

To the Graduate Council:

I am submitting herewith a dissertation written by William Earl McGee entitled "The Relationship Between Learning Methods and Academic Achievement in 10-Year-Old Boys." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Education, with a major in Educational Psychology and Guidance.

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THE RELATIONSHIP BETWEEN LEARNING METHODS AND
ACADEMIC ACHIEVEMENT IN 10-YEAR-OLD BOYS

A Dissertation
Presented For The
Doctor of Education
Degree
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ABSTRACT

The relationship between students' learning methods and their academic achievement was examined in this study. The 48 subjects used in this study were divided into four different groupings on the basis of their academic achievement. The first grouping was made on the basis of teacher ratings of performance in reading and arithmetic, and the remaining groupings were based on achievement test scores in reading and arithmetic.

A series of discrimination problems were posed to each of the 10-year-old male subjects using a method adapted from that used with college students by Levine, Miller, and Steinmeyer (1967). Up to 60 cards were shown to each subject; each card contained three shapes, and each shape was positioned randomly in one of three locations on the card and colored randomly with one of three colors. There was a total of nine discriminants. Each subject was given two practice problems, followed by four problems on which outcome feedback was provided on every third trial. Data were analyzed for the number of problems completed, the number of trials to completion, three-trial units, two-trial units, and for relationships among the dependent variables.

The findings included no support for a relationship between hypothesis-testing strategies and academic achievement groupings. However, there was a relationship between arithmetic achievement test scores and the number of problems completed, and there was an overall population tendency for hypothesis-sampling to be correlated negatively with the number of trials required to complete a problem.

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CHAPTER I

INTRODUCTION

The relationship between academic achievement and intelligence is well established (Cureton & Coleman, 1954), as is the fact that same-age students with equivalent levels of intellectual ability demonstrate equivalent levels of academic achievement (Salvia & Ysseldike, 1978). However, within the average level of intelligence there is a significant number of students who are academic underachievers (Lerner, 1976). A number of explanations have been offered for this ability-achievement discrepancy, among them a variety of sociocultural theories (Wilson, 1963) as well as learning dysfunction theories (Cruickshank, 1977). There is no currently accepted explanation for all ability-achievement discrepancies (Lerner, 1976).

Rationale

Vance (1980) has suggested an attentional deficit as a primary factor in those ability-achievement discrepancies that are the result of a learning dysfunction. As he observed, "one of the basic prerequisites to learning is attention" (p. 153). He further noted that "a primary goal of a teacher is to teach . . . children to detect and attend to relevant cues, to differentiate between the relevant and the irrelevant, and to use strategies for processing information" (p. 153). He also wrote,

Without this capacity of selective attention we would be overwhelmed by stimulation and unable to produce adaptive responses. To be effective and efficient in the processing of information the . . . individual must be able to differentiate between relevant and irrelevant stimuli and learn to ignore the irrelevant. (p. 155)

Selective attention is stimulus discrimination, and stimulus discrimination is discrimination learning (Skinner, 1953; Staats, 1971). Learning methods are comprised of different selective attending skill levels.

Terminology

There are a number of terms that are used by various researchers with very different meanings in each instance. The following are conceptual definitions for this study.

Intellectual ability is referred to frequently as ability or IQ (intelligence quotient) and is an indication of an individual's potentiality. Performance is what the individual accomplishes, and academic achievement is one measure of performance. Herein, academic achievement means within the specific areas of reading and/or arithmetic.

A problem is an instance in which an individual attempts to respond correctly with a limited number of trials or selection choices when presented with a variety of stimuli. If the individual accomplishes this, then the problem is completed; otherwise, it is not completed. The trial on which the last error occurs becomes an important landmark when one is concerned with the individual's learning methods.

By using hypothesis-testing strategies in discrimination learning an individual systematically eliminates incorrect choices until the correct choice is identified consistently (Saltz, 1973). Trial-and-error learning often is referred to as nonsystematic choice selection or elimination in discrimination learning (Hilgard & Bower, 1966). The use of selective attending skills means that an individual's behavior is under the control of one stimulus to the exclusion of others (Skinner, 1953). Discrimination learning is controlled by a particular

stimulus. When the individual is able to generalize from previously learned discriminations (e.g., in one's definition of a rectangle) it is concept formation

A response set is a contiguous series of trials bounded at the onset by the first nonfeedback (blank) trial and nearly always at the conclusion by the occurrence of a feedback trial. Occasionally, the feedback trial may come after the trial with the last error so that only the nonfeedback trial will comprise the response set.

If a response set contains a consistent stimulus choice for each trial, then it may show the use of a learning strategy and is called a hypothesis-testing set. The computation of a hypothesis-testing proportion is derived by dividing the number of hypothesis-testing sets by the total number of response sets, and provides one index of hypothesis-testing strategies.

If the individual makes appropriate choices on the first blank trial following a feedback trial (B_1) then hypothesis-sampling is said to occur. A measure of this learning strategy may be derived by computing the proportion of response sets on which there are appropriate choices on B_1 .

If data are recombined in a variety of ways, each of these recombinations is a different grouping. Even though all or most of the subjects are represented in each grouping method, they may be assigned to different levels or groups within that grouping on the basis of some common factor.

Purpose

In a given student population some students demonstrate ability-appropriate achievement and some demonstrate an ability-achievement discrepancy. One suggested but nonresearched question that may be examined is whether groups of students with and without ability-achievement discrepancies

show differences in their learning methods (Vance, 1980). Thus, four discrete questions may be formulated to discern group differences in learning methods on visual discrimination problems:

1. Do average and subaverage academic achievers differ in the number of problems that they complete?
2. Do average and subaverage achievers differ in the number of trials used to complete a problem?
3. Do average and subaverage achievers differ in the proportion of three-trial choices on which at least one stimulus form is chosen consistently?
4. Do average and subaverage achievers differ in the proportion of appropriate choices on selection trials that immediately follow outcome feedback?

Literature Review

Reading and arithmetic are each symbolic languages, and letters and numerals are the most basic units of those languages (Pollio, 1974; Weaver, 1977). Students learn letters and numerals by means of association learning. For example, they may learn to associate a sound with a graphic form. As Gagne (1965) and Pollio (1974) have observed, the acquisition of these basic associations is not sufficient for the student to read written material or to perform arithmetic calculations, but these basic associations are a necessary preliminary condition to reading and calculation. The student must expend more effort in learning the languages to mastery than in learning the units to mastery because more steps are involved (Anderson & Faust, 1975).

Associational Learning

The first method whereby associations may be established is respondent conditioning and takes the form of a stimulus presentation paired with a reinforcing stimulus. Frequently the response is of the type that is unavoidable by the animal and in the early experiments of this type consisted of a bell ring followed by dry food powder blown into the mouth of a dog followed by the dog's salivation. The association formed is between the bell ring and the food powder (e.g., Pavlov, 1906, 1927) and is called an S-S association. Respondent paradigms are strengthened over repeated pairings with regard to response latency (Pavlov, 1906).

The second method of learning associations is operant conditioning and consists of an organism's exhibiting random behaviors (such as pacing, grooming, urinating, or sniffing) until by chance the organism exhibits the behavioral response necessary to obtain the reinforcing stimulus. The association thus formed is between the requisite behavior and the reinforcing event and is called an S-R association (Skinner, 1953; Thorndike, 1933). Hull (cited in Hilgard & Bower, 1966) suggested that operant associations were strengthened gradually through repeated pairings, although Voeks (1954) argued that they might be established suddenly, in an all-or-none fashion.

Discrimination Learning

The behavior of responding to one stimulus to the exclusion of others is acquired as an association and is called selective attention. Wurtz, Goldberg, and Robinson (1982) explored visual attention and defined it as "the selection of a visual object from the visual field at the expense of other objects" (p. 124). They further stated that the "ability to select objects of interest from the environment is called attention" (p. 124).

Skinner (1953) addressed the issue of attention:

What we usually mean . . . is that the observer continues to look at the object. The behavior [of attending] involves conditioning, and in particular, the special conditioning of the discriminative operant.

.....
But attention is more than looking at something or looking at a class of things in succession. Attention is a controlling relation—the relation between a response and a discriminative stimulus, whether or not its receptors are oriented to produce the most clear-cut reception, if its behavior is predominantly under the control of that detail. The criterion is whether the stimulus is exerting any effect upon . . . behavior. (pp. 122-124)

Selective attention is stimulus discrimination (Skinner, 1953; Staats, 1971).

It might appear that stimulus discrimination is both a more active process on the part of the learner and a higher order learning than is association learning. The difference, however, may be more indicative of differences in selective attentional skills rather than in types of learning. That is, the trial-and-error learner simply may require more pairings as a result of an inability to use selective attending skills effectively, whereas the individual who is using selective attending skills in an active manner may appear to be using a different learning method.

Saltz (1973) proposed a state theory of discrimination learning that culminated in hypothesis-testing strategies as observed in response rates that tended to show learning curves essentially of the none-to-all variety. He hypothesized that the none-to-all curve was the result of the subject choosing more incorrect responses than correct, as a way of "testing" stimulus hypotheses until the incorrect "guesses" were eliminated and the rate of correct responses moved from below the chance level while testing to nearly all correct after incorrect hypotheses were eliminated. He called the other curve the S-R curve; it showed a slope roughly equivalent to the chance probability of correct responses and it was typical of subjects who adopted no discernibly active

discrimination behavior (i.e., seemed to guess on each trial). This sampling or testing effort initially was reported as a subjective observation by Lashley (1929) and later was supported with quantitative data by Krechevsky (1932).

Trial-and-error learning may be thought of as a relatively passive learning strategy because of the reduced attending activity. Differential responding to discriminative stimuli, or discrimination learning, is considered as the first of the relatively active learning methods because of the environmental scanning involved (Gagne, 1965; Skinner, 1953). It is, therefore, the immediate precursor of higher order methods of learning such as concept learning and principle learning (Anderson & Faust, 1975; Gagne, 1968). Stimulus-stimulus and stimulus-response associations may be poorly developed discrimination responses, and as such they demonstrate the continuity and sequential nature of the learning process (Gagne, 1968; Harlow, 1949; Kendler & Kendler, 1970; Saltz, 1973) (see Figure 1).

The Studies of Levine, Miller, and Steinmeyer

Levine, Miller, and Steinmeyer (1967) undertook two successive studies with college students to investigate learning methods in discrimination learning. Their first theorem was that the subject sampled from a set of hypotheses and responded on the basis of the hypothesis sampled; if the correct hypothesis was sampled, then the subject should make no further errors. Their second theorem was that the probability of the appearance of the correct hypothesis selection jumped from near zero to one. As they explained,

Any error, therefore, indicates that at any previous trial only irrelevant H_s (hypotheses) have been sampled. Thus, prior to the last error in the correct H is never sampled; following it the correct H is held exclusively, producing, of course, the criterion run of correct responses. This description of H -sampling behavior before and after the last error will be referred to as the none-to-all theorem. (p. 568)

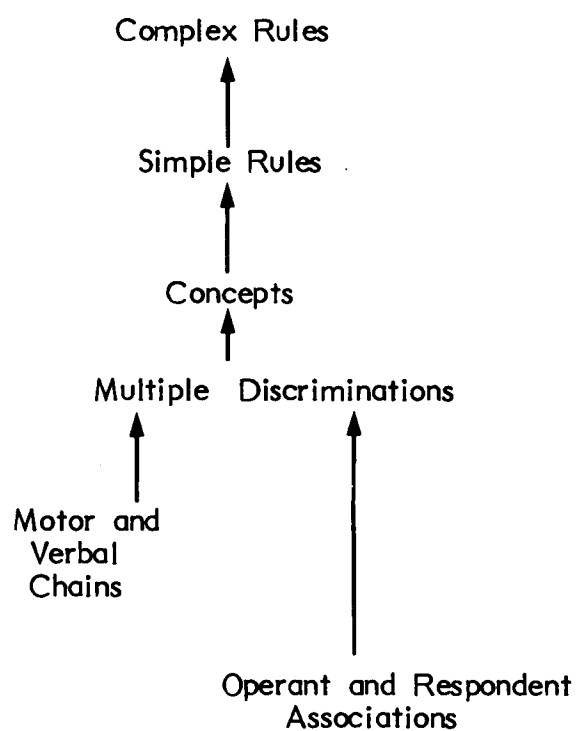


Figure 1. The sequential nature of the learning process (Gagne, 1968).

In the first study, 80 college students served as subjects. Four decks of cards were constructed, each with a pair of letters representing eight conceptual dimensions: letter, color, size, and position. The subjects were presented with four consecutive problems, the solution to each one being one of the four conceptual dimensions. Feedback was provided on the first and every fifth trial to a maximum of 91 trials. There were, consequently, four nonfeedback or blank trials between each pair of feedback trials.

They found that the subjects chose one discriminant and repeated that choice for each nonfeedback trial, and that the subjects shifted or sampled the discriminants on the basis of the preceding feedback trial. Levine et al. concluded that the subjects used hypothesis-testing to complete the problems, and that the use of hypothesis-testing strategies involved the systematic elimination of incorrect choices.

The second study was undertaken to determine the replicability of the findings in the first study. From the same college population 32 subjects were presented with the same problems as in the first experiment. The findings were the same as in the first.

Concept Formation

Gagne (1965) stated that concepts are comprised of more than strings of associations, each of which must be learned individually. He further stated that concept learning is that which makes it possible for the individual to respond to things or to events as a class. Anderson and Faust (1975) described a concrete concept as an object possessing certain critical features. According to Anderson and Faust, "when a person 'knows a concept,' behavior is under the control of the stimuli that embody the critical features which define the concept" (p. 341). The crucial process, therefore, in learning a concept is discriminating the significant stimuli.

Researchers who have investigated Piaget's cognitive development theory have reported that the ability of a child to identify subgroups from within tangible groups is observable beginning around the age of 8 years (Piaget & Inhelder, 1969). The general age range of 8 to 11 years represents the period during which most children are able to demonstrate a knowledge of concepts, beginning with concrete and tangible forms and progressing to more abstract forms after the age of 11 years (Longstreth, 1968).

Bruner (1964) took the view that there were two primary matters in human learning. The second of these points is relevant to this discussion, and was explained as "integration, the means whereby acts are organized into higher-order ensembles, making possible the use of larger and larger units of information for the solution of particular problems" (p. 1).

In describing a computer program and a theory of learning by which individuals and computers come to learn a concept, Winston (1977) detailed the two primary steps and the definition of a model:

1. If you want to teach a concept, you must first be sure your student, man or machine, can build descriptions adequate to represent that concept.
2. If you want to teach a concept, you should use samples which are a kind of non-example.

.....

A model is a proper description augmented by information about what, if anything, must not be present in examples of the concept. (pp. 199-200)

There is less agreement about the formation of concepts than about the formation of associations, and not all researchers are of the opinion that learning progresses in some sequential manner from associations to concepts. For the purposes of this discussion, discrimination learning is a necessary prerequisite to concept formation because it is through discrimination learning that the significant features common to the object are identified by the learner.

Learning Sequence

Gibson (1940, 1965) noted that stimulus discrimination methods are essential to higher order learning. Suppes and Ginsberg (1962) found that paired associate learning with correction (i.e., the learning of simple associations) preceded the acquisition of concepts. Saltz and Sigel (1967) noted that the ability to determine differences between concepts develops at an earlier age than the ability to determine similarities. That is, the ability to discriminate precedes the ability to generalize into meaningful groups or concepts. The process of learning follows the general sequence of associations, stimulus discriminations, and stimulus generalizations, with each step in the sequence representing progressively better developed skills rather than discrete methods.

Memory

Kroll (1975) argued that a subvocal mechanism accounted for much of what is called visual memory processes and reported that the use of naming isolate graphic symbols enhanced the discriminability of those symbols. That is, the symbols were discriminated more quickly if they first were named or verbally coded. Johnson (1978) further argued for the role of some memory mechanism in learning by observing that a previously eliminated hypothesis may be chosen as a result of faulty memory. Skinner (1974) argued that it is attentional focusing rather than a memory mechanism that affects discrimination learning and that incompletely learned stimulus discriminations result in what many individuals refer to as faulty memory.

Academic Performance

Aiken (1971) and Salvia and Ysseldike (1978) stated that academic achievement is an index of attained skills. For this reason, the academic

achievement measures of school students frequently are used as outcome or dependent variables in learning research. Academic achievement measures include teacher ratings, school grades, and achievement test scores. These measures are intended to reflect attained skill levels in the subject area but may be measures of the student's classroom social skills, eye contact with the teacher, personal hygiene skills, test taking ability, or knowledge of the academic area (Anderson & Faust, 1975; Lerner, 1976).

Summary

Academic skills in reading and in arithmetic are learned initially as associations, but these associations are not sufficient for mastery of the academic skills. Higher order learning methods are necessary for mastery learning in reading and arithmetic, and they are based on the individual's selective attending skills. Students with poorly developed selective attending skills are called trial-and-error learners and students with better developed selective attending skills are called hypothesis-testing learners.

Many students demonstrate ability-appropriate academic achievement, but a significant number of students show ability-achievement discrepancies. Vance (1980) suggested that attentional skill deficits appeared to be related to discrepancies between ability and achievement, and he noted the lack of research on that question.

CHAPTER II

METHOD

The research questions for this study were focused on differences in learning methods between average and subaverage or low academic achievers. To evaluate the differences, four hypotheses were posed for investigation.

Hypotheses

Hypotheses were based on performance on discrimination learning problems:

1. Average achievers will complete more problems than subaverage or low achievers.
2. Average achievers will use fewer trials to complete problems than subaverage or low achievers.
3. The hypothesis-testing proportion will be higher for average achievers than for subaverage achievers.
4. The proportion of correct choices on B_1 will be higher for average achievers than for subaverage or low achievers.

Design

The research design was devised to compare the performance of students on a series of discrimination learning problems. The independent variables were groups and administrations (a repeated measures dimension). The number of groups was either two or three, depending upon the grouping combination used, and the number of administrations was four. The first grouping was based on teacher ratings and was comprised of average and subaverage students.

The second, third, and fourth groupings were based on achievement test scores and were each comprised of high, average, and low groups. Dependent variables were four types of performance: (a) the number of problems completed, (b) the number of trials to completion on completed problems, (c) the hypothesis-testing proportion, and (d) the proportion of correct choices on B₁.

To counterbalance the discriminant sequencing in this mixed design, a Latin Square sequencing system was used. Table 1 shows each of the four discriminant sequences which were used.

Table 1
Discriminant Sequencing in a Latin Square Design

Designation	Problem			
	1	2	3	4
Alpha	Blue	Left	Yellow	Circle
Beta	Left	Blue	Circle	Yellow
Gamma	Yellow	Circle	Blue	Left
Delta	Circle	Yellow	Left	Blue

Subjects

The subjects were 10-year-old Caucasian males of average intellectual ability attending one of nine elementary schools in Anderson County, Tennessee. Selection for this study was based on teachers' ratings of academic performance, so that 24 subjects were average achievers and 24 were subaverage achievers. A total of 48 subjects, including 14 repeaters who had failed one school grade, participated in this study. The decision to use 10-year-old students was based

on the fact that 10-year-olds of average ability typically have acquired the skills necessary to formulate concepts using concrete or tangible forms (for example, colors, shapes, or positions) (Piaget & Inhelder, 1969) but are not so advanced that they are on the immediate threshold of more abstract cognitive skills (Flavell, 1963; Richmond, 1971).

Measurement

Academic achievement and learning methods were measured. There were two ways in which achievement was measured, and there were four ways in which learning methods were measured.

Academic Achievement

The Teacher Rating Form (see Figure 3 in Appendix A) was used to obtain teacher ratings of academic performance. The reliability of this form was not evaluated, but in a validity study there was less than 80% correspondence between the obtained ratings on it and arithmetic achievement test scores. There was at least 80% correspondence between teacher ratings and reading achievement test scores. These analyses are summarized in Table 2.

Table 2

Correspondence Between Teacher Rating Form and Achievement Test

Subject Area	N	Agreements Obtained	Agreement Proportion	Expected Proportion	z	p
Reading	48	33	.6875	.8000	-1.85	<.052
Arithmetic	48	19	.3958	.8000	-7.00	<.001

The second measure of academic performance was based on reading and arithmetic percentile rank scores on the Metropolitan Achievement Test (Prescott, Balow, Hogan, & Farr, 1978). For repeaters, the obtained grade level equivalency was assigned the same percentile ranking as if it had been scored by a non-repeater, and the student was then rated based on that derived percentile ranking. For example, subject 33 was in a grade placement of 4 years 8 months at the time he took the achievement test, but if he had not repeated one school year he would have been in a grade placement of 5 years 8 months. On the arithmetic portion of the achievement test his score obtained at the 5.7 equivalency, with an assigned percentile ranking of 66 when compared to other students in grade 4. Had he not repeated a grade and been in a 5.8 placement when he took the achievement test, and had he scored at the same grade level equivalency of 5.7, his assigned percentile ranking would have been 47. This latter percentile rank was used to determine his achievement as compared to others in the appropriate grade placement. Student rankings by teacher ratings and by achievement test scores are shown in Table 4, Appendix B.

Learning Methods

Each subject was presented with four consecutive problems, each time called an administration, in which a specific discriminant was to be identified for five consecutive trials. If this was accomplished, then the problem was completed; otherwise it was not completed. The discriminant dimensions were color, shape, and position, and the discriminants were red, yellow, blue, square, circle, triangle, left position, middle position, or right position. A trial was a single choice, and up to 60 trials were allowed for each problem.

Feedback on the subjects' choice was given every third trial so that these trials were called feedback trials (F). Nonfeedback trials were called blank trials (B). A sequence of trials would appear as F, B₁, B₂, F, B₁, B₂, and so on.

Materials. A variety of card decks was used in this study and each deck was designated by a descriptive name. The subject's choice on each trial on each problem was recorded on the Response Recording Sheet (See Figure 4 in Appendix A).

1. The 9 familiarity cards were stimulus cards which were shown before the problem cards, and allowed the subjects to observe and name the nine discriminants from which they would later be asked to choose. Each familiarity card represented a single discriminant. The first three cards showed the shape discriminants of square, circle, and triangle. The next three cards showed the color discriminants of red, yellow, and blue. The last three cards showed the position discriminants of left, center, and right.

2. The 36 problem cards were stimulus cards which were presented after the familiarity cards. These cards consisted of a square, circle, and triangle in random position on each card. Each shape was randomly colored red, yellow, or blue, so that on each card each shape and each color appeared in random position only once. The card order itself was arranged to be random by assigning each card a number and then sequencing by means of a random number table (Myers, 1972).

3. The answer cards showed the answers to the preselected problems. They were on 6 index cards per sequence, and each card bore one discriminant name. For example, on one card was written "RED," on another "CENTER," and so on. For each subject the cards were selected which corresponded to the pre-selected discriminant sequence and were arranged face down. In this

way, the experimenter could turn over the topmost card at the conclusion of each practice or problem, and would show it to the subject. Because the subjects were divided into four groups, for purposes of discriminant sequencing, one set of answer cards was developed for each of the four groups.

4. The Response Recording Sheet (see Figure 4 in Appendix A) was devised to record subject responses. A separate sheet was used for each administration, so that each subject required six recording sheets. The topmost portion of each sheet contained information for the experimenter, such as subject name and number, problem number, group designation, and a variety of coded information that was designed specifically to assist the experimenter and to appear as an undecipherable symbol grouping to the subjects.

Setting. Each subject was seen individually in his own school by the researcher or a trained assistant. The room contained a table or a desk and two chairs and frequently other furniture. The sessions were conducted within the regular school day, and were scheduled so that they did not interfere with the subjects' normal school arrival or departure times, nor with the lunch period. Restroom breaks were allowed as needed and as governed by the school rules.

Instructions to the subjects. After the subject was seated and comfortable the researcher showed the first familiarity card and asked "What shape are these?" If the subject responded correctly, his response was verbally reinforced. If he responded incorrectly or failed to respond he was told the correct response. This procedure was repeated for each shape card until the subject was able to answer correctly. The same procedure was then followed for the color cards and for the position cards. When it was determined that

the subject could correctly identify each of the nine discriminants the problems were introduced.

1. Each practice problem consisted of a maximum of 60 trials, each with immediate feedback as to the correctness of the subject's choice. Each practice problem was terminated prior to the sixtieth trial when a subject responded correctly on five consecutive trials. The following explanation was given:

Now look at this. On this page I have written down one of the answers that you have just seen. It might be red, yellow, or blue; square, circle, or triangle; left part, middle part, or right part. Your job is going to be to figure out which answer I have written down here. You will guess by touching one of these and I will say "yes" or "no." Then I will turn the page, you will touch another one, and I will say "yes" or "no," and we'll keep going like that until you get the hang of it.

Are you ready? Now remember, I have one of these answers written down on this answer card: square, circle, triangle; red, yellow, blue; left part, middle part, right part. Remember, too, you are to touch instead of saying answers out loud.

The second practice problem followed the same procedure as the first, and the researcher said: "Here is a new answer card. Ready? Here we go."

The task problems followed the completion of the second practice problem. They were conducted just as the practice problems, except that the subject was given feedback on every third trial.

The first task problem was introduced:

Here is a new answer card. But I believe you have the hang of what we're doing now. Because of that I am going to make it a little bit harder. Instead of telling you every time whether you are right or wrong, I will only tell you on every couple of guesses. Understand? Good, here we go.

The remainder of the task problems were introduced: "All right, here is a new answer card. Ready? Here we go."

Operational Definitions

Academic achievement was defined as the student's performance in reading and/or arithmetic. This performance was measured by teacher ratings and by achievement test scores. For teacher ratings, the Teacher Rating Form was used and is shown in Figure 3 in Appendix A. Students who received a rating of 1 or 2 were considered above grade level (and were not used in this study). Subjects who received a rating of 3, 4, or 5 (on or near grade placement level) were designated average in that subject (i.e. reading or arithmetic) if they had never repeated a grade and subaverage if they had repeated a grade. All subjects who received ratings of 6 or 7 were designated subaverage in that subject. Subjects who were designated average in both reading and arithmetic were average achievers and students who were subaverage in reading and in arithmetic were subaverage achievers. The achievement test scores of these same subjects were examined for percentile rank scores in reading and arithmetic on the Metropolitan Achievement Test (Prescott et al., 1978). Percentile rank scores of more than 75 were designated high, 25 to 75 were average, and below 25 were low.

Average ability was defined by an IQ score of 87 to 112. This score included the standard error of measurement based on Aiken's (1971) formula, and in this study the scores were taken from the subjects' most recently administered Otis-Lennon Mental Ability Test (Otis & Lennon, 1967).

Each of the four recombinations of the data for analysis was a grouping, so that there was one grouping by teacher ratings and three groupings by achievement test scores (by reading scores only, by arithmetic scores only, and by combined reading and arithmetic scores). Within each grouping there

were either two groups (average and subaverage by teacher ratings) or three groups (high, average, and low by achievement test score) (see Table 3).

Table 3
The Four Grouping Combinations

Grouping	N	Group	n	Repeaters
Teacher rated	48	Average	24	0
		Subaverage	24	14
Reading achievement	48	High	5	0
		Average	25	4
		Low	18	10
Arithmetic achievement	48	High	13	0
		Average	22	8
		Low	13	6
Reading-arithmetic achievement	47	High	14	0
		Average	12	4
		Low	21	10

A number of learning strategy measures were obtained by analyzing the raw data. The hypothesis-testing proportion for each problem was derived by dividing the number of hypothesis-testing sets by the total number of sets. The hypothesis-testing proportion was devised to provide a measure of the students' use of a hypothesis-testing strategy in the same manner as used by Levine et al. (1967), and was based on data from completed problems only. The appropriate choices on the first blank trial (B_1) were examined as a measure of hypothesis-sampling (Levine et al., 1967). An appropriate B_1 choice was defined as staying with or shifting on the targeted discriminant dimension on each B_1 trial. That is, if the choice on the F trial was correct then the choice on B_1 would be expected to repeat one of the three discriminant

dimensions (i.e., color, shape, or position) that was on the correct F trial. In this study only the dimension containing the discriminant was analyzed, so that if the targeted discriminant had been BLUE only shifts on the color dimension were analyzed. This was done because examining shifts on each of the three dimensions was judged to be less meaningful than examining the targeted dimension. The proportion of appropriate choices on B_I was computed by dividing the number of appropriate B_I choices by the total number of B_I choices for each problem. Only data from completed problems were used in computing the B_I proportions.

Plan for Data Analysis

The emphasis of this study was on average and subaverage or low achievers. The data on high achievers for the achievement groupings were included in the analyses because of the lack of correspondence between teacher ratings and achievement test scores.

A simple randomized analysis of variance was used to determine if there was a difference by group for the number of problems completed. A repeated measures analysis of variance procedure was used to determine if there were group differences for trials to completion, hypothesis-testing proportion, and proportion of correct choices on B_I. Each analysis was repeated for each grouping. Results were considered to be significant with an alpha level of no more than .05.

The number of trials required to complete a problem may be related either to hypothesis-testing or hypothesis-sampling strategies. To investigate whether there was a relationship between the learning methods and the number of trials to completion Pearson product-moment correlation coefficients were

computed between the number of trials to completion and the measures for each of the two learning strategies. Results were considered to be significant with an alpha level of no more than .05.

To determine whether there was a difference in the number of problems completed by discriminant dimension a z proportion was computed. Results were considered to be significant with an alpha level of no more than .05.

CHAPTER III

RESULTS

A quantity of raw data was obtained for each of the dependent variables. These data are shown in Tables 5 through 8 in Appendix C, and summary data are shown in Tables 9 through 12 in Appendix D. In addition to testing each of the research hypotheses, relationships between three of the dependent variables were examined and the number of problems completed was examined by dimension.

Problems Completed

The analyses of variance for the number of problems completed are shown in Table 13, Appendix E. Group differences were observed only for the arithmetic achievement grouping. Sheffe's test (Bruning & Kintz, 1977) to determine which groups differed showed that the high and the average groups each completed more problems than the low group. The hypothesis that average achievers will complete more problems than subaverage or low achievers was supported by the arithmetic achievement grouping.

Trials to Completion

The analyses of variance for the number of trials to completion are shown in Table 14 (see Appendix E). Neither group nor administration differences were observed for any grouping. The hypothesis that average achievers will use fewer trials to completion than subaverage or low achievers was not supported by the data.

Hypothesis-Testing Proportion

The analyses of variance for these data are shown in Table 15, Appendix E. Both group and administration differences were observed.

By Grouping

The teacher rated group showed differences in the hypothesis-testing proportion, such that the subaverage group had a higher measure than the average group. Differences were not observed on the other groupings. The hypothesis that Average achievers will have a higher hypothesis-testing proportion was refuted with the teacher rated grouping, and was unsupported by the other groupings.

By Administration

The analysis of variance for this variable showed a difference by administration. A Scheffe's test (Bruning & Kintz, 1977) showed that the hypothesis-testing proportion on administration 1 was different than on 2, 3, and 4. The hypothesis-testing proportion increased following administration 1 but not after that administration (see Figure 2).

Proportion of Correct Choices on B₁

The analyses of variance are shown in Table 16 (see Appendix E). No differences were observed on this variable in any of the groupings. The hypothesis that the measure of the proportion of correct choices on B₁ would be higher for average achievers than for subaverage or low achievers was not supported by the data.

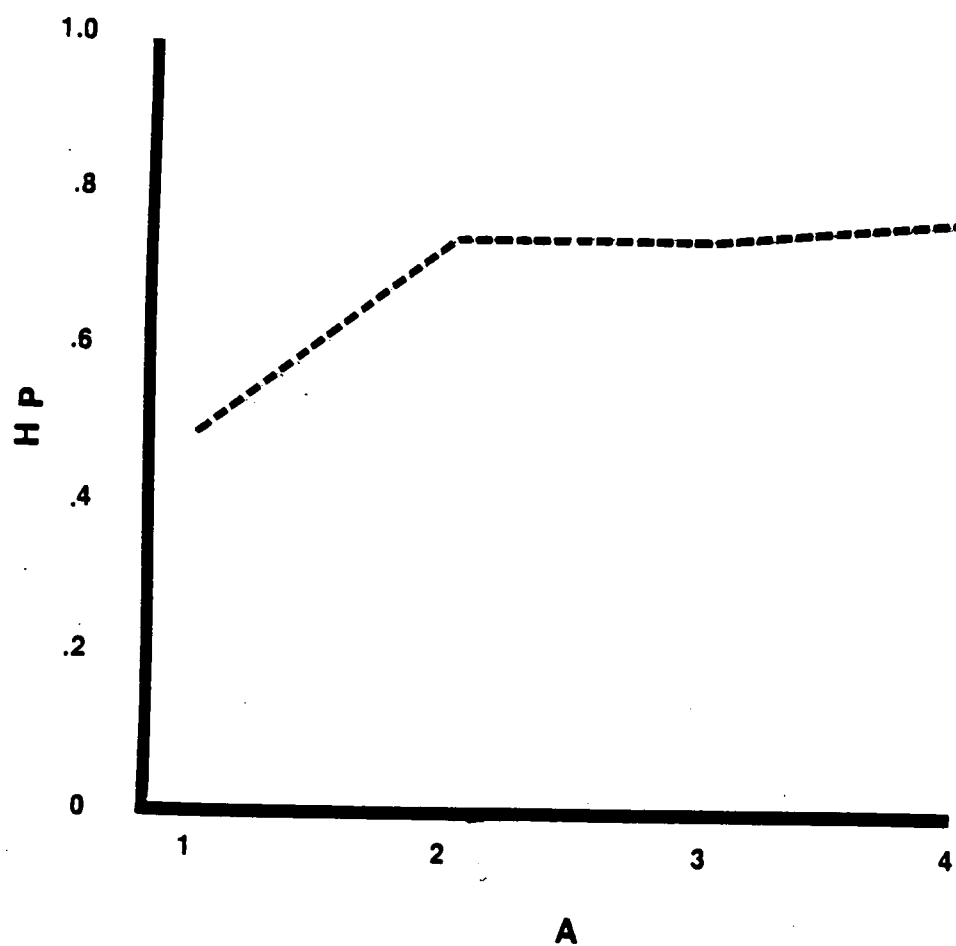


Figure 2. The hypothesis-testing proportion (HP) by administration (A).

Trials to Completion and Learning Strategies

If the subjects had used a learning strategy then there should have been some relationship between it and the number of trials required to complete a problem. Table 17, Appendix F shows the mean scores of the three variables on each administration, and these are further divided by the dimensions of color, shape, and position. A Pearson product-moment correlation coefficient was computed for each combination of variables. The correlation of trials to completion and hypothesis-testing proportion was nonsignificant, $r(11,11)=.22$, $p<.13$. Between trials to completion and the proportion of appropriate choices on B1 the correlation was significant and negative, $r(11,11)=-.69$, $p<.02$.

The relationship observed was that the number of trials to completion was negatively related to the hypothesis-sampling strategy. That is, for increased hypothesis-sampling the number of trials to completion was decreased, and vice versa.

Problems Completed by Dimension

Table 18, Appendix G summarizes the observed and expected proportion of completed problems by dimension. The expected proportion was determined by dividing the total number of problems completed (122) by the number of problems attempted (192). Using a z proportion analysis, it was determined that the proportion of color problems was higher and the number of position problems were lower than expected ($p<.001$ for each).

CHAPTER IV

DISCUSSION

The results which were obtained on this study impact the areas of child learning and educational instruction. There are both theoretical and pragmatic considerations.

Summary

There were no group differences for the number of trials to completion, nor were there differences for the proportion of correct choices for B₁. Group differences for the number of problems completed were observed for the arithmetic achievement grouping. The high and average groups completed more than the low group.

There were group differences for hypothesis-testing proportion with the teacher rated grouping only, so that the subaverage achievers had a higher hypothesis-testing proportion than the average achievers. In addition to the differences by teacher rated groups, there was also an increase from the first to the second administration.

An overall negative relationship was found between hypothesis-sampling strategies and the number of trials to completion. That is, when the proportion of appropriate choices on B₁ was higher the number of trials to completion was lower, and vice versa.

An overall difference in the number of problems completed by discriminant dimension was observed. Specifically, more color problems were completed than shape or position problems, and fewer position problems were completed than color or shape problems.

Finally, there was a lack of correspondence between teacher ratings of academic achievement on the Teacher Rating Form and achievement test scores for arithmetic achievement. The teacher ratings and achievement test scores were within 80% agreement for reading achievement but not for arithmetic achievement.

Discussion

The high and average groups completed more problems than subaverage or low students only when grouped only by arithmetic achievement. Although the relationship between discrimination learning skills and reading skills is reported in the research literature (e.g., Gibson, 1965), it was not observed in the data from this study. It is possible that discrimination learning is more directly related to arithmetic skills, and that the relationship between discrimination learning and reading skills is more complex.

The finding that hypothesis-testing proportion is higher for students rated as subaverage achievers by their teachers is a potentially important finding. The hypothesis-testing proportion appears to be related to some behavior which results in lower teacher ratings of academic performance but not lower achievement test scores.

The overall negative relationship between hypothesis-sampling and the number of trials to completion suggests that this learning strategy is not related to academic achievement but might be more indicative of general learning skills which have been acquired by 10-year-old boys. Similarly, the lack of hypothesis-testing strategies for any group suggests that this learning method is at best poorly developed for 10-year-old boys. In the Levine et al. (1967) studies all of the subjects used both hypothesis-sampling and hypothesis-

testing learning strategies, and the data from this study suggest that there may be a relationship between chronological age and these learning methods.

It was determined that the discriminant dimensions were of differing degrees of difficulty, so that color problems were easier and position problems more difficult than the shape dimension. It was not clear whether this result was related to the dimensions themselves and would be found for all ages, or whether it was related to some other factor (e.g., gender).

Although the Teacher Rating Form was not tested for reliability it was considered to be a useful measurement instrument because it relied on teacher judgements of the students' academic skills. One would expect that teacher ratings of students' performance would be similar to those students' achievement test scores; previous research has supported this relationship (Cappadona & Kerzner-Lipsky, 1979; Madaus, 1981). This study provides only marginal support for that relationship with 10-year-old males. It is possible that teacher ratings are gender-related because the previously cited research used both male and female school students. It is also possible that the relationship between teacher ratings and achievement test scores for reading achievement is a result of the emphasis placed on reading skills in the participating school system. That is, nearly every student is placed in a reading series which is leveled for instructional purposes. In order to pass to the next grade the student must attain a certain skill level. The teachers, therefore, may be more sensitive to students' reading skills but less so to their arithmetic skills because arithmetic may not be stressed to the same extent.

Methodological Considerations

The use of discriminant dimensions (i.e., color, shape and position) of differing difficulty posed the most difficulty in evaluating the data from this

study. With 10-year-olds the use of only color and shape dimensions should eliminate the difficulty experienced with the position discriminant. By using only the two dimensions the researcher would reduce the difficulty level of the problem because the position dimension would be deleted, and because the number of figures and colors would be reduced.

An increase in the number of trials allowed on each problem might also be a consideration. That is, of the 192 problems presented to the subjects only 122 were completed. An increase in the number of problems completed per subject would be useful because three of the four measures used only data from completed problems. In addition, the investigator may wish to reduce the number of problems per subject in order to maintain the same general time limits for each subject. This could be accomplished because there were no differences between data collected on administration 4 and those collected on administration 3. All relationships which were observed with four problems would have been noted with three.

Limitations of the Study

The more obvious limiting factors of the study are the subject selection and geographical restrictions. That is, the same effects may not be found with females, blacks, urban residents, or older or younger children. In order for any of the results to be meaningfully translated into educational terms a more representative sample would have to be used. In other words, the generalizability of these findings are limited.

Another possible limitation of this study was the apparent difference in difficulty levels of the discriminants for the chronological age of the sample. That is, fewer of the position problems were completed than shape or color. Similarly, more color problems were completed than either shape or position.

Future discrimination learning studies with children may wish to consider the relative difficulty levels of the discriminants for the chronological age of the population in question.

The fact that 37% of the problems were not completed is suggestive of the need for either more trials per problem or less difficult problems. Because the proportional data were computed only for completed problems, the number of completed problems is directly related to the amount of useful information available from a study such as this.

Despite the apparent usefulness of the Teacher Rating Form, no measure of its reliability was obtained. A reliability measure would be relatively simple and inexpensive, and would indicate the extent of its usefulness.

Test-retest reliability checks are done infrequently for discrimination learning tests. No reliability index for the learning measure was obtained.

Implications for Future Research

Future research implications were observed for both educationally related skills, and for the factors which result in differences between teacher ratings of academic skills and achievement test scores. That is, a relationship was found between hypothesis-sampling and the number of trials required to complete a learning problem. It might be productive to investigate this relationship in the classroom because it could take the form of teaching the students how to learn (e.g., Harlow, 1949).

Because teachers are in contact with students for extended periods of time during each school day, their opinions of the students' academic performance affects the students in a significant manner. It might be possible to enhance that relationship by investigating the factors which result in

discrepancies between the students' performance as judged by the teacher and as observed on an achievement test.

The learning methods which may be related to chronological age were hypothesis-sampling and hypothesis-testing. That is, the 10-year-olds were observed to use the former strategy but not the latter. The implications of this fact might be useful in determining individual instructional techniques for 10-year-old students. If validity and reliability checks on the discrimination learning test support its usefulness, then evaluating school students' learning methods for purposes of educational instructional planning might add a new dimension both to educational instruction and to psychoeducational assessment.

At the very least, making teachers aware of these learning methods and how they might vary by the age of the student could help teachers to become more sensitive to the individual needs of their students, at least with respect to academic instruction. This communication between professionals in the fields of psychology and education would help to span what some refer to as the gap between learning research and educational practice and theory.

Each of these areas of suggested future research can be very useful to students because of the potential impact on instructional redirection, or because of the potential impact on teacher perceptions of student performance, or because of both. At the very least, more research in this area of child learning can add to our knowledge of learning skills and strategies, and at the most may result in impressive gains in the quality of education for these students.

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APPENDICES

APPENDIX A

Student name: _____

Dear Teacher,

Please rate the above named student on the following 7 point scale. The rating should be based on your knowledge of this student's skill level in the noted skill area (that is, in either arithmetic or reading as specified below), and does not necessarily have to reflect the letter grade or achievement test scores. Research has shown teacher ratings to be extremely accurate measures of student achievement.

This is to be a teacher rating, and will be kept in confidence by me as a part of my dissertation research.

Thank you for your help in this.

William E. McGee
School Psychologist

The student performs as follows in Reading/Arithmetic

- ☐ 1. far above grade level
- ☐ 2. somewhat above grade level
- ☐ 3. slightly above grade level
- ☐ 4. on grade level
- ☐ 5. slightly below grade level
- ☐ 6. somewhat below grade level
- ☐ 7. far below grade level

Figure 3. Teacher Rating Form.

RESPONSE RECORDING SHEET

S#	Name	DOB	School
Date	P1	P2	T1 T2 T3 T4

alpha	(01 05 09 13 17 21 25 29 33 37 41 45)	d1 d2 d3 d4	d1:B1 P1:Sq
beta	(02 06 10 14 18 22 26 30 34 38 42 46)	d2 d1 d4 d3	d2:Ctr P2:Rd
gamma	(03 07 11 15 19 23 27 31 35 39 43 47)	d3 d4 d1 d2	d3:Y1
delta	(04 08 12 16 20 24 28 32 36 40 44 48)	d4 d3 d2 d1	d4:Cir

1 F ryb sct lmr	8 F ryb sct lmr	15 F ryb sct lmr
B ryb sct lmr	B ryb sct lmr	B ryb sct lmr
B ryb sct lmr	B ryb sct lmr	B ryb sct lmr
2 F ryb sct lmr	9 F ryb sct lmr	16 F ryb sct lmr
B ryb sct lmr	B ryb sct lmr	B ryb sct lmr
B ryb sct lmr	B ryb sct lmr	B ryb sct lmr
3 F ryb sct lmr	10 F ryb sct lmr	17 F ryb sct lmr
B ryb sct lmr	B ryb sct lmr	B ryb sct lmr
B ryb sct lmr	B ryb sct lmr	B ryb sct lmr
4 F ryb sct lmr	11 F ryb sct lmr	18 F ryb sct lmr
B ryb sct lmr	B ryb sct lmr	B ryb sct lmr
B ryb sct lmr	B ryb sct lmr	B ryb sct lmr
5 F ryb sct lmr	12 F ryb sct lmr	19 F ryb sct lmr
B ryb sct lmr	B ryb sct lmr	B ryb sct lmr
B ryb sct lmr	B ryb sct lmr	B ryb sct lmr
6 F ryb sct lmr	13 F ryb sct lmr	20 F ryb sct lmr
B ryb sct lmr	B ryb sct lmr	B ryb sct lmr
B ryb sct lmr	B ryb sct lmr	B ryb sct lmr
7 F ryb sct lmr	14 F ryb sct lmr	
B ryb sct lmr	B ryb sct lmr	
B ryb sct lmr	B ryb sct lmr	

Figure 4. Response Recording Sheet.

APPENDIX B

Table 4

Comparison of Teacher Ratings and Achievement Test Scores

Teacher-rated Average			Teacher-rated Subaverage		
S	Reading	Arithmetic	S	Reading	Arithmetic
1	Low	Low	25	Low	Av
2	Av	High	26	Low	Low
3	Av	Av	27	Av	Low
4	Av	Low	28	Low	Low
5	Av	Av	29	Av	Av
6	Av	High	30	Low	Low
7	Av	Av	31	Av	Av
8	Low	Low	32	Low	Low
9	Av	Av	33	Low	Av
10	High	High	34	Low	High
11	Low	Av	35	Low	Low
12	Av	Low	36	Low	Av
13	Av	High	37	Low	Av
14	Av	High	38	Low	Low
15	Av	Av	39	Low	Av
16	Av	High	40	Av	Low
17	Av	Av	41	Low	Av
18	Av	High	42	High	Av
19	High	Av	43	Low	Low
20	Av	Av	44	Av	Av
21	Av	High	45	Low	Av
22	Av	High	46	Av	Av
23	High	High	47	Av	High
24	Av	Av	48	High	High

APPENDIX C

Table 5
Raw Data for Administration I

Subjects	Discriminant Dimension	Trials to Completion	Hypothesis-Testing Proportion	Proportion of Appropriate Choices on B ₁
1	C	60	.15	.65
2	P	60	.55	.65
3	C	19	.17	.83
4	S	60	.40	.60
5	C	60	.15	.45
6	P	60	.25	.60
7	C	60	.40	.65
8	S	60	.35	.80
9	C	36	.17	.75
10	P	30	.80	.60
11	C	05	1.00	1.00
12	S	27	.56	.78
13	C	08	.50	1.00
14	P	60	.15	.60
15	C	05	1.00	1.00
16	S	12	.75	.75
17	C	17	.20	.67
18	P	14	.75	1.00
19	C	23	.29	.75
20	S	21	.86	.71
21	C	14	.67	1.00
22	P	17	.80	.83
23	C	09	.67	1.00
24	S	60	.40	.70
25	C	29	.67	.70
26	P	60	.75	.55
27	C	12	.75	.75
28	S	60	.50	.65
29	C	05	1.00	1.00
30	P	60	.35	.50
31	C	05	1.00	1.00
32	S	60	.50	.55
33	C	11	.33	1.00
34	P	60	.80	.45
35	C	60	.45	.60
36	S	18	.67	.67
37	C	05	1.00	1.00
38	P	48	.71	.50
39	C	05	1.00	1.00
40	S	60	.40	.44
41	C	50	.75	.76
42	P	60	.80	.65
43	C	06	1.00	1.00
44	S	12	.75	.50
45	C	08	1.00	1.00
46	P	60	.90	.55
47	C	10	.33	.67
48	S	60	.65	.70

Table 6
Raw Data for Administration 2

Subjects	Discriminant Dimension	Trials to Completion	Hypothesis-Testing Proportion	Proportion of Appropriate Choices on B ₁
1	P	60	.40	.65
2	C	12	1.00	.75
3	S	60	.55	.70
4	C	34	.45	.73
5	P	60	.25	.50
6	C	46	.27	.47
7	S	21	1.00	1.00
8	C	60	.20	.65
9	P	60	.10	.70
10	C	13	.75	.60
11	S	12	.75	1.00
12	C	06	1.00	1.00
13	P	60	.35	.55
14	C	60	.30	.75
15	S	44	.53	.80
16	C	12	.75	.50
17	P	17	.20	.47
18	C	14	.75	1.00
19	S	23	.29	.90
20	C	21	.86	1.00
21	P	14	.67	.60
22	C	17	.80	1.00
23	S	09	.67	1.00
24	C	60	.40	.40
25	P	52	.82	.35
26	C	19	.67	.83
27	S	60	.85	.60
28	C	42	.50	.64
29	P	60	1.00	.40
30	C	28	.67	.67
31	S	50	.63	.71
32	C	05	1.00	1.00
33	P	38	.75	.77
34	C	60	.60	.65
35	S	60	.20	.40
36	C	09	1.00	.67
37	P	60	.75	.65
38	C	23	.86	.43
39	S	37	.92	.83
40	C	60	.30	.70
41	P	50	1.00	.47
42	C	12	1.00	.50
43	S	60	.90	.50
44	C	06	1.00	1.00
45	P	60	.90	.60
46	C	60	.90	.75
47	S	29	.33	.80
48	C	08	.50	1.00

Table 7
Raw Data for Administration 3

Subjects	Discriminant Dimension	Trials to Completion	Hypothesis-Testing Proportion	Proportion of Appropriate Choices on B ₁
1	C	60	.25	.55
2	S	51	.82	.82
3	C	33	.45	.82
4	P	60	.80	.50
5	C	60	.05	.35
6	S	60	.65	.55
7	C	27	1.00	.44
8	P	60	.60	.35
9	C	60	.15	.50
10	S	10	1.00	.33
11	C	37	.58	.58
12	P	60	.60	.55
13	C	18	.83	.67
14	S	08	.50	1.00
15	C	13	.75	.50
16	P	40	.85	.50
17	C	60	.55	.45
18	S	07	.50	.50
19	C	11	.33	1.00
20	P	33	.64	.64
21	C	60	.75	.45
22	S	12	.75	.75
23	C	09	1.00	1.00
24	P	60	.35	.45
25	C	23	.86	.63
26	S	09	1.00	.67
27	C	60	.65	.65
28	P	60	.70	.45
29	C	60	.85	.65
30	S	60	.70	.65
31	C	21	.71	.57
32	P	60	.45	.85
33	C	39	.92	.15
34	S	13	1.00	.75
35	C	21	.75	.71
36	P	60	.50	.65
37	C	09	1.00	1.00
38	S	12	1.00	.75
39	C	14	1.00	.80
40	P	60	.70	.40
41	C	13	.75	.75
42	S	16	.80	.60
43	C	60	.95	.75
44	P	60	.80	.60
45	C	55	.72	.22
46	S	09	1.00	1.00
47	C	27	.56	.89
48	P	60	.55	.45

Table 8
Raw Data for Administration 4

Subjects	Discriminant Dimension	Trials to Completion	Hypothesis-Testing Proportion	Proportion of Appropriate Choices of B ₁
1	S	60	.35	.70
2	C	07	.50	.50
3	P	60	.65	.80
4	C	13	1.00	.50
5	S	60	.45	.65
6	C	14	.50	.60
7	P	18	1.00	1.00
8	C	16	.60	.80
9	S	30	.30	.80
10	C	09	1.00	1.00
11	P	07	1.00	1.00
12	C	24	.75	.63
13	S	15	.80	.80
14	C	57	.32	.74
15	P	60	.85	.40
16	C	09	1.00	1.00
17	S	60	.40	.70
18	C	06	1.00	1.00
19	P	60	.20	.40
20	C	60	.75	.65
21	S	12	.75	1.00
22	C	26	.63	.78
23	P	26	.75	.67
24	C	18	.83	.67
25	S	14	1.00	1.00
26	C	60	.75	.60
27	P	60	.85	.85
28	C	45	.60	.47
29	S	19	.67	.50
30	C	12	.75	.75
31	P	60	.85	.60
32	C	24	.75	.50
33	S	08	1.00	1.00
34	C	12	1.00	.50
35	P	30	.70	.60
36	C	60	.35	.55
37	S	16	.80	1.00
38	C	05	1.00	1.00
39	P	60	.90	.60
40	C	60	.40	.65
41	S	32	1.00	1.00
42	C	30	1.00	.80
43	P	60	1.00	.50
44	C	07	1.00	.50
45	S	16	.80	.40
46	C	14	.75	.60
47	P	60	.25	.40
48	C	08	1.00	.67

APPENDIX D

Table 9
Mean Dependent Variable Scores for Administration I

Group	Dependent variables			Proportion of appropriate choices on B ₁
	Problems completed	Trials to completion	Hypothesis-testing proportion	
Teacher rated				
Average	.67	21.93	.40	.81
Subaverage	.63	19.80	.62	.76
Reading achievement				
High	.60	20.67	.49	.78
Average	.64	16.85	.40	.79
Low	.67	28.00	.66	.79
Arithmetic achievement				
High	.62	14.25	.42	.86
Average	.77	22.09	.52	.76
Low	.46	29.60	.55	.74
Reading-arithmetic achievement				
High	.64	15.22	.45	.84
Average	.67	21.00	.31	.69
Low	.67	26.30	.62	.78

Table 10
Mean Dependent Variable Scores for Administration 2

Group	Dependent variables			Proportion of appropriate choices on B ₁
	Problems completed	Trials to completion	Hypothesis-testing proportion	
Teacher rated				
Average	.63	21.36	.76	.77
Subaverage	.63	27.27	.74	.71
Reading achievement				
High	.80	11.75	.67	.78
Average	.60	24.64	.74	.76
Low	.67	28.73	.80	.70
Arithmetic achievement				
High	.69	17.25	.63	.77
Average	.64	29.43	.52	.71
Low	.54	22.57	.55	.76
Reading-arithmetic achievement				
High	.71	16.67	.67	.74
Average	.58	28.86	.78	.77
Low	.62	27.38	.78	.72

Table II
Mean Dependent Variable Scores for Administration 3

Group	Dependent variables			Proportion of appropriate choices on B ₁
	Problems completed	Trials to completion	Hypothesis-testing proportion	
Teacher rated				
Average	.58	22.07	.75	.68
Subaverage	.63	22.73	.77	.66
Reading achievement				
High	.80	11.50	.67	.73
Average	.52	23.00	.76	.70
Low	.67	25.42	.79	.62
Arithmetic achievement				
High	.77	19.50	.84	.72
Average	.68	23.53	.72	.65
Low	.31	25.50	.73	.65
Reading-arithmetic achievement				
High	.79	19.00	.73	.73
Average	.50	22.67	.75	.66
Low	.52	26.55	.77	.61

Table 12
Mean Dependent Variable Scores for Administration 4

Group	Dependent variables			Proportion of appropriate choices on B ₁
	Problems completed	Trials to completion	Hypothesis-testing proportion	
Teacher rated				
Average	.71	18.06	.71	.79
Subaverage	.67	19.13	.87	.69
Reading achievement				
High	.80	18.25	.93	.79
Average	.64	18.06	.73	.73
Low	.72	19.33	.81	.75
Arithmetic achievement				
High	.92	16.75	.76	.77
Average	.59	17.62	.89	.79
Low	.62	23.43	.62	.61
Reading-arithmetic achievement				
High	.86	18.25	.76	.80
Average	.50	17.67	.77	.68
Low	.67	19.77	.80	.74

APPENDIX E

Table 13

Summary Table for Analyses of Variance for Problems Completed

Grouping	Source	df	SS	MS	F	p
Teacher rated	Groups	1	.0000	.0000	.00	< .00
Reading achievement	Groups	2	1.7259	.8629	.79	< .46
Arithmetic achievement	Groups	2	7.9027	3.9513	4.04	< .02
Reading - arithmetic achievement	Groups	2	4.7123	2.3561	2.21	< .12

Table 14

Summary Table for Analyses of Variance for Trials to Completion

Source	df	SS	MS	F	p
Teacher rated					
Group	1	156.2218	156.2218	.69	<.41
Administration	3	340.4879	113.4960	.57	<.64
Group x administration	3	302.2532	100.7511	.51	<.68
Reading achievement					
Group	2	792.4770	396.2385	1.99	<.15
Administration	3	138.3876	46.1291	.23	<.88
Group x administration	6	709.0629	118.1772	.59	<.74
Arithmetic achievement					
Group	2	570.4719	285.2360	1.36	<.27
Administration	3	385.5154	128.5051	.66	<.59
Group x administration	6	1,041.9544	173.6591	.89	<.51
Reading-arithmetic achievement					
Group	2	712.8100	356.4050	1.76	<.18
Administration	3	331.5432	110.5144	.53	<.67
Group x administration	6	461.6028	76.9338	.37	<.90

Table 15

Summary Table for Analyses of Variance for Hypothesis-Testing Proportion

Source	df	SS	MS	F	p
Teacher rated					
Group	1	.5695	.5695	4.91	< .03
Administration	3	.9334	.3111	5.01	< .01
Group x administration	3	.0429	.0143	.23	< .87
Reading achievement					
Group	2	.1993	.1000	.82	< .21
Administration	3	.7520	.2507	4.02	< .01
Group x administration	6	.2144	.0357	.57	< .75
Arithmetic achievement					
Group	2	.1492	.0746	.61	< .55
Administration	3	.6548	.2183	3.65	< .02
Group x administration	6	.3650	.0608	1.02	< .42
Reading and arithmetic achievement					
Group	2	.1676	.0838	.69	< .51
Administration	3	.8674	.2891	4.36	< .01
Group x administration	6	.0448	.0075	.11	< .99

Table 16

Summary Table for Analyses of Variance for Proportion of Appropriate B₁ Choices

Source	df	SS	MS	F	p
Teacher rated					
Group	1	.0303	.0303	.79	<.38
Administration	3	.2627	.0876	1.85	<.15
Group x administration	3	.0832	.0277	.59	<.63
Reading achievement					
Group	2	.0263	.0132	.32	<.73
Administration	3	.1617	.0439	1.11	<.35
Group x administration	6	.1532	.0255	.53	<.79
Arithmetic achievement					
Group	2	.0618	.0309	.76	<.47
Administration	3	.0870	.0290	.62	<.61
Group x administration	6	.2779	.0463	1.00	<.44
Reading-arithmetic achievement					
Group	2	.1500	.0750	1.89	<.16
Administration	3	.2698	.0899	1.86	<.15
Group x administration	6	.1478	.0246	.51	<.80

APPENDIX F

Table 17

Mean Scores for Trials to Completion (TC), Hypothesis-Testing Proportion (HP), and Proportion of Appropriate Choices on B₁ (B₁)

Variable	Means		
	Color	Shape	Position
Administration 1			
TC	17.05	18.00	26.00
HP	.68	.80	.77
B ₁	.93	.68	.73
Administration 2			
TC	18.22	28.13	34.20
HP	.77	.64	.69
B ₁	.77	.88	.53
Administration 3			
TC	23.13	14.70	44.30
HP	.76	.84	.73
B ₁	.67	.72	.53
Administration 4			
TC	17.80	18.00	20.25
HP	.80	.79	.86
B ₁	.70	.83	.82

APPENDIX G

Table 18
Differences in the Proportions of Problems Completed By Dimension

Dimension	Proportion		z	p
	Completed	Expected		
Color	.792	.635	3.19	<.001
Shape	.646	.635	.15	< .88
Position	.333	.635	-4.35	<.001

VITA

William Earl McGee was born in Knoxville, Tennessee on October 30, 1948. He attended elementary school in Maryville and in Knoxville, and was graduated from Knoxville Bearden High School in June 1966. He immediately entered The University of Tennessee, Knoxville, and in August 1970 received a Bachelor of Science degree in Psychology.

Following a variety of life experiences he entered the Graduate School of The University of Tennessee, Knoxville, in June 1974. He received a Master of Arts degree with a major in Psychology in March 1976, and the Doctor of Education degree with a major in Educational Psychology and Guidance in August 1982.

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He is married to the former Roslyn Meriwether Vanstone of Nashville, Tennessee, and has three beautiful children: Abigail, Sara, and William.