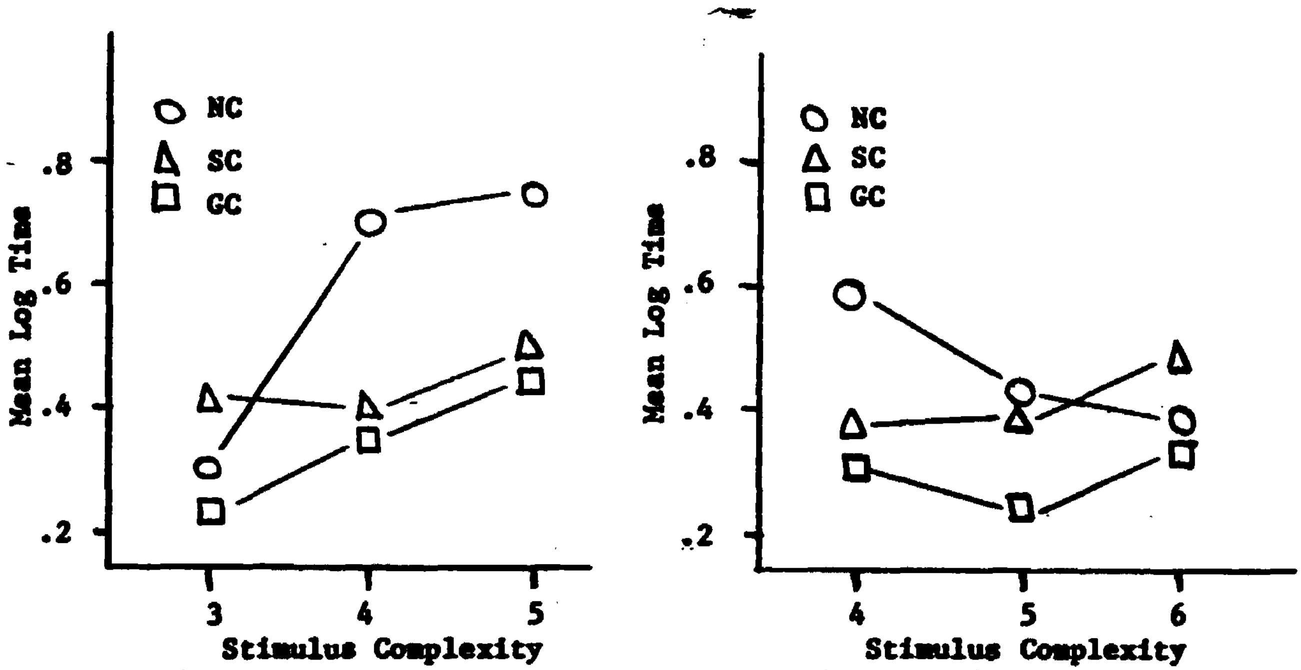
Table 18

Individual Grade Groups: Summary of Analyses of Variance on Log Time to Solution

Source	df	MS	F	p
Grade Group P				
Complexity (C)	2	.3828	4.84	.05
Cue Availability (CA)	2	.2347	2.97	(.10)
C x CA	4	.0451	0.57	
Within (Error between Ss)	36	.0790		
Grade Group 2				
Complexity (C)	2	.0459	0.68	
Cue Availability (CA)	2	.1197	1.77	
C x CA	4	.1590	2.35	(.10)
Within (Error between Ss)	36	.0675		
Grade Group 5				
Complexity (C)	2	.2244	3.75	.05
Cue Availability (CA)	2	.2105	3.52	.05
C x CA	4	.0673	1.12	
Within (Error between Ss)	36	.0599		
Grade Group 8M				
Complexity (C)	2	.0254	0.75	
Cue Availability (CA)	2	.0981	2.89	(.10)
C x CA	4	.0361	1.06	
Within (Error between Ss)	36	.0339		



A. Grade Group P B. Grade Group 2



C. Grade Group 5 D. Grade Group 8M

Fig. 16.--Mean log time to solution for all cue availability and specific complexity conditions within each grade group.

the NC condition only, and in group 5 the NC condition led to a slight decrease in log time to solution with increased complexity.

Cue availability was a significant main effect for grade group 5 (<u>F</u> = 3.52, 2/36 <u>df</u>, <u>p</u><.05) and approached significance in groups P and 8M (<u>F</u>'s = 2.97 and 2.89, both 2/36 <u>df</u>, <u>p</u><.10), with the NC condition eliciting the highest time to solution scores.

While neither Complexity nor Cue Availability were significant in group 2, their interaction approached significance (<u>F</u> = 2.35, 4/36 <u>df</u>, <u>p</u><.10). In this interaction (Figure 16B), log time to solution increased across complexity with the NC condition and decreased in the GC condition. For the SC condition, the log time scores were at about the same levels for the two and four irrelevant dimensions problems, with the scores being much lower in the three irrelevant dimensions problem.

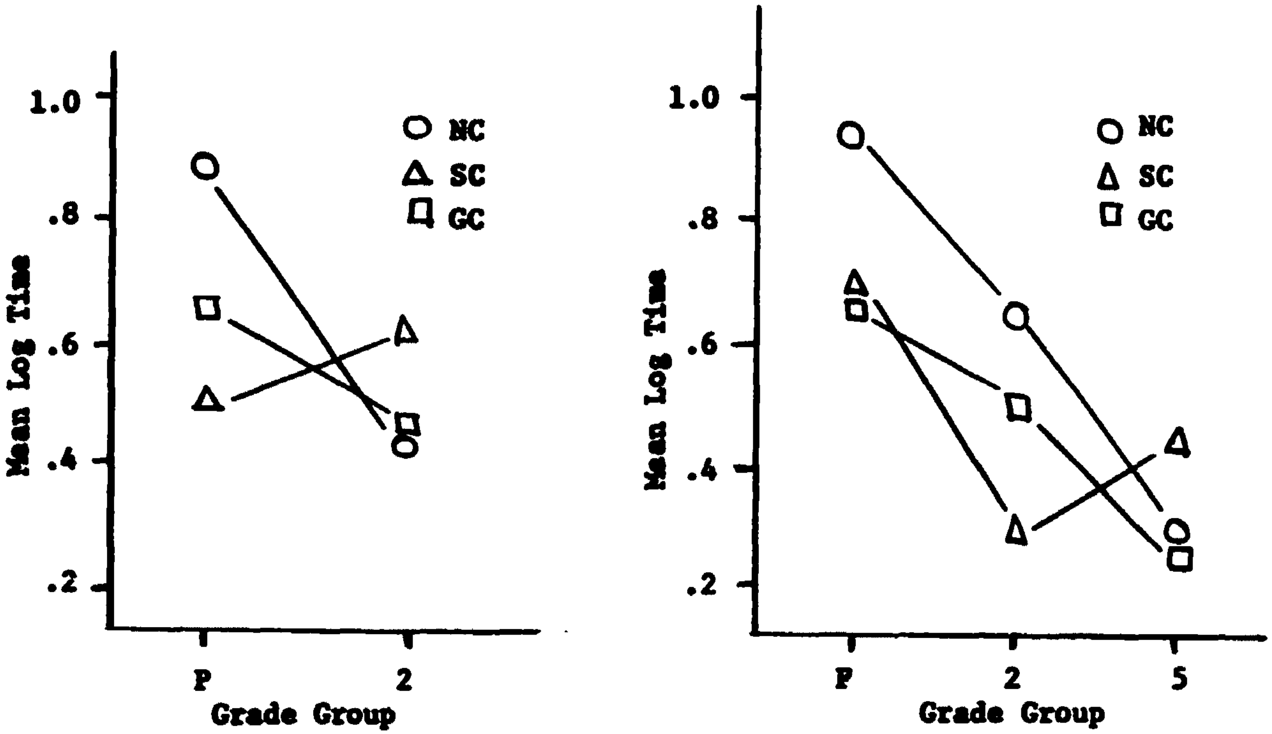
Compared to the log errors analyses for the individual grade groups, the effects of cue availability on the log time to solution were more noticeable. That is, in the log errors analyses of the individual grade groups (Table 8 through 11), Cue Availability approached or reached significance in Groups P, 5 and 8M, and the interaction of Complexity x Cue Availability approached significance in Group 2. Thus, in the lower grade level groups, the time measure was slightly more sensitive (in terms of significance levels) to the effects of cue availability conditions than was the errors measure.

The summary of the analyses of variance for the specific complexity levels on log time to solution scores is presented in Table 19, and the means of the conditions are shown in Figure 17.

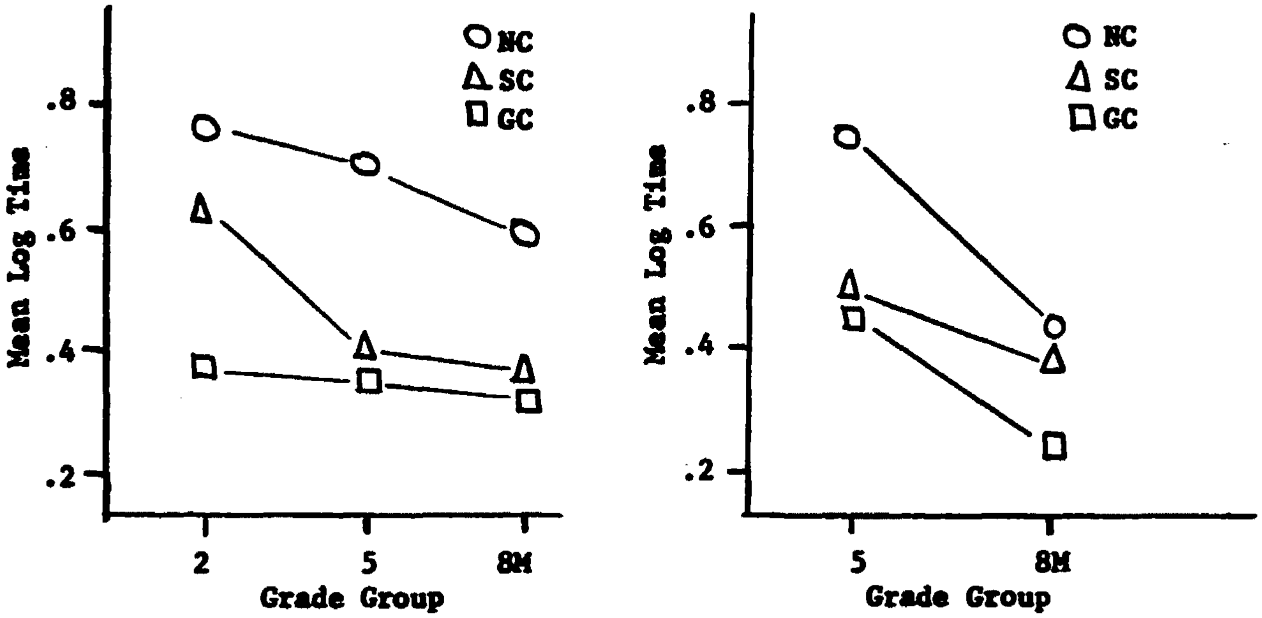
Table 19

Specific Complexity Levels: Summary of Analyses of Variance on Log Time to Solution

Source	df	MS	F	p
Two Irrelevant Dimensions				
Grade (G)	1	.2515	3.76	(.10)
Cue Availability (CA)	2	.0292	0.44	
G x CA	2	.2047	3.06	(.10)
Within (Error between Ss)	24	.0668		
Three Irrelevant Dimensions				
Grade (G)	2	.7714	12.63	.01
Cue Availability (CA)	2	.1289	3.11	
G x CA	4	.0924	1.51	
Within (Error between Ss)	36	.0611		
Four Irrelevant Dimensions				
Grade (G)	2	.0994	1.67	
Cue Availability (CA)	2	.4346	7.29	.01
G x CA	4	.0276	0.46	
Within (Error between Ss)	36	.0596		
Five Irrelevant Dimensions				
Grade (G)	1	.3653	5.65	.05
Cue Availability (CA)	2	.1439	2.22	
G x CA	2	.0288	0.44	
Within (Error between Ss)	24	.0647		



A. Two Irrelevant Dimensions B. Three Irrelevant Dimensions



C. Four Irrelevant Dimensions D. Five Irrelevant Dimensions

Fig. 17.—Mean log time to solution for all combinations of grade and cue availability within specific complexity level problems.

Grade was a significant main effect on the three and five irrelevant dimensions problems ($\underline{F} = 12.63$, 2/36 df, $\underline{p} < .01$, and $\underline{F} = 5.65$, 1/24 df, $\underline{p} < .05$), and approached significance on the two irrelevant dimensions problem ($\underline{F} = 3.76$, 1/24 df, $\underline{p} < .10$). The trend on all of these problems was for log time to solution to decrease with increased S grade level. On the four irrelevant dimensions problem, the grade groups did not perform differently in terms of the log time variable.

Cue availability was a significant variable only on the four irrelevant dimensions problem ($\underline{F} = 7.29$, 2/36 df, $\underline{p} < .01$). On the two and three irrelevant dimensions problems, there was little difference between performance times for the SC and GC conditions (Figure 9A and Figure 9B).

On the two irrelevant dimensions problem, the Grade x Cue Availability interaction approached significance ($\underline{F} = 3.06$, 2/24 df, $\underline{p} < .10$), with the SC condition eliciting the lowest mean log time to solution for grade group P and eliciting the highest time for grade group 2.

The overall picture of the time measure is basically the same as in the errors analysis as would be expected by the high correlation between these variables. That is, there was an increase in time to solution with increased complexity, a decrease in time to solution with higher grade level, and the NC condition elicited the highest time to solution with the SC and GC conditions following. On closer inspection of the data, however, there were a few differences between these two dependent variables. In terms of the individual grade groups, the time to solution variable was slightly more sensitive to the cue availability conditions than the errors variable, particularly for the lower grade-level groups (Groups P and 2). In the specific complexity problems analyses, the time measure produced significant differences between the grade level groups on the five irrelevant dimensions problem while the errors measure did not (Tables 15 and 19). This would appear to be due to the differences in sensitivity of these measures to the cue availability conditions (Figures 11D and 17D). For the other specific complexity level problems, the results of the time and error measures among the grade groups were approximately the same.

Analysis of Rate of Responding

As mentioned in the introduction, there has been little exploration of dependent variables in concept learning tasks, other than errors made prior to solution or trials required to reach solution. In this section the data are presented in terms of rate of responding, a derived measure which represents the average number of responses made per minute which was calculated by dividing the total number of trials to solution by the time to solution for each subject. The correlations of the rate of responding measure with the other two dependent variables are presented in Table 20.

Rate of responding was negatively and significantly correlated with both the log error and log time scores such that the higher the error rate the lower the number of responses per minute, and the longer the time to solution the slower the rate of responding per minute. The correlations were higher with the log time scores than with the log error scores.

The summary of the overall rate of responding analysis of variance with pooled complexity levels is presented in Table 21.

Table 20

Pearson Product-Moment Correlations between Rate of Responding and Log Time and Log Errors for Each Grade Group

Grade Group	Rate of Responding and Log Errors[a]	Rate of Responding and Log Errors[a]
P	-.4599	-.7703
2	-.5271	-.7425
5	-.4673	-.7298
8M	-.3436[b]	-.7213
8F	-.4476	-.6620

[a] Each correlation coefficient is based on 43 *df*; all coefficients are significantly different from zero at $p < .005$ except for *b*.

[b] Significantly different from zero at $p < .025$.

Table 21

Analysis of Variance on Rate of Responding with Pooled Complexity Levels

Source	*df*	MS	*F*	*p*
Grade (G)	3	449.19	16.92	.01
Linear	1	1322.68	49.83	.001
Quadratic	1	11.34	0.43	
Cubic	1	13.56	0.51	
Complexity (C)	2	59.56	2.24	(.10)
Cue Availability (CA)	2	118.29	4.46	.05
G x C	6	65.69	2.47	.05
G x CA	6	23.28	0.88	
C x CA	4	1.95	0.07	
G x CA x C	12	45.90	1.73	(.10)
Within (Error between *Ss*)	144	26.54		

In terms of rate of responding performance on the two problem-types (form-relevant and color-relevant), t-tests were performed within each grade group. These results were: Group P, t = 1.64, p<.10; Group 2, t = 0.93, Group 5, t = 1.30, Group 8M, t = 0.72; all 43 df (with p>.10 for Groups 2, 5 and 8M). Except for Group P, in which the difference in rate of responding performance on form-relevant versus color-relevant approached significance, none of the differences between the two problem-types were significant. The color-relevant and form-relevant problems were combined in all the subsequent analyses of rate of responding.

Rate of responding significantly increased with grade level (F = 16.92, 3/144 df, p<.001), with the slope of the trend being linear and significantly different from zero (F = 49.83, 1/144 df, p<.001) as shown in Figure 18. Duncan's test revealed that the differences in rates of responding between grade groups P and 2 were not significant and that the differences between grade groups 5 and 8M were not significant, but that all other comparisons among the grade groups were significant at the .01 level (144 df).

Pooled complexity level (low, middle and high) approached significance (F = 2.24, 2/144 df, p<.10). The mean rates of responding for the low and middle complexity levels were quite similar (the means were 16.33 and 16.45 respectively) with the mean rate of responding for the high complexity level being somewhat lower (mean = 14.67).

The main effect of Cue Availability was significant (F = 2.47, 6/144 df, p<.05). The lowest rate of responding occurred in the NC condition ($\bar{x}$ = 14.36), the highest rate in the GC condition ($\bar{x}$ = 17.16),

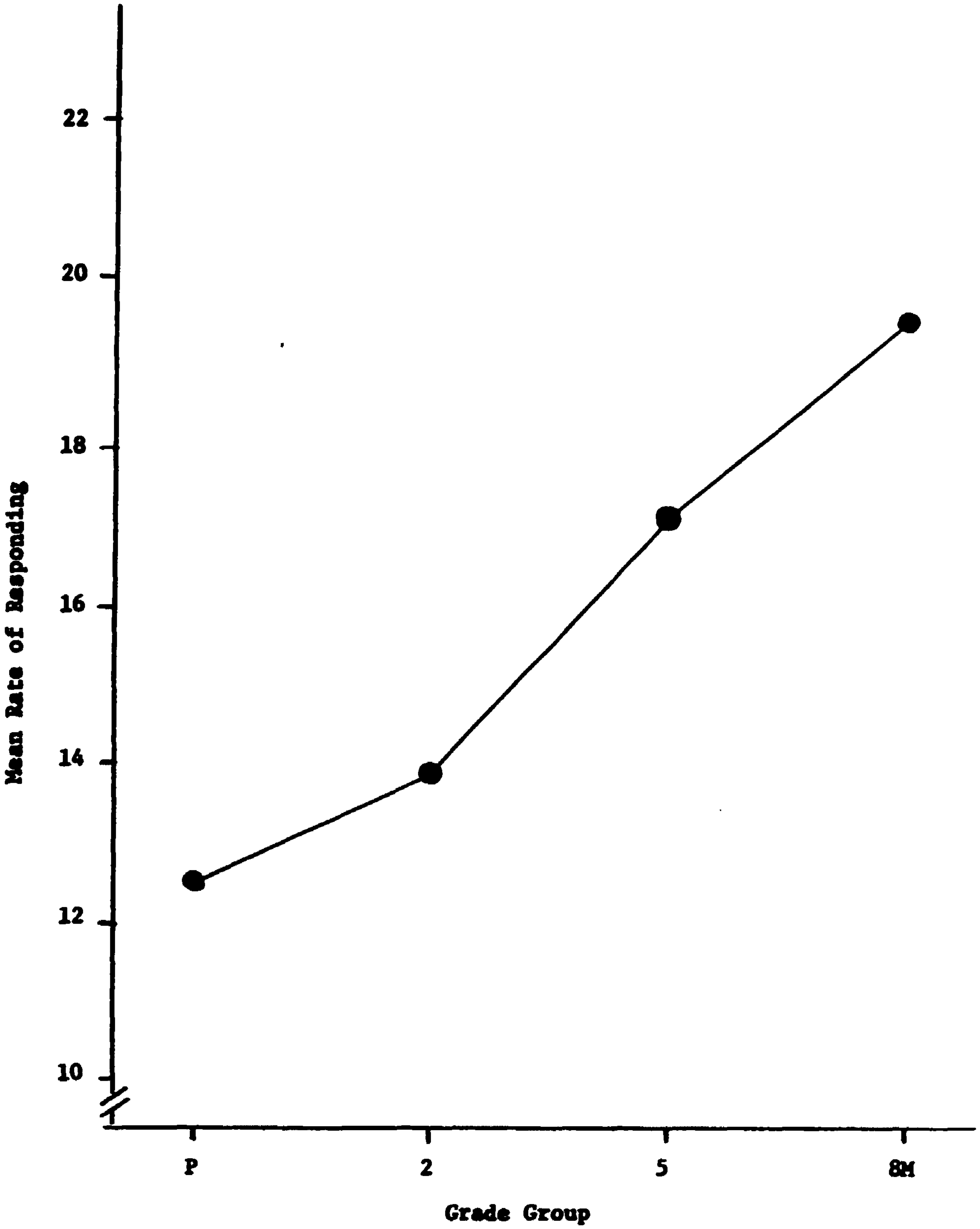


Fig. 18.—Mean rate of responding for the four grade groups.

and the SC condition ($\bar{x}$ = 15.93) was intermediate to the other cue conditions. The difference in rate between the NC and GC conditions was significant at .01, while the SC condition was not significantly different from either the NC or GC conditions (Duncan's test, 144 df).

The Grade x Complexity interaction was also significant (F = 2.47, 6/144 df, $p<.05$). This interaction is shown in Figure 19. To further understand what happened in this interaction simple effects analyses of variance were performed.

For each of the complexity levels, grade was a significant variable (Table 22). For the pooled low complexity level all differences in rate of responding were significant except for the differences between grade groups P and 2 and between grade groups 5 and 8M (Duncan's test, p = .05, 144 df). For the middle complexity level, grade group 8M had a significantly higher rate of responding than grade groups P, 2 and 5. At the .01 level, Groups P, 2 and 5 did not differ from each other (Duncan's test, 144 df). With the high complexity level problem, the rates of responding were significantly different between grade groups P and 8M (p = .01, 144 df), while groups P, 2 and 5 did not significantly differ from each other and neither did groups 2, 5 and 8M.

The summary of the rate of responding simple effects on Complexity is shown in Table 23. For grade groups P and 2, complexity was not a significant variable (F's = 0.63 and 0.74 respectively, both 2/144 df). Complexity was a significant variable for age groups 5 and 8M (F's = 4.05 and 4.24 respectively, both 2/144 df, $p<.05$). In age group 5 the rate of responding was significantly higher for the low complexity problem than for the problems of middle and high complexity

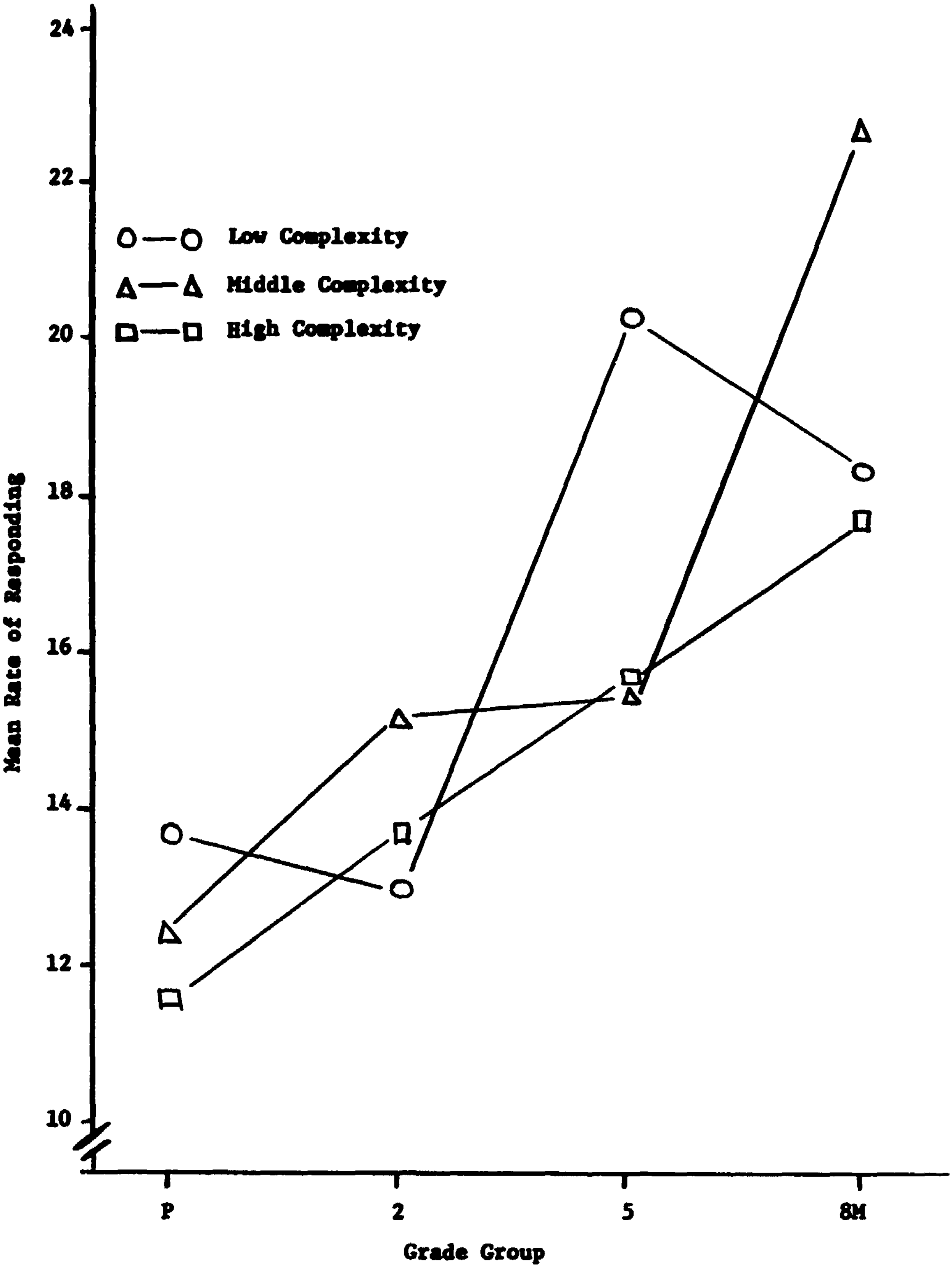


Fig. 19.—Mean rate of responding for each pooled complexity level and grade group.

Table 22

Rate of Responding Simple Effects Analysis of Variance on Grade Groups

Source	*df*	MS	*F*	*p*
Grade for Low Complexity	3	185.56	6.99	.01
Grade for Middle Complexity	3	292.47	11.02	.01
Grade for High Complexity	3	102.25	3.85	.05
Within (Error)	144	26.54		

Table 23

Rate of Responding Simple Effects Analysis of Variance on Complexity Levels

Source	*df*	MS	*F*	*p*
Complexity Level for Grade P	2	16.59	0.63	
Complexity Level for Grade 2	2	19.52	0.74	
Complexity Level for Grade 5	2	107.91	4.06	.05
Complexity Level for Grade 8M	2	112.60	4.24	.05
Within (Error)	144	26.54		

(Duncan's test, p = .05, 144 df). For grade group 8M, the middle complexity level elicited a significantly higher rate of responding than did either the low or high level complexity problems (p = .05, 144 df). Thus, while grade was a significant variable across each pooled complexity level, complexity was a significant variable only for the two older grade groups, groups 5 and 8M, on the rate of responding measure.

The rate of responding variable was also analyzed in terms of specific complexity levels and grade groups. The summary of the analyses of variance for the individual grade groups is presented in Table 24.

The main effects of Complexity for each grade group gave further support to the results of the Grade x Complexity interaction in the pooled analysis (Table 21) and the analysis of simple effects (Table 23). For grade groups P and 2, the main effect of Complexity was not significant (F = 0.85, 2/36 df, and F = 1.02, 2/36 df). For grade group 5, Complexity approached significance (F = 3.01, 2/36 df, $p<.10$). The main effect of Complexity was significant for grade group 8M (F = 3.56, 2/36 df, $p<.05$) with the responding rate being the highest for the five irrelevant dimensions problem.

The main effect of Cue Availability approached significance only in grade group 5 (F = 2.79, 2/36 df, $p<.10$). The effects of the cue availability conditions for each grade group is seen in Figure 20. Because it was hypothesized that the NC condition would lead to the most inefficient performance, and the GC condition would lead to the most efficient performance within each age group (Hypothesis 1, p. 19, and 7, p. 23), further comparisons were made between the cue availability conditions

Table 24

Individual Grade Groups: Rate of Responding Analyses of Variance

Source	*df*	MS	*F*	*p*
Grade Group P				
Complexity (C)	2	16.59	0.85	
Cue Availability (CA)	2	35.05	1.79	
C x CA	4	4.21	0.22	
Within (Error)	36	19.57		
Grade Group 2				
Complexity (C)	2	19.52	1.02	
Cue Availability (CA)	2	42.30	2.20	
C x CA	4	68.15	3.55	.05
Within (Error)	36	19.20		
Grade Group 5				
Complexity (C)	2	107.91	3.01	(.10)
Cue Availability (CA)	2	99.86	2.79	(.10)
C x CA	4	12.24	0.34	
Within (Error)	36	35.79		
Grade Group 8M				
Complexity (C)	2	112.60	3.56	.05
Cue Availability (CA)	2	10.91	0.34	
C x CA	4	55.06	1.74	
Within (Error)	36	31.62		

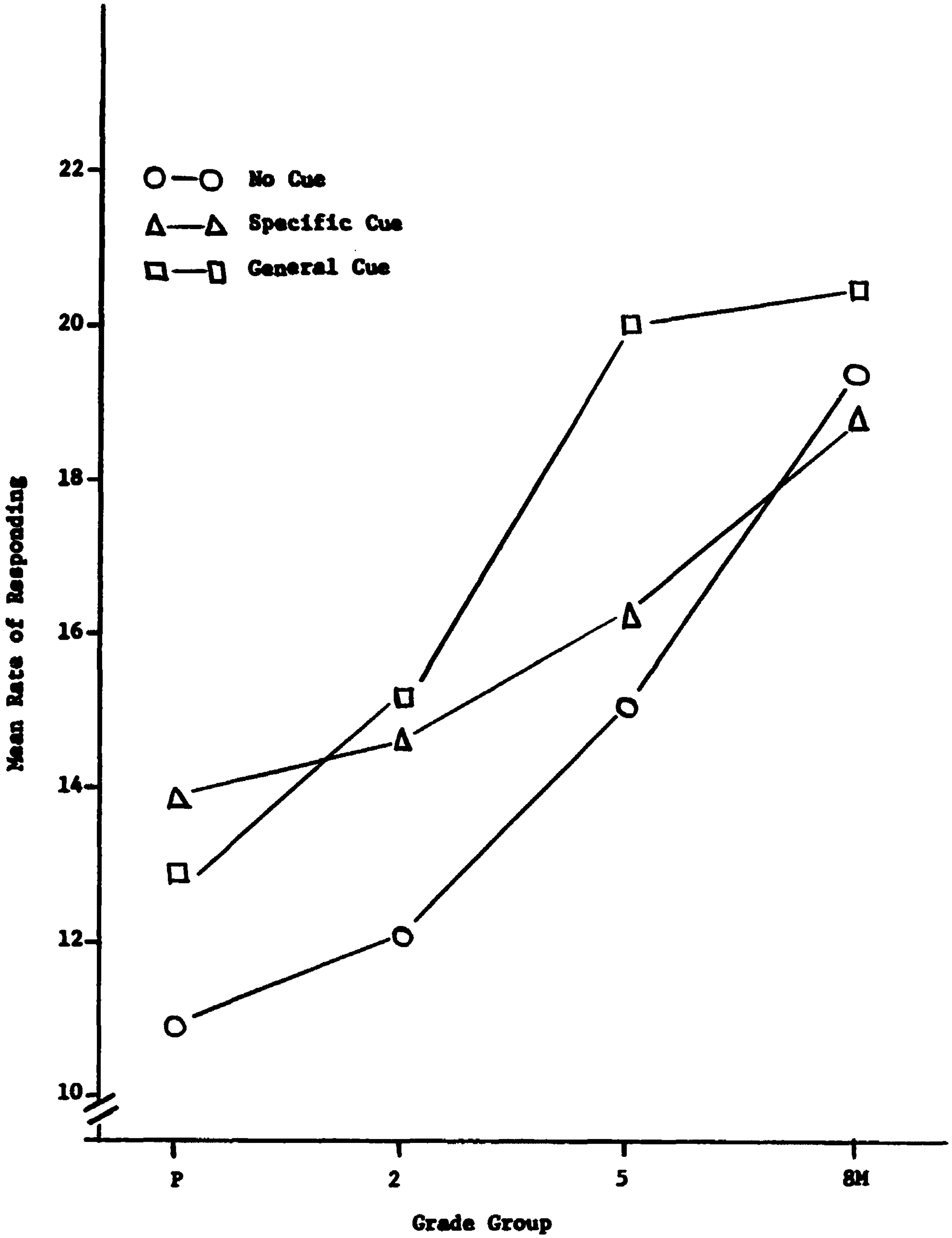


Fig. 20.--Mean rate of responding for each cue availability condition and grade group.

within each grade group. These are presented in Table 25.

Table 25

Comparisons between Cue Availability Conditions within each Grade Group for Rate of Responding

Cue Availability Comparisons	Grade Group	*t*	*p*[a]
No Cue vs. Specific Cue	P	-1.93	.05
	2	-1.46	
	5	-0.61	
	8M	0.25	
No Cue vs. General Cue	P	-1.33	
	2	-1.96	.05
	5	-2.14	.025
	8M	-3.30	.005
Specific Cue vs. General Cue	P	0.61	
	2	-0.25	
	5	-1.61	
	8M	-4.13	.005

[a] Each *t*-test is based on 28 *df*.

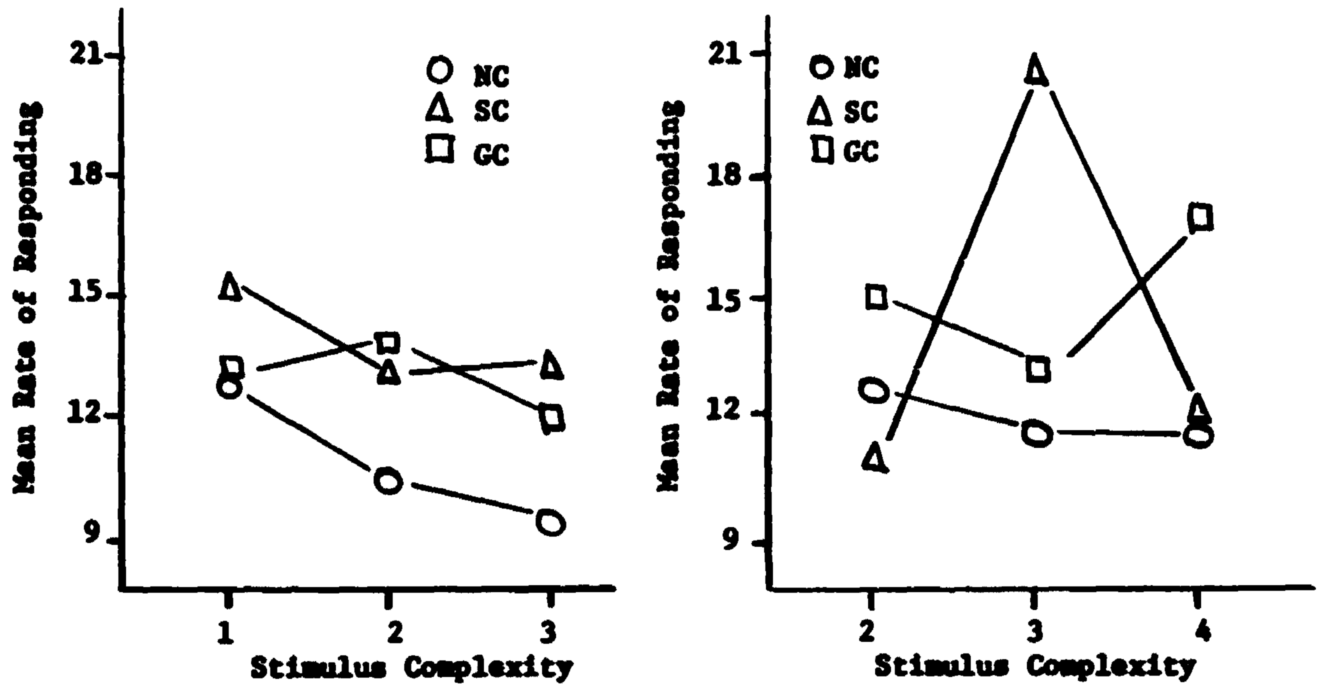
The comparisons between the cue availability conditions on the rate of responding variable were comparable to those in the errors analysis (Table 7). The SC condition led to a faster rate of responding than did the NC condition only in grade group P ($t = -1.93$, 28 *df*, $p < .05$). For the other grade groups, 2, 5 and 8M, the GC condition led to faster response rates than did the NC condition. In grade group 8M, as in the errors analysis, the SC and GC conditions became significantly differentiated with the GC condition leading to the higher rate of responding.

The cell means for all conditions within each grade (i.e., the

Complexity x Cue Availability interactions) are shown in Figure 21. For the rate of responding measure the Complexity x Cue Availability interaction reached significance only in grade group 2 (F = 3.55, 4/36 df, p<.05). While the overall trend in grade group 2 was for the GC condition to lead to the highest rate of responding, this did not hold for the three irrelevant dimensions problem. On this problem the SC condition led to the highest rate. Thus, for this problem, grade group 2 responded more nearly like the overall performance of grade group P (i.e., better performance with the specific cue condition). On the two and four irrelevant dimensions problems, grade group 2 responded more like the older grade groups with the GC condition eliciting the highest rate of responding.

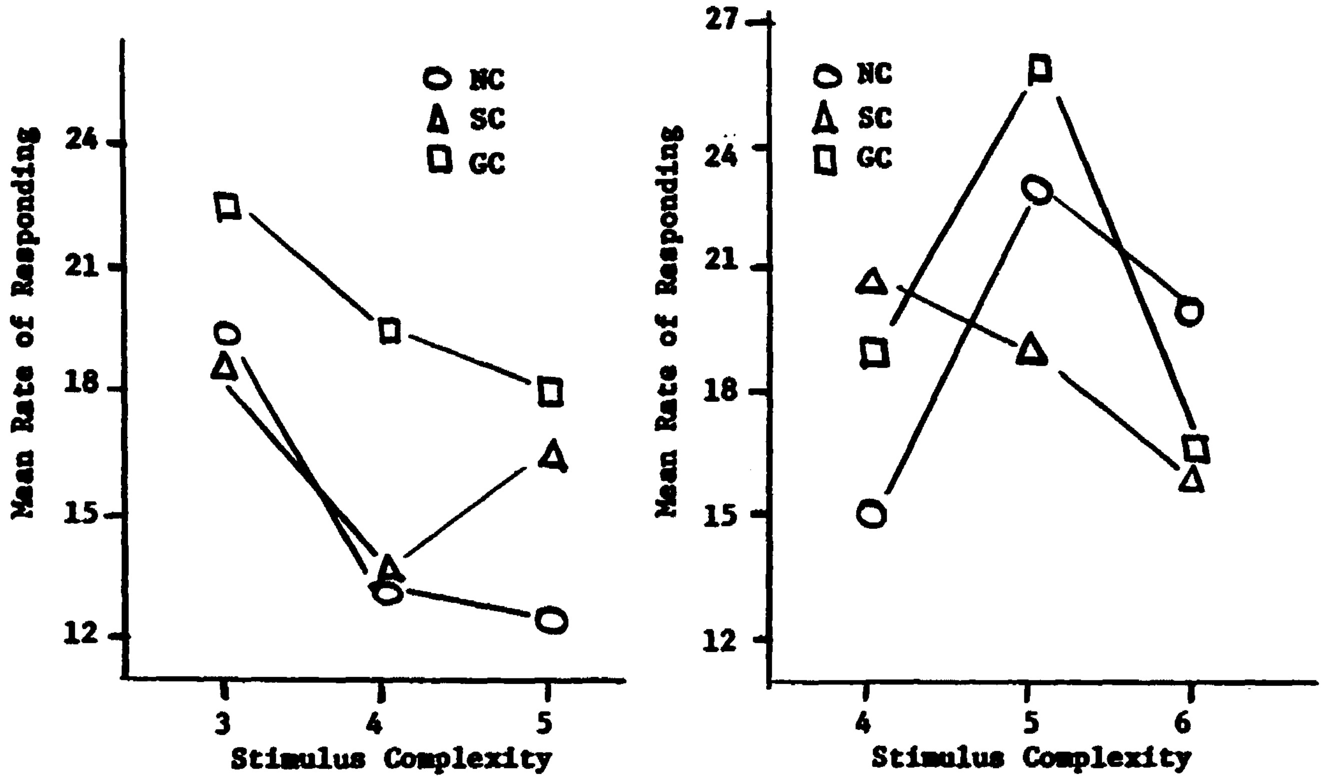
The analyses of variance for the specific complexity levels are summarized in Table 26 and the cell means are shown in Figure 22. Grade was a significant main effect for the three and five irrelevant dimensions problems (F = 12.15, 2/36 df, p<.01, and F = 11.32, 1/24 df, p<.01), and approached significance on the four irrelevant dimensions problem. For all these problems the expected trend of a higher rate of responding for increase in grade occurred.

The main effect of Cue Availability reached significance only on the four irrelevant dimensions problem (F = 3.35, 2/36 df, p<.05) but also approached significance on the three irrelevant dimensions problem (F = 2.70, 2/36 df, p<.10). With the exception of the three irrelevant dimensions problem, the GC condition led to the highest rate of responding and the NC condition led to the lowest rate. In the three irrelevant dimensions problem the highest rate of responding occurred



A. Grade Group P

B. Grade Group 2



C. Grade Group 5

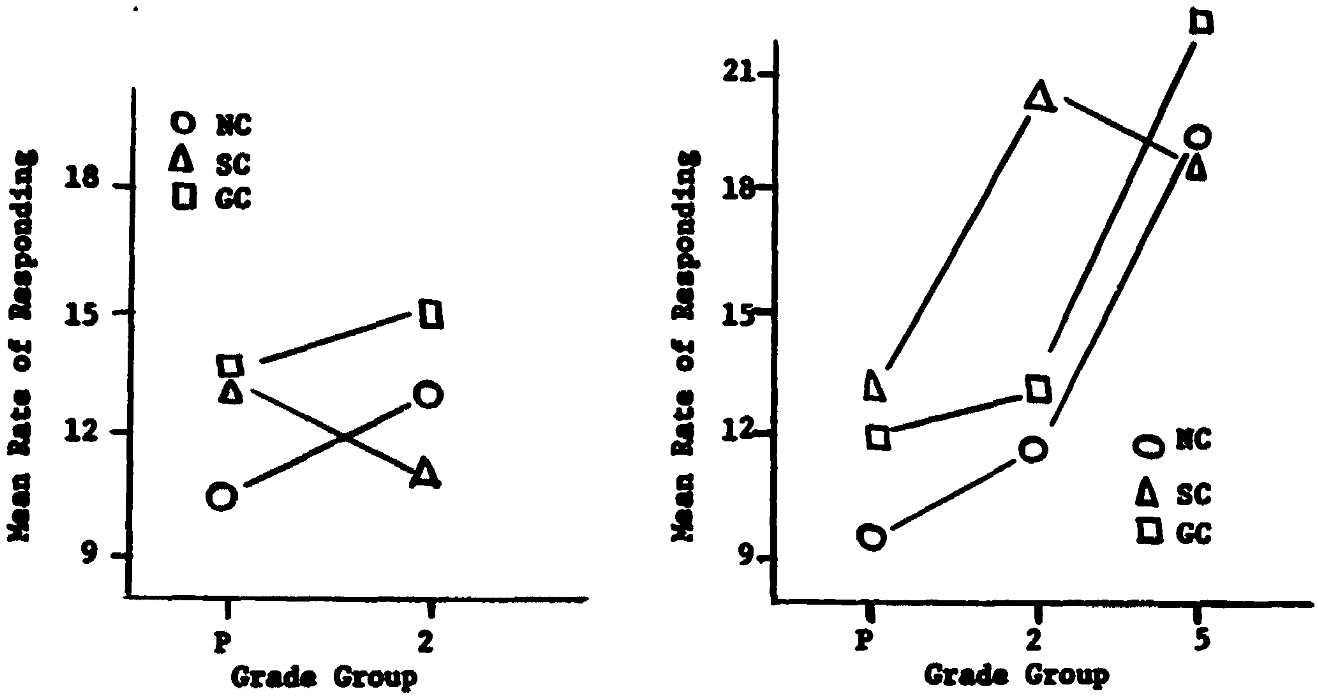
D. Grade Group 8M

Fig. 21.—Mean rate of responding for all cue availability and specific complexity levels within each grade group.

Table 26

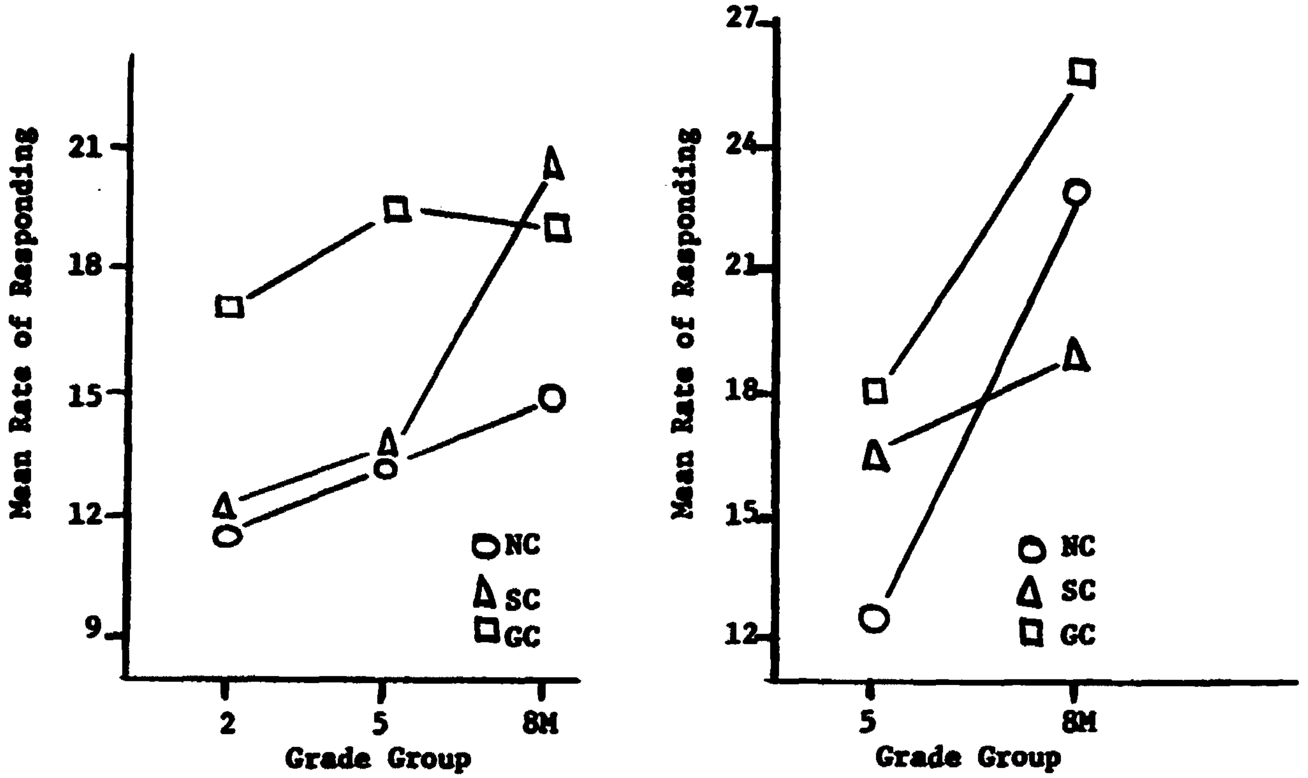
Specific Complexity Levels: Rate of Responding Analyses of Variance

Source	df	MS	F	p
Two Irrelevant Dimensions				
Grade (G)	1	3.56	0.22	
Cue Availability (CA)	2	21.91	1.38	
G x CA	2	12.84	0.81	
Within (Error)	24	15.90		
Three Irrelevant Dimensions				
Grade (G)	2	281.18	12.15	.01
Cue Availability (CA)	2	62.43	2.70	(.10)
G x CA	4	44.68	1.93	
Within (Error)	36	23.15		
Four Irrelevant Dimensions				
Grade (G)	2	83.63	2.72	(.10)
Cue Availability (CA)	2	103.17	3.35	.05
G x CA	4	24.06	0.78	
Within (Error)	36	30.78		
Five Irrelevant Dimensions				
Grade (G)	1	367.92	11.32	.01
Cue Availability (CA)	2	57.91	1.78	
G x CA	2	41.26	1.27	
Within (Error)	24	32.52		



A. Two Irrelevant Dimensions

B. Three Irrelevant Dimensions



C. Four Irrelevant Dimensions

D. Five Irrelevant Dimensions

Fig. 22.—Mean rate of responding for all cue availability and grade group combinations within specific complexity level problems.

with the SC condition. The Grade x Cue Availability interaction did not approach significance in any of the specific complexity level problems.

Thus, the rate of responding measure was negatively correlated with the time and arror variables reported in the previous sections. The average rate of responding increased with grade but was sensitive only to complexity level differences in the oldest grade groups (i.e., groups 5 and 8M). Overall, the GC condition elicited the highest rate of responding in all grade groups except for grade group P in which the SC condition elicited the highest rate. However, there were also other exceptions to this trend, such as grade group 2 showing the highest rate of responding on the SC condition on the three irrelevant dimensions problem. In age group 8M the difference in rate of responding between the GC and SC conditions became significant as it did in the log errors analysis.

Replication on Sex in Grade Group 8

The results that have been presented thus far were based on the performance of male subjects. To further investigate some sex differences that have been found in other studies (Pishkin, Wolfgang and Rasmussen, 1967; Woflgang, 1967b), grade group 8M was replicated for females.

It was reported previously that there were no significant difference between problem-types (color-relevant and form-relevant) for grade group 8M on any of the three measures. This also held for grade group 8F in which the following *t*-values between problem-types were found: log errors, $t = .048$; log time, $t = 0.192$; rate of responding, $t = 0.867$ (all had 43 *df*, $p > .10$). Thus there were no significant differences on problem-type for grade group 8 and the data for both problems of form-relevant and color-relevant were combined in the following analyses.

The analyses of variance on the three dependent variables of the study for grade group 8 (8M and 8F) are presented in Tables 27, 28 and 29.

The main effect of Complexity was not significanct on any of the dependent variables. Cue Availability was a significant main effect in the log errors analysis (_F_ = 3.07, 2/72 _df_, _p_<.05) and in the log time analysis (_F_ = 3.51, 2/72 _df_, _p_<.05). In both cases the NC condition elicited the most inefficient performance and the GC condition led to the most efficient performance, with the SC condition being intermediate. The main effect of Sex approached significance in both the errors and time analyses. The means for males were: log errors = 0.9576; log time = 0.3954. The means for females were: log errors = 1.5760; log time = 0.4784. Thus, the males performed more efficiently than the females in that they have a lower error rate and a faster time to solution (Figures 25 and 26). In examining these sex differences it is important to note that the experimenter was female.

The Complexity x Cue Availability interaction and the Sex x Complexity interaction in the rate of responding analysis of grade group 8 were both significant. In the Complexity x Cue Availability interaction (_F_ = 2.63, 4/72 _df_, _p_<.05), shown in Figure 23, the traditional effect across complexity (i.e. task becomes more difficult with increasing complexity) was seen with the SC and GC conditions, with the responding rate decreasing as a function of increasing complexity.

Table 27

Grade Group 8: Analysis of Variance on Log Errors with Replication for Sex

Source	df	MS	F	p
Between Subjects				
Complexity (C)	2	0.0395	0.11	
Cue Availability (CA)	2	1.0641	3.07	.05
Sex (S)	1	1.0756	3.10	(.10)
C x CA	4	0.2414	0.70	
C x S	2	0.4338	1.25	
CA x S	2	0.0252	0.07	
C x CA x S	4	0.3066	0.88	
Within (Error between Ss)	72	0.3471		
Within Subjects				
Blocks of Trials (B)	7	2.3648	84.34	.001
B x C	14	0.0120	0.43	
B x CA	14	0.0412	1.47	
B x S	7	0.0264	0.94	
B x C x CA	28	0.0273	0.97	
B x C x S	14	0.0172	0.61	
B x CA x S	14	0.0243	0.87	
B x CA x C x S	28	0.0272	0.97	
Within (Error within Ss)	504	0.0280		

Table 28

Grade Group 8: Analysis of Variance on Log Time to Solution with Replication for Sex

Source	df	MS	F	p
Complexity (C)	2	0.0445	0.92	
Cue Availability (CA)	2	0.1700	3.51	.05
Sex (S)	1	0.1551	3.21	(.10)
C x CA	4	0.0632	1.31	
C x S	2	0.0979	2.02	
CA x S	2	0.0010	0.02	
C x CA x S	4	0.0363	0.75	
Within (Error)	72	0.0484		

Table 29

Grade Group 8: Analysis of Variance on Rate of Responding with Replication for Sex

Source	df	MS	F	p
Complexity (C)	2	70.09	1.75	
Cue Availability (CA)	2	32.94	0.82	
Sex (S)	1	60.24	1.50	
C x CA	4	105.55	2.63	.05
C x S	2	136.96	3.41	.05
CA x S	2	3.32	0.08	
C x CA x S	4	41.47	1.03	
Within (Error)	72	40.16		

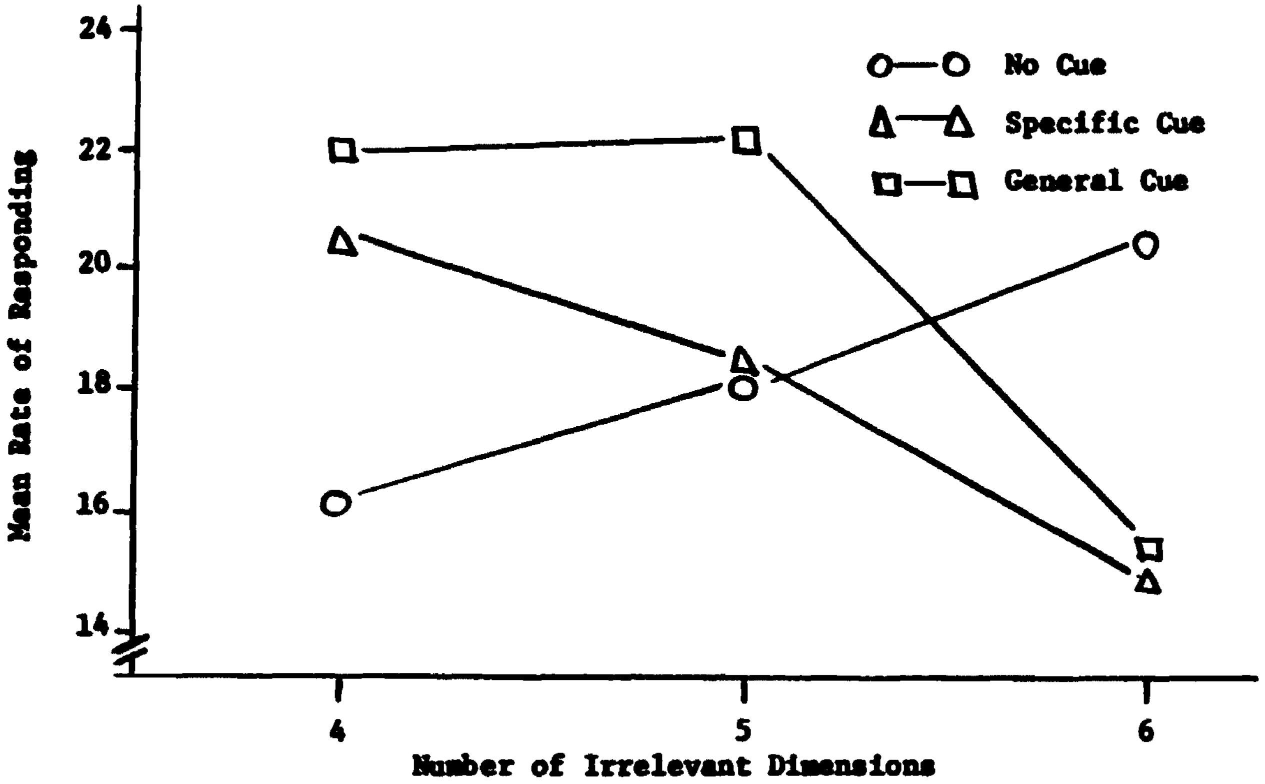


Fig. 23.—Mean rate of responding in grade group 8 (both sexes) for each cue availability and specific complexity combination.

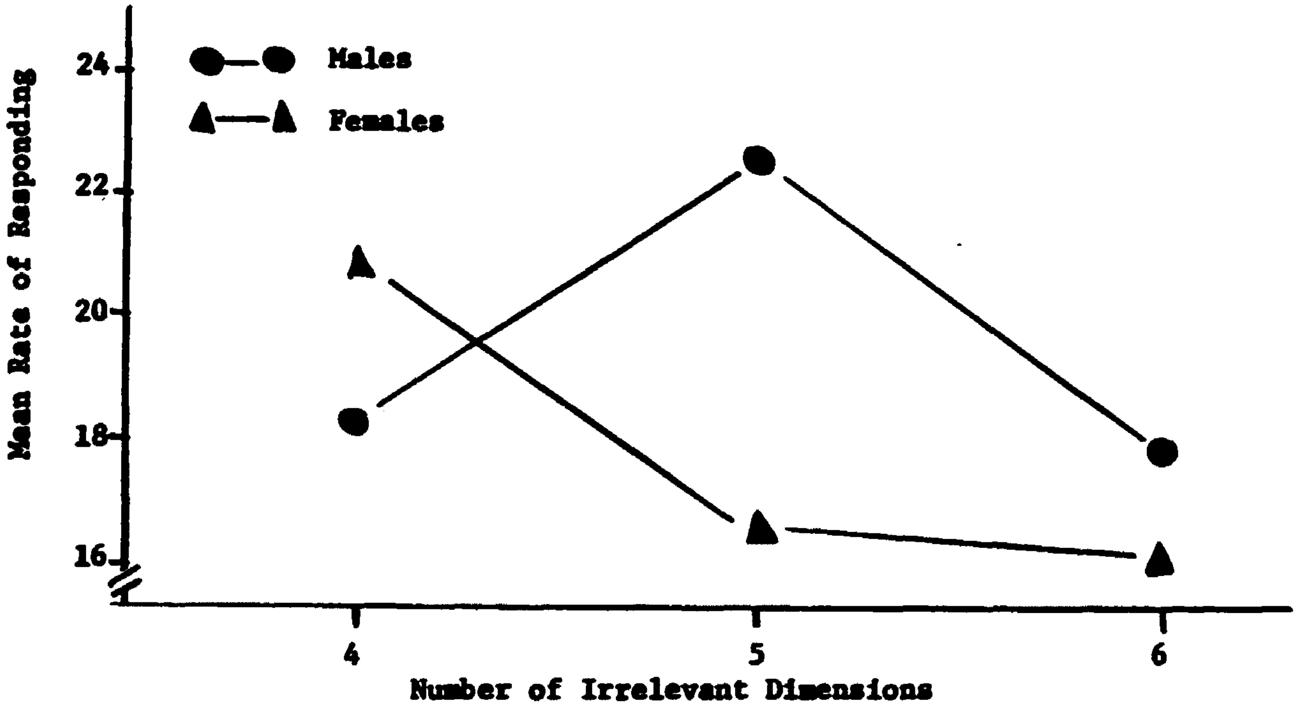


Fig. 24.—Mean rate of responding for males and females in grade group 8 for each complexity level.

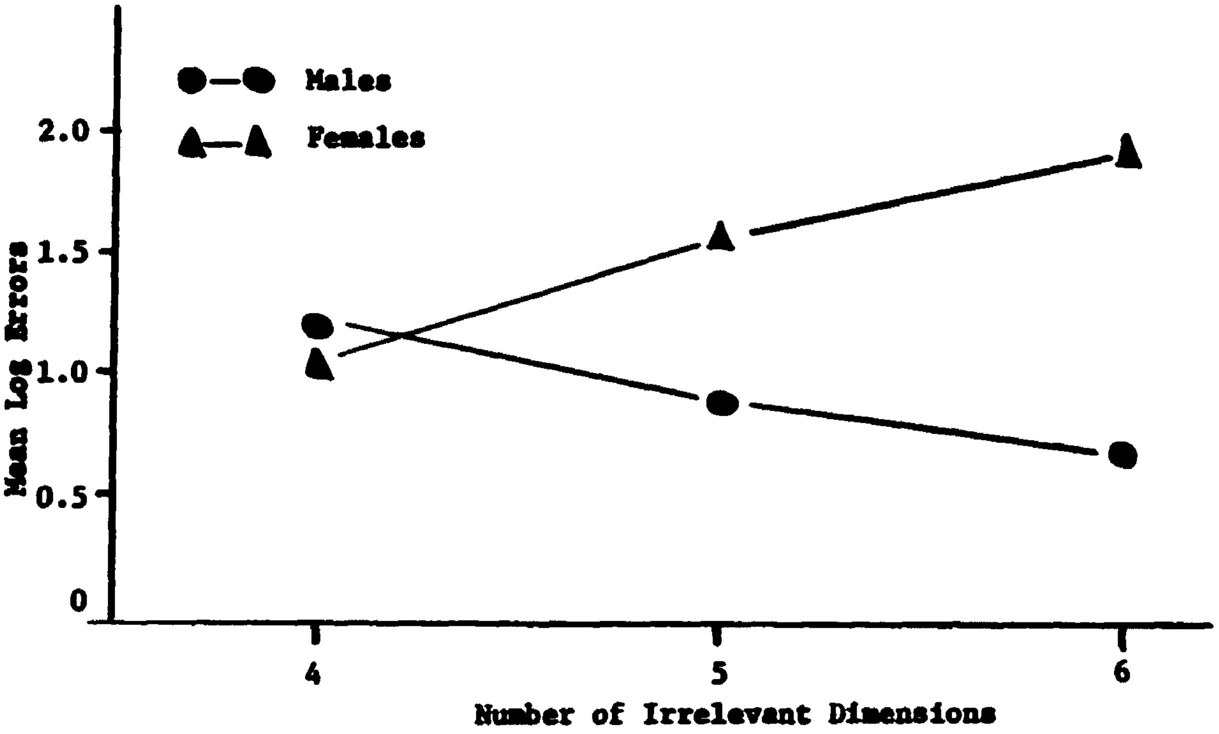


Fig. 25.—Mean log errors for males and females in grade group 8 for specific complexity levels.

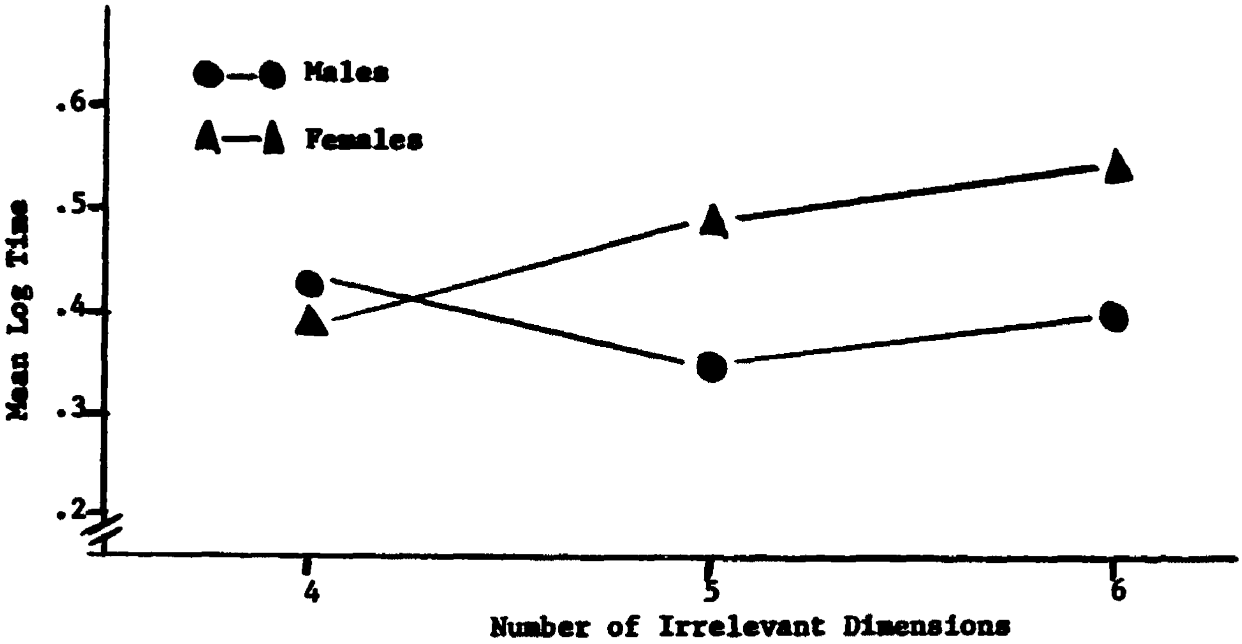


Fig. 26.—Mean log time to solution for males and females in grade group 8 for specific complexity levels.

However, for the NC condition the opposite trend occurred, with response rate increasing with complexity and with the NC condition eliciting the highest rate of response in the six irrelevant dimensions problem.

In the Sex x Complexity interaction ($\underline{F} = 3.41$, 2/72 $\underline{df}$, $\underline{p} < .05$), in the rate of responding analysis shown in Figure 24, the traditional effect of more increased problem difficulty with complexity occurred only for the females, with this trend being that of decreased responding rate with increased complexity. For the males, performance rate increased for the five irrelevant dimensions problem indicating perhaps differential cue saliency between the sexes on the dimensions on this problem. For the males there was little difference in the performance rates between the four and six irrelevant dimensions problems.

While the Sex x Complexity interactions were not significant in the log time or log errors analysis of grade group 8, some differences between the sexes on specific complexity levels did occur. For this interaction in the log errors analysis (shown in Figure 25), the rate increased across complexity for the females but decreased for the males. The difference between the sexes was significant on the six irrelevant dimensions problem ($\underline{t} = 2.115$, 28 $\underline{df}$, $\underline{p} < .05$) but not for the four irrelevant dimensions problem ($\underline{t} = -0.154$, 28 $\underline{df}$) or the five irrelevant dimensions problem ($\underline{t} = 1.154$, 28 $\underline{df}$). In the log time analysis the difference between the sexes was significant on the five irrelevant dimensions problem ($\underline{t} = 2.039$, 28 $\underline{df}$, $\underline{p} < .05$) but was not significant for the four irrelevant dimensions problem ($\underline{t} = 0.589$, 28 $\underline{df}$) or the six irrelevant dimensions problem ($\underline{t} = 1.686$, 28 $\underline{df}$).

Thus, in terms of the sex variable in grade group 8, the males performed slightly better than the females; however, this difference between the sexes was dependent on the complexity level of the problem and on the type of measure that was utilized in assessing their performance. One possibility concerning these sex differences is that they may be a function of Ss developmental level. In order to obtain a better understanding of these differences the means for both sexes and the specific grades within grade group 8 (7th, 8th and 9th graders) are shown in Figures 27, 28 and 29, for the three dependent variables.

For rate of responding (Figure 27) the differences between the two sexes did increase with grade (7th through 9th grade) in grade group 8. For the 9th graders this difference was significant ($t = 1.899$, 28 df, $p<.05$) (For the 7th graders, $t = 0.38$, 28 df, $p>.10$; for the 8th graders, $t = .67$, 28 df, $p>.10$; neither were significant). The same picture was seen in the sex differences between the specific grade-levels on the log time measure (Figure 28). For the 7th graders, there was no significant difference on log time to solution for the two sexes ($t = 1.03$, 28 df). For the 8th graders the difference between the sexes approached significance ($t = 1.52$, 28 df, $p<.10$). The males in the 9th grade performed more efficiently than the 9th grade females ($t = 1.95$, 28 df, $p<.05$). Thus, for the log time and rate of responding measures, the differences in the performance levels of the two sex groups increased with specific grade-level (7th through 9th grades).

There was little difference between the two sexes in the 8th grade ($t = 0.52$, 28 df, $p>.10$), but the difference between the sexes

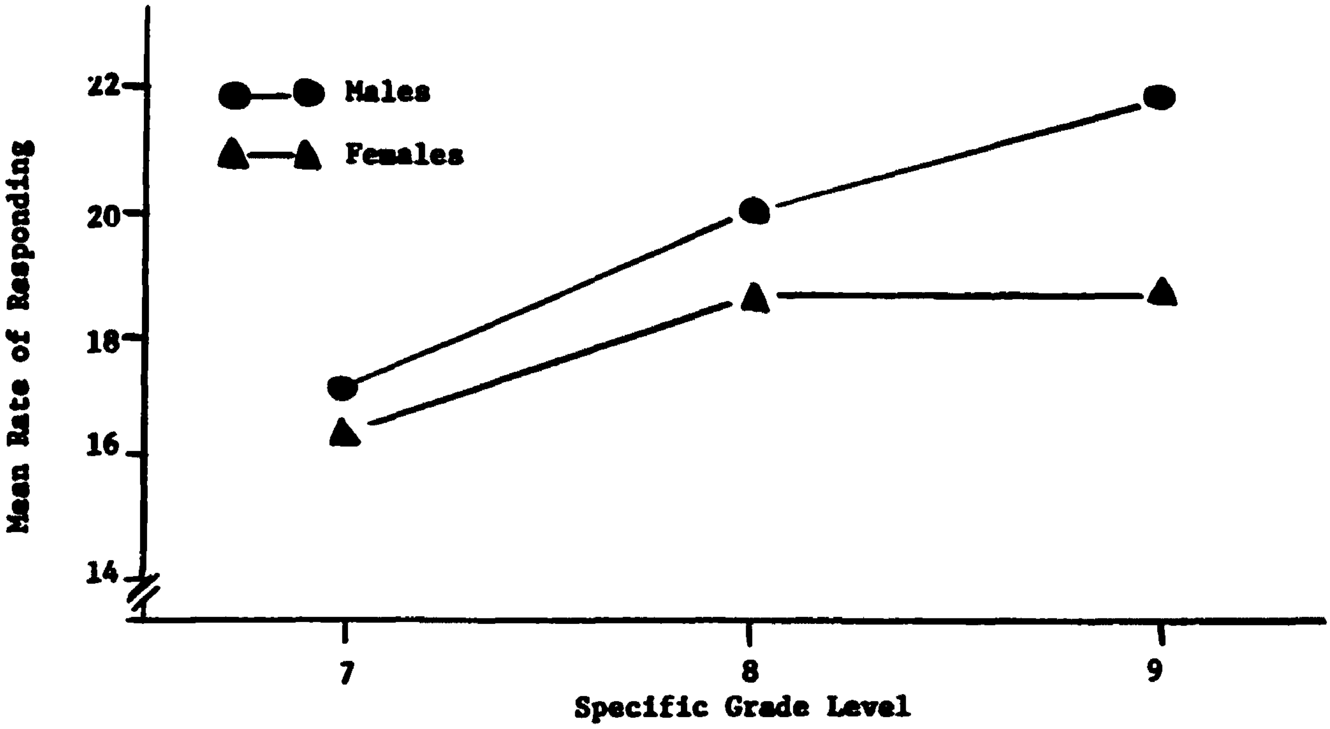


Fig. 27.—Mean rate of responding for each grade level and sex group within Group 8.

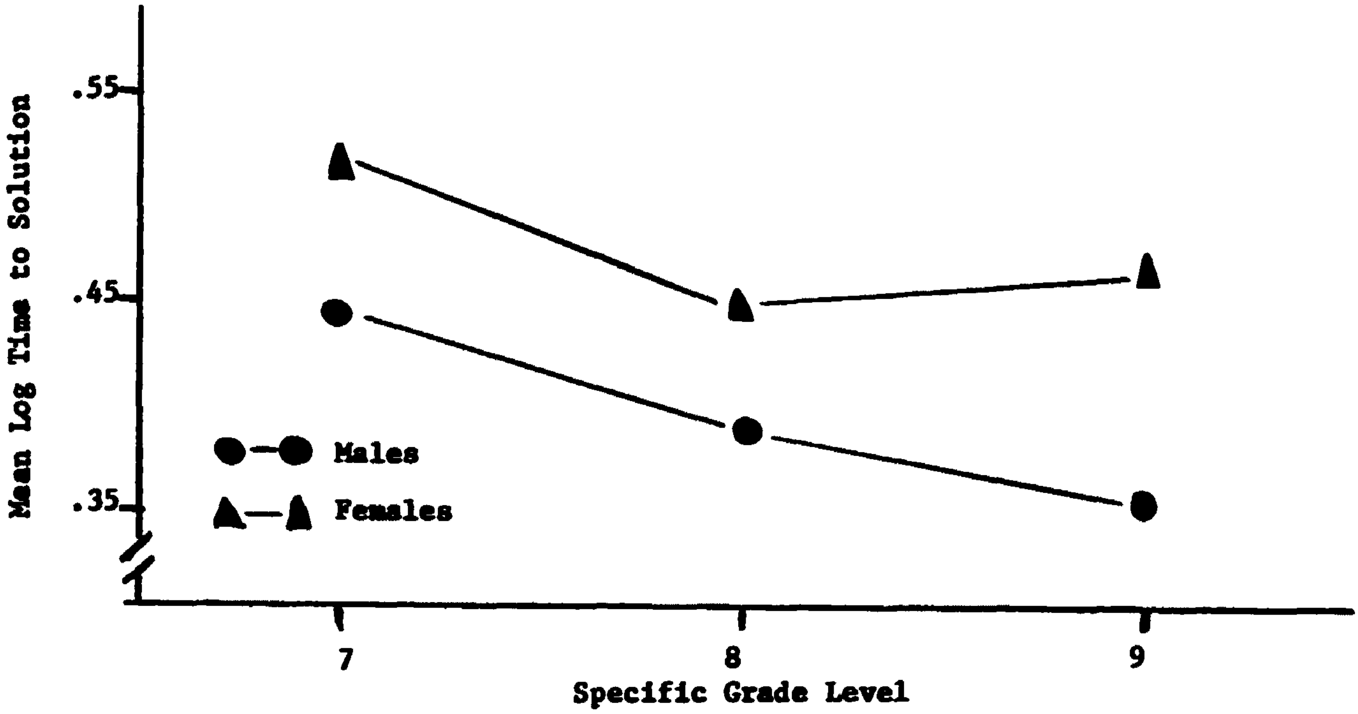


Fig. 28.—Mean log time to solution for each grade level and sex group within Group 8.

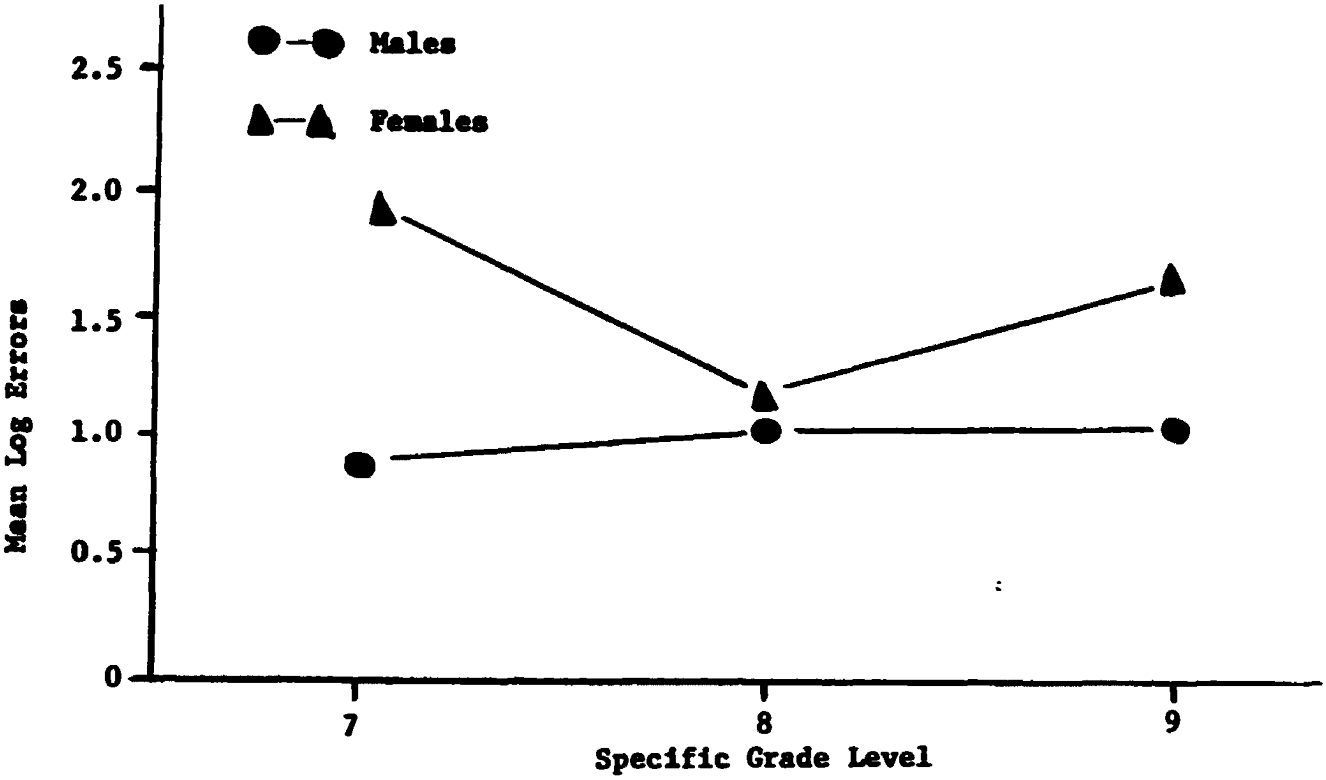


Fig. 29.--Mean log errors for each grade level and sex group within Group 8.

for the 7th graders was significant (_t_ = 2.388, 28 _df_, $p<.025$) and the difference between the sexes in the 9th grade approached significance (_t_ = 1.316, 28 _df_, $p<.10$). Thus, while the difference in levels in performance for the two sexes increased with specific grade level for the rate of responding measure, factors other than the developmental aspects of sex differences should probably be considered for the results that occurred with the errors measure.

CHAPTER IV

DISCUSSION

A major purpose of the present study was to investigate the relationship between stimulus cues which previously had been operationally defined as representing "memory" and "attentional" functions in concept identification tasks. The specific instance cue used in the present study (i.e., the last correct stimulus card remaining visible within each category) was adapted from experiments investigating the role of past stimulus availability on conceptual task performance; past stimulus availability has been linked to the memory requirements of concept identification. The general focusing cue condition in this experiment (i.e., the levels of the relevant dimension were shown to _S_ prior to and during the concept learning task) was drawn from studies using various types of "emphasizers" to call _Ss_ "attention" to specific aspects of the stimulus material. It was predicted that the functions of these two types of cues, the specific instance cue and the general focusing cue, would be closely interrelated, but, that their influence on concept learning performance would depend upon the stimulus complexity of the task and on _Ss_ educational grade level. These predictions were presented in a series of hypotheses. The original hypotheses are now stated and discussed in relation to the observed results.

1. The use of a specific instance cue condition and of a general focusing cue condition will both lead to more efficient performance (i.e., fewer errors and faster time to solution) on a concept learning task than the use of a condition in which no such cues are available to the Ss.

This hypothesis was strongly supported by both the error and time to solution measures used in this study in that both the specific instance cue and general focusing cue conditions led to significantly more efficient performance (i.e., fewer errors and faster time to solution than did the no cues available condition (Figure 3, p. 38 and Figure 14, p. 67). On the rate of responding measure the hypothesis was partially supported in that both the specific instance cue and general focusing cue condition led to a faster rate of responding than did the no cues available condition; however, the specific instance cue condition performance was not significantly faster than the no cues available condition.

These results confirm evidence from other studies which have investigated these "memory" and "attentional" cues separately (e.g., Pishkin and Wolfgang, 1965; Bourne, Goldstein and Link, 1964; Haygood and Bourne, 1965; Archer, 1962; Trabasso, 1963). In addition to both types of cues leading to more efficient performance than the no cues available condition, it is noticeable that the difference between performance on these two cues (when all stimulus complexity levels and S grade groups are combined) is not significant on any of the three measures (log errors, log time to solution, and rate of responding). Thus, the similarity in the performance with the specific instance cue and general focusing cue calls for further evaluation of the interrelatedness of the functions of these cues as they are now conceived. In terms of Hypothesis 1, both types of cues are providing effective additional information to the Ss over and above that provided by the no cues available condition. In order to obtain a clearer picture of the type of information these cues are providing, it is necessary to consider the results in relationship to the other hypotheses.

2. In the beginning trials of performance on the concept learning task, Ss in the general focusing cue condition will show significantly more efficient performance than the Ss in the specific instance cue condition, and that this initial advantage for the general focusing cue condition Ss will lead to somewhat better overall performance for the general focusing cue condition than for the specific instance cue condition performance.

The first part of this hypothesis was supported by the repeated measures analysis of log errors across blocks of 12 trials. In the initial phases of performance (here defined as the first block of trials) the general focusing cue condition led to more efficient performance (i.e., fewer log errors) than did the specific instance cue condition (Figure 8, p. 49). This result gives support to the contention that one of the processes involved in concept learning tasks is to discover what the relevant dimension is, thus supporting the Bower and Trabasso model of concept learning (1964) and Haygood and Bourne's analysis of the processes involved in concept learning (1965). That is, providing the subject information about the relevant dimension (although it was not stated as such to the subjects in this study) led to immediately superior performance compared to the specific instance cue or no cues at all. However, the performance with the specific instance cue approached that of the level of the focusing cue early in the learning process (by the second and third block of trials, Figure 8, p. 49). This result allows for several interpretations of the functions of these cues. One such interpretation might be that the focusing cue offers only a slight advantage over the specific instance cue and that "attention" aids thus offer only a slight advantage over "memory" aids. Another possible interpretation, which seems more plausible, is that both types of cues provide information in the selection or discovery of the relevant dimension, but that the role of the specific instance cue in this regard comes into effect only after the subject has had the opportunity to view a certain number of the stimuli. Thus, the initial information provided by the specific instance cue results in performance no better than the no cue condition; but, after exposure to a small number of the specific instance cues the performance approaches that of the focusing cue with both cues resulting in better performance than no cues available. This last interpretation is also supported by the results of the differential effects of the cue conditions with variations in stimulus complexity (Hypothesis 4).

The second part of Hypothesis 2, that the initial advantage in the general focusing cue condition would subsequently lead to somewhat better overall performance for this condition than the specific instance cue condition, was supported. That is, the general focusing cue condition did elicit somewhat better performance (i.e., fewer mean log errors, faster time to solution, and higher rate of responding) than the specific instance cue condition (Figure 3, p. 38 and Figure 14, p. 67). However, as noted above, this difference was not significant. Thus the initial advantage provided by the general focusing cue condition was just that, as reflected in both the initial performance with the cue availability conditions and the overall performance levels. This provides further support for the assumption that both the "memory" and "attention" cues have similar functions in terms of performance.

3. On tasks of low stimulus complexity, the specific instance cue and general focusing cue conditions will not substantially improve concept learning performance compared to the no cues available condition. However, with increasing stimulus complexity the specific instance cue and general cue conditions will elicit progressively more efficient performance levels than the no cue condition.

This hypothesis was based on the premise that the demands placed on Ss memory and attentional capabilities will vary with the complexity of the task and thus that the effectiveness of "memory" and "attentional" cues, as compared to no cues, would also vary with task complexity. In the design of the present experiment, specific complexity level (i.e., number of irrelevant dimensions) overlapped S grade groups (Table 1, p. 26), such that low complexity here refers to one irrelevant dimension for grade group P, two irrelevant dimensions for grade group 2, three irrelevant dimensions for grade group 5, and four irrelevant dimensions for grade group 8. The specific complexity levels for the middle and high complexity conditions are one and two irrelevant dimensions added, respectively, to those in the low complexity condition for each grade group.

Hypothesis 3 was supported by the errors analysis (Figure 4, p. 40) but not by the time and rate of responding analyses. In the errors analysis there was no difference between the cue availability conditions on the low complexity level problems. Thus the additional information provided by the general focusing and specific instance cues is not giving S any effective additional information in this low complexity level condition. For increased complexity levels, however, this additional information does substantially aid Ss memory and attentional capabilities. That is, for the middle and high complexity level conditions there is a significant difference in the performance levels of the no cue available condition and the two cues available conditions (i.e., specific instance cue and general focusing cue) as seen in Figure 4, p. 40. The two cues available conditions elicited significantly fewer mean log errors than the no cues available condition (more efficient performance) for the middle and high complexity conditions. This makes the effectiveness of the cues dependent on task complexity and the demands placed on Ss capabilities. This relationship is further discussed with Hypothesis 4.

4. In the no cues available condition, more inefficient performance will occur with increases in stimulus complexity, following the Bourne and Restle prediction (1959). However, with the specific instance cue and general focusing cue conditions this trend of increasingly more inefficient performance with increased stimulus complexity will be eliminated or considerably lessened.

In the overall errors analysis of cue availability as a function of stimulus complexity (Figure 4, p. 40), performance became significantly more inefficient (i.e., more errors made) in the no cue condition with increases in stimulus complexity. This result follows the general trend suggested by the Bourne and Restle mathematical model of concept learning (1959) and by many investigators (e.g., Archer, Bourne and Brown, 1955; Pishkin, 1960; Bourne, 1957; Lordahl, 1961; Bulgarella and Archer, 1962). For the specific instance cues and general focusing cues however, the trend was for stimulus complexity not to have a significant effect on performance level in terms of error rate. For the general focusing cue the performance levels were quite similar for all three complexity levels. For the specific instance cue there was no difference in the performance levels between the low and middle complexity levels, but there was a significant increase in errors between the middle and high complexity levels. The fact that the provision of focusing cues eliminated the effect of stimulus complexity upon performance suggests that the traditional effect of stimulus complexity, demonstrated when no cues are provided to the S, is due in large part to the stimulus selection process (i.e., the discovery of the relevant aspects of the stimulus complex), and also in the aiding of the encoding process which this type of cue probably provides. While the overall effect of stimulus complexity on the specific instance cue was not significant, there was a significant increase in error rate from the middle to high levels. This supports the previous contention that the specific cue can also serve as an attention or stimulus selection cue after the subject has been exposed to a certain number of instances. Because the specific instance cue is showing all the variations in the stimuli, both relevant and irrelevant, more and more stimulus instances would have to be viewed by the subject with increased stimulus complexity levels in order for this cue to be effective as a focusing cue. Thus in the high complexity condition (which was three irrelevant dimensions for grade group P, four irrelevant dimensions for group 2, five irrelevant dimensions for group 5, and six irrelevant dimensions for group 8), the general cue condition led to significantly better performance than the specific cue condition. Both of these cue conditions led to significantly better performance than the no cue condition for the middle and high levels of complexity.

Hypothesis 4 was thus supported, and the trend predicted by the Bourne and Restle model (1959) holds only for the no cues available condition. This indicates that the effect of more irrelevant information added to the task is to place more of a demand on _S_s memory and attentional capabilities.

5. _For tasks of equal complexity levels, performance on the concept learning task will improve with grade level; and, for Ss within the same grade level, performance will become more inefficient with increases in task complexity._

The purpose of this hypothesis was to test the sensitivity of the design in the present experiment and to replicate other findings of improved concept learning performance with increased age of _S_ (e.g. Osler and Kofsky, 1965). In spite of the increasing specific complexity levels with age (Table 1, p. 26), performance became more efficient with age; that is, a decrease in error rate (Figure 1, p. 36), a decrease in time to solution (Figure 12, p. 64), and an increase in rate of responding (Figure 18, p. 78). However, as the specific complexity level problems increased in the number of irrelevant dimensions with grade group, a clearer interpretation of what occurred can be obtained by examining the performance of the grade groups on specific complexity level problems.

The first part of Hypothesis 5 was supported by the trend of performance (but not always supported by the significance of the F tests) across age on all the specific complexity level problems (Figure 11, p. 60, Figure 17, p. 73, and Figure 22, p. 89). That is, the higher grade level groups within each problem performed more efficiently. A clearer picture of this trend can be seen in the log errors analysis (Figure 9, p. 53). On the two irrelevant dimensions problem it is noted that grade group 2 made fewer mean log errors than group P, and on the five irrelevant dimensions problem, group 8M made fewer errors than grade group 5. This same trend held for the other specific complexity level problems. Thus the Ss in the higher grade groups demonstrated more efficient performance on specific complexity level problems.

It was also expected that, for Ss within the same grade group, performance would become more inefficient with an increase in stimulus complexity level (second part of Hypothesis 5). This trend was supported by the results with age groups P, 2 and 5, but not for grade group 8M (Figure 10, p. 55, Figure 16, p. 70, and Figure 21, p. 87). These trends can also be seen in Figure 9, p. 53. For grade groups P, 2, and 5 the mean number of log errors clearly increased with stimulus complexity level. For grade group 8M a trend of decreased mean log errors with increasing complexity level occurred; even this trend is complicated by the fact that on the rate of responding measure (Figure 21D, p. 87) performance rate increased from the four to five irrelevant dimensions problem. In the interpretation of these results there are several factors that need to be considered. One factor was that the Ss in group 8M were 7th, 8th and 9th grade boys and that the E was female. This point will be further explored in discussing the sex differences which occurred in Group 8. Another point to consider here would be the saliency of added irrelevant dimensions for the Ss. It is apparent here that the "additivity of cues" assumption of the Bourne and Restle model (1959) is not holding for these Ss, i.e. performance does not become more inefficient with the added irrelevant dimensions. The dimensions that were added were horizontal position of the patterns for four irrelevant dimensions, vertical position of the patterns for five irrelevant dimensions, and orientation of the patterns for six irrelevant dimensions. These dimensions all utilized spatial variations of the patterns in relation to the white card background, whereas the other irrelevant dimensions (form or color, size, and number) involved differences in the attributes of the patterns themselves. While males have been noted to have a good facility for spatial perception and spatial tasks (Maccoby, 1966) they are also able to respond to specific aspects of a stimulus task without being adversely affected by the background or field of the stimulus material (e.g. the analytic ability or field independence of Witkin, Lewis, Hertzman, Machover, Meissner, and Wapner, 1954; Witkin, Dyk, Faterson, Goodenough, and Karp, 1962). Variations in the spatial positioning of the patterns in the present experiment could possibly be associated with the "field" of the stimulus material. In terms of the log error analysis the Ss in group 8M apparently were able to eliminate the spatial irrelevant dimensions more quickly as a function of the number of such dimensions. In the rate of responding analysis (Figure 21D, p. 87) this was particularly true for the increased complexity from four to five irrelevant dimensions. On the rate of responding measure, however, orientation of the pattern (the sixth irrelevant dimension) reflected a decrease in rate of responding (more inefficient performance) indicating that orientation did have the effect of slowing these Ss down (compared to the five irrelevant dimensions problem) though this result was not demonstrated by a higher error rate. The performance of grade group 8M across stimulus complexity levels may thus be due to the saliency of the cues to these Ss.

6. The use of the specific instance cue and general focusing cue conditions will improve the performance of the lower grade level Ss more than that of the higher grade level Ss on concept learning tasks of comparable complexity levels. That is, the difference in the performance levels of the no cue condition and the two cues-available conditions will be greater for the younger Ss than for the older Ss.

The reasoning behind this hypothesis was that as the older Ss presumably have greater attentional and memory abilities these aids would be of less benefit to them. This hypothesis was not supported on any of the overall analyses of the dependent variables (i.e., the Grade x Cue Availability interactions very not significant). In terms of the overall analyses, the lack of a significant Grade x Cue Availability interaction could be due to the fact that the complexity levels investigated in this study increased for successive grade groups. That is, grade group P worked on problems with one, two and three irrelevant dimensions; group 2 worked on problems with two, three or four irrelevant dimensions; group 5 had problems with three, four or five irrelevant dimensions, and group 8 had problems with four, five or six irrelevant dimensions.

A clearer view of this hypothesis can be gained by looking at the results in terms of the specific complexity level problems. However, in none of these analyses does the Grade x Cue Availability interaction reach significance although a trend does occur in the hypothesized direction (Figures 11, p. 60; 17, p. 73; and 22, p. 89). The differences in the performance levels between the cues available and the no cue available conditions becomes less for the higher grade groups working on the individual complexity level problems. One possibility for the absence of strong support for this hypothesis is that the range of grade groups for any one complexity level was not great enough and also that the range of complexity level for any one grade group was not broad enough to adequately test this hypothesis. This would be one possibility for further research.

It is speculated that, if in the present study the same complexity levels had been used across all grade groups, the support for this hypothesis would have been about the same as occurred in the present design. As the discussion of Hypothesis 7 will indicate, it is not only the capabilities of attention and memory that S brings with him to this type of concept learning task which influences performance with the cues-availabile conditions, but also the ability to utilize the cues that will influence subsequent performance. The ability to effectively use the specific instance cue and general focusing cue conditions changed with grade group as indicated by the results to be discussed next.

7. The general focusing cue condition will elicit more efficient performance than the specific instance cue condition for all grade level groups.

This hypothesis was supported for grade groups 2 through 8 (1st through 9th graders) but not for group P (4-year-old preschool and kindergarten Ss). This result was strongly supported in the errors analysis (Figure 5, p. 43) and was also supported in the time and rate or responding analyses (Figure 16, p. 70 and Figure 20, p. 84). For grade groups 2, 5 and 8 the best performance occurred with the general focusing cue. However, the difference between the general focusing cue performance and specific instance cue performance was significant only in grade group 8. For grade group P the best performance resulted from the specific instance cue condition. These results, particularly those with the lower-grade group Ss, can be related to theoretical considerations of the role of mediational mechanisms in learning and to recent theoretical considerations of memory and attentional functions in cognitive development.

Before turning to these considerations, one interpretation should be advanced for the performance by grade group 8 with the general focusing cue, which is not specifically linked to the following theoretical considerations. It was noted earlier that only for grade group 8 did the general focusing cue elicit significantly more efficient performance than the specific instance cue performance. A previous study using one-instance availability in a four category concept learning task found that this condition significantly facilitated performance as compared to no cues available for Ss in this grade range (Pishkin, Wolfgang, and Rasmussen, 1967). It may be that in the present study Ss performance on the three cue conditions was more a function of Ss expectations of the task's difficulty than of the actual task itself. That is, the present study was a two-category task and it is quite possible that the S searched for a more complex solution than was actually required. The use of the specific instance cue condition served to limit Ss expectations to some degree (but not necessarily significantly more than in the no-cues available condition). However, the use of general focusing cue, which was shown to S prior to his working on the task, served to "focus" those Ss on the possibility that the task had an "easy" solution. It is thus possible that the difference between the cue availability conditions for group 8 is associated with Ss's set or expectations about the task.

The relationships between the cue availability conditions for the different grade groups can also be compared to the mediational approaches which stress the roles of overt and covert verbalization processes in the development of conceptual ability although the test of the "goodness of fit" to this type of approach is more difficult to make. The Kendler and Kendler approach (1962) has been to compare differences in performance on the reversal non-reversal shift paradigm with children of different ages. It has been found that pre-school children transfer most readily to the non-reversal shift in which the relevant dimension is changed (Kendler, Kendler, and Wells, 1960). In the age range from 5- to 7-years-of-age a shift occurs to a slight preference for the reversal shift in which the same dimension remains relevant but the overt responses are reversed (Kendler and Kendler, 1969). For college students a definite preference for the reversal shift solution has been found (Kendler and D'Amato, 1955). This change in preference for the different solutions in relation to age has been interpreted in terms of strict S-R learning in the preschool years and to a shift to a mediational S-S process beginning around 5- to 7-years-of-age (Kendler and Kendler, 1962).

Ad hoc observations associating language behavior to reversal non-reversal shift performance has found that those subjects who prefer the non-reversal solution do not make relevant verbalizations about the stimulus material while those subjects preferring the reversal shift solution do make relevant stimulus material verbalizations (Kendler, 1963). These observations have led to the conclusion that the ability to label the attributes of the relevant dimension is correlated with concept shift performance and thus verbalization is an important aspect of the mediational process, although this conclusion is not always felt to be warranted (e.g., Wolff, 1967). However, relating the results of the reversal shift studies with the present results, it can be noted that the age levels in the Kendler studies in which proper verbalizations are not usually given, corresponds to grade group P in which the general focusing cue was not effective. The age level in the Kendler studies at which proper verbalizations are elicited, correspond to the grade levels in the present study in which the general focusing cue is most effective. In the current study no test of verbalization related to the relevant dimension was made and thus a direct correspondence to the Kendler results cannot be tested. The fact that a point was made of not labeling the general focusing cue for the subject in the present study would seem to indicate that the present study was not confounded by overt labels from the experimenter. The mediation approach would probably interpret the superiority of the specific instance cue in grade group P to straight S-R learning or conditioning, while the superiority of the general focusing cues in the older age groups would be interpreted in terms of covert mediation and verbalization processes.

In their theorizing about the growth of cognitive processes, both Bruner (1964) and Wohlwill (1962) have emphasized the role of the perceptual qualities of, and dependence on, the immediate stimulus field in the development of the memory processes of the young child. As the child matures, according to these theorists, he is seen as making more inferences via symbolic representation beyond that provided by the immediate stimulus field. In the present study the specific instance cues may be thought of as providing immediate stimulus field cues while the general focusing cue may be thought of as providing information to the subject which is not in the immediate stimulus field (i.e. representational or memory information), in terms of the location within the task and to the subject and also to the fact that these cues were not in the same format as those in the immediate stimulus field. Within this framework the 4- and 5-year-old preschool children in this experiment (grade group P) could not utilize the general focusing cue information as effectively as they could the information provided in the immediate stimulus field (the specific instance cue) and thus these children can be thought of as being tied to the perceptual qualities of the immediate stimulus field (Bruner's approach) or dependent on the information provided by the immediate stimulus field (Wohlwill's approach). That is, it would appear that the grade group P Ss are unable to bridge the gap of association between the specific instance cue (immediate field information) and the general focusing cue (which is outside the immediate field and thus providing symbolic or representational information to these Ss).

The Bruner and Wohlwill interpretations and the current results are also closely related to recent considerations of the relationship between observing responses and spatial variables (Stollnitz, 1965). An observing response is defined as any response that results in exposure to a discriminative stimulus. One of the assumptions of observing-response theory is that the probability of an observing response occurring is based on the spatial separation between the stimulus cue and the response. Stollnitz's review of these variables (1965) finds that this assumption can account for much of the effects of spatial variables in discrimination learning with monkeys, chimpanzees and children. It can also be related to the current results in that the general focusing cue is spatially separated from the immediate stimulus field in which the child makes his response while the specific instance cue is located within the immediate stimulus field in which the response is made. Thus the effects of the cue availability conditions for grade group P can be accounted for by two different types of approaches, one related to the ability to encode and make inferences beyond the immediate stimulus field and the other concerned with the role of attentional factors, i.e. the capability to make use of observing responses.

The children in the older grade groups, 2, 5 and 8 (1st through

9th grades), were able to utilize the information provided outside the immediate stimulus field (i.e., the general focusing cue) significantly better than the no-cues available condition. But only in age group 8 (7th through 9th grades) did the performance levels significantly differ between the general focusing cue and the specific instance cue. In terms of the Bruner (1964) and Wohlwill (1962) approaches the children in grade groups 2 and 5 were able to make effective use of the information outside the immediate stimulus field but only for the highest grade group did this type of information become significantly more effective than immediate field information.

These results can also be interpreted in relation to the role of memory and mediation. The greater utilization of the general focusing cue with the Ss in the higher grade groups may indicate that this cue condition involves not "attention" as it was operationally defined at the beginning of this study but that, in fact, it involves mediational and memory processes. In order for S to effectively utilize this general focusing cue it is required that he is able to call upon mediational processes in order to "bridge the association gap" of the cue's function and the task itself. Once the S is able to do this, this cue may be serving a memory function. Conversely, it is also possible that the specific instance cue originally designated as the "memory" cue may not involve memory functions at all, but may be doing nothing more than specifically calling Ss attention to past correct instances.

In terms of the effectivenss of the different cue availability conditions for the different age groups, the results can thus be interpreted in terms of recent theorizing concerning the role of encoding processes and the immediate stimulus field on children's conceptual development and also in terms of attentional variables such as the observing response. While the results can be related to the mediational and verbalization approach, no direct test in terms of verbalization was made.

The line of reasoning developed here, in relation to several types of theoretical considerations of the functions of the specific instance cue and general focusing cue with Ss of varying grade-level groups, leads to the conclusion that the functions of these cues change with Ss developmental level and that the effectiveness of the cues is dependent upon Ss ability to utilize mediational or representational forms of information. For the preschool Ss (group P) the superiority of the specific instance cue indicates that they are bound to perceptually immediate field cues and that this cue serves as an attention aid (i.e., directs their observations) to past stimulus information. For the older Ss, the superiority of the general focusing cue indicates that these Ss are able to effectively utilize representational information outside of the immediate stimulus field and thus this cue is associated more with mediational and memory processes than was originally supposed. The general focusing cue is probably still providing attentional cues to the older Ss, but the ability to utilize this information as an "attentional" cue depends on Ss ability to use mediational and symbolic information. Thus it would appear that the interrelationship between the types of information provided by these two types of cues is dependent on Ss developmental level.

In addition to the testing of the seven hypotheses that have just been discussed another purpose of the present study was to explore possible sex differences in Group 8 (7th, 8th and 9th grades). The results of the replication of Group 8 for both sex groups are now presented and discussed.

It was found in the present study that the males performed slightly better than the females, thus supporting other evidence that males are superior to females on problem-solving tasks (e.g., Tyler, 1965). However, the difference between the sexes was a function of the stimulus complexity level (Figure 24, p. 94; and Figures 25, p. 95 and 26, p. 95) and also of specific grade level within group 8 (Figure 27, p. 98; Figure 28, p. 98, and Figure 29, p. 99).

The difference between the sexes in relation to the stimulus complexity levels is considered first. In the log errors analysis (Figure 25, p. 95) the performance of the females followed the traditional Bourne and Restle trend of increased errors with increased complexity level (Bourne and Restle, 1959), while the performance of the males was contrary to this trend, showing a decrease in error rate with increased complexity. (This decrease was not significant, however.) This result is contrary to that found by Wolfgang (1967b) for college students, in which males demonstrated an increased error rate and the females a decreased error rate, with an increase from six to seven irrelevant dimensions. However, this seemingly apparent contradiction of the results of the present study and of the Wolfgang study can be resolved by a closer look at the results and what is known about the saliency of certain types of dimensions for the two sexes and probably is not due to the different ages of the S̲s in the two studies. As was discussed under

Hypothesis 5, the dimensions used for the four, five and six irrelevant dimensions problems involved the progressive addition of the following irrelevant dimensions: horizontal position of the patterns on the cards, vertical position of the patterns, and orientation of the patterns (in tilted or normal position). These all involved spatial variations of the patterns and not variations within the pattern itself. As noted previously, males generally have good facility with tasks involving spatial perception, while females do not (Maccoby, 1966), and males are also able to respond to specific aspects of a stimulus task without being hindered by the background or field of the stimulus task while females are hindered by the presence of such background information (Witkin at al, 1954; Witkin et al, 1962). These sexual differences in responding to spatial aspects of stimuli have also been extended and noted to be important aspects of differences in intellectual functioning (Sherman, 1967) and in perception (Wapner and Werner, 1965). Relating these results to the present study, the males in Group 8 were not adversely affected by the addition of more spatial irrelevant cues to the concept learning task while the females were. In the six irrelevant dimensions problem of the Wolfgang study (1967b), the irrelevant dimensions were form or number, color, size, horizontal position of the patterns, orientation of the patterns, and color of background field, much the same as in the present study (except for the last dimension). On the six irrelevant dimensions problem in Wolfgang's study, the females performed significantly more inefficiently than the males. This is verified by the present study. However, for Wolfgang's seventh irrelevant dimension, a line was added to the pattern itself (i.e. not a spatial variable but an attribute of the pattern itself). Wolfgang's males suddenly increased significantly in error rate with this added dimension while the females decreased in error rate. This result can be interpreted by the same line of reasoning, i.e. the role of spatial variables in intellectual functioning. Because males are more dependent upon the information within the field and not tied to variations of the background or variations in relation to the background, the addition of another attribute of the stimulus itself should adversely affect their performance as it did in the Wolfgang study. The females, however, are more adversely affected by the spatial variations and since the seventh irrelevant dimension was not spatial in nature, their performance was not adversely affected. One interpretation of the sex differences that occurred in the present study can thus be linked to the differential role of spatial variations in the stimulus material for the two sexes.

The difference between the sexes also changed as a function of specific grade level within group 8. Figures 27, p. 98, and 28, p. 98, showed the differences between the two sexes increased with increase in specific grade level (7th through 9th grades) on the time to solution and rate of responding measures. The difference between the sexes became significant for the 9th graders but was not significant for the 7th and 8th graders. The sex differences did increase with grade level for these Ss. This developmental approach to the growth of these sex differences is complicated by the results which occurred on the errors analysis (Figure 29, p. 99). On this analysis the difference between the sexes was significant for the 7th graders, was not significant for the 8th graders, and approached significance for the 9th graders. The error rate for the males stayed at approximately the same level across the three grade levels while the performance of the females started at a higher error rate for the 7th graders, decreased for the 8th graders, and then increased slightly for the 9th grade females. These differences in results between the log errors analysis and the rate of responding analysis can be partially tied to the relationship of these two variables for this age group. The correlation between rate of responding and log errors was -.3436 for the males in group 8 and was -.4476 for the females (Table 20, p. 84). Thus the degree of relationship between these two variables was not as high for the males as for the females.

Another possible interpretation of the sex differences discussed above is that the E of this experiment was female. In this adolescent period of the Ss (7th through 9th graders) it is quite possible that the motivation of the S on the task would be affected by the sex of the E. While there is little evidence on this topic in relation to cognitive tasks for Ss of the grade level being studied here, some studies have found that Es of the opposite sex of the Ss do elicit higher efficiency from the Ss than do Es of the same sex (Kuhn, 1960; Stevenson and Allen, 1964). In the present study this could be the case, as the male Ss performed more efficiently than the female Ss and the E was female. However, even with this explanation of the results, it would seem that the degree of relationship is also affected by Ss educational grade level or age, since the degrees of efficiency changed with the specific grade level.

Several interpretations of the results are offered in terms of the sex differences that occurred in group 8. These include sex differences due to the saliency of the cues, particularly in relation to spatial variables, the development of sex differences with age, and the motivation of S on the task being affected by the sex of the E. Probably a combination of these interpretations would best explain the results that occurred, but there are many questions yet to be more fully explored by further research in this area.

Finally, in regard to cue saliency, it was noted in the results of the present study that there were no significant differences for any of the grade groups with the use of different relevant dimensions. The problem-type of form-relevant resulted in the same performance levels as color-relevant. This is not always the case, however. In a replication of the preschool group in this study (Group P) with low-socio-economic males enrolled in Head Start classes (Rasmussen and Pishkin, 1969) it was found that the problem-type of form-relevant elicited significantly more efficient performance levels than the problem-type of color-relevant ($t = 1.70$, 43 df, $p<.05$). This difference was found to hold for the no cues available condition only ($t = 2.68$, 13 df, $p<.01$). It is quite probable that the differences between these two groups of preschool Ss on the saliency of the two relevant dimensions (i.e., form and color) can be related to the different environmental background of the Ss. The Ss in the present study were enrolled in a private school in a high-socio-economic area. These Ss were obviously more aware of stimulus attribute differences for both dimensions (form and color) than were the low-socio-economic Ss. However, the low-socio-economic Ss were able to take advantage of both the general focusing cue and specific instance cue to make both problem-types equally salient. Saliency of cues can thus be associated with Ss socio-economic background.

Some Implications

The similarity of the performance with specific instance cues and the general focusing cues, which have been operationally defined as representing "memory" and "attentional" functions in concept learning situations, calls for further evaluation of the interrelationship of these operations and functions as they are now conceived. The influence of the specific instance cues (previously linked to the memory requirements of the task) and the general focusing cue (previously linked to the attentional requirements of the task) was to significantly improve performance at all but the lowest levels of stimulus complexity used in this study. The effects of both types of cues upon performance were similar in the context of the two-category card-sorting task used in this experiment. Only at the highest levels of complexity, in the early stages of performance and in the higher grade grouping of children studied, did the two types of cues become differentiated. However, the ability of Ss of different grade groups to effectively utilize these cues varied with Ss grade group and the results that have been discussed indicate that perhaps the operationally defined functions of these cues are not correct. The superiority of the specific instance cue for the preschool children (Group P) suggests that the function of this cue is to call attention to specific past instances and provide a rudimentary type of memory aid that is strictly tied to the immediate stimulus field. The superiority of the general focusing cue with the grade school Ss (groups 2 and 5) and particularly with the junior high school Ss (group 8) suggests that this cue provided memory and attentional information connected with mediational and symbolic processes. These results indicate that the primary functions of these two types of cues have been incorrectly classified, and that the specific instance cue is the "attentional" cue and that the general focusing cue is the "memory" cue.

This study also serves to point out some areas needing further investigation. One question regards the saliency of the relevant and irrelevant cues for the Ss. While the present study has shown that experimental manipulations to direct attention to specific aspects of the stimuli result in improved performance levels, the results for the replication on sex in grade group 8 has also served to point out that the saliency of the irrelevant cues within the stimulus setting plays an important role which has yet to receive significant experimental attention. One possible way to further investigate this problem would be to obtain individual assessments of cue saliency from the Ss, as Suchman and Trabasso (1966a) did with children, or by the relevant redundant cue approach now being investigated by Trabasso and Bower (1968), and then have the Ss work on tasks in which cues of various saliency levels are relevant or irrelevant.

It is also possible that attentional factors have other roles in the learning process besides those that have already been considered (i.e. spatial relationships of cues to response, directing attention and encoding processes by experimental manipulation, saliency of irrelevant stimulus dimensions). In comparing this study to other studies with children, for example, it is noticeable that the mean number of errors was considerably less in the present study even when only the no cues available condition means are compared. In this study the mean errors for grade groups P and 2 on the two irrelevant dimensions problem on the no cues available condition were 22.6 and 2.2 (Appendix II, Table 33, p. 152). In the Osler and Kofsky study (1965), with the same stimulus dimensions present, the mean errors were 55, 52, and 28 for the 4-, 6-, and 8-year-old groups of subjects. This appears to be quite a large difference in error rate. Procedurely there were several differences between these two studies. The present study was a card-sorting task, used corrective feedback, provided information feedback to the Ss for each response ("Right" or "Wrong"), had a criterion of 16 consecutive correct responses, and provided no pretraining in procedure or discrimination abilities. The Osler and Kofsky study (1965), on the other hand, presented the stimuli on a display panel with a lever for the subject to indicate his response choice, provided a marble reinforcement for correct responses, had a criterion of 10 consecutive correct responses, and had discrimination tests and trial runs on the apparatus prior to the concept learning task. With the pretraining, the less strict criterion, and the marble reward, it would appear at first that the Osler and Kofsky subjects would be at an advantage over the present study subjects, but there are other contraindications for this. The Osler and Kofsky task situation was more complex, with apparatus, levers and physical rewards; that is, there would appear to be many more distracting elements within the immediate test situation. It is thus quite possible that those subjects spent more time attending to the apparatus and marbles than to the stimulus material. In the present study the subjects handled and placed the stimulus material into the categories and thus probably spent more time attending to the stimulus material itself. Another major difference between the studies is the type of feedback used. The present study used corrective and informational feedback; the only type of feedback in the Osler and Kofsky study was a marble. It is suggested the differences in the results of these two studies is based on a combination of these factors, i.e. the role of distracting variables within the immediate test situation and the differences in the feedback conditions. In relation to the role of corrective feedback, Pishkin (1967) found for college Ss that the use of corrective and informational feedback for both "Right" and "Wrong" category choices in a no-cues available (i.e. 0-availability) condition, elicited significantly superior performance to a similar experiment in which corrective feedback was not used (Pishkin and Wolfgang, 1967). The difference in the roles of the feedback conditions receives confirmation by a recent study by Spence and Dunton (1967) in which both lower- and middle-class children performed better with "Right" and "Wrong" reinforcement than with a candy reward on a discrimination learning task.

Another question that the present study raises is in relation to sex of E and S sex differences. There was a strong indication that some of the differences which occurred between male and female Ss may have been due to the different degrees of saliency of the irrelevant cues used in this study for the two sex groups in the 7th, 8th and 9th grades. More exploration of the role of these cues as both relevant and irrelevant dimensions is needed. In addition, the possible effect of Es sex on Ss performance level has some interesting educational implications that need to be studied. The results would suggest that for the best efficiency of students we need to utilize teachers of opposite sex for the students, at least for the grade levels in which the sex variable was investigated here. Another question involves the extent of these S sex differences as a function of the sex of E and age or grade level of Ss.

While this study has shown that cues which have been operationally defined as related to memory and attentional aspects of concept learning do have an effect on the performance levels that are obtained, the relationship that occurs is dependent on stimulus complexity level, stage of learning, grade level of subject, and individual differences in the saliency of irrelevant dimensions. It would be quite valuable to have more information on the relationships of these operationally defined functions of memory and attention with individual and independent assessments of these functions as with psychometric evaluation of memory and attentional processes. There is a beginning to this effort in relation to memory functions with college students (Bunderson, 1967; Blaine and Dunham, 1968; Dunham and Bunderson, 1968) and to attentional factors with the previously mentioned approaches of Suchman and Trabasso (1966b) and Trabasso and Bower (1968). These approaches and other new ones need to be extended to different age levels and to relationships with different types of cue availability and feedback conditions within the concept learning framework.

CHAPTER VII

SUMMARY AND CONCLUSIONS

Recent theorizing in cognitive development has been stressing the possible functions of memory and attentional processes as underlying the changes which occur in the growth of cognitive abilities. There is an accumulation of evidence from the experimental investigation of mathematical models of concept identification indicating the important role of attentional and memory factors in concept learning tasks. Specific experimental manipulations within the concept identification paradigm have been linked with these factors. More specifically, past stimulus availability has been associated with the memory requirements of the concept learning task. In addition, the use of various types of dimensional emphasizers (e.g., pretraining and determination of dimensional preferences or manipulations changing the "noticeability" of specific stimulus attributes) have been linked to the attentional aspects of concept learning.

The overall purpose of the present study was fourfold:

A. Role of Attention and Memory Requirements.

> The first goal was to compare the effectiveness and interrelatedness of experimental manipulations linked to the "attentional" and "memory" requirements of concept learning tasks. Much of the current research has been concerned with only one or the other of these functions. It was a hypothesis of

the present study that experimental manipulations of "attention" and "memory" are closely related in terms of performance.

B. Relationship of Complexity with Attention and Memory Aids.

The second goal was to investigate the relationship of "attention" and "memory" aids to variations in task complexity. It was hypothesized that these aids would have little effect on tasks of low complexity levels, but as task complexity increases these aids would substantially improve performance compared to conditions in which no cues are provided.

C. Relationship of Age to Attention and Memory Aids.

The third goal was to ascertain the relationship of "memory" and "attention" for children of different educational levels. It was hypothesized that these aids would have more of an effect on the performance of the younger than for the older Ss. It was also hypothesized that "attentional" aids would lead to the best performance for all grade groupings.

D. Exploration of Sex, Attention and Memory.

The fourth goal was to explore possible sex differences in concept learning in an adolescent group of Ss. Some previous research has indicated that sex differences do occur and that these differences may be related to different attention and memory capabilities of the two sexes. However, the role of these influences in a concept learning situation has not been sufficiently investigated.

Thus, the purpose of the present study was to compare the effectiveness of a specific past instance cue (linked to the memory requirements of the task) and a general focusing cue (linked to the attentional aspects of the task) to the use of no cues in a two-choice concept learning task as a function of age, sex and task complexity.

The design of the present experiment was basically 4 x 3 x 3 factorial. The Ss were 180 males from 4-year-old preschool through

9th grade classes divided into four grade groups. As a supplementary study concerned with the sex variable, the oldest grade group (7th through 9th graders) was replicated with 45 females. Three conditions of cue availability were utilized: 1) specific instance cue (the last correct past instance remained visible within each card-sorting category); 2) general focusing cue (the levels of the relevant dimension were shown to the S̲ and left exposed throughout the task); and 3) no cues available. Three levels of stimulus complexity were used within each grade group, with the complexity levels increasing with age. In addition, two problem-types were used: form or color relevant.

The hypothesis that experimental manipulations "attention" and "memory" are closely related was supported. The influence of both types of cues (the specific instance cue and the general focusing cue) was to significantly improve performance compared to no cues available at all but the lowest levels of complexity. The effectiveness of these cues became differentiated only in the early stages of performance, at the highest complexity levels and for the oldest group of S̲s. In all these cases, the general focusing cue elicited superior performance over the specific instance cue.

The overall effect of the general focusing cue was to eliminate the effects of task complexity; with this cue, increases in stimulus complexity did not produce changes in performance. However, with no cues present, the traditional result of decreased efficiency with increased complexity occurred, supporting the Bourne and Restle model of concept identification (Bourne and Restle, 1959).

With the specific instance cue the effects of complexity were lessened, although a significant increase in errors did occur between the middle and high complexity levels. These results indicate that the assumption of "cue additivity" (all varying dimensions in the stimulus complex add to task difficulty, i.e., equal "attention" values) of the Bourne and Restle model and the "no-memory" assumption of the Restle model (Restle, 1961; 1962) are inadequate in explaining concept learning performance of this study. The Bower and Trabasso model (1964) which considers two processes in concept learning, stimulus selection and association of response to particular values of the relevant dimension, appears to give a more adequate explanation of <u>S</u>s performance rates in terms of the current results.

The hypothesis that the general focusing cue would lead to the best performance in all grade groups was partially supported. For the 1st through 9th grade <u>S</u>s the general focusing cue did lead to the best performance. However, for the youngest grade group (4-year-old preschool and kindergarten <u>S</u>s) the specific instance cue produced the best performance. This result can be interpreted in terms of dependence of these young <u>S</u>s on the immediate stimulus field (Wohlwill, 1962; Bruner, 1964) in relation to both the encoding process (Bruner, 1964) and the role of attentional variables (Stollnitz, 1964; Zaporozhets, 1960), and can also be related to the operation of the mediational hypothesis (Kendler and Kendler, 1962). Considered in this framework, the finding that the difference in performance levels for these two types of cues is significant only for the oldest grade group would indicate that the growth of representational and mediational systems and reliance on information outside the immediate stimulus field is a gradual process. These results also lead to the conclusion that the effective utilization of different types of cue availability conditions is dependent on Ss developmental level. The general focusing cue, considered to be primarily an attentional aid, does not provide effective information to the S until he can utilize symbolic information and thus is dependent on Ss memory and/or mediational abilities.

The hypothesis that the specific instance and general focusing cues would influence the younger Ss more than the older Ss was supported by the trend, but not significantly. An adequate test of this hypothesis was not feasible because of the increasing complexity levels over grade level in the design of the experiment.

The sex differences occurred with changes in complexity in the adolescent group (7th through 9th grade Ss), with males becoming more efficient with increased complexity and females becoming less efficient. This finding emphasizes the plausible role of sex differences in cue saliency and the role of the saliency of the irrelevant dimensions on concept learning. While these sex differences may be specifically related to previous findings on the role of spatial variations of stimulus elements for the two sexes, it is also possible that they may be related to the sex of E. For all groups of Ss there were no differences in the saliency of the relevant dimension. All groups performed equally well on the color and form problem types.

This study points out the need for further investigation of the relationship between individual differences in cue saliency and concept learning performance, particularly in relation to sex differences, in order to further understand the role of saliency factors in concept learning.

In conclusion, this investigation has shown that experimental manipulations of "attention" and "memory" effect efficiency of concept learning. Within this study the effectiveness of attention and memory cues was dependent on the age and sex of the S, complexity of the task, and the stage of learning. A demonstrated need for further investigation of these functions has been presented, particularly in relation to individual assessments of cue saliency and memory abilities for the two sexes and levels of development.

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APPENDIX I

SUBJECT INSTRUCTIONS

Instructions--No Cue Condition

Listen carefully to what I am going to say. When I say "Begin", take the first card (E pointing to file of stimulus cards). Show me where you think each of the cards should go, here or here (E pointing to the two slots of the wood tray). I will tell you if you are right or wrong. You then place the card face down in the correct slot and then take the next card.

Try to be right as often as you can. I will stop you when you have correctly placed 16 cards in a row. Whenever you think you can tell me the correct answer you may tell me what you think the solution is.

Are you ready to begin?

Instructions--Specific Cue Condition

Listen carefully to what I am going to say. When I say "Begin", take the first card (E pointing to file of stimulus cards). Show me where you think each of the cards should go, here or here (E pointing to the two slots of the wood tray). I will tell you if you are right or wrong. You then place the card face up in the correct slot and then take the next card.

Try to be right as often as you can. I will stop you when you have correctly placed 16 cards in a row. Whenever you think you can tell me the correct answer you may tell me what you think the solution is.

Are you ready to begin?

Instructions--General Cue Condition

Listen carefully to what I am going to say. When I say "Begin", take the first card (E pointing to file of stimulus cards). Show me where you think each of the cards should go, here or here (E pointing to the two slots of the wood tray). I will tell you if you are right or wrong. You then place the card face down in the correct slot and then take the next card.

(E shows the General Cue attribute cards.) These cards show one of the ways that the cards you'll be seeing are different from each other. We'll leave these cards here (placed to the side of the wood tray) and you may look at them whenever you want to.

Try to be right as often as you can. I will stop you when you have correctly placed 16 cards in a row. Whenever you think you can tell me the correct answer you may tell me what you think the solution is.

Are you ready to begin?

APPENDIX II

TABLES OF MEAN SCORES FOR ALL DEPENDENT VARIABLES

Table 30

Means of Log(x+1) Errors for No Cue (NC), Specific Cue (SC) and General Cue (GC) Availability Conditions for each Complexity Level and Grade Group

Complexity Level		1	2	3	Total
Grade Group P	NC	0.6123	3.6323	5.0058	3.0834
	SC	0.3714	0.9327	2.5813	1.2952
	GC	1.7126	2.8520	2.3183	2.2876
	Sum	0.8988	2.4657	3.3018	2.2221

Complexity Level		2	3	4	Total
Grade Group 2	NC	0.4317	2.2285	3.5604	2.0735
	SC	1.8672	0.3964	2.4710	1.5776
	GC	0.9855	1.0415	0.3362	0.7878
	Sum	1.0949	1.2221	2.1219	1.4796

Complexity Level		3	4	5	Total
Grade Group 5	NC	0.2408	3.6120	3.5412	2.4647
	SC	1.0926	0.5169	1.3042	0.9712
	GC	0.1806	0.4451	1.6107	0.7455
	Sum	0.5047	1.5246	2.1520	1.3938

Complexity Level		4	5	6	Total
Grade Group 8M	NC	2.2663	1.4531	0.8123	1.5106
	SC	0.8359	1.0676	0.9236	0.9424
	GC	0.4919	0.3714	0.3964	0.4199
	Sum	1.1980	0.9641	0.7108	0.9576

Complexity Level		4	5	6	Total
Grade Group 8F	NC	1.0105	3.0880	1.9093	2.0026
	SC	1.8345	1.4172	1.9863	1.7460
	GC	0.4567	0.4760	2.0057	0.9794
	Sum	1.1006	1.6604	1.9671	1.5760

Table 31

Means of Log(x+1) Time to Solution (in Minutes) for No Cue (NC), Specific Cue (SC) and General Cue (GC) Availability Conditions for each Complexity Level and Grade Group

Complexity		1	2	3	Total
Grade	NC	.4921	.8905	.9442	.7756
Group	SC	.3700	.5202	.7078	.5327
P	GC	.5474	.6659	.6717	.6284
	Sum	.4698	.6922	.7746	.6456

Complexity		2	3	4	Total
Grade	NC	.4344	.6581	.7732	.6219
Group	SC	.6346	.2998	.6396	.5247
2	GC	.4583	.5067	.3654	.4434
	Sum	.5091	.4882	.5927	.5300

Complexity		3	4	5	Total
Grade	NC	.3130	.7102	.7512	.5915
Group	SC	.4313	.4046	.5112	.4490
5	GC	.2503	.3672	.4512	.3563
	Sum	.3316	.4940	.5712	.4656

Complexity		4	5	6	Total
Grade	NC	.5912	.4189	.3859	.4653
Group	SC	.3640	.3926	.4854	.4140
8M	GC	.3385	.2400	.3420	.3068
	Sum	.4312	.3505	.4044	.3954

Complexity		4	5	6	Total
Grade	NC	.4329	.6807	.4936	.5357
Group	SC	.4395	.4567	.5999	.4987
8F	GC	.2747	.3526	.5750	.4008
	Sum	.3824	.4967	.5562	.4784

Table 32

Means of Rate of Responding for No Cue (NC), Specific Cue (SC)
and General Cue (GC) Availability Conditions for
each Complexity Level and Grade Group

Complexity Level		1	2	3	Total
Grade	NC	12.77	10.42	9.44	10.88
Group	SC	15.28	13.03	13.30	13.87
P	GC	13.03	13.61	12.11	12.91
	Sum	13.69	12.35	11.62	12.55

Complexity Level		2	3	4	Total
Grade	NC	12.82	11.78	11.60	12.07
Group	SC	11.15	20.68	12.27	14.70
2	GC	15.16	13.30	17.10	15.19
	Sum	13.04	15.25	13.66	13.98

Complexity Level		3	4	5	Total
Grade	NC	19.42	13.32	12.51	15.08
Group	SC	18.83	13.51	16.61	16.31
5	GC	22.47	19.62	18.03	20.04
	Sum	20.24	15.48	15.72	17.15

Complexity Level		4	5	6	Total
Grade	NC	15.16	23.04	20.04	19.41
Group	SC	20.84	19.16	16.47	18.82
8M	GC	19.02	25.96	16.53	20.51
	Sum	18.34	22.72	17.68	19.58

Complexity Level		4	5	6	Total
Grade	NC	16.90	13.34	20.90	17.05
Group	SC	20.37	17.98	13.71	17.35
8F	GC	25.23	18.73	14.35	19.44
	Sum	20.84	16.68	16.32	17.72

Table 33

Means of Number of Errors for No Cue (NC), Specific Cue (SC) and General Cue (GC) Availability Conditions for each Complexity Level and Grade Group

Complexity Level		1	2	3	Total
Grade Group P	NC	3.4	22.6	33.6	19.9
	SC	1.4	4.8	16.0	7.4
	GC	11.4	19.8	15.2	15.5
	Sum	5.4	15.7	21.6	14.2

Complexity Level		2	3	4	Total
Grade Group 2	NC	2.2	14.8	25.0	14.0
	SC	11.8	1.4	16.8	10.0
	GC	5.4	6.6	1.4	4.5
	Sum	6.5	7.6	14.4	9.5

Complexity Level		3	4	5	Total
Grade Group 5	NC	1.0	24.0	25.0	16.7
	SC	5.6	2.4	7.8	5.3
	GC	0.8	2.4	11.4	4.8
	Sum	2.5	9.6	14.7	8.9

Complexity Level		4	5	6	Total
Grade Group 8M	NC	14.8	4.5	4.2	7.8
	SC	5.2	6.6	5.2	5.7
	GC	2.4	1.4	1.6	1.8
	Sum	7.5	4.2	3.7	5.1

Complexity Level		4	5	6	Total
Grade Group 8F	NC	6.2	20.6	13.2	13.3
	SC	12.4	8.6	12.4	11.1
	GC	2.8	2.8	13.6	6.4
	Sum	7.1	10.7	13.1	10.3

Table 34

Means of Time to Solution in Minutes for No Cue (NC), Specific Cue (SC)
and General Cue (GC) Availability Conditions
for each Complexity Level and Grade Group

Complexity Level		1	2	3	Total
Grade Group P	NC	2.75	7.21	8.25	6.07
	SC	1.36	2.62	5.74	3.24
	GC	3.55	5.93	4.70	4.72
	Sum	2.55	5.25	6.23	4.68

Complexity Level		2	3	4	Total
Grade Group 2	NC	1.78	5.12	6.53	4.48
	SC	4.16	1.01	4.51	3.23
	GC	2.22	2.99	1.35	2.19
	Sum	2.72	3.04	4.13	3.30

Complexity Level		3	4	5	Total
Grade Group 5	NC	1.10	4.88	7.40	4.46
	SC	2.02	1.58	2.45	2.02
	GC	0.78	1.62	2.75	1.72
	Sum	1.30	2.89	4.20	2.95

Complexity Level		4	5	6	Total
Grade Group 8M	NC	4.01	1.70	1.55	2.42
	SC	1.45	1.58	2.72	1.92
	GC	1.25	0.74	1.26	1.08
	Sum	2.24	1.33	1.85	1.82

Complexity Level		4	5	6	Total
Grade Group 8F	NC	1.94	4.70	2.83	3.15
	SC	2.46	2.18	3.83	2.82
	GC	0.94	1.29	3.83	2.02
	Sum	1.78	2.72	3.50	2.67

APPENDIX III

ORIGINAL DATA

Table 35

Grade Group P: Original Data for Error Scores (E), Time to Solution in Minutes (T) and Rate of Responding (R)

Complexity Level	1			2			3		
Score	E	T	R	E	T	R	E	T	R
No Cue	1	1.75	10.86	8	9.42	6.26	51	9.97	9.63
	1	1.28	14.84	44	10.07	9.53	34	9.42	10.51
	0	0.73	21.92	6	3.78	10.05	2	3.50	5.71
	13	8.03	6.48	11	4.63	14.47	37	7.83	12.26
	2	1.95	9.74	44	8.13	11.81	44	10.57	9.08
Specific Cue	1	1.17	16.24	10	4.12	9.95	36	7.83	12.26
	2	1.32	14.39	3	1.05	18.10	16	13.52	3.62
	2	1.80	16.67	3	1.08	17.59	1	0.88	20.45
	2	1.60	11.88	7	4.62	10.61	2	1.33	15.04
	0	0.93	17.20	1	2.25	8.89	25	5.15	15.15
General Cue	1	1.65	10.30	40	9.98	9.62	2	1.52	14.47
	2	2.23	14.80	1	0.83	20.48	47	9.75	9.85
	2	1.10	17.27	55	15.75	6.10	0	0.92	17.39
	1	1.32	14.39	0	1.13	14.16	22	4.95	11.92
	51	11.45	8.38	3	1.98	17.68	5	6.38	6.90

Table 36

Grade Group 2: Original Data for Error Scores (E), Time to Solution in Minutes (T) and Rate of Responding (R)

Complexity Level	2			3			4		
Score	E	T	R	E	T	R	E	T	R
No Cue	1	2.13	9.39	45	14.33	6.70	53	11.92	8.05
	5	2.87	9.76	19	6.28	9.08	1	1.08	16.67
	2	1.33	15.04	1	1.00	19.00	4	1.77	15.25
	0	1.22	13.11	3	1.50	13.33	43	8.93	10.75
	3	1.37	16.79	6	2.50	10.80	24	8.93	7.28
Specific Cue	1	2.70	9.26	1	0.83	21.69	1	0.98	19.39
	14	5.50	8.00	1	1.28	13.28	1	1.58	10.76
	42	9.80	9.08	1	0.98	19.39	34	9.17	8.50
	1	1.42	14.79	1	0.72	23.61	5	2.13	11.68
	1	1.37	14.60	3	1.22	25.41	43	8.70	11.03
General Cue	1	1.15	14.78	1	1.02	18.63	1	0.80	21.25
	2	1.77	11.30	1	2.12	10.38	1	1.23	13.01
	21	5.63	12.79	3	1.35	14.07	3	1.22	21.01
	3	1.72	17.44	25	9.20	6.63	0	1.93	8.29
	0	0.82	19.51	3	1.25	16.80	2	1.57	21.66

Table 37

Grade Group 5: Original Data for Error Scores (E), Time to Solution in Minutes (T) and Rate of Responding (R)

Complexity Level	3			4			5		
Score	E	T	R	E	T	R	E	T	R
No Cue	0	1.95	10.19	0	1.25	12.80	28	4.98	13.86
	1	1.00	20.00	43	8.12	11.82	49	11.87	8.09
	0	0.73	21.92	8	2.45	11.84	0	1.00	16.00
	1	0.80	25.00	22	4.58	18.12	46	18.20	5.27
	3	1.00	20.00	47	8.00	12.00	2	0.93	19.35
Specific Cue	17	4.70	17.66	1	2.10	8.57	1	0.80	22.50
	2	1.07	18.69	5	2.23	9.87	4	3.58	11.17
	3	0.90	22.22	0	1.28	12.50	4	1.58	13.29
	1	0.72	26.39	3	1.10	19.09	16	3.67	14.71
	5	2.72	9.19	3	1.20	17.50	14	2.62	21.37
General Cue	0	0.60	23.53	0	0.63	25.40	2	2.52	7.14
	1	0.83	22.89	0	0.63	25.40	52	9.05	10.61
	0	0.68	23.53	9	4.37	8.47	1	0.88	19.32
	0	0.92	17.39	2	1.67	12.57	0	0.55	29.09
	3	0.80	25.00	1	0.80	26.25	2	0.75	24.00

Table 38

Grade Group 8M: Original Data for Error Scores (E), Time to Solution in Minutes (T) and Rate of Responding (R)

Complexity Level	4			5			6		
Score	E	T	R	E	T	R	E	T	R
No Cue	4	1.75	11.43	2	1.88	15.96	13	2.85	14.74
	21	8.57	7.00	17	1.97	28.93	1	0.95	17.89
	2	0.97	18.56	20	2.50	22.40	1	0.97	17.53
	45	7.80	12.31	1	0.68	30.88	4	2.23	19.28
	2	0.98	26.53	5	1.47	17.01	2	0.78	30.77
Specific Cue	11	2.32	13.36	3	1.28	17.97	8	8.18	5.62
	0	0.55	29.09	14	2.38	16.39	6	1.93	18.65
	1	0.95	20.00	2	0.82	21.95	3	1.32	15.91
	13	2.60	18.85	13	2.58	17.83	7	1.42	16.20
	1	0.83	22.89	1	0.83	21.69	2	0.77	25.97
General Cue	3	1.18	17.80	2	0.75	26.67	0	0.88	18.18
	7	2.32	15.52	1	0.63	26.98	3	0.80	23.75
	0	0.80	20.00	1	0.67	25.37	1	0.97	17.53
	1	1.25	16.80	1	0.87	26.44	1	2.30	7.39
	1	0.68	25.00	2	0.78	24.36	3	1.33	15.79

Table 39

Grade Group 8F: Original Data for Error Scores (E), Time to Solution in Minutes (T) and Rate of Responding (R)

Complexity Level	4			5			6		
Score	E	T	R	E	T	R	E	T	R
No Cue	5	1.63	15.34	44	10.08	9.52	1	0.45	48.89
	18	4.58	13.76	1	1.07	15.89	5	1.67	14.97
	1	1.30	16.15	12	3.40	17.65	12	2.67	13.11
	6	1.43	17.48	45	6.72	14.29	1	1.28	15.63
	1	0.78	21.79	1	2.25	9.33	47	8.07	11.90
Specific Cue	1	0.98	21.43	11	3.12	16.35	1	1.97	9.14
	51	8.05	11.93	3	0.85	22.35	1	0.77	25.97
	1	0.68	25.00	2	1.15	18.26	2	2.12	8.96
	3	1.20	22.50	24	4.72	14.83	17	4.80	14.58
	6	1.38	21.01	3	1.05	18.10	41	9.50	9.89
General Cue	1	0.67	25.37	1	1.00	23.00	3	1.13	16.81
	12	1.93	19.17	1	1.75	10.29	37	6.13	13.54
	0	0.78	20.51	2	1.33	18.80	5	1.57	14.65
	0	0.55	29.09	9	1.63	16.56	23	9.50	7.47
	1	0.75	32.00	1	0.72	25.00	0	0.83	19.28