INTERFERENCE PHENOMENON IN YOUNG CHILDREN AS MEASURED BY THE ASSOCIATION OF WORDS WITH COLORS

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

IN THE GRADUATE SCHOOL OF THE

TEXAS WOMAN'S UNIVERSITY

COLLEGE OF EDUCATION

BY

FATEMEH BAFIGHADIMI FIROZ, B.A., M.A.

DENTON, TEXAS

DECEMBER 1981

The Graduate School

Texas Woman's University

Denton, Texas

July 14, 1981

We hereby recommend that the dissertation prepared under our supervision by Fatemeh Bagighadimi Firoz entitled Interference Phenomenon in Young Children as Measured by the Association of Words with Colors

Dissertation/Theses signature page is here.

To protect individuals we have covered their signatures.

ACKNOWLEDGMENTS

It is with special gratitude that I express my deep appreciation to Dr. Sam Ed. Brown, Dr. Paul Thetford, Dr. Sidney Bergquist, Dr. Patricia Payne, and Dr. A. D. Castle for serving on my committee. To Dr. David Marshall goes special thanks for guiding me through the statistical procedures. Their direct or indirect contribution to this study gave me support in conducting this research. I express my thanks to the Denton Public School District, to private schools, and to other school care programs with cooperating principals, pupils, parents, and teachers.

I express thanks to Bahar and Elnaz who interested me in investigating children's color concepts and color learning.

To my husband, Dr. Firoz, and to our parents, I should like to express my deep appreciation for their love, patience, encouragement, and moral support.

TABLE OF CONTENTS

LIST OF TABLES

Table

CHAPTER I

INTRODUCTION

Interference phenomenon, in a general sense, can be defined as any function of hindrance or prevention. It is obvious that one function will occasionally hinder or prevent another action with which it is incompatible. The present study is concerned with the interference phenomenon which occurs when words are printed in conflicting or incongruent colors. For example, the word grass might be printed in red color, which is incompatible with the color of grass.

The study of interference or inhibition phenomenon is almost a century old. The investigation was begun by physiologists prior to 1890 (Bowditch & Warren, 1890). At the present time, the continuation of this phenomenon has been conducted by psychologists, and numerous studies in different areas of interest have been completed.

Experiments investigating interference or inhibition have produced several unanswered questions. For example, researchers are studying questions such as: What is the source of interference? Why do people take more time to name the colors than read the words? What is the role of

associative inhibition? What is the role of practice on interference? What is the relationship between the personal variables (sex and age) and interference? Is the interference effect due to response competition? Is the interference effect due to controlled and automatic human information? Is the interference effect a genetic factor? Is the interference effect a cognitive differentiation of an individual? Many, many other similar questions have been studied.

The Color-Word Interference Test was first introduced by John Ridley Stroop (1935) into American psychology. This test consists of three different cards with 100 color-words printed in incongruent colors on the first page, 100 color patches consisting of varying lengths of X's, each patch printed in different colors on the second page, and 100 color-words printed in black ink on the third page. Most of the experiments have been done by using the original aforementioned Stroop Test with adult subjects, however, little research has been conducted using younger participants.

In terms of the source of the interference, the main questions will still remain: Is the source of the interference in the materials themselves? Does exposing a subject to words printed in incongruent colors cause a subject

to change her/his attitude toward the test? Do young children go through the same interference processes as adults? What is the relationship or correlation between the interference effect and the child's developmental level as defined by Jean Piaget (1970)? What is the value of studying the interference phenomenon? The present study will attempt to consider these unclear questions.

Statement of the Problem

Teaching color names with words (such as the word red printed in red color) is a dual coding system, and children must go through both a verbal (telling) and image (recalling) system. Keele (1972) cited that there are two different responses with which a child must deal in color-word tasks which occur at about the same time. Important here is that one response (verbal or recall) is usually delayed. The reason for this is that both responses (reading the word and recalling the color) cannot be handled at the same time. Internally, this process will affect children's learning systems and will develop an interference phenomenon.

Teachers and psychologists should become more aware of the complexities of individual learning systems and their corresponding curriculum implications. Such awareness would permit the organizers of elementary curriculum

to point out the possible difficulties existing due to the color interference phenomenon. While recognizing the significance of the teaching method which incorporates words printed in colors, the literature does little to address the factors that affect this relevant and important aspect of the interference factor. The present study examines the interference phenomenon using words and colors.

Since it was assumed, in younger children, that the growth of conservation, as described by Piaget (1930), affects the type of interference being studied, correlations between interference and conservations were made using Goldschmid and Bentler (1968) Concept Assessment Kit - Conservation Task.

In order to examine the effect of children's reading ability on interference phenomenon, correlations were made using 40 words printed in black ink used in the experimental tasks. The objective of testing children's reading ability was to control different levels of reading performance within the experimental groups.

Significance of the Problem

Review of the literature reveals related information concerning some factors that are possible causes of the interference phenomenon. Since almost all the researchers have conducted studies by using adult subjects,

educational implication is rather rare. Investigators have been most concerned with the psychological aspect of human behavior in this interesting phenomenon. For example, Klein (1964) investigated the effects of verbal texts varying in their relationship to the colors. He used six different experimental conditions and showed that as the words became more meaningful and more closely related to colors, subjects showed more interference effect. His subjects were 90 undergraduate and graduate students. He concluded that the reason for interference increment is a function of the meaningfulness of the words; that is the semantic relation of the words with colors.

Schneider and Shiffrin (1977) proposed two fundamentally different theories of information processing. They referred to these theories as automatic and nonautomatic information processing. They differentiated automatic from nonautomatic information processing as follows: Automatic information processing occurs involuntarily and is independent of the central nervous system. Nonautomatic information processing is the activation of unlearned sequences of elements within the subject's control and with his/her attention.

Supporting the automatic information processing hypothesis, Regan (1978) investigated the color-naming

task in two experiments. In the first experiment, he used five different word stimuli including neutral words, incompatible color-related words, compatible color-related words, incompatible color-words, and compatible color-words based on focal (colors close to the focal point) and nonfocal (colors farthest from the focal point) colors. The result of the first experiment indicated that color naming was delayed by word reading, even when the word was not visually, phonetically, or semantically related to the color. In the second experiment, Regan used four different letter stimuli including a control digit (the digit four), control letter (six letters chosen randomly such as C, D, K, N, Q, T), incongruent color-word letter (initially incompatible with the ink name, such as letter R in blue ink), and congruent color-word letter (initially compatible with the ink name, such as letter R in red ink). These four different letter stimuli were printed in red, green, and blue colors. The result of the second experiment showed that initially incompatible single letters delayed color-naming, while compatible single letters facilitated color-naming. Moreover, the data from both of these experiments support the hypothesis that familiar items are processed involuntarily on the basis of automatic information processing.

Furth and Youniss (1964) investigated the role of environmental influences on human learning by comparing five year old hearing children who are exposed to verbal experiences, and five year old deaf children, who are not exposed to verbal experiences. The experimental tasks consisted of four nonverbal color-object-paired associates as an indication of response, and four colored cards which were incompatible with the color of objects, and four colored cards which were compatible with the color of objects as an indication of a stimuli. The result showed that deaf children had less interference and scored lower as compared to hearing children. They concluded that deaf children showed superiority because of experimental poverty and lack of perceptual rigidity. It is important to believe that environment does play an important role in human perception, learning, and reacting.

Piaget's (1955) observations led him to accept the crucial importance of experiences in intellectual and perceptual development of an individual. He strongly believed that development is a function of external elements with which the child comes in contact.

Peterson and Peterson (1957) examined past research on interference phenomenon and concluded that most of the investigated research has poor experimental instruments,

designs, implications, testing atmosphere, and interaction between subject and examiner. They believed that strong caution should be taken in terms of any result of the experimental studies.

Because of a lack of data and research on the interference effect in young children, this study was an attempt to specifically measure this phenomenon using words and colors. It is anticipated that updated and relevant information revealed by these findings can help teachers and psychologists to understand human learning better, and thus develop improved curriculum.

Purpose of the Study

John Ridley Stroop (1935) cited that the use of color in printed meaningful words caused processing interference resulting in longer processing time. He showed that the subjects would take more time to recall color names as compared to reading the color-words in non-color prints. Still, the question of the role of color in facilitation or inhibition remains unclear. There are many controversial research studies on how color works in human learning in many different areas, using various approaches. For example, Calvin and Clifford (1956) showed that subjects had a more difficult time when concept attainment tasks were presented with color than when they were presented

without color. Supporting this research, Lamberski and Myers (1980) also determined that subjects learned better and scored higher on black/white learning and testing materials than they did on materials printed in color. They concluded that color motivated the subject, but produced no significant achievement effects unless a proper time was provided.

Contrary to these research studies, Saltz (1963) showed that color cues enhanced a subject's performance on learning and testing conditions. He further concluded that cognitive differentiation became a functional cue during the testing condition.

The course of children's acquisition of color concepts is influenced by their direct or indirect environmental experiences with this complex learning behavior. Being conditioned to the many different stimuli in our external world along with the associations which take place, enables human beings to control or to direct behavior. For example, the red traffic light means to stop, and also means the color of the light is red. Children have been conditioned to this stimulus, and have obtained the concept of the red color from multiple experiences. It is evident that environmental influences are factors that are difficult to control, and affect all aspects of an individual's behavior (Otto & Askov, 1968).

George Guthrie (1975) cited that moving from an old situation to a new situation can be a profound and conflict-producing experience. The generalization of this phenomenon is observed when an individual becomes confused in a situation which conflicts with a previously learned and adopted behavior. Lee (1965) investigated environmental influences upon form/color preference. He indicated that preference for color decreases around the age of six. He suggested that this decrease might be a result of the introduction of reading, which causes attention to be given to form. One year later, Suchman (1966) tested color/form matching tasks in three different countries, Zaria, Nigeria, and Africa. A total of 357 children from age three to 15 were tested. From 357 subjects, only 24 subjects preferred form over color. He concluded that color preference may be a result of cultures in which form is not an important cue.

The usefulness of color in human learning still remains a question. What particular stimulus should be used with which particular group? In other words, a different age group, with different ability and skill development, may respond differently to available cues. According to Piaget's theory, the children's conceptual and intellectual structure develops as they move from the pre-operational

to the concrete operational stage (Wadsworth, 1979). Qualitative changes of cognitive structure are gradual and develop as a result of the children's active experiences. Through assimilation and accommodation, children's intellectual development organizes and gives structure to thought. In terms of Piaget's (1967) theory, younger children whose perception is not yet decentered, attend only to one dominant characteristic of a stimulus, but older, more cognitively mature, children attend to all characteristics of a stimulus, holding "One dimension invariant in the face of changes in other dimensions" (Wadsworth, 1979, p. 83).

In contrast to young children (before the age of seven), it appears that older children (after the age of seven) decenter their perceptions and attend to transformations. As the children move from the preoperational to the concrete operational stage, they "make cognitive and logical decisions as opposed to perceptual decisions" (Wadsworth, 1979, p. 96). Their actions are directed by logical thought processes rather than centering on perceptual aspects.

Piaget and Inhelder (1958) describe the complexity of content structure, stating that the content might become so structured that the learner would build various

logical relationships or associations in order to understand the content. He further says that often the type of associative verbal chaining found in most textbooks does not lead the learner to build logical relationships and does not increase the level of comprehension.

The purpose of the present study was to identify the effect of the association of words with the colors. The primary aim was to determine 1) to what extent the semantic association of words with colors affects a subject's performance on associate and non-associate color words and Persian words printed in colors, and 2) to what extent the colors (red, green, yellow, blue, and brown) influence a subject's correct response in either task. The present study specially addressed the following research questions:

1. Do children exposed to familiar words that are associated with colors (grass/green) experience more interference in identifying the color if the same words are printed in incongruent colors (grass printed in red color)?

2. Do children exposed to familiar words that are normally unrelated to colors (such as table and car) experience less interference in identifying the colors?

3. Do children exposed to Persian words printed in colors experience less interference in identifying the colors?

4. Does the phenomenon of color interference have equal effects on children who have not yet developed the concept of conservation and on children who demonstrated conservation ability?

5. Does the phenomenon of color interference have equal effects on second, third, and fourth grade children?

6. Do children with high reading ability experience low interference in identifying the colors?

Statement of the Null Hypotheses

To carry out the relationship between semantic association of the printed words and the colors, the following null hypotheses were formulated:

1. There will be no statistically significant difference between the measures of interference in children when presented with familiar words associated with colors printed in congruent colors, and when presented with familiar words associated with colors printed in incongruent colors.

2. There will be no statistically significant difference between the measures of interference in children when presented with familiar words associated with colors

printed in congruent colors, and when presented with familiar words not associated with colors printed in colors.

3. There will be no statistically significant difference between the measures of interference in children when presented with familiar words associated with colors printed in congruent colors, and when presented with Persian words printed in colors.

4. There will be no statistically significant difference between the measures of interference in children when presented with familiar words associated with colors printed in different colors, and when presented with familiar words not associated with color printed in colors.

5. There will be no statistically significant difference between the measures of interference in children when presented with familiar words associated with colors printed in incongruent colors, and when presented with Persian words printed in colors.

6. There will be no statistically significant difference between the measures of interference in children when presented with familiar words not associated with colors printed in colors, and when presented with Persian words printed in colors.

7. There will be no statistically significant relationship between the raw scores derived from the conservation test Concept Assessment Kit, and the time score measures of the interference in young children on Card A; related color words printed in incongruent colors, Card B; related color words printed in congruent colors, Card C; unrelated color words printed in colors, and Card D; Persian words printed in colors, when reading ability card or Card F; 40 words listed in Card A and/or Card B and Card C printed in black ink was used as a covariate.

8. There will be no statistically significant difference between the second, third, and fourth grade levels, and the time measures of the interference in young children.

9. There will be no statistically significant relationship between the reading performance on black and white printed words and the time measures of the interference in young children.

Definition of Terms

For the purpose of the present study, the following definitions were formulated:

1. Assimilation - The cognitive process of integration of new perceptual stimuli into existing schemata.

2. Accommodation - The process of changing old schemata to fit new situations.

3. Pre-operational Stage - A stage of cognitive development as presented by Piaget (1970) which develops between the ages of two to seven years. It refers to a period when a child is unable to conserve, sequence, and to perform logical operation.

4. Concrete Operational Stage - A stage of cognitive development as presented by Piaget (1970) which starts at about the age of seven and extends to the age of eleven. In this period, a child is able to conserve, to decenter, and to mentally manipulate objects and reverse the manipulation.

5. Conservation - According to Piaget (1930), conservation is the conceptualization that certain properties of an object stay the same regardless of any changes in an irrelevant dimension. For this study, the operational definition was the score which an individual received on the Concept Assessment Kit - Conservation using Form A and Form C.

6. Invariant Quantity - Mentally capable of identifying the quantity property (weight) of an object regardless of any changes in its arrangement.

7. Compensation - The capability to simultaneously hold in mind two dimensions of visual presentation (decentering) and realize that one compensates for the other (Labinowicz, 1980).

8. Reversibility - The cognitive ability to reverse an operation, to mentally return the object to its original state.

9. Environmental Exposure - The influence of external elements on the information-processing functions within the individual.

10. Semantic Association of Color-Word - The relatedness or association of the meaning of the words or of different attributes of the words to the colors.

11. Interference - Any function of hindrance or prevention of an action due to an incompatible situation. For the present study, the operational definition for interference is the time score which an individual receives on four different color names of the experimental tasks (Card A, Card B, Card C, and Card D) as compared to the control Card (Card E).

Limitations

The following limitations were imposed on the present study due to the design of the experiment:

1. The subjects selected for the present study were chosen from second, third, and fourth grade students.

2. This study was limited to only five different colors which were used in the experimental tasks.

3. When referring to the environmental exposure, defined in the Definition of Terms section of this study, the influence of the previous environmental factors in children's color concept and color learning was not evaluated.

4. When referring to the interference phenomenon, defined in the Definition of Terms section of this study, only the speed of color naming was considered as the measure of a subject's interference score.

5. The children's reading ability referred only to the subjects' ability to read correctly all of the 40 words listed on the Experimental Task, excluding Persian words.

CHAPTER II

REVIEW OF SELECTED LITERATURE

Introduction

The review of the literature includes four sections. The present study requires a comprehensive survey of the literature dealing with the interference phenomenon and the young child. Some factors that are related to this phenomenon will also be cited.

Section I considers the past and the present research dealing with the interference phenomenon.

Section II explores the role of color in human learning and its relationship to the interference phenomenon.

Section III reveals the theory of semantic association and reviews the experimental results related to the interference phenomenon.

Section IV considers the cognitive development or cognitive differentiation of a young child and its relationship to the interference phenomenon.

Past and Present Research Concerning the Interference Phenomenon

Past studies of the interference phenomenon including researched factors that are primarily related to the

present study, go back to the early nineteenth century. One of the first researchers in the field of the interference phenomenon was James McKeen Cattell (1886). His experimental study reported the relative speeds of color naming and color-word reading. He found that color naming took more time than word reading. Later on, in 1908, William James supported Cattell's results, agreeing that word reading is an easier task than color naming. Studies by Brown (1915) and Lund (1927) also have shown that subjects require more time to name color than to read words, and require more time to respond to color patches and nonsense configurations, compared to reading the words printed in black ink.

The difference in response times between color naming and word reading is called the Stroop (1935) Interference Effect. This phenomenon was first introduced to American psychology by Stroop in 1935.

Later, a growing interest in examining the Stroop Interference Effect developed, and different interpretations were given by different investigators. The attribution of such an effect could be due to testing materials (Stroop, 1938), mental growth (Das, 1970), output of the memory system (Keele, 1972), involuntary automatic processing hypothesis (Regan, 1978), response competition (Klein,

1964), developmental stages of the participants (Schiller, 1966), cognitive differentiation of the subjects (Smith & Klein, 1953), and semantic association (Dyer, 1972).

Daniel (1969) developed a new version of the Stroop Test which had a higher interference effect. His test consisted of words printed in incongruent colors on colored backgrounds that were different from the incongruent colors of the words. The subject was asked to name successively the color of the background, and then the color of the word. The results indicated that twice as much time was required than in the traditional Stroop Test. In other words, repeating double color-naming tasks produced higher interference phenomenon.

The most theoretical aspect of the interference phenomenon is the influence of color and word-response times which are involved in a color-word interference task. A general explanation in most of the research studies of the interference phenomenon is response competition and/or perceptual conflicts. Hock and Eget (1970) explained the perceptual conflict hypothesis by saying that the subject is distracted by the presence of the word, and is not able to encode the color dimension because of his reading of words. They further explained that a limited processing capacity with the word dimension being primary is the common cause of the interference phenomenon.

Morton's (1969) explanation of response competition parallels Hock and Eget's perceptual conflict hypothesis. He believes that color-word stimuli will elicit interference whenever the subject's response associated with the word becomes available before the relevant color response. He further explains that the degree of interference is dependent upon the recognizability of the words and their association and relatedness to the color. He says that more recognizability and relatedness of the words to the colors will produce more interference. He cites three prime and important factors in the measurement of the degree of interference phenomenon. These three elements include presence of words, presence of colors, and the relatedness of words and colors.

Perhaps the best recent explanation of the response competition hypothesis includes Treisman's (1969) claim that the subject is unable to focus on either the color or the word. As it has been shown in almost all of the experiments, word response time is much shorter than color response time. The generalization of this function might indicate that fast readers will tend to read the words before they name the colors. Therefore, the task which requires the subject to name the colors might take a longer time than reading the words.

Lassen (1974) in his dissertation investigated three experiments using a modified Stroop Test in order to measure the interference phenomenon. In the first experiment, incongruent drawings were paired with words. The task was to name the pictures and ignore the words. The result of this experiment showed a significant interference effect. In the second experiment, onset of the irrelevant stimulus was varied. The highest interference occurred when pictures and words were incongruent. In the third experiment, the Stroop arrangement was the combination of 'same' and 'different' stimulus/response sequencings. Subjects were asked to match either congruent pictures or congruent words, but to respond to different picture-word stimuli. The results indicated that subjects scored higher on matching the pictures than matching the words, and 'same responses' were made faster than 'different responses'.

Review of the literature and experimentations reveal that color-word interference tests with many modifications and variations were used to study a variety of other variables, such as the study of drug effects and arousal, perceptual styles, personality and developmental variables, brain dysfunction, cognitive processes, memory structures, and other important factors. Some of these variables will be discussed in the following sections of this chapter.

Role of Color in Human Learning and its Relation to Interference

In recent years, the use of color in educating young children has created widespread interest. The question of its positive/negative effect or no effect has remained unclear. There is a sizable body of literature on the role of color in learning in general terms, but no specific and certain answer has been formulated. The purpose of this section is to review the literature considering the role of color in human learning and its possible relation to the interference phenomenon.

In everyday life we are attracted by colors while walking or riding along streets, often wondering why some signs or cues are more recognizable than others. We live with color consciously or without awareness of its effect upon us, sometimes with lasting impressions. Visualizing ourselves in a colorless atmosphere gives us a different expression of our environment. It might logically be said that a colorless environment would provide a colorless human. Unlimited usefulness of color in daily life provides a broader opportunity to think, to experience, and to wonder about it. We often see the role of color in business, science, industry, and symbolic representatives (Gatto, 1974). Several research studies have shown the important role of color in enriching the environment and

in making it attractive (Birren, 1978). Lamberski's (1980) study has also shown that colored learning materials motivate the subject.

Hudspett's (1979) study of the effect of the colors of the teacher's clothing upon the behavior of kindergarten children showed a significant result. The result indicated a significant difference in motor activity between the control and the experimental groups. The experimental group exhibited higher motor activity when the teacher used warm color clothes. Children exhibited less motor activity when the teacher used cold color clothes in the classroom atmosphere.

A study of children's preferences for colored illustrated/photographed textbooks was conducted by Conger in 1979. Her findings supported a similar study conducted by Whipple (1953). Conger's and Whipple's studies showed that children preferred realistic drawings to photographs. Amsden (1960) conducted a study using black/white illustrated/photographed and colored/illustrated/photographed materials. Her experiment included children ages three to five. The results indicated that children preferred black/white photographs to black/white drawings. Her research further indicated that children preferred colored illustrations over colored photographs.

Influence of color on children's behavior in the educational environment is the major concern of this section. The positive or negative effects of color on human learning remain unclear. Ewbank's (1978) study of teaching with color points to the importance of colors in designing toys, nursery equipment, and teaching materials. Birren (1978) says that the most important value of the color is its use in a correct way in children's environments. He believes that presence of color contributes to children's mental and physical growth.

An apparent concern of research regarding the degree of relationship between color and interference has converged from several directions. Recently, Lamberski and Myers (1980) conducted a study to assess the efficiency of verbal and visual color or black/white coded materials. It was indicated that color and black/white coded materials produce similar efficiency results. These findings supported the previous results on movitation, increased attention, preference, and processing interference (Young, 1973; Dwyer, 1972; Galbraith, Hohmann, & Creutzfeldt, 1975).

The instructional value of color, obviously, is dependent upon the complexity of the task and the interaction of the learner. For example, the application of color in nonsense word tasks, letters, shapes, and numbers

indicated that color facilitates learning and motivates the subjects (Peterson & Peterson, 1957; Underwood, Ham, & Ekstrand, 1962; Goodman, 1975).

Fantetti and Fingeret's (1975) study of the color and verbal components of compound stimuli as a function of interstimulus conceptual similarity showed that as the number of categories decreases, the effectiveness of color increases. They further cited that recall for component cues was significantly lower in one category and greater in eight categories.

There is some contradictory evidence for the value of color in facilitating or inhibiting a learner's achievement. Studies of color and black/white instructional materials indicated the inferiority of color to black/white instructional materials, in that color might distract the learner's attention from the important learning cues, and might interfere with his/her learning system (Chute, 1979).

In considering color and its possible relationship to interference phenomenon, most of the researchers have used a modified Stroop Test or a similar task. Along with the Stroop Interference Effect, Dulsky (1935) studied the student's recall using retrieval tasks. He noted that when the subjects had received black/white instructional materials during the acquisition of a concept, measuring their

recall with color coded materials might cause interference and conflict with their recall. Therefore, alternating colored and black/white instructional and testing materials, in retrieval tasks, affects a learner's recall. Later on, Saltz in 1963 and Lamberski in 1975 noted this issue in their investigation indicating similar conclusions.

Reviewing the literature in terms of color and interference reveals few findings. Most of the studies have been carried out without awareness of such phenomenon. The value and effect of color on an individual's learning has been studied, but little research has dealt with the interference phenomenon, specially when the phenomenon involves young children. Further investigative research may help to clarify this trend.

Semantic Association and Interference Phenomenon

Olson (1970) defines the theory of semantics in terms of meaning by defining a word by pointing to its referent. He thinks that perceptual knowledge is the basis of semantic meaning, and cognitive differentiation plays an important part in semantic decision.

Klein's (1964) definition of the semantic theory is based upon the relationship or association between the meaning of the words and colors. He shows a positive correlation or relationship between semantic association and

interference phenomenon. Supporting Klein's findings, D'alrymple-Alford (1972) indicated a positive relationship between interference and similarity of meaning among interfering and response words. He found that the semantic similarity of words increased the color word interference score. The longer the response time, the greater the interference score, and the greater the semantic similarity, the greater the interference. In research similar to Klein and D'alrymple-Alford's study, Scheibe, Shaver, and Carrier (1967) studied the association and the frequency of words to colors. They indicated that words frequently used with colors produce more interference and are related positively to the association of words to the colors. In other words, frequency and association of words with colors are highly related and are the cause of the color-word interference phenomenon. It is interesting to note that the result of both studies (Klein, 1964; Scheibe, Shaver, & Carrier, 1967), in the close color-name condition, show over twice the interference of the distant color-name condition.

Recently, Fox, Shor and Steinman (1971) applied different dimensions besides color in order to study semantic association and its relationship to the interference phenomenon. Their tasks consisted of demonstrating spatial direction and numerosity ranging from incongruent names to

nonsense words and figures. Their results were parallel to the findings of Scheibe et al. and Klein. They further indicated that the greater the semantic aspects of the stimuli, the greater the interference phenomenon.

Harrison and Boese (1976) investigated the locus of semantic interference in the Stroop color-naming task. They suggested that the subject's acquisition of verbal and visual information is the result of different but interrelated memory structure.

Ray (1974) studied the degree of interference in a color-naming task. He hypothesized that the degree of interference is a function of the semantic relationship between the irrelevant word and relevant color response. He assumed that manipulating the ease of recognition of the words would alter the time taken to respond to the stimuli. In this study, he used four different experimental conditions varying in the set size of the color and color-words. These set size conditions were C_3, C_5, CW_3, CW_5. The letter C is the indication of color, the letter W is the indication of word, and the numbers are the indication of set size. He found that the smaller the set size, the faster the response time. In other words, a negative correlation was found between a set size and the interference phenomenon. He further showed that the degree

of interference is dependent upon the degree of the relationship between the words and the colors.

Reviewing the studies of semantic association and its relatedness to the interference phenomenon reveals that almost all of the studies reach the same conclusion, implying that interference has a positive relationship with semantic association.

Cognitive Differentiation of a Young Child: Its Relationship to Interference

Recently, emphasis has been placed upon cognitive processes of young children involved in interference tasks. In order to analyze the relationship between the cognitive differentiation and the interference phenomenon, research provides a literature framework, first about the young child's cognitive differentiation, and second, its possible relationship to the interference phenomenon. A survey of the literature reveals a paucity of studies dealing with interference and cognitive differentiation in young children. For the purpose of the present study, the concept of cognitive differentiation and logical principles of conservation and transition will be discussed.

The concepts of conservation and transition are the most important factors within the framework of the concrete operational stage (Piaget, 1970). A definition of this stage is presented in Chapter I in "Definition of Terms."

The period of the concrete operational stage lasts for about five years. The influence of the child's immediate environment and his/her interaction with it is not a forgettable case. During these five years, the emergence of new skills will enable him/her to conceptualize the relationships between objects and events, and to build basic scientific concepts, such as the concept of classification, seriation, reasoning, and so on. A number of researchers have investigated studies measuring the aforementioned concepts (Baylor & Gascom, 1974; Smedslund, 1964; Modgil, 1974; Shapiro & O'Brien, 1970).

Cognitive functioning in the period of concrete operations, the period which is the focus of interest for the present study, involves what Piaget (1926) calls logical operations. The child who is at the level of the concrete operational stage can solve conservation problems with reasoning and logical thoughts. Most important, he/she can decenter and transform his/her perception, and can attend to a different dimension of an object. A young child (before age seven) whose perception is not yet decentered and cannot transform his/her ideas and thoughts, will attend only to a dominant characteristic of an object. Considering these two important characteristics of the concrete operational period and applying them to the present study, the researcher might see if the child is attending

to one characteristic of the stimuli (color cue) or is attending to all characteristics of the stimuli (color, word, association, and symbolic representation). Discussion of this evidence will be presented in Chapter V of this study. For the purpose of relating cognitive differentiation to the interference phenomenon, some studies concerning these two factors will be presented.

If it is logical to assume that the abilities of reading, matching, preferring, and numbering require some level of cognitive functioning during the concrete stage of development, then a relationship between the interference phenomenon and these variables should exist. Some research studies related to these factors will be presented.

Shor (1970) analyzed the processing of spatial information from pictorial and verbal symbols. His subjects included 30 undergraduate students. His experimental tasks consisted of the drawing of arrows pointing up, down, right, and left, printed with corresponding word names. His design was a matched and mismatched design printed within the arrows. The task was first to name the direction of the arrows and second to read the words. He found an interference phenomenon the same as the Stroop Effect, indicating that mismatched conditions produced more interference phenomenon than matched conditions.

An interesting study by Hobbs (1978) indicated a relationship between attentional interference and self-actualization. He believed that attentional interference is the process of cognitive functioning and is related to self-actualization. His experimental tasks included the Stroop Color-Word Test as the measure of attentional interference, and the Personal Orientation Inventory as the measure of self-actualization. The subjects were 100 undergraduate male and female students. It was hypothesized that the self-actualized person will have less interference phenomenon compared to subjects who are less self-actualized. The result shows a significant correlation between color-naming on the Stroop Test and self-actualization on the Personal Orientation Inventory.

Golden's (1975) study of the Stroop Interference Effect and its relation to brain dysfunction is an interesting research study about the relationship between these two phenomena. This study used 141 adults with neuropsychological problems. In order to measure and diagnose the subject's right brain damage, left brain damage, diffuse damage, or no brain damage, the Halstead-Reitan Neuropsychological Battery (HRNB) was administered. In addition to HRNB, the Stroop Color-Word Interference Test was given to each subject in order to analyze the

relationship between these two variables (brain dysfunction and interference variable). A multiple correlation analysis indicated a high positive correlation of .45 ($p < .001$) between the Stroop Test and HRNB. It was further found that word naming correlated with the measure of left brain damage (by correlating the subscale of HRNB on verbal IQ and Aphasia scores), and the performance on color naming, correlated with the measure of both right and left brain damage scores. The author suggested that the Stroop Test is a good instrument to screen the brain damaged from non-brain damaged patients, because of a high correlation between these two scales. He further concluded that color naming is a better predictor than word reading, because it can identify both right and left brain damage.

Smith and Klein (1953) indicated that the individual's response pattern in serial behavior (representative behavior in the Stroop Effect) is controlled by his/her cognitive processes. Supporting their hypotheses, Justus (1979) conducted two different experimental conditions by manipulating three different factors: a) number of alternatives for the word, b) number of alternatives for the color, and c) congruent or incongruent color-words. In the first condition, the high compatible condition, the subject was asked to press the button corresponding to the color and say the word. In the second condition, the low compatible

condition, the subject was asked to press the button corresponding to the word and say the name of the color. One subject was used in each experimental condition.

From the results of this experiment, the author suggested two causes for the difficulty of dual response in the Stroop Task. First, the source of delay might be the subject's decision about naming the color or reading the word. In this process the subject can only make one decision at a time, and that is a single channel response hypothesis. Additionally, it was suggested that when the subject was asked to name the color, the decision about the word was made first, and when the subject was asked to read the words the decision about the color was made first. Thus, the order of the decision was dependent upon how the task was presented, and upon what response was asked from the subjects.

A second cause of delay was that the subject's mental processes parallel or follow the two decisions, and are prolonged when the stimuli conflict. In other words, decision making is a cognitive process related to the subject's performance on the indicated or similar experimental tasks.

Cramer (1967) studied the Stroop Effect in preschool aged children. She provided an experimental task consisting

of forms with nameable colors. Testing the children with experimental and control tasks (words with nameable colors) showed that children had a more difficult time, and had more interference on the control task than on the experimental task. She suggested that naming the color names is perhaps more difficult when they are presented in a written form, than naming the colors when they are presented in form shapes.

Children's responses to color cues have different notions. For example, Lamberski (1980) concluded that young learners generally prefer color cues in passive materials due to motivational rather than identified cognitive functions. T.V., films, slides, and pictures are considered as passive materials. He did not find a significant difference between children's performances on color/black and white coded active materials. Textbooks, posters, and programmed instruction are considered as active materials. Crowder (1976) and Estes (1976) both indicated that responses to color cues change as a person goes through maturation and developmental processes. They believed that development of verbal skills is highly related to an individual's cognitive growth, and that it has a reliance relationship with the development of color concepts.

For studying a comprehensive review of past and present empirical findings along with theoretical studies, the reader is referred to Dyer's (1973) study. In his survey, the use of the Stroop Test in some other areas as a tool for the study of different variables is discussed.

CHAPTER III

METHODOLOGY

The main purpose of the research was to study the interference phenomenon in young children as measured by the Color-Word Associate Test. The relationship between interference phenomenon and children's cognitive differentiation was also explored by using Goldschmid and Bentler (1968) Concept Assessment Kit (CAK) - Conservation Task. This chapter discusses the procedures used to collect the data, and will include the subjects, description of the instruments, collection of the data, design and procedure of the study, and analysis of the data.

Subjects

Second, third, and fourth grade students were used. The number of participants was 72. Because the children were tested with five different colors (red, yellow, blue, green, and brown), students were checked to see if they knew these colors prior to the experimental sessions. Those subjects who had problems with color recognition were excluded from the experiment. One of the subjects who had a color recognition problem was excluded from the experiment. The subjects wishing to participate were

tested to see if they are able to read the 40 words listed in the Experimental Tasks (see Appendix B), excluding Persian words. The children who had problems with this word-reading task were excluded from the experiment. None of the participants had problems with the word-reading task, and therefore all were included in the study. Since reading ability affects children's performance on the interference phenomenon, approximate reading ability of the subjects on the 40 words listed in the Experimental Task controlled reading variability. The main interest was to see how reading ability and cognitive differentiation affected interference tasks. Children who were familiar with the Persian Language were also exluded from the study. Important here was to see how children responded to the color cue without going through the word recognition task.

Written permission for testing was requested from parents of children who were enrolled in the second, third, or fourth grade levels (see Appendix A). The parents returned the signed permission letter to the school or teacher, and the investigator collected the letters prior to the child's participation in the experimental sessions.

Instruments

Two different experimental instruments were used:

First, the Color-Word Associate Test (CWAT) consisting of six different cards labelled A through F with six

different tasks, which had been prepared by the investigator. A description of each of these cards is as follows:

1. Card A consists of 20 familiar words normally associated with colors (red, green, blue, yellow, and brown) printed in different (incongruent) colors. For example, the word grass was printed in red ink. Using this card, each child was asked to name the printed colors and ignore the written words. It was expected that environmental influences upon children's color learning and color concept development would interfere perceptually in the completion of this task. In other words, there would be an interference effect as a result of previously acquired experiences.

2. Card B consists of the same 20 familiar words that a child would likely associate with a particular color due to environmental exposure. These words are printed in the expected colors. For example, the word grass is printed in a green color. It is assumed that children often experience these associations in their culture and environment, and that they associate certain words with certain colors. Using this card, each child was asked to name the printed colors and ignore the written words.

3. Card C consists of 20 familiar words that are unlikely to be associated with particular colors due to

environmental exposures. These words were presented in random selected colors, such as red, blue, green, brown, and yellow. For example, table was printed in red or blue ink. With this card, the child was asked to name the printed colors and ignore the written words (Stroop Interference Effect, 1935). It is obvious that there are some objects that a child sees in a variety of colors and to which he/she is not, therefore, expected to make a definite color association.

4. Card D consists of 20 Persian words printed in red, blue, yellow, green, and brown ink. In this instance, the association of words with colors is minimal, and the concept of the printed words is none. Therefore, a child should have the least difficulty in obtaining the correct response on this task.

5. Card E consists of 20 color patches (different numbers of the letter X) printed with felt-tipped pens in either red, blue, green, yellow, or brown ink. This card is a control card whose purpose is to check the child's ability to name and identify the printed colors.

6. Card F consists of 20 words associated with colors (identical with the words printed on Card A and/or Card B), and 20 words not associated with colors (identical with the words printed on Card C). These 40 words were printed in black ink. The purpose of this card was to check the

child's ability to read the printed words as accurately as possible. All the items on each card were arranged in random order. The words listed on Card A and Card B were identical, but were printed in a different color format.

Second, the Concept Assessment Kit - Conservation Task (CAK) was administered to measure the child's ability to perform conservation tasks. The Concept Assessment Kit - Conservation Task (CAK) was developed by Goldschmid and Bentler in 1968. This test consists of three scales: Form A, Form B, and Form C. Forms A and B are parallel forms, each including six tasks: Two-dimensional space, Number, Substance, Continuous Quantity, Weight, and Discontinuous Quantity. The items in Form C include a measurement of the conservation of Area and Length. On each scale, the level of conservation is measured by both the child's judgment and comprehension, or ability to adequately explain the judgment. For the purpose of the present study, since Forms A and B are parallel, only one, Form A, was administered in conjunction with Form C.

Collection of Data

A total of 72 subjects from second, third, and fourth grade students participated in this study. The investigator acted as the examiner. The examiner explained what was expected of the children prior to the experimental

sessions. Approximate testing time, including the directions, was one-half hour on each experimental task (Color-Word Associate Test and Concept Assessment Kit - Conservation Task). In order to prevent the fatigue effect, interference and conservation tasks were given one hour apart. The time was scored and coded by using a stopwatch for each individual for data processing. At each testing session, a room separate from the regular classroom was used. Prior to the administration of the interference tasks, the child's reading ability on the 40 words, which were used in the task, was determined (see Appendix B).

All of the participants were checked to see if they knew and recognized the colors which were used in the experiment prior to the experimental sessions. One of the subjects who had a color recognition problem was excluded from the experiment.

Design and Procedure

Prior to the administration of the interference tasks, Card F was presented to each subject. The subject was asked to read the printed words as accurately as he/she could. Time was recorded for each subject by using a stopwatch. After the completion of Card F, using the interference tasks, the following general instructions were given to each subject:

> A series of cards will be presented to you. You will be asked to perform a certain task on each card. The following instructions are for Card A, Card B, Card C, and Card D. Your job is to name the color of the ink in which the words appear, as fast as you can. On Card E, your job also is to name the color of the ink in which the color patches appear. Name only the colors. Start at the left and go to the right. When I give you a signal, begin immediately. Name the colors as fast as you can without making a mistake. If you make a mistake, correct it, but do not start over from the beginning of the list. Do you understand?

Following these instructions, the cards were presented in the following order: Card E, Card D, Card C, Card B, and Card A.

On Card E, which consists of 20 color patches, the subject was asked to name the colors as fast as he/she could. On Card D, which consists of 20 Persian words, the subject was asked to name the colors. The same performance was expected on Card C, Card B, and Card A; i.e., naming the color of the ink in which the words appeared. A stopwatch was used to measure the time score on each task.

A specially prepared scoring page enabled the experimenter to follow the subjects word-for-word, and to record the number of errors made by each subject. The measure utilized was the total time taken for responding to the 20 items and the number of errors made by the subjects on each card. The measure of interference was the total time taken by the subjects on each card, with Card E acting as a covariate.

The second experimental task, Concept Assessment Kit - Conservation Task, was given to all subjects who had no problems in the color recognition and the word reading task. The Conservation Task was administered approximately one hour after the first experiment. This test was administered individually, and instructions were given according to the manual. The scoring procedure was followed step-by-step as described in the manual. A standardized scoring sheet was used to obtain the subject's conservation score. The scoring procedure on each of Form A and Form C was as follows: One point was given for the child's conservation judgment, and one point was given for the comprehension or explanation of the judgment, if both were correct. Comprehension was judged correct if one of the three principles were indicated: Invariate Quality, Compensation, or Reversibility.

Analysis of Data

The primary aim of this study was to determine the relationship between the association of the words and the colors. The aim was to determine to what extent the colors affected a subject's correct responses in the experimental tasks. The secondary aim was to relate the subject's performance on the association of the words and colors to a Piagetian Conservation Task. The final aim was to determine to what extent the subject's reading ability of black/white printed words affected his/her performance on interference and convervation tasks. Expectations were as follows:

1. It was expected that reporting the color of the words which are associated with the colors and printed in congruent colors (grass printed in green) would take more time than reporting the color of the words which are not associated with the colors (e.g., table and car).

2. It was expected that reporting the color of the words which are associated with the colors and printed in incongruent colors (grass printed in red) would take more time than reporting the color of the Persian words.

3. It was expected that reporting the color of the words which are not associated with the colors (table and car) would take more time than reporting the color of the Persian words.

4. It was expected that reporting the color of the words which are associated with the colors and printed in incongruent colors (the word grass printed in red or blue ink) would take more time than reporting the color of the words which are printed in congruent colors (the word grass printed in green ink).

5. It was expected that reporting the color of the words which are associated with the colors and printed in congruent colors (grass/green) would take more time than reporting the color of the Persian words.

6. It was expected that reporting the color of the words which are associated with the colors and printed in incongruent colors (the word grass printed in red or blue ink) would take more time than reporting the color of the words which are not associated with the colors (car and table).

7. It was expected that conservation would account for differences in the interference phenomenon for all interference tasks.

8. It was expected that second grade subjects would take more time and show more interference phenomenon compared to the third and fourth grade subjects for all interference tasks.

9. It was expected that reading ability (Card F) would account for differences in the interference phenomenon for all interference tasks.

Data were recorded for each subject on each task separately. A total time score and total number of errors made by each subject on each card were obtained.

To determine whether there were statistically significant differences between a subject's performance on each card, the data were analyzed by using Two Factor Repeated Measure Analysis of Covariance. For this analysis, Card E (the color patches card) was used as a covariate. It was presumed that Card E would yield some measure of the child's overall ability to name colors. Effects of Card E, or variances due to Card E, were removed from the rest of the experimental design to control the individual differences in color naming ability. Card E was not used as a treatment card. Significant effects were further analyzed using Student-Newman-Keuls technique in order to test all possible pairwise differences among the four different levels of treatment variables. A level of significance of .05 was used for all analyses.

To determine whether there was a significant relationship between the subjects' grade level and the interference phenomenon, data were analyzed by using a Two Factor

Analysis of Covariance, using Card E as a covariate. The primary interest was to see the main effects of different grade levels on the interference phenomenon, while controlling for Card E (or the color patches card). In order to test all possible pairwise differences among the three different grade levels, the Student-Newman-Keuls procedure was applied at .05 level of significance.

To determine whether there was a significant relationship between a subject's reading ability (Card F) and interference phenomenon, data were analyzed by using the Two Factor Analysis of Covariance. In this analysis, Card E and Card F were used as the covariates.

The method of scoring on Concept Assessment Kit - Conservation was carried out exactly as described in the Test Manual. On Form A and Form C, one point was given for each child's correct conservation behavior, and one point was given for each correct comprehension statement, as described previously. After obtaining the raw data, the conservation scores were used to determine whether there was a significant relationship between conservation and the interference phenomenon. Two Factor Analysis of Covariance with Repeated Measures was applied by using Card F and a combination of Form (A+C) conservation scores as the covariates. The primary interest was to observe the main

effects (interference and conservation effects) and the interaction of these effects.

In order to represent the experimental effects, and to apply the results to the null hypotheses of the present study, the following factors were determined:

First, there will be no statistically significant difference between the effects of the four levels of factor A (interference factor).

Second, there will be no statistically significant relationship between the interference factor and the conservation factor (factor B).

Third, there will be no statistically significant difference between the effects of the three levels of factor C (grade level factors).

Fourth, there will be no statistically significant relationship between reading ability and grade level factor differences on interference.

Fifth, there will be no statistically significant relationship between the conservation factor and grade level factor differences on interference.

Sixth, there will be no statistically significant relationship between sex differences on interference, reading ability, and conservation factors.

CHAPTER IV

RESULTS OF THE STUDY

The primary purpose of the present study was to identify the relationship between colors and words. Colors which were used in this study were blue, red, green, brown, and yellow. Words were categorized into three areas. The first category was 20 related color-words such as grass, lemon, etc. printed in congruent and incongruent colors. The second category was 20 unrelated color-words such as table, car, etc. The third category consisted of 20 Persian words which were unknown and unfamiliar to the subjects. The words on the second and the third categories were printed in red, green, blue, brown, and yellow colors selected in random order. Twenty color patches varying in length, printed in aforementioned colors, were employed as a control variable. The 40 words of the first and second categories were printed in black ink to measure the subjects' reading ability.

For the purpose of the present study, two different instruments were administered to all of the subjects. The first instrument was the Color-Word Associate Test (CWAT).

This test included six different cards labelled A through F with six different tasks, which was prepared by the investigator. This test was employed to collect data from second, third, and fourth grade students. The purpose of this test was to measure children's performance on interference phenomenon using words and colors.

The second instrument, the Concept Assessment Kit - Conservation Task (CAK) developed by Goldschmid and Bentler (1968) was used to measure subjects' Conservation ability. The data was collected during the Fall of 1980.

Chapter IV is divided into six sections. The first section contains a description of the population used in the study. Section two addresses the analysis of the CAK and CWAT. Section three explores the analysis of the interference phenomenon. Section four describes the relationship between interference and reading ability or conservation and reading ability. The fifth section of this chapter presents data which resulted from the use of multiple correlation. In the last section, the null hypotheses will be discussed. All of the analyses include sex and grade variables. The alpha level that was used to determine significance was .05.

Description of the Population

A total of 72 second, third, and fourth grade students participated in this study. Out of 72 subjects, 26 were in second grade, 25 were in third grade, and 21 were in fourth grade. Of the students surveyed, 35 were boys and 37 were girls. Table 1 shows the frequency of conservation, interference, and reading ability scores which the subjects had obtained in the experiment. The score of interference and reading ability was the total time taken on each card by each subject in seconds. This table also shows the number of subjects in different grade levels with regard to their sex. No attempt was made to control for socioeconomic variables. There was no investigation of parents' educational or occupational backgrounds.

Because the study was concerned with colors, it was necessary to screen the subjects' color recognition ability. One of the subjects who had a color recognition problem was excluded from the experiment.

Since it was assumed that the subject's reading ability would affect his/her interference score, this variable was controlled by giving the subjects a short reading ability test. The words listed in this test were chosen by the investigator, and were identical with the words listed on Card A and/or Card B (color related words

Table 1

Table of Frequencies

Conservation Scores						Interference Scores (in Seconds)												Reading Ability		Sex		Grade in School		
Form A	f	Form C	f	Combination Form (A+C)	f	Card A	f	Card B	f	Card C	f	Card D	f	Card E	f	Total Interference	f	Card F	f	M	F	2nd	3rd	4th
2	2	4	1	6	1	19	1	17	1	18	1	11	1	11	1	110	1	19	1	35	37	26	25	21
3	1	5	1	10	1	20	1	20	3	19	1	12	1	13	4	112	1	20	1					
4	2	6	1	11	2	21	2	21	1	20	2	14	4	14	10	119	1	21	1					
5	1	7	1	12	2	22	4	22	5	21	4	15	7	15	3	120	1	22	3					
6	1	8	8	14	1	23	1	23	1	22	1	16	9	16	10	126	2	23	1					
7	1	10	4	15	3	24	3	24	3	23	5	17	8	17	5	127	2	24	3					
8	4	11	1	18	1	25	4	25	5	24	4	18	4	18	9	131	1	25	5					
10	4	12	55	20	6	26	3	26	9	25	5	19	4	19	3	133	2	26	3					
11	2			22	2	27	2	27	4	26	4	20	9	20	8	135	1	27	2					
12	54			23	1	28	2	28	2	27	2	21	8	21	4	138	1	28	2					
				24	52	29	5	29	2	28	3	22	3	22	5	140	1	29	1					
						30	7	30	5	29	5	23	3	23	3	143	1	30	2					
						31	2	31	5	30	6	24	3	24	1	144	3	31	1					
						32	3	32	1	31	1	25	4	25	1	147	1	32	3					
						33	3	33	4	32	3	26	1	26	1	149	1	33	2					
						34	2	34	2	33	1	29	1	28	2	150	1	34	2					
						35	2	35	3	34	2	40	1	30	1	151	2	35	4					
						36	1	36	3	35	3	48	1	41	1	152	2	36	2					
						37	1	37	4	36	4					153	1	37	2					
						38	2	38	1	37	2					154	2	38	2					
						39	2	39	1	38	1					156	2	39	1					
						40	3	40	1	39	3					157	1	40	1					
						41	2	41	1	40	2					159	2	42	1					
						42	1	42	2	45	1					163	2	45	1					
						43	1	44	1	48	1					168	2	46	2					
						44	5	48	1	50	2					170	1	48	3					
						45	2	49	1	52	1					172	1	54	1					
						46	2			57	1					174	2	55	1					
						48	1			63	1					182	3	57	1					
						52	1									184	1	63	2					
						56	1									185	1	65	1					
																190	1	67	1					
																191	1	68	1					
																193	2	71	1					
																194	1	72	1					
																205	2	76	1					
																209	1	78	1					
																211	1	90	1					
																212	1	112	1					
																214	2	118	1					
																217	1	180	1					
																227	1	190	1					
																233	1	225	1					
																237	1	235	1					
																240	1	240	1					
																253	1							
																262	1							
																285	1							
																328	1							
																336	2							
																363	1							
																418	1							
																441	1							

printed in colors) and Card C (unrelated color-words printed in colors). Appendix B contains the word lists.

In order to see the effect of conservation on the subjects' interference score, the participants were tested with the Goldschmid and Bentler (1968) Conservation Task. The subjects' correct responses on Form A (conservation of eight different tasks such as: two-dimensional space, number, weight, substance, continuous quantity, discontinuous quantity) and Form C (conservation of area and length) of the conservation test were obtained. The summary statistics are displayed in Tables 2, 3, 4, 5, 6, and 7 which include the mean time scores and the standard deviation for different sex and grade levels on different cards (Tables 2 and 3), mean total interference score (in seconds) and standard deviation for different sex and grade levels (Tables 4 and 5), and the subjects' correct responses and standard deviation for different sex and grade levels on Form A and Form C of the Conservation Task (Tables 6 and 7).

Results of Analysis of the CWAT and CAK

The program used for the analysis of the interference related to the conservation score for this study was Two Factor Analysis of Covariance (ANCOVA) of the University of California Statistical Package for the Health Sciences (SPSS), which was performed at the computer center at the

Table 2

Mean Time Scores (in Seconds) and Standard Deviation for Each Sex on Different Cards

Sex	Card	Mean Time	Standard Deviation
Male	A	34.57	8.65
	B	31.23	7.52
	C	34.29	9.52
	D	21.26	6.98
	E	19.94	5.55
	F	60.06	62.77
Female	A	31.46	8.16
	B	28.97	6.06
	C	28.03	7.89
	D	18.00	3.06
	E	17.27	3.45
	F	46.62	30.68

Table 3

Mean Time Scores (in Seconds) and Standard Deviation for Different Grade Levels on Each Card

Grade	Card	Mean Time	Standard Deviation
Second	A	34.35	7.98
	B	31.35	5.95
	C	34.62	9.21
	D	21.65	7.55
	E	20.23	6.38
	F	80.77	60.85
Third	A	31.04	9.47
	B	29.32	7.30
	C	28.36	6.68
	D	18.44	3.44
	E	17.40	3.33
	F	43.68	42.47
Fourth	A	33.57	7.82
	B	29.38	7.42
	C	29.91	10.45
	D	18.38	3.87
	E	17.91	3.21
	F	30.24	10.34

Table 4

Mean Total Interference Scores (in Seconds) and Standard Deviation for Different Sex

Sex	Mean Total Interference Scores	Standard Deviation
Male	207.00	83.10
Female	169.76	42.77

Table 5

Mean Total Interference Scores (in Seconds) and Standard Deviation for Different Grades

Grade	Mean Total Interference Scores	Standard Deviation
Second	229.65	81.29
Third	168.20	52.52
Fourth	159.52	33.35

Table 6

Mean Correct Responses and Standard Deviation for Each Sex on Form A, Form C, and Combination Form (A+C)

Sex	Form	Mean Correct Responses	Standard Deviation
Male	Form A	10.74	2.75
	Form C	11.12	2.08
	Combination Form (A+C)	21.86	4.70
Female	Form A	10.78	2.55
	Form C	11.02	1.74
	Combination Form (A+C)	21.87	3.90

Table 7

Mean Correct Responses and Standard Deviation for Different Grade Levels on Form A, Form C, and Combination Form (A+C)

Grade	Form	Mean Correct Responses	Standard Deviation
Second	Form A	9.58	3.57
	Form C	10.04	2.43
	Combination Form (A+C)	19.69	5.61
Third	Form A	11.32	1.80
	Form C	11.76	0.88
	Combination Form (A+C)	23.08	2.59
Fourth	Form A	11.57	1.36
	Form C	11.52	1.54
	Combination Form (A+C)	23.10	2.86

Texas Woman's University in Denton, Texas during the spring of 1981. Analysis of Covariance was used to determine the relationship between the total interference score, as a dependent variable, and conservation effects in regard to sex and grade variables. In this analysis, Card E and Combination Form (A+C) conservation scores were used as the covariates. The reason for using conservation scores as the covariates was to control statistically for conservation effects by removing dependent variability due to conservation. Conservation variability did not allow blocking on conservation, so direct effects of conservation could be tested.

Using this analysis, the following results were obtained: There were statistically significant differences between sex and grade level factors, indicating that male subjects had higher interference than female subjects. The results show that the subjects who were in the second grade had higher interference than third and fourth grade; and third grade had less interference than second grade, but higher interference than fourth grade students (2>3>4) regardless of sex. The results indicated that there was no interaction between sex by grade variables using Card E and Combination Form (A+C) conservation scores as the covariates, indicating that an increase of one point in the score

on Card E decreased the conservation score by six points. In other words, conservation and interference factors are negatively correlated. Summary statistics are displayed in Table 8.

Data Results from Analysis of the Interference Phenomenon

In order to analyze the total time taken by each subject to respond to each card, Two Factor Analysis of Covariance was used. In this method, Card E was used as a covariate, and the total interference score was used as a dependent variable. The results indicated statistically significant differences among the grade levels, showing that fourth grade students had the least interference effect, third graders had a higher interference effect than fourth graders, and second graders had the most interference effect (2>3>4).

The Student-Newman-Keuls procedure was applied, at .05 level of significance, in order to compare significant differences among the grade levels. The comparison of three grade levels, using this method, indicated that fourth grade students had the least interference with the lowest mean, third grade students were in the middle, and second grade students had the most interference with the highest mean (second grade = 229.65 > third grade = 168.20 > fourth grade = 158.86).

The results indicated no statistically significant differences between male and female subjects. Therefore,

Table 8

Summary Table of Analysis of Covariance Using Card E and Combination Form (A+C) as the Covariates

Source	df	SS	MS	F	Tail Probability	Beta Estimates
Mean	1	33441.71	33441.71	22.78	0.000	
Sex	1	7207.25	7207.25	4.91	0.030	
Grade	2	13798.63	6899.32	4.70	0.013	
Sex by Grade	2	1364.76	682.38	0.46	0.630	
Card E	1	42661.37	42661.37	29.06	0.000	6.27
Combination Form (A+C)	1	31799.05	31799.05	21.66	0.000	-5.91
All Covariates	2	124766.92	62383.46	42.50	0.000	
Error	64	93939.59	1467.81			

Note. Adjusted Cell Means for first Dependent Variable (Total Interference):

Sex	Male	Male	Male	Female	Female	Female
Grade	Second	Third	Fourth	Second	Third	Fourth
Total Interference	218.94	200.98	173.92	193.93	170.56	165.50

it seems that sex differences disappeared when there was no control on conservation. However, using Card E and Combination Form (A+C) conservation scores showed a sex difference, and showed no difference when only Card E was used as a covariate. Summary statistics are displayed in Table 9.

In the second analysis, Two Factor Analysis of Covariance with Repeated Measures was used. In this analysis, scores on Cards A through D were the Dependent Variable. Card E was used as a covariate. This analysis showed no statistically significant differences between sex and grade level, and no interaction between sex by grade. In other words, card effect with Repeated observation factors did not interact with sex by grade variable. The results showed significant differences among the cards due to Card D having less interference effect than the other cards. The statistical results of this analysis are shown in Table 10.

Analysis of Interference, Reading Ability and Conservation

Section four of this chapter indicates the effects of reading ability and conservation on the interference phenomenon. Two different statistical analyses were used for the purpose of analyzing these variables. These analyses were a) A Two Factor Analysis of Covariance and

Table 9

Summary Table of Analysis of Covariance

Using Card E as a Covariate

Source	df	SS	MS	F	Tail Probability	Beta Estimate
Mean	1	3077.39	3077.39	1.59	0.212	
Sex	1	3804.57	3804.57	1.97	0.166	
Grade	2	31317.67	15658.83	8.09	0.001	
Sex by Grade	2	650.88	325.44	0.17	0.846	
Card E	1	92967.87	92967.87	48.06	0.000	8.456
Error	65	125738.64	1934.44			

Note. Adjusted Cell Means for first Dependent Variable (Total Interference):

Sex	Male	Male	Male	Female	Female	Female
Grade	Second	Third	Fourth	Second	Third	Fourth
Total Interference	226.86	187.92	167.51	204.35	171.53	160.43

Table 10

Summary Table of Analysis of Covariance with Repeated Measure Using Card E as a Covariate

Source	df	SS	MS	F	Tail Probability	Beta Estimate
Mean	1	4978.49	4978.49	39.82	0.000	
Sex	1	318.12	318.12	2.54	0.112	
Grade	2	180.18	90.09	0.72	0.470	
Sex by Grade	2	89.60	44.80	0.36	0.700	
Card E	1	1443.34	1443.34	11.54	0.001	0.53
First Error	65	8126.67	125.03			
Card	3	7746.07	2582.02	110.98	0.000	
Card by Sex	3	176.39	58.80	2.53	0.059	
Card by Grade	6	182.57	30.43	1.31	0.255	
Card by Sex by Grade	6	157.70	26.28	1.13	0.346	
Second Error	198	4606.81	23.27			

Note. Adjusted Cell Means for first Dependent Variable (Card A, Card B, Card C, and Card D):

Sex / Grade	Male Second	Male Third	Male Fourth	Female Second	Female Third	Female Fourth
Card A Interference	33.80	34.32	33.52	33.15	29.89	34.46
Card B Interference	30.64	31.62	29.43	30.30	28.82	30.13
Card C Interference	34.57	32.72	33.18	32.92	26.49	26.35
Card D Interference	22.41	20.12	18.85	19.15	18.35	18.58

b) A Two Factor Analysis of Covariance with Repeated Measures. Three separate Analyses of Covariance were used on part (a) and three separate Analyses of Covariance with Repeated Measures were used on part (b).

On part (a), the first analysis was a Two Factor Analysis of Covariance using Card F as a first covariate, Form A conservation score as the second covariate, and Form C conservation score as the third covariate. The total interference score was used as a dependent variable. The result of this analysis indicated a statistically significant difference between sex, regardless of grade, showing that male subjects had higher interference effect than female subjects. There were no grade differences and there was no interaction between grade and sex variables. As far as the covariates are concerned, Card F is a significant covariate, which means that it is significantly correlated with the total interference score. The second covariate, Form A conservation score, is not a significant covariate by itself. The third covariate, Form C conservation score, is a significant covariate by itself. Altogether, three covariates are significant. This means that when we take into account Form A, Form C, and Card F covariates, there is a sex difference.

As far as the weight of the covariates is concerned, the weight of the Card F covariate is positive, which means

that the higher the Card F score (reading ability), the higher the interference. The weight of the Form A conservation score is negative, which means that the more conservation, the less interference. The third covariate, Form C conservation score, is significant by itself, and has negative weight. The negative weight indicates that the more conservation, the less interference. Statistical analyses are shown in Table 11.

On part (a), the second analysis was Two Factor Analysis of Covariance, using Card F as the first covariate and Combination Form (A+C) conservation score as the second covariate. The total interference score was used as the dependent variable. The result of this analysis showed a statistically significant difference between sexes indicating that male subjects had higher interference scores than did female subjects. There were no significant differences among the grade levels, and no interaction between grade and sex variables. Both covariates were significant predictors, and were highly related to the interference phenomenon. As far as the weight of the covariates are concerned, the weight of the Card F covariate is positive. This positive weight indicates that the higher the Card F score, the higher the interference. The weight of the Combination Form (A+C) conservation score was negative,

Table 11

Summary Table of Analysis of Covariance Using Card F, Form A, and Form C as the Covariates

Source	df	SS	MS	F	Tail Probability	Beta Estimates
Mean	1	115187.28	115187.28	112.02	0.000	
Sex	1	12118.82	12118.82	11.79	0.001	
Grade	2	983.62	491.81	0.48	0.622	
Sex by Grade	2	2672.45	1336.23	1.30	0.280	
Card F	1	71115.81	71113.81	69.16	0.000	0.811
Form A	1	817.88	817.88	0.80	0.376	-2.341
Form C	1	8970.65	8970.65	8.72	0.004	-10.311
All Covariates	3	153926.56	51308.85	49.90	0.000	
Error	63	64779.95	1028.25			

Note. Adjusted Cell Means for first Dependent Variable (Total Interference):

Sex	Male	Male	Male	Female	Female	Female
Grade	Second	Third	Fourth	Second	Third	Fourth
Total Interference	212.375	205.027	187.680	175.338	170.484	179.089

indicating that subjects with low conservation scores showed higher interference, and that those with high conservation scores showed low interference. There is a tendency that when the interference score goes up by one point, the conservation score is decreased by six points. The result of this analysis is shown in Table 12.

On part (a), the third analysis was Two Factor Analysis of Covariance using Card F as the first covariate and Card E as the second covariate. The total interference score was used as the dependent variable. The result of this analysis indicated no statistically significant differences between sex or grade variable, and no interaction between these two. However, both covariates were statistically significant. Summary statistics are displayed in Table 13.

On part (b), the first analysis was Two Factor Analysis of Covariance with Repeated Measures. In this analysis, Cards A, B, C, and D were used as dependent variables. Card F and Combination Form (A+C) conservation score were used as the first and second covariates, respectively. The result of this analysis showed statistically significant sex differences indicating that males have a higher interference score than females. There was no grade effect and no interaction of sex by grade. The results showed a significant card effect indicating that Card D has the least interference score of all other cards. Card effect did not

Table 12

Summary Table of Analysis of Covariance Using Card F and Combination Form (A+C) as the Covariates

Source	df	SS	MS	F	Tail Probability	Beta Estimates
Mean	1	120215.42	120215.42	115.79	0.000	
Sex	1	11590.99	11590.99	11.16	0.001	
Grade	2	1613.49	806.74	0.78	0.464	
Sex by Grade	2	2915.12	1457.56	1.40	0.253	
Card F	1	70155.78	70155.78	67.57	0.000	0.776
Combination Form (A+C)	1	31411.70	31411.70	30.26	0.000	-5.721
All Covariates	2	152261.32	76130.66	73.33	0.000	
Error	64	66445.19	1038.21			

Note. Adjusted Cell Means for first Dependent Variable (Total Interference):

Sex	Male	Male	Male	Female	Female	Female
Grade	Second	Third	Fourth	Second	Third	Fourth
Total Interference	213.416	204.148	186.743	178.242	168.101	179.615

Table 13

Summary Table of Analysis of Covariance Using Card E and Card F as the Covariates

Source	df	SS	MS	F	Tail Probability	Beta Estimates
Mean	1	9923.99	9923.99	9.02	0.004	
Sex	1	2819.28	2819.28	2.56	0.114	
Grade	2	5453.52	2726.76	2.48	0.092	
Grade by Sex	2	629.39	314.70	0.29	0.752	
Card F	1	55757.82	55757.82	50.69	0.000	0.727
Card E	1	27158.18	27158.18	24.69	0.000	5.124
All Covariates	2	148462.80	74231.40	67.48	0.000	
Error	64	70402.37	1100.04			

Note. Adjusted Cell Means for first Dependent Variable (Total Interference):

Sex	Male	Male	Male	Female	Female	Female
Grade	Second	Third	Fourth	Second	Third	Fourth
Total Interference	211.29	189.38	181.86	190.82	175.55	176.57

interact with sex by grade, so there were two main effects that were significant; the card by itself and sex by itself.

As far as the covariates are concerned, Card F and Combination Form (A+C) conservation scores are so highly correlated that the Combination Form (A+C) conservation score, the second covariate, was eliminated from the analysis, and only Card F was used. Card F, though, was a significant covariate for the card effect so that when Cards A, B, C, and D were adjusted by Card F, differences between the cards remained. This means that Card D is lower than Cards A, B, and C in interference score. Statistical analysis for this procedure is shown in Table 14.

To determine pairwise comparison among the cards, the Student-Newman-Keuls procedure was applied at .05 level of significance. The results of this technique showed that Card D has the lowest mean among all other cards (Card D = 19.58 < Card B = 29.88 $\cong$ Card C = 31.07 < Card A = 32.97).

On part (b), the second analysis was Two Factor Analysis of Covariance with Repeated Measures using Card F as the first covariate, Form A conservation score as the second covariate, and Form C conservation score as the third covariate. The dependent variable was the total score of each of A, B, C, and D cards. The results showed significant sex differences, indicating that male subjects had

Table 14

Summary Table of Analysis of Covariance With Repeated Measure Using Card F and Combination Form (A+C) as the Covariates

Source	df	SS	MS	F	Tail Probability	Beta Estimates
Mean	1	56051.29	56051.29	371.57	0.000	
Sex	1	904.38	904.38	6.00	0.017	
Grade	2	540.60	270.30	1.79	0.175	
Sex by Grade	2	171.06	85.53	0.57	0.570	
Card F	1	1.13	1.13	0.01	0.931	-0.003
Combination Form (A+C)	0	0.00	0.00	0.00	1.000	0.000
First Error	65	9805.32	150.85			
Card	3	7952.36	2650.79	118.42	0.000	
Card by Sex	3	113.52	37.84	1.69	0.170	
Card by Grade	6	100.70	16.78	0.75	0.610	
Card by Sex by Grade	6	175.60	29.26	1.31	0.256	
Card F	1	411.71	411.71	18.39	0.000	-0.054
Combination Form (A+C)	0	0.00	0.00	0.00	1.000	0.000
Second Error	197	4409.76	22.39			

Note. Adjusted Cell Means for first Dependent Variable (Card A, Card B, Card C, and Card D):

Sex Grade	Male Second	Male Third	Male Fourth	Female Second	Female Third	Female Fourth
Card A Interference	38.48	35.52	32.71	34.36	28.55	33.91
Card B Interference	35.33	32.82	28.62	31.52	27.48	28.02
Card C Interference	35.73	32.44	32.07	31.79	24.49	25.41
Card D Interference	23.58	19.84	17.73	18.02	16.35	17.63

higher interference scores than females. There were neither grade differences nor grade by sex interactions. The result showed significant card differences, with Card D the lowest, and Card F being a significant covariate or predictor. Second, Form A, and third, Form C, covariates were highly correlated so they were eliminated. The result of this analysis is shown in Table 15.

On part (b), the third analysis was Two Factor Analysis of Covariance with Repeated Measures using Card F as the first covariate and Card E as the second covariate. The dependent variable was the total score of each of A, B, C, and D Cards. The result of this analysis showed a significant sex and card difference. In this analysis, males had a higher score than female subjects, and Card D was lower than the other cards. Card F covariate did not significantly affect the sex effect, but it did significantly affect the card effect. Card E covariate was not significant. When Card F was considered as a covariate, sex by card interaction was not significant. But, overall, in terms of interference, male subjects showed a higher interference effect than female subjects, regardless of which card was being used. See Table 16 for further analysis.

Table 15

Summary Table of Analysis of Covariance with Repeated Measure Using Card F, Form A, and Form C as the Covariates

Source	df	SS	MS	F	Tail Probability	Beta Estimates
Mean	1	71190.94	71190.94	471.89	0.00	
Sex	1	890.33	890.33	5.90	0.02	
Grade	2	507.08	253.54	1.68	0.19	
Sex by Grade	2	167.19	83.60	0.55	0.58	
Card F	1	0.26	0.26	0.00	0.97	0.001
Form A	0	0.00	0.00	0.00	1.00	0.000
Form C	0	0.00	0.00	0.00	1.00	0.000
First Error	65	9806.19	150.86			
Card	3	7492.78	2497.59	110.62	0.00	
Card by Sex	3	112.98	37.66	1.67	0.18	
Card by Grade	6	97.13	16.19	0.72	0.64	
Card by Sex by Grade	6	176.77	29.46	1.30	0.26	
Card F	1	256.01	256.01	11.39	0.001	-0.053
Form A	1	0.32	0.32	0.01	0.91	-0.002
Form C	0	0.00	0.00	0.00	1.00	0.000
All Covariates	2	396.26	198.13	8.78	0.00	
Second Error	196	4425.22	22.58			

Note. Adjusted Cell Means for first Dependent Variable (Card A, Card B, Card C, and Card D):

Sex Grade	Male Second	Male Third	Male Fourth	Female Second	Female Third	Female Fourth
Card A Interference	38.82	35.83	33.01	34.69	28.85	34.21
Card B Interference	35.38	32.93	28.86	31.64	27.70	28.25
Card C Interference	35.54	32.15	31.79	31.58	24.21	25.15
Card D Interference	23.42	19.56	17.46	17.82	16.11	17.36

Table 16

Summary Table of Analysis of Covariance with Repeated Measure Using Card F and Card E as the Covariates

Source	df	SS	MS	F	Tail Probability	Beta Estimates
Mean	1	64081.22	64081.22	426.07	0.00	
Sex	1	835.40	835.40	5.55	0.02	
Grade	2	412.32	206.16	1.37	0.26	
Sex by Grade	2	153.99	77.00	0.51	0.60	
Card F	1	30.42	30.42	0.20	0.65	0.02
Card E	0	0.00	0.00	0.00	1.00	0.00
First Error	65	9776.03	150.40			
Card	3	7782.05	2594.02	115.34	0.00	
Card by Sex	3	117.92	39.31	1.75	0.16	
Card by Grade	6	100.71	16.79	0.75	0.61	
Card by Sex by Grade	6	172.11	28.69	1.28	0.27	
Card F	1	390.82	390.82	17.38	0.00	-0.06
Card E	0	0.00	0.00	0.00	1.00	0.00
Second Error	197	4430.66	22.49			

Note. Adjusted Cell Means for first Dependent Variable (Card A, Card B, Card C, and Card D):

Sex Grade	Male Second	Male Third	Male Fourth	Female Second	Female Third	Female Fourth
Card A Interference	38.44	35.55	32.80	34.37	28.63	34.00
Card B Interference	35.28	32.85	28.72	31.53	27.56	28.11
Card C Interference	36.00	32.34	31.92	31.80	24.30	25.30
Card D Interference	28.85	19.74	17.59	18.03	16.16	17.52

Data Results from Multiple Correlation Coefficients

In order to correlate different variables used in this study, a Pearson Correlation Coefficient, which might be called a Square Symmetric Correlation Matrix, was applied. A total of 19 variables with 361 correlations were analyzed. Twelve of these variables were the focus of interest for the present study. Considering four different factors (sex, grade, conservation, and interference), the results of the correlation indicated that total interference had a negative correlation with sex (-0.277). Total conservation had a positive correlation with sex (0.001). Total interference had a negative correlation with grade (-0.432), indicating that the lower grade students had more interference effect than upper grade students. Total interference had a negative correlation with conservation (-0.646), indicating that the subjects who scored high on interference tasks showed less conservation ability. Conservation had a positive correlation with grade (0.334), showing that the fourth grade students had a higher conservation ability than third and second grade students. Table 17 gives a comprehensive review of these and other correlations among different variables.

For the significant results, Factor Analysis was not recommended. The reason was that so many important

Table 17

Intercorrelation of CWAT with CAK Regarding Sex and Grade Variables

	Sex	Grade	Form A	Form C	Combination Form (A+C)	Card A	Card B	Card C	Card D	Card E	Reading Ability	Total Interference
Sex	1.0000 (0) S= .001											
Grade	-0.0494 (72) S= .340	1.0000 (0) S= .001										
Form A	0.0078 (72) S= .474	0.3160 (72) S= .003	1.0000 (0) S= .001									
Form C	-0.0231 (72) S= .424	0.3322 (72) S= .002	0.7949 (72) S= .001	1.0000 (0) S= .001								
Combination Form (A+C)	0.0009 (72) S= .497	0.3341 (72) S= .002	0.9606 (72) S= .001	0.9289 (72) S= .001	1.0000 (0) S= .001							
Card A	-0.1845 (72) S= .060	-0.0474 (72) S= .346	-0.1605 (72) S= .089	-0.2381 (72) S= .022	-0.2098 (72) S= .038	1.0000 (0) S= .001						
Card B	-0.1657 (72) S= .082	-0.1209 (72) S= .156	-0.0952 (72) S= .213	-0.2199 (72) S= .032	-0.1591 (72) S= .091	0.7378 (72) S= .001	1.0000 (0) S= .001					
Card C	-0.3452 (72) S= .001	-0.2221 (72) S= .030	-0.2934 (72) S= .006	-0.4354 (72) S= .001	-0.3759 (72) S= .001	0.6277 (72) S= .001	0.7136 (72) S= .001	1.0000 (0) S= .001				
Card D	-0.2956 (72) S= .006	-0.2478 (72) S= .018	-0.5129 (72) S= .001	-0.5703 (72) S= .001	-0.5715 (72) S= .001	0.4583 (72) S= .001	0.4897 (72) S= .001	0.5811 (72) S= .001	1.0000 (0) S= .001			
Card E	-0.2829 (72) S= .008	-0.2088 (72) S= .039	-0.4013 (72) S= .001	-0.4531 (72) S= .001	-0.4445 (72) S= .001	0.2899 (72) S= .007	0.3360 (72) S= .002	0.3804 (72) S= .001	0.7440 (72) S= .001	1.0000 (0) S= .001		
Reading Ability	-0.1378 (72) S= .124	-0.4245 (72) S= .001	-0.4853 (72) S= .001	-0.3443 (72) S= .002	-0.4462 (72) S= .001	-0.0409 (72) S= .367	-0.0188 (72) S= .438	0.2753 (72) S= .010	0.4092 (72) S= .001	0.5276 (72) S= .001	1.0000 (0) S= .001	
Total Interference	-0.2768 (72) S= .009	-0.4315 (72) S= .001	-0.6314 (72) S= .001	-0.5864 (72) S= .001	-0.6464 (72) S= .001	0.3590 (72) S= .001	0.3854 (72) S= .001	0.7669 (72) S= .001	0.7669 (72) S= .001	0.7136 (72) S= .001	0.8001 (72) S= .001	1.0000 (0) S= .001

variables could be reduced, and some important factors could be eliminated.

Concluding Statements of the Null Hypotheses

In order to retain or to reject the null hypotheses for the present study, several statements concerning each null hypothesis may be made. First, Two Factor Analysis of Covariance with Repeated Measures testing the first null hypothesis showed a significant difference among the cards, due to Card D being lower than the other cards. The Student-Newman-Keuls technique further analyzed the card effect, revealing that Card B was lower than Card A, or Card A was higher than Card B (Card A = 32.97 > Card B = 29.89). This result indicated that subjects had lower interference when they were presented with familiar words associated with colors printed in a congruent color (Card B) and had higher interference when presented with familiar words associated with colors printed in different colors (Card A). Therefore, the first null hypothesis, which stated, "There will be no statistically significant difference between the measures of interference in children when presented with familiar words associated with colors printed in congruent colors, and when presented with familiar words associated with colors printed in incongruent

colors" was rejected, since there was a significant difference resulting between Card A and Card B.

Two Factor Analysis of Covariance with Repeated Measures testing the second null hypothesis indicated a significant difference among the cards due to Card D being lower than the other cards. For further analysis, the Student-Newman-Keuls technique was applied. This technique did not show a significant difference between Card B and Card C. This result indicated that the subjects showed statistically an almost equal amount of interference on Card B (congruent color-words) and Card C; unrelated color-words (Card B = 29.88 $\cong$ Card C = 31.07). This result indicated that subjects had the same amount of interference when they were presented familiar words associated with colors printed in a congruent color (Card B) and when presented with familiar words not associated with colors printed in colors (Card C). Therefore, the second null hypothesis, which stated, "There will be no statistically significant difference between the measures of interference in children when presented with familiar words associated with colors printed in congruent colors, and when presented with familiar words not associated with colors printed in colors" was retained, since there was no significant difference resulting between Card B and Card C.

Two Factor Analysis of Covariance with Repeated Measures testing the third null hypothesis indicated a significant difference among the cards due to Card D being the lowest. In order to compare the significant difference among the cards, further analysis of Student-Newman-Keuls was applied. The result of this technique indicated that subjects shown familiar words associated with colors printed in congruent colors (Card B) had higher interference scores than when presented with Persian words printed in colors (Card D). In other words, subjects scored higher on Card B than on Card D (Card B = 29.88 > Card D = 19.58). Therefore, the third null hypothesis, which stated, "There will be no statistically significant difference between the measures of interference in children when presented with familiar words associated with colors printed in congruent colors, and when presented with Persian words printed in colors" was rejected, since there was a statistically significant difference resulting between Card B and Card D.

Two Factor Analysis of Covariance with Repeated Measures testing the fourth null hypothesis indicated a significant difference among the cards, due to Card D being lower than the other cards. The Student-Newman-Keuls procedure was applied to check this significance. Using

this procedure, the result showed that the subjects' performance on Card A did significantly differ in performance on Card C (Card A = 32.97> Card C = 31.07). Therefore, the fourth null hypothesis, which stated, "There will be no statistically significant difference between the measures of interference in children when presented with familiar words associated with colors printed in different colors, and when presented with familiar words not associated with color printed in colors" was rejected.

Two Factor Analysis of Covariance with Repeated Measures testing the fifth null hypothesis indicated a significant difference among the cards due to Card D having the least interference effect. In order to check this significant difference among the cards, the Student-Newman-Keuls technique was applied. Using this procedure, the results showed a significant difference between Card A and Card D, indicating that subjects scored significantly higher on Card A than on Card D (Card A = 32.97 > Card D = 19.58). Therefore, the fifth null hypothesis, which stated, "There will be no statistically significant difference between the measures of interference in children when presented with familiar words associated with colors printed in incongruent colors, and when presented with Persian words printed in colors" was rejected, since there was a

statistically significant difference between Card A and Card D.

Two Factor Analysis of Covariance with Repeated Measures testing the sixth null hypothesis indicated a significant difference among the cards due to Card D being lower than the other cards. The Student-Newman-Keuls procedure was applied to check this significant difference. The result of this technique showed a significant difference, indicating a higher score on Card C compared to Card D (Card C = 31.07 > Card D = 19.58) at the .05 level of significance. Therefore, the sixth null hypothesis, which stated, "There will be no statistically significant difference between the measures of interference in young children when presented with familiar words not associated with color printed in colors, and when presented with Persian words printed in colors" was rejected, since there was a significant difference between the subjects' performance on Card C (familiar words not associated with color printed in colors), and Card D (Persian words printed in colors).

Two Factor Analysis of Covariance with Repeated Measures testing the seventh null hypothesis showed a significant difference among the cards, due to Card D being lower than the other cards. The Card F and Combination

Form (A+C) covariates indicated the high correlation between these two covariates, so that the Combination Form (A+C) covariate was eliminated. Since these two covariates were highly related, and Card F was a significant covariate for card effect, therefore, the Combination Form (A+C) covariate would also be a significant covariate. Consequently, the seventh null hypothesis, which stated, "There will be no statistically significant relationship between the raw scores derived from the conservation test Concept Assessment Kit, and the time score measures of the interference in young children on Card A; related color words printed in incongruent colors, Card B; related color words printed in congruent colors, Card C; unrelated color words printed in colors, and Card D; Persian words printed in colors, when reading ability card or Card F; 40 words listed on Card A and/or Card B and Card C printed in black ink was used as a covariate" was rejected due to a significant relationship between the conservation and the measure of interference in young children.

Two Factor Analysis of Covariance testing the eighth null hypothesis indicated a significant grade level factor. The Student-Newman-Keuls procedure was applied to check this significant difference. The result of this technique showed a significant difference indicating that the second

grade students showed higher interference compared to third grade and fourth grade students (2>3>4). Consequently, the eighth null hypothesis, which stated, "There will be no statistically significant difference between the second, third, and fourth grade levels, and the time measures of the interference in young children" was rejected.

Two Factor Analysis of Covariance testing the ninth null hypothesis showed that the subject's reading ability is a significant predictor of his/her performance on interference phenomenon. Therefore, the ninth null hypothesis, which stated, "There will be no statistically significant relationship between the reading performance on black and white printed words and the time measures of the interference in young children" was rejected.

Summary conclusions of each of the null hypothesis, considering the comparison of the experimental tasks on interference (Cards A through D), conservation tasks, grade level, and reading ability are shown on Table 18.

Table 18

Summary Conclusions of Each Null Hypothesis

Comparative Variables	Null Hypotheses								
	1	2	3	4	5	6	7	8	9
Card A with Card B	*								
Card B with Card C		**							
Card B with Card D			*						
Card A with Card C				*					
Card A with Card D					*				
Card C with Card D						*			
Conservation							*		
Grade								*	
Reading Ability									*

Note. Minimum level of significance was .05.

*Null hypothesis was rejected.

**Null hypothesis was accepted.

CHAPTER V

SUMMARY, CONCLUSIONS OF FINDINGS, AND SUGGESTIONS FOR FUTURE STUDY

Summary

Reviewing the literature survey on the subject of the interference phenomenon indicates that the interference phenomenon appears when two conflicting and/or incompatible functions both appear at the same time. Possible causes of this phenomenon have been reviewed, but still some questions remain unanswered.

The present study was designed to determine: a) the measure of interference phenomenon, in young children, using words and colors, b) the relationship between childrens' growth of conservation and the interference phenomenon, c) the effect of children's reading ability on the interference phenomenon, and d) the relationship between the interference phenomenon and grade level factors.

The Color-Word Associate Test (CWAT) was administered to all subjects in the study. The CWAT measures interference phenomenon using words and colors. This test included six different tasks, and was developed by the

investigator. The Concept Assessment Kit (CAK) - Conservation Task was administered to all subjects in the study. The CAK measures children's conservation ability, and was developed by Goldschmid and Bentler (1968). Prior to the administration of the interference task, the children's reading ability was measured by using the 40 words listed in the experimental tasks (see Appendix B), excluding Persian words. The children's color recognition was also checked prior to the experimental sessions.

Written permission for testing was requested from parents of children who were enrolled in the second, third, and fourth grade level (see Appendix A). Prior to the child's participation in the experimental sessions, letters of permission to participate signed by parents were collected, and each child was asked if he/she wished to participate in the study. Seventy-two second, third, and fourth grade students were tested. Data were gathered during the fall of 1980. No regard was given to socio-economic level or parental education.

The data were analyzed using Two Factor Analysis of Covariance, and Two Factor Analysis of Covariance with Repeated Measures. Significant results were further analyzed by using the Student-Newman-Keuls procedure. The level of significance which was used in the study was .05.

Discussion of the Results

Significant findings resulting from the present study relating to the experimental hypotheses would warrant discussion about the importance of the child's concept of color and its important relationship to his/her conservation and reading ability with regard to his grade level factor.

The data were analyzed by two different statistical procedures. The first procedure was the Analysis of Covariance with Repeated Measures, testing the interference phenomenon by computing the total time taken by each individual on each interference card (Cards A through D). In this procedure, the child's overall ability to name the colors was measured by the color patches card (Card E). This card was used as a covariate in order to control the individual differences in color-naming ability.

The second procedure was the Analysis of Covariance using the total interference score as the dependent variable. The covariates were varied within the purpose of the related hypothesis.

The purpose of hypotheses one through six was to measure the interference phenomenon in young children by presenting words and colors. Analyzing data by comparing the total time taken on each card indicated that children

exhibited more interference when they were presented familiar words instead of unfamiliar words. The Student-Newman-Keuls procedure further analyzed the card effect by indicating the least interference effect on unfamiliar words (Persian words). Therefore, comparing the subject's performance on familiar and unfamiliar color-word tasks supported the view that being familiar with the words in identifying the colors will lead the subject to show more interference phenomenon.

It seems likely that being familiar with the words when identifying the colors tends to interfere with the subject's perception, and therefore causes delay in the color-naming task. This notion parallels the perceptual conflict hypothesis developed by Hock and Eget (1970) which was followed by Dyer (1974). They hypothesized that subjects are distracted by the presence of the words and are not able to name the color dimensions due to efforts to read the words.

The reason for using the Persian words listed on Card D was an effort by the researcher to discover the source of the interference phenomenon. All of the children who participated in the experiment showed significantly less interference when this card was compared to the other cards. It is likely that the subjects' attention

was not divided between the written words as the indication of stimuli and naming the colors as the indication of response. In other words, Persian words were highly unfamiliar to the subjects, and were highly not associated with the colors, therefore subjects showed less confusion and did not go through the two-step procedures of naming colors and reading the words. The channel of association between the written words (Persian words) and naming the colors was minimal, therefore, the subjects did not associate the words with the colors, and had an easier time recalling the color-names. This result seems to indicate that the dual coding system did not appear, and the subjects had only one choice. That choice was to name the colors. An attempt to read the words did not interfere in naming the colors, and therefore the subjects took less time to respond to the colors. Moreover, each word or a part of a word (letter) of familiar words can also provide related information and serve as an important cue in the processing of information. These cues could result in eliciting processing interference, and therefore cause subjects to take more time. Persian words, in contrast, carry less information, and thus take less time to process.

In general, findings of the present study related to the notion that being familiar and/or unfamiliar with the

words support the expectation that being familiar with the words will cause more interference than being unfamiliar with the words.

In order to define the interference effect further, familiar words were categorized into two different areas. The first category was the words which were familiar to the subject and related to color-words such as grass, which is related to green color. This category was printed in congruent and incongruent colors. The second category was the words which were familiar to the subject, but unrelated to a color-word such as car, which is unrelated to green color.

Findings of the present study and a review of the literature reveal that relatedness of words to colors is the other possible cause of the interference phenomenon on color-word interference tasks. Presenting a subject with related color-words printed in incongruent colors, which is a highly incompatible situation, causes conflicting behavior. The primary explanation is that perceptual confusion is caused by a conflict situation which a person must deal with, and must decide to which dimension to respond. Therefore, a person falls into a confused state, and spends more time in decision-making processes than in responding.

Comparing the subjects' performance on Card B (congruent color-words) with Card A (incongruent color-words) revealed a significant result. Subjects showed more interference on Card A when compared to Card B. A possible explanation is that the subjects matched the colors with corresponding words on Card B, and decreased the tension of the conflict situation, and therefore took less time to respond to the color.

Significant results of the subjects' performance on Card C (not associated or unrelated color-words), indicates that semantic association of words and colors plays an important part in the subjects' performance on a color-word interference task. This result supports Stroop (1938), Klein (1964), and Dyer's (1973) findings concerning the power of the semantic association theory. The subjects' performance on Card C indicates that the subject was less confused due to less semantic association or relatedness with color and words on Card C compared to Cards A and B. The significant result seemed to be that the higher the association between words and colors, the higher the interference phenomenon. In general, findings of the present study supported the expectation that related color-words will cause more interference than unrelated color-words.

Findings resulting from the Analysis of Covariance with Repeated Measures, testing the seventh null hypothesis, showed a significant relationship between the interference and the conservation factors.

The significant relationship between conservation and interference appears to indicate that the conservation ability of the subjects plays an important part in their performance on a color-word interference task. A multiple correlation coefficient analyzing this relationship also showed a significant negative relationship between conservation and the interference factor.

Piaget's (1970) theory of the concrete-operational stage supports an idea about what might be the cause of negative correlation between interference and the conservation factor. Piaget believed that children at the age of 7-11 would provide increased emphasis on logical reasoning and differentiation, and also would establish correspondence or identity among elements in different ways. Most important, children at this stage of cognitive development can establish transformation, classification, and correspondence. Analyzing the subjects' scores on the Persian word card relating to the principle of differentiation gives evidence that the subjects could differentiate colors from the words, with no perceptual conflicts, and

therefore could score lower and show less interference. Since all of the students included in the present study scored lower on the Persian card, it might be concluded that differentiational processes of 7-11 year old children were the primary indicators of their performance on interference tasks.

The result of the present study relating to hypothesis seven supported the expectation that conservation would account for differences in the interference phenomenon for all interference tasks.

Two Factor Analysis of Covariance testing the eighth null hypothesis showed significant differences among grade levels. The Student-Newman-Keuls, comparing this significance among the grade levels, indicated that the second grade students exhibited higher interference than the third and the fourth grade students, but the third and fourth grade students did not differ significantly.

A significant result seems to indicate that the subject's response to the experimental tasks in terms of a different grade level is a function of the subject's developmental growth of cognition and his/her differentiation. Another possible explanation for this significant difference could likely be due to the fact that the second grade students, tested in the present study, did not perform proficiently because they were younger than the third

and fourth grade students. The result of the present study testing the eighth null hypothesis supported Schiller (1966) and Comalli, Wapner, and Werner's (1962) developmental study of the interference phenomenon in subjects from different age groups.

The results of the present study relating to hypothesis eight supported the expectation that the second grade subjects would take more time and show more interference when compared to the third and the fourth grade subjects for all interference tasks.

Two Factor Analysis of Covariance testing the ninth null hypothesis showed a significant relationship between the reading performance on black and white printed words and the time measures of the interference in young children. This result appears to indicate that the subjects' reading ability did account for performance on all interference tasks. Estes (1976) and Crowder (1976) showed that the subjects' color concept is highly related to the development of verbal skills. Testing the children's reading ability, the present study showed that the reading skill of the subjects had a positive relationship with their performance on the total interference task. This indicated that the subjects who scored high on Card F had higher interference than the subjects who scored low on the

reading ability card. A possible explanation for this occurrence is that the subjects who are good readers attempt to read the words rather than name the colors. For example, on Card D (Persian words), reducing word legibility reduced the reading response, and therefore weakened the color-naming interference.

The results of the present study relating to hypothesis nine supported the number nine expectation of this study, that is, it was expected that reading ability (Card F) would account for differences in interference phenomenon for all interference tasks. It was concluded that the subject's reading ability is a good predictor of his/her performance on interference tasks. This conclusion seems to support the theory of the dual coding system of color-word interference tasks.

Conclusions of the Study

In synthesizing the outcomes of the present study, several significant results among the important factors of interference, conservation, reading ability, grade level, and sex were obtained.

Particularly, comparison of the interference exhibited on different cards supported the hypothesis that the interference is a function of the semantic relationship between stimulus and response. Moreover, the interference

phenomenon appears when the represented stimuli is other than what had been learned and habituated in daily life. Considering the experimental tasks of interference (CWAT) used in the present study, each card differed in the strength and the power of the semantic association between stimuli and response. The degree of the interference performed by each subject was dependent upon the degree of the semantic relation. The results of the present study supported Klein (1964) and Bakan and Alperson's (1967) findings in that the degree of interference is a function of semantic relatedness or association. As the relationship between words and colors decreased, the interference phenomenon also decreased. As the words got more meaningful and more related to the colors, the subjects showed more interference and scored higher. It is logical to conclude that the interference effect can be diminished if there is no direct semantic association between the printed words and the required color names. It seems clear that the implication of color cues tends to be a useful and less confounding variable when other cues and similarities are minimal.

Significant negative correlation between total conservation and total interference appears to indicate that subjects who scored high on conservation tasks showed

lower interference phenomenon. This result supports the view that as children get older, their differentiational processes become higher, and therefore they can focus on different dimensions of a stimuli (Piaget, 1970).

The results of the present study showed that the second grade subjects had higher interference than the third and fourth grade subjects. Performance at this age level reflected undifferentiated response tendencies, and thus required more time. The reason is that when the two response tendencies become more differentiated, the subjects will have a better chance to choose the correct response by taking less time, having greater speed, and showing less interference. In the case of the second grade students, the reverse was true.

The effect of the subjects' reading skill on the interference phenomenon was one of the other significant results which was found in the present study. The results indicated that the students who scored high on the reading ability card had higher interference than the students who scored low on the reading ability card. This result paralleled the grade level factor, that is, second grade students who were also poor readers had higher interference when compared to the third and the fourth grade students. Results seem to indicate that reading ability accounts for the interference by showing that as the reading ability

score on Card F increases, the interference phenomenon increases.

Subjects' grade level, as mentioned before, showed a negative correlation with the total interference effect. Lower grade subjects had higher interference, and higher grade subjects had lower interference phenomenon. Perhaps one possible interpretation of this result is that children in the lowest grade (second graders) were not old enough to differentiate, and therefore took a longer time to choose a correct response. The result of the present study supported Schiller's (1966) findings on color-naming using different grade level subjects.

The results of the present study indicated that female subjects exhibited lower interference than male subjects. If it is reasonable to accept the fact that females are more verbatim than males, then good readers (female subjects) should have shown more interference compared to poor readers (male subjects). The result of the present study was contrary to this view, by indicating a lower interference effect among the female subjects than the male subjects.

In summary, it was the belief of the researcher that semantic association greatly contributes to the source of interference and is dependent upon several factors which can affect and determine this interesting phenomenon.

This belief is supported by the results of the present study and a review of the literature.

Generalizing the conclusion of the present study in order to take into consideration the interference phenomenon, it seems helpful to imply that teaching the colors without knowledge of color-words or without using the color-words themselves might help children to understand the color concept and help to prevent the perceptual conflict and interference effect. This effort might help children to overcome a conflict learning situation in some other areas which might affect their learning system in the long run.

Implications of the Results and Recommendations for Teachers

Based on the findings and analysis of the present study and the review of the literature survey on interference effect, the following implications and recommendations are made:

1. The primary implication is that teaching the concept of color to a young child without going through a dual coding system is very important for his/her future learning behavior. It is recommended that teachers become aware of this phenomenon in order to help prevent the interference effect in young children.

2. An implication, based on the dual coding system, is that different teachers have different methods of teaching colors to a young child. Almost all of the literature dealing with the interference phenomenon supports the idea that semantic association of color-words, shapes, forms, symbolic representatives, numbers, or any other semantic referents are the cause of the interference effect. Therefore, it is highly recommended that teachers should provide a single channel response, and should avoid combining two concepts, no matter what they might be, in order to be more effective with the young children's learning behavior.

3. Since the results indicate a negative relationship between conservation and interference, teachers are advised to be aware of the young child's developmental level, and not to push the child to a level that he/she cannot perform. For example, what is the use of teaching a child different dimensions if the child cannot attend to all of the characteristics of a stimulus?

4. Since there was a significant relationship between children's reading ability and interference, it should be helpful for teachers to be aware of such a relationship in order to take steps to prevent reading difficulties. For example, a nonverbal method of teaching color concepts might prevent a young child's reading difficulty in the early grades.

5. Last and most important, school systems should be aware of these and other complex learning behaviors in order to prepare proper curriculum to help handle conflicts and difficulties created by the interference phenomenon.

Suggestions for Future Research

Past and present research studies, including interference phenomenon using different tasks and methods, have developed many new questions but some old questions still remain unanswered. Observing new effects are the usual procedures of research, but finding the 'causes' and answering the 'whys' are the difficult aspects. Therefore, it would be helpful for future studies to search the following needed areas:

1. It might be profitable to carry out a future experiment using several other colors in order to test the subject's performance on interference tasks. Would subjects perform differently if they were or were not accustomed to certain colors?

2. Research is needed in the area of interference phenomenon by providing 'real objects' and asking children to name the color with congruent and incongruent conditions.

3. So far little experimentation has been carried out on the role of pronounceability of the words, further

experimentations need to explore this important aspect of the degree of the interference phenomenon.

4. Further experimentations are needed to explore the habit strength of the subject in order to study the source of the interference phenomenon.

5. Further experiments are needed in the area of young children's performance on conservation and the interference effect.

6. Since there is very little or no application of color-word interference effect for children, further research needs to explore this interesting phenomenon by using young children.

7. Since reading ability is an important predictor for the interference effect, further research is needed to examine the relationship between these two factors. In order to measure the interference effect by controlling the reading ability of the subjects, it is recommended that the subjects be required to point to specific colors rather than name specific colors.

8. Children's reactions to meaningful words, as opposed to nonsense syllables, also need more experimentation and exploration.

APPENDIX A

PERMISSION LETTER

September, 1980

Dear Parents,

I am a graduate student at the Texas Woman's University and I am conducting research concerning children's concepts of color. Your child has been selected to participate in this study if he/she has your permission. The interaction between the investigator and child will be about 30 minutes in duration. It is believed that the results of this study will be helpful in children's color learning and color concept in the future.

This study will be completely anonymous and only the results will be used in the research. Individual children and schools will not be identified in the report of this study. If you agree to let your child participate please sign the enclosed form and return to your child's teacher.

Please feel free to call me with any questions at (817) 566-1600.

Sincerely,

Fatemeh Bafighadimi Firoz
Texas Woman's University
Doctoral Student

Enclosure

APPENDIX B

WORD LISTS

LIST OF 20 RELATED COLOR WORDS WITH YELLOW, RED, BLUE, GREEN, AND BROWN COLORS

banana	corn	mustard	lemon
heart	lips	tomato	blood
ocean	sky	bluejay	blueberry
pickle	grass	lettuce	spinach
coffee	tea	brownie	chocolate

LIST OF 20 UNRELATED COLOR WORDS

table	car	food	toy	book
dress	cup	cake	hat	bell
chair	bus	shoe	dog	ring
paper	cat	gift	bed	boat

REFERENCES

REFERENCES

Amsden, R. H. Children's preferences in picture story book variables. Journal of Educational Research, 1960, 53, 309-312.

Baken, P., & Alperson, B. Pronounceability, attensity, and interference in the color-word test. American Journal of Psychology, 1967, 80, 416-420.

Baylor, G. W., & Gascon, J. An information processing theory of aspects of the development of weight seriation in children. Cognitive Psychology, 1974, 6, 1-40.

Birren, F. Color and human response. New York: Litton Educational Publishing, Inc., 1978,

Bowditch, H. P., & Warren, J. W. The knee-jerk and its physiology modifications. Journal of Physiology, 1890, 11, 25-46.

Brown, W. Practice in associating color-names with colors. Psychological Review, 1915, 22, 45-55.

Calvin, A. D., & Clifford, L. T. Relative efficiency of various stimulus objects in discriminative learning by children. American Journal of Psychology, 1956, 69, 103-106.

Cattell, J. McK. The time it takes to see and name objects. Mind, 1886, 11, 63-65.

Chute, A. G. An experimental study investigating the comparative effectiveness of a color and a monochrome version of an instructional film presentation on incidental and task-relevant discrimination learning (Doctoral dissertation, University of Wisconsin at Madison, 1978). Dissertation Abstracts International, 1979, 39(01), 74A (University Microfilms No. 78-06414).

Comalli, P., Wapner, S., & Werner, H. Interference effect of Stroop Color-Word Test in childhood, adulthood, and aging. Journal of Genetical Psychology, 1962, 100, 47-53.

Conger, C. Children's preference in book illustration color photographs versus similar, realistic illustration. Unpublished master's thesis, Department of Education, Texas Woman's University, Denton, Texas, 1979.

Cramer, P. The Stroop effect in preschool aged children: A preliminary study. Journal of Genetical Psychology, 1967, 111, 9-12.

Crowder, R. G. Principles of learning and memory. New York: John Wiley and Sons, 1976.

Das, P. J. Changes in a Stroop Test response as a function of mental age. British Journal of Social and Clinical Psychology, 1970, 9, 68-73.

Daniel, J. Performance in an interference test and some changes in the vegetative functions. Studia Psychology, 1969, 11, 267-271.

Dalrymple-Alford, E. C. Associative facilitation and interference in the Stroop Color-Word Task. Perception and Psychophysics, 1972, 11, 274-276.

Dulsky, S. G. The effect of a change of background on recall and learning. Journal of Experimental Psychology, 1935, 18, 725-740.

Dwyer, F. M., Jr. A guide for improving visualized instruction. State College, Pa.: Learning Services, 1972.

Dyer, F. N. Latencies for movement naming with congruent and incongruent word stimuli. Perception and Psychophysics, 1972, 11, 377-380.

Dyer, F. N. The Stroop phenomenon and its use in the study of perceptual, cognitive, and response processes. Memory and Cognition, 1973, 1(2), 106-120.

Dyer, F. N. Stroop interference with long pre-exposures of the word: Comparison of pure and mixed pre-exposure sequences. Bulletin of the Psychonomic Society, 1974, 3, 8-10.

Estes, W. K. Handbook of learning and cognitive processes: Volume 4--Attention and memory. Hillsdale, New Jersey: Lawrence Erlbaum Associates, Inc., 1976.

Ewbank, W. A. The use of color for teaching mathematics. Arithmetic Teacher, 1978, 26, 53-57.

Fantetti, D. J., & Fingeret, A. L. Cue effectiveness of words vs. color as function of categorical relatedness of word cues. Psychological Reports, 1975, 36, 692-694.

Fox, L. A., Shor, R. E., & Steinman, R. J. Semantic gradients and interference in naming color, spatial direction, and numerosity. Journal of Experimental Psychology, 1971, 91, 59-65.

Furth, G., & Youniss, J. Color-object paired associates in deaf and hearing children with and without response competition. Journal of Consulting Psychology, 1964, 28, 224-227.

Gatto, J. A. Color and value. Worcester, Massachusetts: Davis Publications, Inc., 1974.

Galbraith, G. C., Hohmann, A., & Creutzfeldt, O. D. Correlation between the chromatic visual evoked response and McCollough aftereffect. Psychophysiology, 1975, 12(6), 667-672.

Goodman, M. D. The rate of learning colored vs. black letters with elementary school children (Doctoral dissertation, Brigham Young University, 1975). Dissertation Abstracts International, 1975, 35(05), 2428B (University Microfilms No. 74-24553).

Goldschmid, M. L., & Bentler, P. M. Concept Assessment Kit - Conservation, Form A and Form C. San Diego, California: Educational and Industrial Testing Service, 1968.

Golden, C. J. The relationship of the Stroop Color and Word Test to the presence and localization of brain dysfunction (Doctoral dissertation, University of Hawaii, 1975). Dissertation Abstracts International, 1975, 36(01).

Guthrie, G. A behavior analysis of culture learning. New York: John Wiley and Sons, Inc., 1975.

Harrison, N. A., & Boese, E. The locus of semantic interference in the Stroop Color-Naming Task. Perception and Psychophysics, 1976, 20(5), 408-412.

Hobbs, V. A. Self-actualization and the Stroop Color and Word Test (Lamar University, 1978). Master's Abstracts, 1978, 17(03).

Hock, H. S., & Eget, H. E. Verbal interference with encoding in a perceptual classification task. Journal of Experimental Psychology, 1970, 83, 299-303.

Hudspett, N. J. The effects of color in the teacher's dress on the serene behavior of kindergarten children. Unpublished master's thesis, Department of Education, Texas Woman's University, Denton, Texas, 1979.

James, W. Hegel and his method. Hilbert Journal, 1908, 7, 63-75.

Justus, S. R. A critical path generalization of Sternberg's method: Single channel theory of the Stroop effect (University of Michigan, 1979). Dissertation Abstracts International, 1979, 40(02)B.

Keele, S. Attention demands of memory retrieval. Journal of Experimental Psychology, 1972, 93, 245-248.

Klein, G. S. Semantic power measured through the interference of words with color-naming. American Journal of Psychology, 1964, 77, 576-588.

Labinowicz, E. The Piaget primer: Thinking, learning, and teaching. Menlo Park, California: Addison-Wesley Publishing Company, Inc., 1980.

Lamberski, R. J. An exploratory study in maximizing retention by utilizing black/white and color coding in visualized instruction. A paper presented at the Annual Convention of the Association for Educational Communications and Technology, Dallas, Texas, 1975.

Lamberski, R. J. The achievement effect of a color or black/white code in learning and test materials. A paper presented at the Annual Convention of the American Educational Research Association, Boston, Massachusetts, 1980.

Lamberski, R. J., and Myers, B. E. The efficiency of a color or black/white code in learning and test materials. A paper presented at the Annual Convention of the American Educational Research Association, Boston, Massachusetts, 1980.

Lassen, G. L. Extension of the Stroop interference effect to pictures and words (University of Arizona, 1974). Dissertation Abstracts International, 1974, 35/08-B.

Lee, L. C. Concept utilization in pre-school children. Child Development, 1965, 36, 221-227.

Lund, F. H. The role of practice in speed of association. Journal of Experimental Psychology, 1927, 10, 424-433.

Modgil, S. Piagetian research: A handbook of recent studies. London: NFER, 1974.

Morton, J. Categories of interference: Verbal mediation and conflict in card-sorting. British Journal of Psychology, 1969, 60, 329-346.

Olson, D. R. Language and thought: Aspects of a cognitive theory of semantics. Psychological Review, 1970, 77, 257-273.

Otto, W., & Askov, E. The role of color in learning and instruction. Journal of Special Education, 1968, 2, 155-165.

Peterson, L. R., & Peterson, M. J. The role of context stimuli in verbal learning. Journal of Experimental Psychology, 1957, 53, 102, 105.

Piaget, J. The language and thought of the child. New York: Harcourt Brace Jovanovich, 1926.

Piaget, J. The child's concept of physical causality. New York: Harcourt Brace Jovanovich, 1930.

Piaget, J. Perceptual and cognitive (or operational) structures in the development of the concept of space in the child. Acta Psychology, 1955, 11, 41-46.

Piaget, J. Six psychological studies. New York: Vintage Books, 1967.

Piaget, J. Science of education and the psychology of the child. New York: Viking Press, 1970.

Piaget, J., & Inhelder, B. The growth of logical thinking: From childhood to adolescence. New York: Basic Books, 1958.

Ray, C. The manipulation of color response times in a color-word interference task. Perception and Psychophysics, 1974, 16(1), 101-104.

Regan, J. Involuntary automatic processing in color-naming tasks. Perception and Psychophysics, 1978, 24, 130-136.

Saltz, E. Compound stimuli in verbal learning: Cognitive and sensory differentiation versus stimulus selection. Journal of Experimental Psychology, 1963, 66, 1-5.

Scheibe, K. E., Shaver, P. R., & Carrier, S. C. Color association values and response interference on variants of the Stroop Test. Acta Psychology, 1967, 26, 286-295.

Schiller, P. H. Developmental study of color-word interference. Journal of Experimental Psychology, 1966, 72, 105-108.

Schneider, W., & Shiffrin, R. M. Controlled and automatic human information processing: I. Detection, search, and attention. Psychological Review, 1977, 84, 1-66.

Shapiro, B. J., & O'Brien, T. C. Logical thinking in children ages six through thirteen. Child Development, 1970, 41, 823-829.

Shor, R. E. The processing of conceptual information on spatial directions from pictorial and linguistic symbols. Acta Psychology, 1970, 32, 346-365.

Smedslund, J. Concrete reasoning: A study of intellectual development. Child Development Monographs, 1964, 29, 2.

Smith, G. J. W., & Klein, G. S. Cognitive controls in serial behavior patterns. Journal of Personality, 1953, 22, 188-213.

Stroop, J. R. Studies of interference in serial verbal reactions. Journal of Experimental Psychology, 1935, 18, 643-662.

Stroop, J. R. Factors affecting speed in serial verbal reactions. Psychological Monograph, 1938, 50, 38-48.

Suchman, R. G. Cultural differences in children's color and form preferences. Journal of Social Psychology, 1966, 70, 3-10.

Treisman, A. M. Strategies and models of selective attention. Psychological Review, 1969, 76, 282-299.

Underwood, B. J., Ham, M., & Ekstrand, B. Cue selection in paired-associate learning. Journal of Experimental Psychology, 1962, 64, 405-409.

Wadsworth, B. J. Piaget's theory of cognitive development. New York: Longman, Inc., 1979.

Whipple, G. Appraisal of the interest appeal of illustrations. The Elementary School Journal, 1953, 53, 262-269.

Young, R. A. The perception of color with temporal pulse-count coding of electrical stimuli applied to the eye (Doctoral dissertation, New York University, 1973). Dissertation Abstracts International, 1974, 34(08), 4103B (University Microfilm No. 74-01987).