HYPOTHESIS TESTING BEHAVIORS OF CHILDREN WITH ATTENTION-DEFICIT HYPERACTIVITY DISORDER

DISSERTATION

Presented to the Graduate Council of the University of North Texas in Partial Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

Sidney Reins Epperson
Denton, Texas
December, 1992
HYPOTHESIS TESTING BEHAVIORS OF CHILDREN WITH ATTENTION-DEFICIT HYPERACTIVITY DISORDER

DISSERTATION

Presented to the Graduate Council of the University of North Texas in Partial Fulfillment of the Requirements For the Degree of

DOCTOR OF PHILOSOPHY

By

Sidney Reins Epperson
Denton, Texas
December, 1992
Doctor of Philosophy (School/Child Clinical Psychology),
December, 1992, 154 pp., 20 tables, references, 103 titles.

The hypothesis testing behaviors of 50 boys with Attention-Deficit Hyperactivity Disorder (ADHD) were compared to those of 50 boys without ADHD. The two groups were randomly assigned to one of two feedback conditions: a) boys in the "instruction and rule" condition learned additional strategies to aid their performance on the Wisconsin Card Sorting Test (WCST); b) children in the "verbal only" condition learned no additional strategies. There were no significant group or condition differences between the boys on the primary dependent measures used.

The results from the WCST were also evaluated according to five aspects of problem solving: (a) selective attention, (b) stimulus differentiation, (c) response generation, (d) response execution, and (e) responding appropriately to feedback. The study showed a tendency for the children with ADHD to respond according to a position or hypothesis set. Similarly, children in the "verbal only" condition tended to respond to feedback less appropriately
than did children in the instruction and rule condition.
These tendencies however, did not differentiate between the
boys with ADHD and boys without ADHD.
# TABLE OF CONTENTS

**LIST OF TABLES** ........................................ vi

**Chapter**

I. INTRODUCTION ......................................... 1

   Purpose of the Study
   Review of the Literature
      Attention-Deficit Hyperactivity Disorder
      History
      Moral control
      Biological functioning
      ADD with/without hyperactivity
      ADHD
   Diagnosis and description
      Attention
      Impulsivity
      Distractibility
      Rule-governed behavior
      Perseveration
      Perceptual search
   Stages of cognitive development
      Concept learning
      Cognitive stage theory
      Hypothesis testing theory
      Integration
      Effectiveness of hypothesis testing: Normal children and children with learning disabilities
   Types of concept learning tasks
      Concept shift tasks and ADHD
      Card sorting tasks and ADHD
   Rationale and Conclusion
   Hypotheses

II. METHOD .................................................. 71

   Subjects
   General procedure
      Pretraining problems
      Pretraining feedback procedures
      Pretraining problems
      Wisconsin Card Sorting Test
   Data Analysis
TABLE OF CONTENTS—Continued

III. RESULTS ......................... 82
   Subject Variables
   Wisconsin Card Sorting Test
   Research Question One
      Hypothesis One-A
      Hypothesis One-B
      Hypothesis One-C
      Hypothesis One-D
      Hypothesis One-E
      Hypothesis One-F
      Hypothesis One-G
      Hypothesis One-H
   Research Question Two
      Hypothesis Two
   Research Question Three
      Hypothesis Three-A
      Hypothesis Three-B
      Hypothesis Three-C
      Hypothesis Three-D
      Hypothesis Three-E
      Hypothesis Three-F

IV. DISCUSSION ...................... 95
   Introduction
   Hypothesis and Research Questions
   Implications
   Summary
   Limitations

APPENDICES ...................... 106

REFERENCES ..................... 137
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Demographic Information for ADHD and Control Groups Mean and Standard Deviations</td>
<td>83</td>
</tr>
<tr>
<td>2. WCST Measures of Problem Solving Means and Standard Deviations</td>
<td>85</td>
</tr>
<tr>
<td>3. Position and Hypothesis Difference Scores Means and Standard Deviations</td>
<td>88</td>
</tr>
<tr>
<td>4. WCST Measures of Responding to Feedback Means and Standard Deviations</td>
<td>92</td>
</tr>
<tr>
<td>5. Correct Hypotheses Maintained and Rejected Wrong Hypotheses Maintained and Rejected Means and Standard Deviations</td>
<td>94</td>
</tr>
<tr>
<td>6. Conners Parent Z-Scores Means and Standard Deviations</td>
<td>122</td>
</tr>
<tr>
<td>7. Conners Parent T-Scores Means and Standard Deviations</td>
<td>123</td>
</tr>
<tr>
<td>8. Number of Errors: Analysis of Variance</td>
<td>124</td>
</tr>
<tr>
<td>9. Number Correct: Analysis of Variance</td>
<td>125</td>
</tr>
<tr>
<td>10. Categories Achieved: Analysis of Variance</td>
<td>126</td>
</tr>
<tr>
<td>11. Position Difference Scores: Analysis of Variance</td>
<td>127</td>
</tr>
<tr>
<td>12. Hypothesis Difference Scores: Analysis of Variance</td>
<td>128</td>
</tr>
<tr>
<td>13. Perseverative Errors: Analysis of Variance</td>
<td>129</td>
</tr>
<tr>
<td>14. Perseverative Responses: Analysis of Variance</td>
<td>130</td>
</tr>
</tbody>
</table>
LIST OF TABLES—Continued

15. Nonperseverative Errors:
   Analysis of Variance .................. 131

16. Failure to Maintain Set:
   Analysis of Variance .................. 132

17. Correct Hypothesis Maintained:
   Analysis of Variance .................. 133

18. Correct Hypothesis Rejected
   Analysis of Variance .................. 134

19. Wrong Hypothesis Maintained:
   Analysis of Variance .................. 135

20. Wrong Hypothesis Rejected
   Analysis of Variance .................. 136
CHAPTER I
INTRODUCTION

The study of children with attention deficits, hyperactivity, and impulsivity has a rich and varied history. Researchers (Barkley, 1981a, 1981b, 1989, 1990a, 1990b; Douglas, 1983; Henker & Whalen, 1989) report that these deficits may result in more referrals to child medical clinics than any other child behavior disorder. Studies of children with these deficits continue to be important, as hyperactivity and attentional difficulties affect many children and because the difficulties may affect the child's long-term development (Barkley, 1981a, 1981b, 1989, 1990a; Douglas, 1983; Henker & Whalen, 1989). The purpose of this paper is to present an overview of the Attention-deficit Hyperactivity Disorder (ADHD) literature with a specific focus on the hypothesis testing abilities of children with ADHD, and to develop a rationale for additional research in this area.

The present research is a synthesis of findings from two research areas, one concerning children with ADHD, and the other concerning hypothesis testing. Several researchers (Boucugnani & Jones, 1989; Chelune & Baer, 1986; Chelune, Ferguson, Koon, & Dickey, 1986; Chelune & Thompson,
1987; Gorenstein, Mammato, & Sandy, 1989) suggest that the behavioral deficits observed in children with ADHD on concept learning tasks (increased perseveration, more total errors, and fewer problems solved) are the result of frontal lobe impairment. Boucugnani (1989), Chelune et al., (1986), Chelune and Thompson (1987), and Gorenstein et al., (1989) suggest that the frontal lobe impairment hinders or prevents the solving of complex learning tasks. Other researchers (Levine, 1975; Gholson, 1980) observing the same types of behaviors in normal children, suggest that as children age they use more complex strategies to solve concept learning problems. A synthesis of these two research areas suggests that the behavioral deficits noted in children with ADHD may be the result of them using less complex problem solving strategies and not physical impairment.

Initially, a review of the history and diagnostic criteria for ADHD is presented. A foundation for the research on hypothesis testing behaviors is developed by discussing the stages of cognitive development, with a focus on two theories of problem solving, after which evidence integrating the two theoretical viewpoints is presented. A discussion of the types of concept learning tasks used in hypothesis testing tasks is presented next. The discussion of the concept learning tasks is organized according to: (a) reversal or concept shift tasks, and (b) card sorting tasks. The performance of children with ADHD is compared to
the performance of children without ADHD on each type of task. Finally, a rationale for additional research will be developed.

Attention-Deficit Hyperactivity Disorder

History

Barkley (1982) defines ADHD as
a developmental disorder of attention span, impulsivity, and/or overactivity as well as rule-governed behavior, in which these deficits are significantly inappropriate for the child's mental age; have an onset in early childhood; are significantly pervasive or cross-situational in nature; are generally chronic or persistent over time; and are not the direct result of severe language delay, deafness, blindness, autism, or childhood psychosis (p. 72).

This definition represents a refinement of the research conducted over the past ninety years and reflects the current emphasis on short attention span, impulsivity, and overactivity; however, the history of this disorder often reflects disagreement concerning the label, diagnosis and causes of ADHD. Researchers have described the behavioral deficits in several ways, depending on when the research was conducted (Barkley, 1988a; Carlson, 1986; Childers, 1935; Doouglas, 1972, 1980; Still, 1902). The current understanding of ADHD is a progression and refinement of the theories developed over the last ninety years during which
there have been four major changes in the understanding and diagnosis of this disorder. Initially, researchers proposed that the deficits resulted from poor "moral control." A second transition occurred when researchers studied the relationship between the brain and the child's behavior. A third change reflected a shift away from the biological causes to the symptoms of attention deficit, with or without hyperactivity. The fourth change represents an equal emphasis on attention span, impulsivity, and hyperactivity. Each of these shifts will be discussed briefly, as the changes in theory and criteria provide important information about the current understanding of ADHD.

Moral control. George Still (1902) provided the first full description of children with attention and behavior difficulties in lectures at the Royal College of Physicians in England. Still's medical practice included the treatment of children who were aggressive, oppositional, resistant to correction, overly-emotional, and demonstrated little control over their behavior. Still postulated that these deficits resulted from a lack of "moral control" or a "reckless disregard for command and authority in spite of such training and discipline as experience shows will render a healthy child law-abiding" (Still, 1902, p. 1009). He proposed that the moral deficits were the result of
inherited susceptibility or mild forms of brain damage or physical disease that impaired the child's moral control.

A few years later, Tredgold (1914) described a group of children as uncoordinated, excessively active, inattentive and distractible. These behaviors occurred in children reared in environments that should have allowed the development of more appropriate behaviors. Tredgold (1914) suggested that these moral deficits were the result of inherited defects in higher levels of the brain. Both Still and Tredgold believed that the problematic behaviors were a reflection of moral defects caused by innate or inherited factors and not environmental factors. Their writings provided a theoretical connection between behaviors such as aggression, uncoordination, inattention, distractibility, overactivity, and mild forms of brain damage.

Biological functioning. After Still and Tredgold's initial publications, few researchers studied these behavior problems; those who did focused on overactivity and motor restlessness, not moral conduct (Childers, 1935; Levin, 1938). The shift in emphasis away from moral factors to biological aspects was partly the result of a discovery by Charles Bradley in 1937, who prescribed benzedrine to decrease headaches in children recovering from encephalitis. Surprisingly, he found that school performance improved and that activity level decreased (Bradley, 1937). Later researchers discovered that Dexedrine decreased certain
types of seizures (Livingston, Kajdi, & Bridge, 1948) and reduced childhood behavior disorders (Bradley, 1950). (A research finding that strengthened the relationship between the biological functioning of the child and childhood behavior problems).

Another line of research that increased the emphasis on biological functioning was by Strauss and Lehtinen (1947), who found that children with brain damage tended to be restless and inattentive. They therefore assumed that all children who displayed these behaviors were also brain damaged, even when there was no evidence of physical injury. These researchers coined the term "minimal brain damage" to describe these children.

During the late 1950’s and early 1960’s, researchers placed emphasis on the inability of the central nervous system to efficiently control the amount of stimulation, thus resulting in overstimulation that was displayed as excessive movement (Laufer, Denhoff, & Solomons, 1957). Cruikshank, Bentzen, Ratzeburg, and Tannhauser (1961) used this model of brain functioning to develop recommendations for educating children with these types of problems.

ADD with/without hyperactivity. Research conducted during the early 1970’s included measures other than activity level. The findings of these studies shifted the emphasis away from the child’s overactivity to their attentional difficulties and impulsive behaviors (Barkley,
1981a, 1981b, 1990a; Douglas, 1972; Henker & Whalen, 1989). In her research, Douglas (1972) found that hyperactive children differed most from nonhyperactive, on measures of sustained attention and impulse control, and not physical activity level. Douglas and her colleagues (Douglas, 1980; Douglas & Peters, 1979) published a series of studies suggesting that the child's primary difficulties involved an inability to inhibit responses, inability to maintain attention, inability to use environmental cues to modify their level of arousal, and the inability to wait for reinforcement (Douglas, 1983; Routh, 1978). According to Barkley (1988a, 1988b, 1989, 1990a), Edelbrock (1985) and Henker and Whalen (1989) the shift in research emphasis and clinical knowledge resulted in the adoption of DSM-III by the American Psychiatric Association [APA] (1980) and a relabeling of the disorder from "Hyperkinetic Reaction of Childhood" to "Attention Deficit Disorder (with or without Hyperactivity)." The criteria adopted under this label described the three primary symptoms: impulsivity, attentional difficulties and sometimes hyperactivity. This change reduced the emphasis on overactivity, as the research of Douglas (1972, 1980) and Douglas and Peters (1979) had shown that children had more difficulty with attention and impulse control than with overactivity.

Attention Deficit Hyperactivity Disorder. Recently, another refinement occurred regarding the diagnostic
criteria used for this disorder. Researchers using DSM-III criteria found that there were significant differences between children labeled ADD and ADD-without Hyperactivity on aspects other than hyperactivity (Carlson, 1986; Edelbrock, Costello, & Kessler, 1984; Koriath, Gualtieri, Van Bourgondien, Quade, & Werry, 1985; Lahey, Schaughency, Frame, & Strauss, 1985). Following these studies researchers began to criticize the subgrouping of children according to "with or without Hyperactivity" (Lahey, Schaughency, Hynd, Carlson, & Nieves, 1986; Werry, Reeves, Elkind, 1987) because there was evidence suggesting that the deficits in children without Hyperactivity could be a subtype of ADD (Edelbrock et al., 1984; Koriath et al., 1985) or a completely different diagnostic category (Lahey et al., 1985; Lahey et al., 1986). The research evidence and criticism resulted in a division of the three primary symptoms found in DSM-III (attention, impulsive, and hyperactive) into the fourteen diagnostic criteria adopted in DSM-III-R. The disorder was relabeled "Attention-deficit Hyperactivity Disorder."

**Diagnosis and Description**

The diagnostic criteria for ADHD (see Appendix A) were listed according to their discriminating power as found in field trials (APA, 1987). A child must meet at least eight of the fourteen criteria to receive a diagnosis of ADHD.
One primary characteristic of ADHD children is their attention and concentration difficulties, which when compared to those of children of the same age and sex are significantly greater. A second aspect involved an inability to respond to environmental cues and their lack of inhibitory control or their impulsivity. A third aspect was their distractibility. The fourth factor, described more recently, suggests that children with ADHD have difficulty complying with rules and instructions (APA, 1987; Barkley, 1981a, 1982, 1989, 1990a, 1990b). A fifth area of difficulty noted by Ross (1976), Chelune et al., (1986) and Gorenstein et al., (1989) was that ADHD children have difficulty with perseverative behaviors. Lastly, a review by Douglas (1983) suggests that ADHD children have problems with tasks that require organized visual search strategies. In the following sections, each of these symptoms will be discussed in detail, as deficits in these areas may impair the child's problem solving abilities.

Attention. Barkley (1989) and Douglas (1983) and clinical evidence (Barkley, 1989, 1990a, 1990b) suggest that a primary deficit of children with ADHD involves attention span. More specifically, Douglas (1983) concludes that children with ADHD have difficulty maintaining their attention to task or level of vigilance. Luk (1985), Milich & Landua (1982), and Ullman, Barkley and Brown (1978) found that difficulties in attention and concentration increase
when the activities are tedious, boring, or require some type of repetitive movement. According to Barkley (1989, 1990a) and Douglas (1983) several aspects of attention can be studied. For our purposes the most critical aspect involves sustained attention and distractibility. These terms refer to a person's ability to focus on critical target stimuli while "ignoring" nontarget stimuli. Thus, the child with ADHD may not adequately attend to the relevant stimulus dimension and ignore the irrelevant dimensions on the hypothesis testing task.

Impulsivity. Researchers have used several terms to describe the child's inability to control his or her own behavior, impulsivity (Douglas, 1983), inhibitory control (Zentall & Zentall, 1983), or disinhibition (Gorenstein & Newman, 1980). Zentall and Zentall (1983) suggest that hyperactive children tend to respond to peripheral or irrelevant stimulation more than nonhyperactive children. They suggest that the hyperactive child experiences underarousal and then acts to increase the level of stimulation (Zentall, 1975, 1977). In a later study, Zentall (1985) found that children with ADHD appeared to have a higher threshold for stimulation than normal children. As stimulation decreases, the child's inattention and hyperactivity increase to maintain an optimal level of central nervous system arousal. Gorenstein and Newman (1980) defined disinhibition as "human behavior that has
been interpreted as arising from lessened controls on response inclinations" (p. 320). The child’s ability to inhibit responding was influenced by several factors. Some difficulties occurred when external controls were lacking or when the child developed a strong response set toward an activity that they found reinforcing. These findings suggest that on a hypothesis testing task the child with ADHD may have difficulty maintaining his or her response after receiving positive feedback and changing the response when feedback is negative.

**Distractibility.** This term usually refers to the ability of the child to focus his or her attention on one stimulus while ignoring other stimuli. Douglas and Peters (1979) reviewed the literature and concluded that the addition of distracting material does not particularly disrupt test performance. Research using tasks that require flexibility found deficits in the child’s ability to respond selectively to relevant information and inhibit responses to the irrelevant stimuli (Rosenthal & Allen, 1978). In an attempt to evaluate this, Rosenthal and Allen (1980) used a classification task to measure the effects of irrelevant stimuli on the performance of children with hyperactivity. They found no differences between the control and hyperactive groups when the irrelevant stimulus was low on the child’s salience hierarchy. There was a significant difference between the groups, with the hyperactive children
showing increased responsiveness to the irrelevant stimulus when the irrelevant stimulus was high on the child’s salience hierarchy. This suggests that the irrelevant stimulus was more difficult to ignore when it had a higher salience value. On the hypothesis testing task, deficits in this area could result in the child responding according to a particular stimulus dimension in spite of negative feedback.

**Rule-governed behavior.** Barkley (1981a, 1981b, 1988a, 1988b, 1989, 1990a, 1990b) suggests that children with ADHD have more difficulty following social and community rules than do normal children. He defines this as "the ability of language (commands, directions, instructions, descriptions, etc.) or other symbol systems to serve as discriminative stimuli for behavior" (Barkley, 1988b, p. 72). The child, therefore, has difficulty following the commands or directions that are given by parents, teachers, or those in authority. The hypothesis testing task requires the child to respond appropriately to feedback. Deficits in rule-governed behavior may impair the child’s ability to respond appropriately to feedback.

**Perseveration.** A fifth type of deficit noted by some researchers was an increase in perseverative behaviors. Ross and Ross (1982) reported perseveration problems in hyperactive children. More recent research by Chelune et al., (1986) and Gorenstein et al., (1989) suggests that
children with ADHD had significantly higher rates of perseverative responses than did normal children. Gorenstein et al., (1989) concluded that the children with ADHD were less able to change their response style than normal control children. On the hypothesis testing task, perseverative responses could be a reflection of deficits in attention, distractibility, impulsivity, or rule-governed behavior. Furthermore, the child with ADHD may be responding to a preferred stimulus dimension, noticing only one or two of the three stimulus dimensions, or not responding appropriately to feedback.

**Perceptual search.** Hyperactive children do poorly on complex cognitive tasks requiring visual strategies such as scanning a visual field in an organized, purposeful manner, or conducting an exhaustive search for critical aspects of task stimuli (Douglas, 1983). Douglas and Peters (1979) found that the evaluation strategies used by children with ADHD were not as efficient as those used by normal children; therefore, they may not attend to or discriminate among the stimulus dimensions on the hypothesis testing task.

In summary, historically there have been many theories and criteria used to diagnose and describe ADHD. Current diagnostic criteria places equal emphasis on attention deficits, impulsivity, and hyperactivity. In addition to these core deficits, researchers suggest that children with ADHD may have difficulty with distractibility, rule-governed
behaviors, perseverative responses, and perceptual search strategies. Deficits in any of these areas may result in impaired performance in problem solving abilities.

Boucugnani and Jones (1989), Chelune and Baer (1986), Chelune et al., (1986), Chelune and Thompson (1987), Gorenstein et al., (1989) employed a concept learning task to study the problem solving abilities of children with ADHD. They found that children with ADHD performed significantly worse than children without ADHD. The results from these studies (Boucugnani & Jones, 1989; Chelune & Baer, 1986; Chelune, et al., 1986; Chelune & Thompson, 1987; Gorenstein, et al., 1989) along with those of Douglas and her colleagues (Freibergs & Douglas, 1969; Parry & Douglas, 1983) suggest that children with ADHD have deficits in problem solving. Boucugnani and Jones (1989) Chelune and Baer (1986), Chelune et al., (1986), Chelune and Thompson (1987), Gorenstein et al., (1989) suggest that the deficits observed in children with ADHD on concept learning tasks were the result of frontal lobe impairment; however, Levine (1975) and Gholson (1980) observed the same types of deficits in normal children. Children who used less complex problem solving strategies tended to perform worse than children using sophisticated strategies; therefore, the deficits noted in children with ADHD may be the result of them using less complex strategies on the concept learning task and not frontal lobe impairment.
Additional information concerning concept learning, hypothesis testing and cognitive development is necessary for a complete understanding of the problem solving abilities of children with ADHD. Prior to presenting the theories of cognitive development, a brief summary of concept learning tasks is presented. These types of tasks were used by Piaget (1969) and Levine (Levine, 1975) in the development of their theories of cognitive development.

Stages of Cognitive Development

Concept Learning

Concept organization is the combination of concepts or stimulus dimensions into different categories or groups (concepts, concept learning, and concept attainment are terms describing concept organization). Concepts (e.g., red, dog, freedom) are stimulus dimensions in the environment that may be identified and classified (Bruner, 1973; Bruner, Oliver, & Greenfield, 1966). Concept learning (or discrimination learning) refers to responding selectively to one stimulus dimension in the presence of multiple stimuli (Reese, 1976). Bruner, Goodnow, & Austin (1956) suggests that concept attainment is the process by which other examples of a concept are identified (furniture: chair, sofa, table).

Concept organization can be divided into three types: (a) simple concept selection, (b) concept formation, and (c) complex concept formation. Simple concept selection tasks
consist of two dimensional stimuli that require the child to display a preference for a certain stimulus dimension or identify examples of a predetermined concept (Restle, 1962). Concept formation tasks involve stimuli that can be categorized in several ways and require the child to select a specific stimulus dimension over other potential stimulus dimensions (Bruner et al., 1966) Complex concept selection tasks involve multidimensional stimuli (Levine, 1975; Gholson, 1980).

Piaget (1969) used all three types of concept organization tasks in the development of his theory. Levine (1975) primarily used complex concept tasks. The brief summary of concept learning tasks provides a foundation for understanding the tasks that Piaget (1969) and Levine (1975) used in the formation of their theories of cognitive development.

A number of theories describe the stages of cognitive development (Gholson, 1980; Levine, 1975; Levine, 1987; Piaget, 1969). One aspect of the cognitive theories of Piaget and Levine concerns the problem solving abilities of children. Piaget (1967) used different types of activities to evaluate the problem solving abilities of children, one of which was concept learning tasks; whereas Levine and his colleagues (Levine, 1975; Gholson, 1980) primarily used concept learning tasks to study the problem solving abilities of children and adults. The following discussion
presents an overview of two theories of problem solving: (a) Piaget’s cognitive stage theory (Piaget 1969), and (b) Levine’s hypothesis testing theory (Levine, 1975).

**Cognitive Stage Theory**

Children develop through stages defined by different intellectual requirements and accomplishments (Piaget, 1969). During the sensorimotor stage from birth to approximately 2 years of age, the child’s interactions with the environment shift from inborn reflexive movements to the emergence of intentional behaviors, and finally to representational activities.

During the preoperational stage (about 2 to 7 years), the child operates on the level of symbolic representation as evidenced by their imitation and memory displayed in drawings, dreams, language, and make-believe play. The first attempts at conceptualization occur in this stage, during which the child often overgeneralizes and does not distinguish between representatives of a class and the class itself (e.g., all slugs are "the slug"). Toward the end of this period, the child often uses trial and error learning to discover how certain things are related; however, the child has difficulty manipulating more than one stimulus dimension at a time (e.g., blue beads cannot simultaneously be wooden beads). In the concrete operational stage (about 8 to 12 years), reasoning increases and certain behaviors are exhibited that require flexible thought processes. The
child in this stage can sequence a series of objects, classify them into groups, and perform other logical manipulations on them. During the formal operation stage (12 years through adulthood), abstract logic predominates. Piaget suggests that the child can reason or hypothesize about abstract propositions, things, or properties that he or she has never directly experienced. The child develops the ability to use deductive and inductive reasoning to solve problems.

Piaget (1967) suggested that the three processes allowing change from one stage to another were assimilation, accommodation, and equilibrium. According to Piaget, assimilation was the process of taking in from the environment all forms of stimulation and information, organizing and integrating the information into the person's existing structures, thus creating new structures or scheme. While accommodation was the process of reaching out and adjusting to new and changing conditions in the environment, so that preexisting patterns of behavior were modified to cope with new information or feedback from external situations. According to Piaget (1969), accommodation and assimilation occur simultaneously and were in a state of equilibrium, referring to a dynamic, continuously self-regulating process of balancing caused by assimilation and accommodation. Equilibrium was the organizing factor underlying all biological and intellectual development. The
equilibrium between these processes allows future learning and adaptation to occur.

**Hypothesis Testing Theory**

Bruner proposed the most influential theory of strategy and concept development (Bruner, 1973; Bruner et al., 1956; Bruner et al., 1966; Gholson, 1980; Levine, 1975). Further refinement occurred through research conducted by Restle (1962), Bower and Trabasso (1963, 1964; Trabasso, 1963; Trabasso & Bower, 1966, 1968). In turn, research by Levine resulted in hypothesis testing becoming a widely accepted theory in developmental psychology (Gholson, 1980). In 1969, Levine and his students (Eimas, 1969, 1970; Foreit, 1974; Gholson, Levine, & Phillips, 1972; Gholson & McConville 1974; Gholson, Phillips, & Levine, 1973; Ingalls & Dickerson, 1969; Nuessle, 1972; Weisz & Achenbach, 1975; Williams, 1974) began a series of research studies that focused on the concept learning abilities of children. Gholson and his students continued this line of research to the present (Gholson, 1980; Gholson, Eymard, Morgan, & Kamhi, 1987; Gholson & Schuepfer, 1983). The next section traces the development and refinement of hypothesis testing theory.

Bruner et al., (1956) suggested that concept learning was a hierarchical process related to the development of language. Bruner used the term concept attainment to describe the constructive and active process of
encountering, generating, and evaluating hypotheses. The person selects a hypothesis to test. If the feedback to the response was positive, the person accepted the initial hypothesis. If the feedback to the response was negative, the person changed the hypothesis to make it consistent with hypotheses not rejected.

Bruner (1973) describes decisions as strategies involving acquisition, retention, and utilization of information to meet certain objectives (e.g., solution of the problem in the fewest number of trials possible). Bruner (1973) identified two types of strategies that can be used to solve problems. The first, focusing or "wholist" strategy, was useful for maximizing the information gained and for reducing the strain on inference and memory. The strategy begins with the person taking the first positive instance and making it the initial hypothesis. From this strategy, several rules can be developed to aid future situations: a) positive feedback, maintain the current hypothesis; (b) negative feedback, take as the next hypothesis what the previous hypotheses and what the present hypothesis has in common.

The second strategy, labeled the part-scanning strategy, begins with the selection of a hypothesis about part of the initial situation. When this hypothesis fails to be confirmed by some subsequent situation, the person changes it by referring back to all situations previously
met and makes modifications accordingly. The person attempts to develop a hypothesis that is consistent with all situations previously encountered. This strategy also provides rules for future situations: (a) positive feedback, maintain the current hypothesis, (b) negative feedback, change the hypothesis to make it consistent with past hypotheses, or choose a hypothesis not previously rejected.

Restle (1962) adapted the procedures and methods used by Bruner et al., (1956) and expanded the model. He argued that a person develops a set of hypotheses when faced with a problem and divided this set of hypotheses into three categories: (a) correct strategies, always lead to correct responses, (b) wrong strategies, always lead to wrong responses; (c) irrelevant strategies, tend to lead to correct and incorrect responses with equal frequency.

From this theoretical basis, Restle proposed three forms of hypothesis testing. Only the first will be described as Restle proved that all three lead to the same predictions about problem solving. The first premise was that the child samples and tests only one hypothesis at a time. If the response to the hypothesis was correct, the hypothesis was retained and used in the next response. If the response to the hypothesis was incorrect, that hypothesis is returned to the set of hypotheses and randomly select another hypothesis before the next response.
Following the publication of Restle's (1962) article, Bower and Trabasso (1963, 1964; Trabasso, 1963; Trabasso & Bower, 1966, 1968) started evaluating Restle's model. According to Restle, once the person has found the correct hypothesis he or she will continue responding according to that hypothesis, which results in a series of correct responses. Conversely, if the response results in an error, then the person continues to select different hypothesis to test.

The research findings of Trabasso and Bower (1968) resulted in the refinement and modification of Restle's model. They suggested that during a concept learning task, the person used two different modes: (a) the search mode, and (b) the test mode. The search mode begins after errors and aids the person in making decisions about which dimensions to select. In this step, the person determines which stimulus values were in the designated stimulus array. After an error, the person determines which stimulus values remain that could be correct. This assumption, called the local-consistency rule, suggests that after an error, subjects sample only from those hypotheses that were in the correct stimulus array.

The test mode begins with the person testing the correctness of a hypothesis from the correct stimulus array. When a response receives positive feedback, the subject retains the hypothesis in the stimulus array that dictated
the response and the hypotheses leading to other responses were immediately discarded. This process narrows the potential hypotheses and eventually leads to the correct response. When an error occurs, the search mode is reactivated, new stimulus dimensions are selected, new hypotheses are included in the stimulus array, and the testing mode begins again.

A series of studies by Levine between 1959 and 1975 continued the development and refinement of hypothesis testing theory (Levine, 1975). Initially, Levine described the behaviors of college students and adults on concept learning tasks. Later, he began to include children in his research studies (Levine, 1969).

Levine showed both college students and children a pair of bivalued four-dimensional stimuli such as shape (square or circle), color (white or black), size (large or small), and type of border (solid or dashed). Later studies (Levine, 1975) included up to eight stimulus dimensions: letter (A or T), size (large or small), letter color (black or white), underline (solid or dashed), border shape (circle or square), border number (one or two lines), border texture (solid or dashed), and number of spots (one or two). The child was required to discover which of the stimulus dimensions was the solution. Initially, Levine (1963) provided feedback on every trial of the problem. Later, Levine, Leitenberg, and Richter (1964) used no feedback
trials to determine the effects of not receiving feedback. Levine et al., (1964) used two types of trials: feedback trials, in which the feedback was correct or incorrect, and trials consisting of no feedback (blank trials).

Research by Gholson et al., (1972) used a two-value four dimensional task involving color (white or black), letter (X or T), bar above letter, bar below letter, and size (large or small). 50 second graders, 50 fourth graders, 50 sixth graders, and 50 college students (age 17-24 years) were included as subjects in this study. Each person in the study received a series of six 76-trial problems with feedback occurring every fifth trial from one through 76. Thus, there were 16 feedback trials and 15 sets of four blank trials.

Gholson et al., (1972) analyzed their data in two ways. First, the blank trial data indicated that the response patterns were significantly different from 50%, the score expected for completely random responding. This indicates that the responses of the elementary school children and the college students were strongly systematic.

The second analysis evaluated involved the effects of feedback. The analysis (Gholson et al., 1972) found that significantly more of the children and college students maintained a hypothesis when followed by positive feedback. The tendency to reject a positive hypothesis decreased significantly with increasing age. Significantly more of
the college students switched responses after receiving negative feedback. As age increased, significantly more of the children also switched, but there were no significant differences among the grade levels. These results suggest that children at all age levels tend to abandon a hypothesis when the feedback information was negative. In addition, children of elementary school age tended to return a rejected hypothesis to the universe of hypotheses before randomly selecting a new hypothesis.

Levine (1975) and his colleagues (Gholson et al., 1972) analyzed their data and found that children and college students tended to use several problem solving strategies. One pattern of responses corresponded to the strategy previously identified by Bruner et al., (1956) as the focusing strategy. They also subdivided Bruner’s part-scanning strategy into two additional strategies, hypothesis checking and dimension checking. In addition, they noted that several groups of children responded according to stereotypic response sets.

According to Levine (1975) and Gholson et al., (1972) the focusing strategy was the most effective strategy, allowing the problem-solver to solve the problem in the fewest number of trials. Children who used this strategy could immediately eliminate all the rejected hypotheses. For example, if on a given feedback trial the child chose the large, black T with a line on the top and the feedback
was negative, then all four of these hypotheses were eliminated. The stimulus values remaining would be white and X. The next two responses would be selected to eliminate these values and not the values already eliminated. This strategy would allow the child to solve the problem in three trials.

The second most efficient method was the dimension checking strategy. Children who use the dimension checking strategy do not process and evaluate all the available information. These individuals tend to check all four dimensions systematically, one dimension at a time. For example, the first hypothesis might be large, the second white, the third bar down, and lastly, T. This strategy would allow the child to solve the problem in four trials.

The hypothesis checking strategy was the least effective method. Children who use this strategy process and evaluate the all eight hypotheses systematically, one stimulus dimension at a time. For example, the first hypothesis might be large, the second small, the third white, the fourth black and so on through the values of the stimulus dimensions. This strategy would allow the child to solve the problem in eight trials.

The other response patterns described by Levine (1975) and Gholson et al., (1972) were stimulus preference, position alteration, and position perseveration. Levine and Gholson labeled these stereotypes, because they would
theoretically never lead to a solution. The child who used the stimulus preference response style maintained the same hypothesis throughout the test in spite of negative feedback. An example was the child who selects large every trial. Position alteration describes the behavior of the child that alternates position (selects a stimulus on the right side and then on the left) from trial to trial in each blank trial. On the other hand, position perseveration describes the style in which the child responds according to the position and the stimulus.

The results of these studies by Levine (1975) and his colleagues (Gholson et al., 1972) suggest that children who could select and test different hypotheses could eventually solve the concept learning problems. Children who consistently made selections according to a specific stimulus dimension or perseverated on a specific hypothesis were less likely to solve the concept learning task.

The complexity and effectiveness of the strategies increased as children became older. Older children tend to use more efficient strategies. This appears to reflect an increase in at least two abilities: (a) the ability to attend and process several hypotheses simultaneously, and (b) the ability to compare feedback information across trials.

Levine developed and refined the theory of hypothesis testing through a series of studies that he and his
colleagues completed (Levine 1975; Gholson et al., 1972, 1973). First, problem solvers approach a problem with a universe of potential hypotheses. Second, the child selects one specific hypothesis to test. Third, if the child receives positive feedback for that hypothesis, he or she retains that hypothesis for future responses. If the child receives negative feedback, he or she eliminates that hypothesis and selects a new one. Fourth and last, when not provided feedback, the child continues to use the same hypothesis on future trials (Levine, 1975). Hypothesis testing theory suggests that there are five primary steps involved in problem solving and concept learning: (a) stimulus differentiation, (b) selective attention, (c) response generation, (d) response execution, and (e) responding appropriately to feedback.

Integration. Piaget’s cognitive stage theory can help explain research findings concerning children’s hypothesis testing abilities. Research conducted by Gholson et al., (1972, 1973) classified the protocols of various aged children according to the type of strategy used. Their analysis indicated that the kindergarten children manifested stereotypes in approximately 90% of their trials. Children in elementary school (grades two through six) tended to use dimension checking and hypothesis testing on 65 and 80% of the trials. The focusing strategy was used on 15% of the trials.
According to Piaget, preoperational children do not view a problem to be solved as a set of causes and effects that are independent of their behavior. Research by Inhelder and Piaget (1958) found that children represent the external environment as a set of uncoordinated forces that were only partially differentiated from the child’s own activities; therefore, Piaget’s theory would suggest that preoperational children would tend to respond according to a position oriented stereotype. A second aspect suggests that the preoperational child may center attention upon one salient stimulus dimension and ignore other features. Thus, the child does not consider other stimulus dimensions of the problem (Piaget, 1952, 1963); therefore, the preoperational children may respond according to a stimulus preference stereotype.

Lastly, the preoperational child does not seem to understand the process of class inclusion. Inhelder and Piaget (1964) suggest that the preoperational child’s reasoning often is from particular to particular, from one salient feature of a problem to another, but not in part-to-whole (A to B) or whole to part (B to A) relations. Thus, the preoperational child may attend to the different stimulus dimensions, but have difficulty seeing how they are related. Developmental trends in the child’s hypothesis testing abilities can be integrated with Piaget’s cognitive stage theory.
Developmental changes in strategies occur at first, second, and sixth grades (Gholson et al., 1972; Reiber, 1969; Piaget & Inhelder, 1969). Preschool and kindergarten children often perseverate on a specific stimulus or position of the stimulus during many concept learning tasks. Though they do not solve the problems, the response patterns are systematic and orderly (Gholson et al., 1972). Between the ages of 5 and 7 years, a transitional period occurs. Inconsistent or random responding increases (Reiber, 1969); physical quantities are not successfully manipulated; and literal interpretations of stimuli occur (Piaget & Inhelder, 1969).

At 7 to 8 years of age, the child begins to respond to specific stimulus dimensions and formulate plans that lead to the solutions of problems (Bruner, 1973; Levine, 1975; Gholson & McConville, 1974). The responses of the child become more logical and their response to feedback becomes more predictable and anticipated (Piaget & Inhelder, 1969). After age 8, the efficiency of the strategy employed increases and the child solves more problems (Gholson et al., 1972).

Around sixth grade, or at 10 years of age, children use more sophisticated strategies and on certain tasks score similarly to adults (Chelune & Baer, 1986). At the same age, attention to relevant information increases (Hallahan, Kauffman, & Ball, 1973) and attention to irrelevant
information decreases (Hagen, 1967). Furthermore, the child's responses to feedback become more appropriate as the child learns to maintain a response when correct and to reject a response when told it is incorrect (Gholson et al., 1972; Levine, 1975).

In summary, the previous section presented a synthesis of two theories of problem solving. Piaget suggests that preoperational children have difficulty attending to all the stimulus dimensions of a problem or comparing the values of a stimulus dimension. These tendencies lead preoperational children to respond according to stereotypic response patterns. Research using hypothesis testing tasks suggest that as children increase in age these stereotypic response patterns decrease. In addition, they can use more complex types of strategies to solve these tasks. The changes in strategy development appear to parallel the cognitive changes observed by Piaget.

The development of complex problem solving strategies requires several hypothesis testing behaviors (Levine, 1975; Gholson, 1980). These behaviors include: (a) stimulus differentiation, (b) selective attention, (c) response generation, (d) response execution, and (e) responding appropriately to feedback. In the next section the focus shifts to the factors that influence the child's problem solving abilities.
Effectiveness of hypothesis testing: Normal children and children with disabilities. Researchers suggest that a number of factors may influence the effectiveness of children's hypothesis testing behaviors. The ability to differentiate between stimuli was implicated by Gholson and McConville (1974) while others suggest that selective attention (Offenbach, 1974) and the ability to respond to feedback (Gholson & McConville, 1974; Parrill-Burnstein, 1978) influence the effectiveness of hypothesis testing.

Gholson and McConville (1974) evaluated the effects of receiving feedback on a stimulus differentiation task on later performance on a hypothesis testing task. In the first session, the kindergarten children were presented 24 stimulus differentiation problems, each six trials in length. The children were shown three stimuli and asked to choose which of the two stimuli were the same and which one was different. Children in the experimental group received feedback about the correctness of their groupings after each trial. Children in the control group received no feedback after the trials. In a second session, the children in both groups were given a series of six 46-trial hypothesis testing tasks. No differences were found on the stimulus differentiation task, as the performance of the children in both groups was almost perfect.

The results Gholson and McConville (1974) reported were consistent with those of Gholson et al., (1972). The
children who had received feedback on the stimulus discrimination task solved more of the problems and developed more consistent hypotheses during the hypothesis testing trials. In addition, they were less likely to use a stereotypic response style, were more likely to abandon a rejected hypothesis, and more likely to test a closely related hypothesis after negative feedback. Furthermore, the children who received feedback were more likely to retain a hypothesis after positive feedback than did the children receiving no feedback.

Offenbach (1974) evaluated the effects of selective attention on children's hypothesis testing behaviors. Offenbach used first, third, and fifth graders, college students, and older adults as subjects. Offenbach's task required the subject to select and point to one of the eight hypotheses that were decomposed and represented individually on a wheel (i.e., red component, green component). Subjects picked their choice on the wheel prior to making their response on the hypothesis testing task. Pretraining was provided to teach the subjects to select their choice on the wheel. The results using Offenbach's (1974) wheel technique were comparable to the results using the blank trial probe task. One major difference was that requiring the subject to select a hypothesis prior to stimulus selection eliminated most position perseveration. The selective attention procedure used by Offenbach (1974) appeared to
help subjects focus their attention on the stimulus dimension used. This increase in selective attention appeared to increase the ability of the individuals to develop a wider range of hypotheses and be more efficient in their problem solving.

Parrill-Burnstein (1978) reported an investigation in which she presented four-dimensional problems containing blank-trial probes to groups of kindergarten children. She analyzed the problem solving task into four sequentially dependent units. Each of the units was designed to correspond to a specific cognitive strategy or series of strategies.

Three colored strips were mounted on a large magnetic chalkboard. The strips, going from the child's left were green, yellow, and red. During pretraining, the children learned either a component or a sequence of components necessary to solve the discrimination learning problems. The children learned the components of the dimension checking strategy (Gholson et al., 1972). There were four conditions: (a) children in group 1 stated the four cues contained in the stimulus complex associated with the first correct stimulus, (b) the children in group 2 received the same training as group 1 and received magnetic visual representations of the four hypotheses relevant to the solution. As the child stated the hypothesis contained in the correct stimulus complex, they placed the correct visual
representation on a green strip (memory training, (c) the children in group 3 received the same training as children in groups 1 and 2 and learned to isolate and test one cue at a time. The child moved one of the visual representations, representing one hypothesis to a yellow strip and to name this hypothesis on each trial of the first blank-trial probe, and (d) children in the final condition learned the complete sequence of problem-solving steps learned by children in groups 1, 2, and 3. In addition, the children in group 4 learned to respond appropriately to positive and negative feedback. The children learned to move the stimulus cue that was rejected to the red strip. Once on the red strip, that stimulus cue was eliminated from further consideration. The child then selected a new stimulus cue from the green strip and moved it to the yellow strip. This was the hypothesis for the next trial. If feedback was positive, the child left the cue on the yellow strip and continued to use it as the hypothesis.

During the pretraining trials, the children in all groups solved on the average about 10% of their problems. After training, the children in groups 1, 2, 3, 4, solved 30, 36, 56, and 100% of the problems respectively. The children displayed a consistent hypothesis in 44-56% of their trials during pretraining and between 62 and 97% after training. During pretraining, the percentage of trials in which a correct hypothesis was maintained ranged between 41
and 55% and 52 to 94% after training. Likewise, the percentage of trials in which a negative hypothesis was maintained ranged between 31 and 41% during pretraining. Following training, the children in groups 1, 2, 3, 4, maintained disconfirmed hypotheses for 21, 31, 52, and 2% of the trials respectively.

In a follow-up study, Parrill-Burnstein (1979, cited by Gholson, 1980) attempted to teach kindergarten children to use the focusing strategy (Gholson et al., 1972). Parrill-Burnstein adapted the methods described above and found that children who learned the complete sequence of problem solving steps solved approximately 70% of the problems. This was significantly better than those in the other training conditions; however, the kindergarten children in this study solved fewer of the problems than did the children that learned to use the dimension checking strategy in the previous study.

Parrill-Burnstein concluded that it was more difficult for the kindergarten children to process the stimulus information simultaneously than separately. Parrill-Burnstein interpreted her results as indicating that the training of a strategy did elicit problem solving behaviors. Teaching the complete task analysis, including instructions about responding appropriately to feedback, was successful in producing more sophisticated problem solving behaviors in
children who initially perseverated on unsuccessful responses.

In summary, hypothesis testing behaviors were facilitated by a number of different techniques, stimulus differentiation training (Gholson & McConville, 1974) teaching the complete task analysis, including the appropriate response to feedback (Parrill-Burnstein, 1978; Parrill-Burnstein, 1979, cited by Gholson, 1980), and increasing attention through hypothesis selection prior to responding (Offenbach, 1974). These studies also yielded consistent developmental findings. Preschool children tended to respond according to stimulus position or stimulus preference (Gholson et al., 1972; Parrill-Burnstein, 1978), while older children used strategies and solved more of the problems. The efficiency of the strategy used increased with age. Children in the first grade frequently used the hypothesis checking strategy, while children in the second grade were more likely to use the dimension checking strategy. Fourth graders and some sixth graders used the dimension checking strategy (Gholson et al., 1972; Gholson & McConville, 1974). By the sixth grade most children were using the focusing strategy (Gholson et al., 1972; Gholson & McConville, 1974).

The children used in these studies were children with no learning disabilities or ADHD. No prior studies have looked specifically at the hypothesis testing behaviors of
children with ADHD. A study by Parrill-Burnstein and Baker-Ward (1979) compared the hypothesis testing behaviors of children with learning disabilities with children without learning disabilities.

Parrill-Burnstein and Baker-Ward (1979) used a hypothesis testing task and a blank trial procedure with children with and without learning disabilities. The children were between the first and fifth grade and attended private schools for children with learning disabilities. When equated on achievement, children in LD I were older than those in the other school (LD II). A third group of children from the same private schools without learning difficulties served as a comparison group. The measures were the number of tasks solved, the number of hypotheses tested, and the number of responses that were consistent with the feedback information.

Parrill-Burnstein and Baker-Ward (1979) found that the children with learning disabilities solved significantly fewer problems than those in the comparison group. A significant age effect was also noted: children in the first grade solved significantly fewer problems than children in the fifth grade. These developmental findings were consistent to those obtained with children without learning disabilities discussed earlier (Gholson et al., 1972).
Parrill-Burnstein and Baker-Ward (1979) observed the following types of deficits in children with learning disabilities. Children with learning disabilities tested significantly fewer hypotheses and were less consistent following feedback than children without learning problems. Children with learning disabilities also tended to respond in a stereotypical manner, such as stimulus position or stimulus preference. This type of responding was more similar to that observed with younger children without learning problems (Gholson & Beilin, 1978; Gholson & McConville, 1974). The children with learning disabilities also had difficulty responding appropriately to feedback when testing hypotheses. The children in the two different schools tended to respond inconsistently to feedback, but for different reasons. Those in LD II with verbal learning disabilities, tended to retain the same hypothesis after negative feedback. Children in LD I tended to discard the hypothesis no matter what the feedback was. Furthermore, the children with learning disabilities were more likely to test a hypothesis that had already been tried and discarded.

In summary, children with learning disabilities solved fewer problems than children without learning difficulties. Children with learning disabilities tended to test hypotheses less frequently than children without learning disabilities, select previously used hypotheses that were incorrect, and did not respond appropriately to feedback
Douglas and her colleagues (Douglas, 1983; Douglas & Peters, 1979; Freibergs & Douglas, 1969; Parry and Douglas, 1983) suggest that children with ADHD will have the same types of difficulties.

Types of Concept Learning Tasks

Hypothesis testing theory (Gholson, 1980; Levine, 1975) suggests that deficits in (a) stimulus differentiation, (b) selective attention, (c) response generation, (d) response execution, and (e) responding appropriately to feedback impair the child’s ability to use complex problem solving strategies. These deficits may result in an increase in stereotypic response sets or perseverative behaviors.

Recently, researchers (Boucugnani & Jones, 1989; Chelune & Baer, 1986; Chelune et al., 1986; Chelune & Thompson, 1987; Gorenstein et al., 1989) focused their attention on the stereotypic and perseverative behaviors of children with ADHD. These studies are discussed in greater detail because they use concept learning tasks to suggest that the behavioral deficits are related to impairment in frontal lobe functioning.

The task that Boucugnani and Jones (1989), Chelune and Baer (1986), Chelune et al., (1986), Chelune and Thompson (1987), Gorenstein et al., (1989) is a combination of two types of concept learning tasks. The first involves a reversal or concept shift during the trials. The other type of task is sorting cards according to stimulus dimensions.
The discussion that follows presents some of the research using concept learning and card sorting tasks. For comparison purposes, research using children without ADHD is presented first, followed by a discussion of the studies using children with ADHD.

**Concept shift tasks and ADHD.** Several researchers (Tighe, Glick, & Cole, 1971; Tighe & Tighe, 1972; Kendler & Kendler, 1962) have used reversal or concept shift type tasks to study the development of concept learning in normal children. Other researchers (Freibergs & Douglas, 1969; Parry & Douglas, 1983) use the same types of tasks with children with ADHD.

Tighe and Tighe (1972) discuss the influence of rule-governed behavior on the development of a child's concept reversal learning. The learning of rule governed behavior occurs because of differential reinforcement and represents consistent responding in the presence of specific cues (Barkley, 1982; Skinner, 1953). Tighe et al., (1971) and Tighe and Tighe (1972) used two types of tasks in their studies, reversal shift and nonreversal shift. In the first, the correct hypothesis changes after a reversal shift. A reversal shift task requires the child to respond to one value of the same stimulus dimension and then shift their response to the other value after the reversal occurs. For example, the child receives a reward for selecting the large ball and ignoring the small ball. After the reversal
shift, the child receives a reward for selecting the small ball.

In the second task (the extradimensional shift task), the child responds to one stimulus dimension and ignores the others. After the nonreversal shift, reinforcement is provided for selecting the previously ignored dimension. For example, reinforcement is given for selecting the large ball and not for selecting the black ball. After the shift, they must select the black ball and ignore the large ball to receive reward.

In terms of development, changes in concept shift performance occurred before age 5 (Caron, 1970; Tighe & Tighe, 1970; Tighe, et al., 1971), between age 5 and 7 (Kendler & Kendler, 1962; Tighe, et al., 1971), and after age 10 (Tighe & Tighe, 1970; Tighe, et al., 1971). Before the age of 5, children learned the extradimensional shift task more easily than reversal shift. Between the ages of 5 and 7 years, children learned the reversal and extradimensional shifts with equal difficulty. After age 10 and during later childhood, children learned reversal shifts faster than extradimensional shifts.

Dickerson (1966) studied the reversal learning abilities of preschool children. He used three shift tasks: reversal shift, extradimensional shift, and intradimensional shift. The first two concept shift tasks were described earlier. In an intradimensional shift task, the child
responds to one value of a stimulus dimension, and ignores
the other values within that same stimulus dimension. After
the shift they receive reward for selecting a different
value within the same stimulus dimension. For example, the
child received a reward for selecting the red ball and for
ignoring the black ball. After the shift they received a
reward for selecting the black ball and for ignoring the red
ball.

Dickerson (1966) found that the preschool children
learned the extradimensional shift task significantly slower
than they did the reversal and intradimensional shift tasks.
The pattern suggested that the children could use the
learning gained on the reversal task to improve their
performance more on the intradimensional task than on the
extradimensional. Using the same types of tasks, Caron
(1970) found different results with a group of 3 year-old
children. These preschool children learned the
extradimensional shift task faster than they did the
reversal shift when the irrelevant stimulus dimension was
the same within trials. These results were similar to those
reported earlier by Tighe et al., (1971) and Tighe and Tighe

From a Piagetian and hypothesis testing perspective
studies using younger children have found inconsistent
results. Results from two of the studies (Caron, 1970;
Tighe, et al., 1971; Tighe & Tighe, 1972) suggest that the
younger children shift responses better when they respond to a different stimulus dimension. The other study (Dickerson, 1966) noted that these children shifted their responses better when the solution was within the same stimulus dimension; however, Caron noted that the irrelevant stimulus dimension had to be the same in all trials, otherwise the children learned the reversal task better.

Developmentally, younger children appear to respond more inconsistently to both positive and negative feedback than do older children. The middle age group (5-7) appears to be in a transition period that involves attending to the stimuli within a single stimulus dimension among different stimulus dimensions. These children responded appropriately to feedback when the solution was within the same stimulus dimension or in a different stimulus dimension. The older group of children responded to feedback more favorably when the task required a shift within the same stimulus dimension. The results from the concept shift tasks are consistent with the results reported earlier on other types of hypothesis testing tasks.

The preceding section discussed studies that used a concept shift task to study hypothesis testing in children. Tighe, et al., (1971), Tighe and Tighe (1972) used a combination of reversal and nonreversal tasks and found that older children learned the reversal shift more easily, while younger children learned the reversal task more easily.
Using three types of shift tasks (reversal, nonreversal, and intradimensional), Caron (1970) suggested that three-year-old children learned nonreversal tasks more easily, while Dickerson's (1966) preschoolers learned reversal tasks more quickly.

The focus now shifts to studies using reversal shift tasks with children with ADHD. This research will be compared to the findings presented earlier for children without ADHD. In addition, the results from these studies will be analyzed from a hypothesis testing perspective.

Freibergs and Douglas (1969) studied the concept shift learning abilities of 65 children with hyperactivity and 99 children without learning problems. Statistical analysis of the child's level of intelligence and age were not significantly different between the two groups.

The experiment occurred in two sessions with the first session serving as a pretest. The second session followed approximately two months later. Two concept learning tasks were presented during each session: a concept identification task and a reversal shift task. Stimuli for the concept identification task were in pairs with only one containing the correct stimulus dimension. The procedures used four concepts with 150 unduplicated stimulus pairs involving two black figures of different geometric shape and two dots of different color and two object concepts consisting of flowers and birds. After the child had
correctly sorted 10 of the stimulus pairs, a reversal shift occurred. The children did not know that a reversal would occur.

The two groups of children were randomly assigned to one of three reinforcement schedules. One group received partial reinforcement (PR), the second group received continuous-immediate reinforcement (CI), and a third group received continuous-delayed reinforcement (CD). The continuous-immediate group of control and children with hyperactivity received reinforcement four seconds after every correct response. The partial reinforcement group (PR) of control and children with hyperactivity received reinforcement for every second correct response. The continuous-delayed group (CD) of children with hyperactivity and the control children received reinforcement 8 seconds after every correct response.

Freibergs and Douglas (1969) found that significantly more of the children in the normal control group reached criterion than the children with hyperactivity. In addition, the rate of reinforcement had an interesting effect. There were no significant differences between the two groups of children when they received reinforcement on a continuous basis, whether immediately or delayed; however, concept learning was significantly more difficult for both groups of children receiving partial reinforcement, with the group of children with hyperactivity having the most
difficulty. Freibergs and Douglas (1969) suggested that continuous reinforcement increased the child's orienting response to the task resulting in better and more sustained attention.

During the second session, Freibergs and Douglas (1969) used new stimuli and followed the same format described above. They obtained similar results on the second set of concept identification tasks. Differences between groups were not significant when reinforced continuously, while both groups of children continued to have difficulty when reinforced on a partial basis. These effects were especially noticeable in the children with hyperactivity. In addition, the performance of the normal children was significantly better during the second session, while the performance of the children with hyperactivity was significantly worse. These results suggest that positive transfer of learning from the first session to the second session occurred in the normal children, but not in the children with hyperactivity. The reversal shift results indicated that the hyperactive children took significantly more trials to reach criterion after the reversal shift than normal children.

Freibergs and Douglas (1969) state that they found no evidence of perseveration in the hyperactive group. After the reversal the hyperactive children discovered the new rule and changed their response; however, they also noted
that the children with hyperactivity required significantly more trials to reach criterion. This suggests that they had difficulty responding appropriately to the feedback they received. There are several possible explanations for this effect: (a) children in the partial reinforcement conditions received less feedback than the children in the continuous reinforcement groups, (b) they were not attending to the feedback they received, (c) they were responding according to a stereotypic response set, or (d) they were responding randomly.

Parry and Douglas (1983) report a follow-up study using the same concept learning task as Freibergs and Douglas (1969). The methods were similar but Parry and Douglas (1983) did not include a reversal shift. The children in this study included 33 children diagnosed with attention deficit disorder and 33 control children. Children were matched on age, WISC IQ, and socioeconomic level. There were 30 boys and 3 girls in each group with an average age of 9.6 ($\text{SD} = 2.1$) years for the children with hyperactivity and 9.5 years ($\text{SD} = 2.0$) years for the control group.

Concepts used in this study were slides of "flowers" and the number "2." This included various geometric shapes and forms. The researchers asked the children to select the picture that was correct and to state a reason for their selection. When the children reached a criterion of ten
consecutive responses or a maximum of 300 trials, they were told that they had won and were given a quarter.

The findings of Parry and Douglas (1983) support the results of Freibergs and Douglas (1969). The children with hyperactivity and the control children had no difficulty when receiving continuous reward. Both groups of children had difficulty with partial reinforcement, with the children with hyperactivity being most affected. In addition, they noted that each group (continuous and partial) received the same amount of feedback information and the significant differences remained.

Freibergs and Douglas (1969) proposed that the performance deficits in hyperactive children were the result of higher than average sensitivity to frustration. They concluded that frustration may have influenced performance in two ways: first, the frustration may have raised the child's level of arousal above an optimal level, decreasing the likelihood of task-relevant discriminations by interfering with attention; and secondly, the frustration appeared to result in the child switching strategies before reaching the criterion of 10 and abandoning their attempts to solve the problems rationally. Parry and Douglas (1983) conclude that motivational factors were responsible for the difficulties experienced by the hyperactive children.

Neither Freibergs and Douglas or Parry and Douglas, however, analyzed their data to determine if the children were
actually shifting to a different strategy, if the children were responding according to a position or stimulus preference, or if they were responding randomly. Previous research by Gholson (1980) and Levine (1975) found that children typically respond according to a strategy or stereotypic response sets. This suggests that frustration may impair the children's ability to use complex response patterns and result in them using stereotypic response sets.

In summary, research conducted by Douglas and her colleagues (Freibergs & Douglas, 1969; Parry & Douglas, 1983) suggests that continuous reinforcement increases the task orienting response, while partial reinforcement may decrease attention, due to an increase in the level of frustration. Yet, there are other possible reasons for these results. First, partial reinforcement maintains higher rates of responding than continuous reinforcement (Reynolds, 1968; Skinner, 1953). From a hypothesis testing view, continuous reinforcement may allow the child to test his or her responses more consistently and to therefore discover the correct stimulus dimension quicker. This could be necessary for the responses to be maintained if they are correct, or eliminated if incorrect. Second, both groups of children maintained the irrelevant, but inconsistently reinforced responses. This suggests that the children had difficulty responding appropriately to feedback.
From a hypothesis testing perspective, the reversal, extradimensional, and intradimensional task require the same types of hypothesis testing behaviors. The child first attends to the stimulus dimensions that are present in the problem situation. The child uses the stimulus dimensions to formulate potential hypotheses and then tests one of these hypotheses. If the response is positive, the child continues responding according to that hypothesis. Once the number of consecutive correct responses reaches a criterion level, a shift occurs in the correct dimension, and the child receives negative feedback. After negative feedback, the child returns to the set of potential hypotheses and selects a new hypothesis to test.

In summary, research using concept shift tasks reflect a developmental progression in the child’s ability to solve reversal, extradimensional, and intradimensional problems. Young children are more successful on nonreversal tasks, while older children are more successful on reversal tasks. These developmental changes are consistent with Piaget’s cognitive stage theory. Studies using children with ADHD suggest that they have more difficulty on concept shift tasks than do normal control children. Furthermore, children with ADHD had difficulty responding appropriately to feedback.

Card sorting tasks and ADHD. The next section presents a review of the research using card sorting tasks.
Researchers (Annett, 1959; Boucugnani & Jones, 1989; Chelune & Baer, 1986; Chelune et al., 1986; Chelune & Thompson, 1987; Gorenstein et al., 1989; Parry, 1973) have used card sorting tasks to evaluate the problem solving skills and hypothesis testing abilities of normal, learning disabled, and ADHD children.

Card-sorting tasks allow inferences to be made about the categories and hypotheses developed by the subject. The card-sorting task allows for an assessment of the child's ability to organize information spontaneously. Success requires skills in (a) stimulus differentiation, (b) selective attention, (c) response generation, (d) response execution, and (e) responding appropriately to feedback.

Annett (1959) used a standard card sorting task to investigate free classification abilities of children. She presented the children with line drawings of four animals, four plants, four vehicles, and four pieces of furniture and asked them to group the pictures that 'went together.' Annett (1959) found that the types of categories developed varied with age. The within-group sorting (e.g., putting animals with animals, and plants with plants) increased while between-groupings decreased with age.

The child also stated a reason for grouping each set of items together. Annett (1959) categorized the reasons into five types of verbalizations: (a) no explanation, (b) enumeration, in which the child mentioned different facts
about each object with no explanation of why the objects belonged together (e.g., dog, cat, horse), (c) continuity, in which the child related objects in a complementary fashion (e.g., 'The apple grows on the tree'; 'The butterfly settles on the flower'), (d) similarity, in which the child based the grouping on some common characteristic (e.g., 'You can ride them all'), and (e) class name, in which the subject gave a superordinate name that included all the objects in the group. Annett (1959) found that the types of reasons varied depending on the age of the child. The 5 year-old children tended to have no specific explanation for their groupings. This category of "no explanation" decreased significantly with age. Children between the ages of 6 and 8 tended to use the 'continuity' explanation. The 6 to 8 year-old children grouped items into pairs (i.e., screw and screwdriver). While children between the ages of 9 and 11 were beginning to use the 'similarity' more than the 'continuity' explanation. Annett (1959) also found that the children increased the number of items within each category and decreased the total number of categories formed as they became older. Annett concluded that as the children aged they were able to notice more stimulus dimensions in each of the drawings and that their ability to process the information improved.

More recently, Chelune and Baer (1986) used the WCST to measure the problem solving abilities and hypothesis testing
skills of normal children. The WCST was originally a measure of abstract reasoning among normal adult populations (Berg, 1948; Heaton, 1981). The WCST consists of two decks of 64 cards with four different colors, four different shapes, and one, two, three, or four objects, and four stimulus cards. The person must sort the cards according to color, form, or number of stimuli that are on the card. After 10 correct responses, a reversal occurs and one of the other stimulus dimensions becomes the correct solution. The correct dimension shifts from color to form, form to number, and number to color. The test ends after the person has correctly sorted to each stimulus dimension twice or has sorted all 128 cards. Standard testing procedures require several aspects of hypothesis testing: (a) stimulus differentiation, (b) selective attention, (c) response generation, (d) response execution, and (e) responding appropriately to feedback. In addition, this test provides information on several factors: (a) the ability of the child to discover underlying dimensions on which stimuli can be ordered, and (b) the inclination of children to group the stimuli into unique or unusual categories.

Chelune and Baer (1986) present developmental norms for the WCST. The children included 53 males and 52 females enrolled in first through sixth grade regular education classes. There were between sixteen and twenty students at each grade level. Heaton's (1981) scoring criteria were
used with one exception. Chelune and Baer (1986) defined "Failure to Maintain Set" as (a) failure to complete a category after any five consecutive correct responses had been achieved, or (b) three consecutive unambiguous correct responses before making an error.

They found that by age 9 children achieved the same number of categories as adults. In addition, by age 10 the mean number of perseverative errors and failures to maintain set were no longer significantly different from those obtained by adults.

These results can be interpreted from a hypothesis testing perspective. The number of categories achieved is comparable to the number of problems solved on the hypothesis testing task. Results on this measure suggest that as children age, they can differentiate between stimulus dimensions better, selectively attend to relevant stimulus dimensions, generate hypotheses, respond according to a consistent hypothesis, and respond appropriately to feedback.

The number of perseverative errors could be considered a measure of the child's ability to respond appropriately to negative feedback. The child should continue to respond according to one stimulus dimension when the feedback is positive and shift to another dimension when the feedback is negative. Their results suggest that as children age, they
exhibit fewer perseverative responses. In other words, they could shift their responses when feedback was negative.

Lastly, the failure to maintain set is a measure of the child's ability to respond appropriately to positive feedback. When the child is receiving positive feedback, he or she should continue using the same hypothesis. Results suggest that children between the ages of 6 and 9 are more likely to shift to another stimulus dimension when they are receiving positive feedback. By the age of 10, the children could regulate their responses according to the feedback they were receiving. In addition, these results are comparable to those found using a standard hypothesis testing task (Levine, 1975; Gholson, 1980). In summary, the results from Chelune and Baer (1986) suggest that by the age of ten, a child's scores on the WCST was comparable to the scores of normal adults.

Parry (1973) studied the performance of hyperactive and normal children on the WCST. When she (1973) employed the usual methods for scoring the WCST, she found that her hyperactive subjects made fewer correct choices, more perseverative errors, and unique responses than the control group. A more careful examination of the data revealed that one-third of the hyperactive children used only two of the three possible sorting categories (a fact that artificially inflated the perseveration scores). A second analysis, excluding those children who did not discover all three
categories, no longer yielded a significant group difference on the perseveration measure. The fact that many of the children with hyperactivity did not discover a third sorting category represents an example of the child’s failure to examine the problem situation thoroughly. Parry noted that often many of her ADHD subjects did not look carefully at the cards or pay close attention to the feedback provided. Depending on one’s definition of perseveration, the failure of some of the children to discover a third sorting category could, be evidence of perseveration, in itself since it might involve overfocusing on irrelevant stimuli.

Research by Chelune and Baer (1986) suggest that the child’s performance on the WCST improves as he or she ages; therefore, the results of Parry (1973) may be confounded due to the wide age range used (Her subjects ranged in age between 6 and 12). Chelune and Barr (1986) found that, as children aged, the number of categories achieved increased, the number of perseverative errors decreased, and the number of failures to maintain set decreased. When evaluated together, the performance of the children at either end of the age spectrum could mask the performance of the children at the other end. This confound may have decreased the observed differences between the ADHD children and the normal children. Recent research with the WCST support these conclusions.
Chelune et al. (1986) evaluated the performance of 24 children with ADHD and 24 matched normal control children on the WCST. The children in the ADD group met DSM-III criteria for ADD. In addition, parent and teacher ratings from the Conners' (1969) rating scales reflected significant ratings of hyperactivity and attentional problems. The average age in each group was 112.6 months and consisted of 17 males and 7 females.

The children in the control group achieved significantly more categories, made fewer perseverative errors, and obtained a higher percent correct than the children with ADD. Performance increased with age on categories achieved, perseverative errors, and total percent correct. Both ADD and normal children became more proficient in meeting the demands of the WCST with age. The performance levels of the older ADD group tended to parallel those of the control group two years younger. For example, the performance of the 8-9 and 10-12 year old ADD groups was comparable to the 6-7 and 8-9 year old control groups.

While not designed to be a study of reinforcement, the standard administration of the WCST requires that the person be given feedback concerning their responses. Thus, the children received either positive or negative feedback for every response. The performance of the children with ADD suggests that they were not responding appropriately to the feedback and that they had difficulty shifting their
responses to other stimulus dimensions. Chelune et al., (1986) concluded that the children with ADD were significantly impaired relative to their age-matched controls on a task requiring sustained attention, cognitive flexibility and regulation of goal-directed activity through environmental feedback.

Gorenstein et al., (1989) also evaluated the performance of children with ADHD on the WCST. The ADHD group consisted of 21 children who were disruptive enough to be placed in a special classroom for such children. Each child received a mean rating of at least 1.5 on the five items of the Inattentive-Overactive subscale of the Conners' (1969) Teacher Rating Scale. Mean age at the time of testing was 120.8 months (SD = 14.7) for the ADHD group. The control group consisted of 26 children in normal classrooms at the same school as the ADHD group. Mean age of the control group was 122.2 months (SD = 13.6). Behavioral ratings from the Conners' for the ADHD group was a mean 1.88 (SD = .34) and for the control group a mean of .63 (SD = .58).

The ADHD group completed an equal number of categories, performed an equal number of total errors but committed significantly more perseverative errors than the control group. Otherwise the results obtained in this study were similar to those found by Chelune et al. (1986).
Boucugnani and Jones (1989) compared the performance of children with ADHD to the performance of normal children on the WCST. They matched the 28 children (24 males, 4 females) with ADHD and 28 normal children according to gender and age. The ADHD children received a diagnosis of ADHD by a psychologist, physician, or psychiatrist. They also scored at or above the criteria on the Child Behavior Checklist (Achenbach & Edelbrock, 1983), the Bristol Social Adjustment Guides (Stott & Marston, 1970), and the Conners Rating Scale (Conners, 1969) Parent or Teacher edition.

They found significant differences between the ADHD and control group on the following WCST variables, categories achieved, percentage correct, perseverative responses, and perseverative errors. Children with ADHD achieved fewer categories and made more errors, perseverative responses, and perseverative errors on the WCST. There were no differences on the failure to maintain set score and no significant age or gender effects noted between the two groups.

In summary, studies using the WCST have found some consistent and some inconsistent results. The results from Boucugnani and Jones (1989), Chelune et al. (1986), Gorenstein, et al. (1989) and Parry (1973) consistently found that ADHD children made more total errors and made more perseverative errors and responses than normal control children. One inconsistency noted in the number of
categories that were achieved by the children with ADHD: Boucugnani and Jones (1989), Chelune et al. (1986), and Parry (1973) found that the ADHD children achieved fewer categories, while Gorenstein et al. (1989) found no differences on this measure.

A hypothesis testing perspective suggests that children with ADHD had difficulty differentiating between stimulus dimensions (Parry, 1973), were less able to attend to relevant stimulus dimensions (Boucugnani & Jones, 1989; Chelune et al., 1986; Gorenstein et al., 1989), and responded less appropriately to positive and negative feedback (Boucugnani & Jones, 1989; Chelune et al., 1986; Gorenstein et al., 1989; Parry, 1973). More specifically, the number of perseverative errors could be considered a measure of the child's ability to respond appropriately to negative feedback. The children should shift to another dimension when the feedback is negative. The children with ADHD were more likely to continue responding in an incorrect manner than to shift to a new stimulus dimension. Lastly, the failure to maintain set is a measure of the child's ability to respond appropriately to positive feedback. The scores on this measure suggest that the ADHD children were not more likely to change stimulus dimensions after positive feedback.

There are several possible explanations for these results: (a) the ADHD children may not have differentiated
among the three stimulus dimensions contained in the WCST (Parry, 1973), (b) they may have not been attending to the feedback, (c) given a negative feedback they did not eliminate the rejected hypothesis, (d) their responses may have consisted of a stereotypic response set described by Levine (1975) and Gholson (1980), such as stimulus preference, position preference, or position alteration. Five, the ADHD children may have returned to a previously tested and rejected hypothesis, and (e) the children may have responded randomly on each trial.

**Rationale and Conclusion**

Hypothesis testing theory suggests that there are five primary steps involved in problem solving and concept learning: (a) stimulus differentiation, (b) selective attention, (c) response generation, (d) response execution, and (e) responding appropriately to feedback. The research discussed above with the WCST suggests that children with ADHD have difficulty differentiating among stimulus dimensions, attending to relevant stimulus dimensions, developing potential responses, and responding appropriately to feedback. These problems hinder their ability to find solutions to the concept learning tasks. This occurred with concept identification tasks (Freibergs & Douglas, 1969; Parry, 1973; Parry & Douglas, 1983) and with card sorting tasks (Boucugnani & Jones, 1989; Chelune et al., 1986; Gorenstein et al., 1989; Parry, 1973).
The original purpose of the WCST was to measure the abstract reasoning abilities of normal adults (Berg, 1948; Grant & Berg, 1948). The WCST was also sensitive to frontal-lobe disorders (Milner, 1963) and useful in the study of cognitive deficits following brain injuries (Drewe, 1974; Gorenstein, 1982; Robinson, Heaton, Lehman, & Stilson, 1980). In addition, several researchers recently used the WCST to measure the concept learning abilities of children with ADHD (Boucugnani & Jones, 1989; Chelune et al., 1986; Gorenstein et al., 1989; Parry, 1973). These studies have resulted in some inconsistent results and should be further evaluated.

Until recently, there were no age level norms by which one could compare the performance of a child to other children, or of a child to adults (Chelune & Baer, 1986). Prior to Chelune and Baer, some researchers (Goldman, 1974; Golden, 1981) thought that the WCST was inappropriate for use with children. Concept learning, goal-directed activity and modulation of impulsive responding, activities assessed by the WCST and believed to be mediated by the prefrontal areas (Luria, 1980) are, however of great clinical concern to clinicians and are appropriate developmental tasks for children (Mattes, 1980; Ponitus & Ruttiger, 1976). In addition, Rosenthal and Allen (1978) conclude that it would be meaningful to examine the concept of distractibility by measuring the child’s ability to
attend to relevant information within the task context; that is, the focus of such investigations would be on the child's ability to respond selectively to a relevant stimulus dimension while inhibiting responding to the remaining stimulus dimensions of the stimulus array (p. 711).

Recent empirical studies (Chelune & Baer, 1986; Passler, Isaac, Hynd, 1985) suggest that these behaviors, presumed to be dependent on frontal lobe functioning, develop rapidly from the age of 6 years and essentially reach adult levels of mastery between the ages of 10 and 12. ADHD is often defined as a disorder of maturation. The cognitive and behavioral disabilities of the ADHD child are not seen as deviant, but as developmentally inappropriate for the child's chronological and mental age.

A hypothesis testing perspective will provide additional information concerning the developmental nature of ADHD. When analyzed from a hypothesis testing view, the WCST can provide information concerning the primary steps involved in problem solving and concept learning: (a) stimulus differentiation, (b) selective attention, (c) response generation, (d) response execution, and (e) responding appropriately to feedback. Previous research with the WCST suggests that children without ADHD tend to do significantly better than children with ADHD (Boucugnani & Jones, 1989; Chelune et al., 1986; Gorenstein et al., 1989).
In addition, Chelune et al. (1986) found that children with ADHD performed approximately two years behind children without ADHD. Research by Levine (1975) and Gholson (1980), however, suggests that children younger than ten tend to use stereotypic response styles on bivalued concept learning tasks. Together, these results suggest that the deficits observed on the WCST may be the result of normal developmental changes in concept learning.

This research blends previous research concerning hypothesis testing behaviors and children with ADHD. The present study attempts to determine if hypothesis testing theory can explain some of the deficits noted on concept learning tasks. More specifically, this research has implications in two areas: theory of ADHD and treatment.

Some researchers (Barkley, 1982, 1988a, 1988b, 1989; Douglas, 1983) suggest that the behavioral deficits represent a delay in the development of age appropriate skills. If this is correct, the children with ADHD should use less complex strategies to solve the concept learning task.

The second area involves treatment. Researchers (Gholson, 1980; Levine, 1975) show that concept learning tasks require hypothesis testing skills. The success of the child depends on the types of response patterns used and the child’s hypothesis testing behaviors. Children who use stereotypic response patterns are relatively unsuccessful.
Children who use a response strategy usually solve the problem. If ADHD children do use less efficient strategies, treatment could then focus on training the child with ADHD to use more effective hypothesis testing behaviors.

Hypotheses

Hypothesis testing theory suggests that problem solving and concept learning involves at least five aspects: (a) selective attention, (b) stimulus differentiation, (c) response generation, (d) response execution, and (e) responding appropriately to feedback. These steps may be used to generate a series of questions and hypotheses concerning the problem solving abilities of normal children and children with ADHD.

Research Question One

How do normal children and children with ADHD compare on their abilities to use these five problem solving steps? The WCST provides three overall measures of the child’s ability to use the five steps, total number of errors, total number of correct responses, and the number of categories completed. Responses also provide information concerning the types of problem solving strategies or response sets are being used by the children.

Hypothesis one-A. The children with ADHD in the verbal only condition will make significantly more total errors on the WCST than will children without ADHD in the instruction and rule condition.
**Hypothesis one-B.** There will be no significant differences between the the children with ADHD in the instruction and rule condition and children without ADHD in verbal only condition on the total errors.

**Hypothesis one-C.** The children without ADHD in the instruction and rule condition will have a significantly higher rate of correct responses on the WCST than will children with ADHD in verbal only condition.

**Hypothesis one-D.** There will be no significant differences between the the children with ADHD in the instruction and rule condition and children without ADHD in verbal only condition on the total number of correct responses on the WCST.

**Hypothesis one-E.** The children without ADHD in the instruction and rule condition will achieve a significantly higher number of categories than will children with ADHD in the verbal only condition.

**Hypothesis one-F.** There will be no significant differences between the the children with ADHD in the instruction and rule condition and children without ADHD in verbal only condition on the number of categories achieved on the WCST.

**Hypothesis one-G.** Children without ADHD in the instruction and rule condition will have a significantly lower percentage of hypothesis bias or position bias scores.
than will children without ADHD in the verbal only condition.

**Hypothesis one-H.** Children with ADHD in the instruction and rule condition will have a significantly lower percentage of hypothesis bias or position bias scores than will children with ADHD in the verbal only condition.

**Research Question Two**

Are the differences noted by previous researchers due to the ADHD children not attending to or differentiating among the stimulus dimensions?

**Hypothesis two.** A significantly higher percentage of children without ADHD will attend to and sort cards to each of the stimulus dimensions of the WCST than will children with ADHD.

**Research Question Three**

Are the differences noted by previous researchers due to the ADHD children not responding to feedback appropriately and are the ADHD children maintaining confirmed hypothesis and rejecting a disconfirmed hypothesis? The total number of perseverative errors, the total number of perseverative responses, the total number of nonperseverative errors, and the failure to maintain set provides information concerning the last two problem solving steps.

**Hypothesis three-A.** The children without ADHD in the instruction and rule condition will have significantly
fewer perseverative errors, perseverative responses, nonperseverative errors, and failure to maintain set than will children with ADHD in the verbal only condition.

Hypothesis three-B. There will be no significant differences between the children without ADHD in the verbal only condition and the children with ADHD in the instruction and rule condition on the number of perseverative errors, perseverative responses, nonperseverative errors, and failure to maintain set.

Hypothesis three-C. The percentage of trials that a confirmed hypothesis is maintained will be significantly higher for the children without ADHD in the instruction and rule condition than for the children with ADHD in the verbal only condition.

Hypothesis three-D. There will be no significant differences between the children without ADHD in the verbal only condition and for the children with ADHD in the instruction and rule condition on the percentage of trials that a confirmed hypothesis is maintained.

Hypothesis three-E. The percentage of trials that a disconfirmed hypothesis is maintained will be significantly higher for the children with ADHD in the verbal only condition than for the children without ADHD in the instruction and rule condition.

Hypothesis three-F. There will be no significant differences between the children without ADHD in the verbal
only condition and for the children with ADHD in the instruction and rule condition on the percentage of trials that a disconfirmed hypothesis is maintained.
CHAPTER II

METHOD

Subjects

Boys in this study were between the ages of 6 and 9. The 50 children in the ADHD group were recruited from children evaluated at the Kennedy Krieger Institute in Baltimore, Maryland and from support groups for parents of children with ADHD in the Baltimore area. All the children’s parents were contacted, to include those of boys evaluated at the Learning Center during the past two years and those who attended the parent support group. The parents were asked if they would be interested in participating in a study evaluating the problem solving abilities of boys with ADHD. Other criteria used to select the asked if they would be interested in children with ADHD follows the procedures used by Douglas, Barr, O’Neill, Britton (1986) and Douglas, Barr, Amin, O’Neill, Britton (1988). All boys met the DSM-III-R (APA, 1987) diagnostic criteria for ADHD. The boys with ADHD also received ratings two standard deviations at or above the mean on the Hyperactivity Index of the Revised Conners Parent Rating Scales (Goyette, Conners, & Ulrich, 1978). ADHD was the child’s primary DSM-III-R diagnosis.
Psychologists and pediatricians not associated with the study diagnosed each boy before their inclusion in the study. Nine of the boys in the ADHD group met the diagnostic criteria for other DSM-III-R disorders besides ADHD. One child met the criteria for Oppositional Defiant Disorder, two met the criteria for developmental motor disorders, and the remaining six met the criteria for a learning disability. The criteria for both reading and written language were met by two children. One child met the criteria for both reading and math, and three children for written language. None of the boys were in classes for the emotionally disturbed. Interviews with the mothers ruled out children with symptoms of mental retardation or psychosis and those with serious visual or auditory deficits.

Children being prescribed medications were also included in the ADHD group due to two factors: the first factor resulted from difficulties locating children who were not prescribed medications, the second was that parents did not want to stop medications even for a short period of time. Methylphenidate was prescribed to 29 of the boys, sustained release methylphenidate to one, and dexedrine to one. Parents gave the normal dosages to six of the children before testing. The remaining children had not received their medications before testing, while the other nineteen
boys had never taken medications or they were not currently treated with medications.

The control group of 50 boys without ADHD was recruited in two ways. Parents of the children in the ADHD group received letters describing the study (Appendix B). They gave the letters to their friends who had children within this age group requesting that the parents contact the researchers if they were interested in participating in a study. The remaining children were recruited through friends and colleagues who gave the letters to parents they knew. Children in this group did not meet the DSM-III-R criteria for ADHD. In addition, they scored within one standard deviation of the mean on the Hyperactivity Index of the Revised Conners Parent Rating Scales (Goyette et al., 1978). All families provided written informed consent after a thorough explanation of the procedures (see Appendix C). Approval for conducting the research was obtained from the necessary review boards prior to the initiation of the study.

The Vocabulary subtest of the Wechsler Intelligence Scale for Children-Revised [WISC-R] (Wechsler, 1974) provides a high correlation with overall IQ. This measure estimated the cognitive functioning of children in the ADHD and normal control groups. IQ measures controlled for the differences between groups on intellectual functioning and
to show that any significant differences were not the result of IQ.

**General Procedure**

The children in the normal control group and in the ADHD group were randomly assigned to one of two pretraining conditions resulting in four groups of twenty-five children each. Children in the four groups were exposed to preliminary instructions and pretraining that had five problems. A preliminary instruction and pretraining period introduced the three quad-valued dimensions and the potential hypotheses. Pretraining tasks preceded the administration of the WCST, after which the WCST was administered according to standard procedures to all four groups to assess the effects of training.

**Pretraining problems.** A general pretraining procedure was adapted from the methods developed by Phillips (1976) and Phillips and Levine (1975). Pretraining problems consisted of a series of five concept learning tasks. The first three problems involved sorting a series of twenty-four cards. The remaining two problems were a series of ten cards. A correct response involved sorting the response card to the appropriate stimulus card. Feedback always followed immediately after the child sorted the stimulus card to the stack. The pretraining problems involved the same stimulus dimensions used on the WCST, but were not the same colors or shapes. Solutions to the pretraining
problems were number, color or form, with sequence of solutions being random for each group. After the twelfth or twenty-fourth trial of the first three and the tenth trial of the last two pretraining problems, the children were asked if they had "figured out what is always correct," and to state the solution. If they were unable to do so, they received a hint about the solution dimension. For example, "try one of the colors, see if one of them is always correct," and the problem was continued or presented again. A solution was requested again on the appropriate trial. If they were still unable to state the solution, the child received the answer. For example, "the answer to this puzzle is color, see if you can select the colors," and the problem was presented again. The children received no additional hints or help. If the child stated a multiple or conjunctive hypotheses, they were reminded that the answer could only be one dimension. To continue beyond pretraining, a criterion of 10 consecutive correct sorts was required in the first three problems and five consecutive correct sorts in problems four and five.

**Pretraining feedback procedures.** Due to the attentional differences displayed by children with ADHD, variations in feedback-delivery procedures were used to produce changes in performance on the WCST (Tumblin & Gholson, 1980). Feedback was of two types: (a) "instruction and rule" condition and (b) "verbal only" condition.
The instruction and rule condition involved the following: (a) instruction feedback: "Correct. The answer is in that stimulus card."; or "Wrong. The answer is in one of the other stimulus cards."; (b) rule feedback: "Correct. The answer is in that stimulus card."; or "Wrong, I want you to think to yourself that 'wrong means the answer is not in the stimulus card I picked, so wrong means I have to look at the other stimulus cards.'"

During problems 1 and 2, choices on every trial were responded to with either "correct" or "wrong." Following the second problem, but before the presentation of the third, they were told, "There is something I would like you to remember about how to play this game. Whenever you place the card and I tell you 'wrong,' I want you to think to yourself that 'wrong means the answer is not in the stimulus stack I chose. So, wrong means I have to look at the other stimulus cards.' OK? So remember, whenever you hear 'wrong,' just think 'wrong means look at the other stimulus cards.'" On pretraining problem three, instructional feedback occurred on Trials 5, 6, 11-13, 17-19, and 23. On Trials 1-4, 7-10, 14-16, 20-22, and 24 the children were told that "wrong means look at the other stimulus cards," or "after awhile I am not going to remind you any more, so I want you to try really hard now and remember that 'wrong means I have to look at the other stimulus cards.'" In pretraining problem four, instructional feedback occurred on
Trials 4, 8, and 9 and rule provision was provided on Trails 1-3, 5-7, and 10. During the fifth problem, the children received verbal-only feedback on all 10 trials.

(b) Verbal only condition. The children in this condition were told "right" or "wrong" after each card sort.

Materials

Pretraining problems. A series of pretraining problems similar in format to the WCST were developed. Twenty-four response cards and four stimulus cards were made. The stimulus cards and response cards contained between one and four objects. Each card had one of the five colors and one of the five shapes. The sequence of the response cards conformed to Levine's (1966) orthogonality criterion. Any three consecutive trails within a problem logically specified the solution. In addition, no one stimulus cue alternated or occurred for more than two consecutive trials.

Wisconsin Card Sorting Test. The WCST (Berg, 1948; Grant & Berg, 1948; Heaton, 1981) consists of 4 stimulus cards and two groups of 64 response cards. The stimulus cards are: first, one red triangle; second, two green stars; third, three yellow crosses; and fourth, four blue circles. The four stimulus cards are placed in front of the person from left to right in the order named. The person was given the pack of response cards and told, "I want you to put these cards into four groups, underneath the ones lying on
the table. I will tell you whether you are 'right' or 'wrong'."

Previous research has shown that patients with prefrontal lesions commit more perseverative errors than patients with nonfrontal lesions and normal controls (Drewe, 1974; Milner, 1963; Robinson et al., 1980). Research with antisocial psychiatric patients (Gorenstein, 1982), and alcoholics (Gorenstein, 1987; Jenkins & Parsons, 1980) suggests that they also made more perseverative errors. Boucugnani and Jones (1989), Chelune et al. (1986), Gorenstein et al. (1989) found that children with a diagnosis of ADHD also made more perseverative errors than controls.

The following scores were obtained from the WCST: (a) number of errors, (b) number of correct responses, (c) number of categories completed, (d) number of perseverative errors, (e) number of perseverative responses, (f) number of nonperseverative errors, and lastly, (g) failure to maintain set. Heaton's (1986) scoring procedures were used for all measures with one exception. Chelune's (1986) procedures were used to score the failure to maintain set. To receive a score on this measure, the child failed to complete a category after any five consecutive correct responses had occurred or made three consecutive unambiguous correct responses before making an error.
In addition, four dependent measures were derived from the individual responses on the WCST. The first measure was the percentage of children in each group that sorted cards according the three stimulus dimensions. This was to discover if the boys attended to and differentiated among the stimulus dimensions.

The second and third dependent measures involved the response strategies and stereotypic response sets used by the children. Responses can be classified according to strategy set, stereotypic sets and random responses. Data for the response set information was derived from the sequence of card sorting. This information was analyzed from two perspectives: the position or location that the cards were sorted to and the stimulus dimensions that the cards were sorted to (such as color, form, number or random).

The position bias scores were derived in the following manner. In an ideal situation, a person would sort cards to the following positions fourteen times to 1, nineteen times to 2, fourteen times to 3, and Lastly, thirteen times to 4. These numbers were subtracted from the number of times that each person sorted to each position. These position difference scores were summed for each person, group and condition.

The use of the different hypotheses was evaluated in the same manner, with one exception. The most efficient way
of solving the WCST is to sort the minimum number of cards to each stimulus dimension and then to anticipate the switch from one dimension to the new dimension with the best score possible being 60; therefore, the minimum number of cards necessary for each category is twenty. This number was subtracted from the number of times that the child sorted to each stimulus dimension. These hypothesis difference scores were summed for each person, group and condition.

The final derived measure evaluated the effects of feedback. The two measures were: (a) the percentage of trails that a confirmed hypothesis was rejected and (b) the percentage of trials that a disconfirmed hypothesis was maintained. These scores were obtained in the following manner. The individual response patterns were analyzed to find the percentage of trials that the boys maintained or rejected a correct hypothesis and the percentage of trials that the boys rejected or maintained an incorrect hypothesis. The sequence of correct responses was analyzed to see if responses that received positive feedback were followed by the same stimulus dimension or a different stimulus dimension. Similarly, the sequence of incorrect responses was evaluated to determine if responses that received negative feedback were followed by a different stimulus dimension or the same stimulus dimension.

All statistical analyses were generated using the SAS Version 6.03 (1988) statistical package. Levels of
significance for all analyses was alpha = .05. Demographic information and data from the WCST were analyzed using one-way analysis of variance procedures.
CHAPTER III

RESULTS

Data analyses were completed in four steps. Analysis of variance procedures were used in all data analyses, with one exception. Ratings from the Revised Conners Parent Rating Scales were compared using the $t$ statistic. The first step involved the analysis of the demographic information about each child. The next three levels of analyses were based on the research questions and the hypotheses concerning the problem solving abilities of normal children and children with ADHD.

Subject Variables

Several demographic variables were obtained from each child. The measures were age, father’s and mother’s education, and an estimate of the child’s level of intelligence (see Table 1). The mean age of the normal children was $7.754 \ (SD = 0.09)$ and $8.132 \ (SD = 0.89)$ for the children in the ADHD group. The overall two-way analysis of variance was not significant. $F(1, 96) = 3.023, p = 0.085$. The analysis suggests that there were no differences between the two groups on age.

The mean years of education for the fathers of the normal boys were $13.74$ years and $13.1$ years for the fathers of the boys with ADHD. $F(1, 96) = 1.898, p = 0.172$. While
the mean years of education for the mothers of the boys with
ADHD were 13.18 years and 13.22 years for the mothers of the
normal boys. F(1, 96) = 0.008, p = 0.930. The overall two-
way analyses of variance was not significant, with the
results suggesting that there were no significant
differences in the number of years of parent education.

Table 1

Demographic Information for ADHD and Control Groups Mean and
Standard Deviations

<table>
<thead>
<tr>
<th>Demographic Information</th>
<th>ADHD Verbal</th>
<th>ADHD Ins/Rul</th>
<th>Normal Verbal</th>
<th>Normal Ins/Rul</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>M</td>
<td>8.112</td>
<td>8.152</td>
<td>7.866</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.979</td>
<td>0.838</td>
<td>1.353</td>
</tr>
<tr>
<td>Father Education</td>
<td>M</td>
<td>12.720</td>
<td>13.480</td>
<td>13.880</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>2.112</td>
<td>2.616</td>
<td>2.587</td>
</tr>
<tr>
<td>Mother Education</td>
<td>M</td>
<td>13.240</td>
<td>13.120</td>
<td>13.880</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>2.919</td>
<td>2.616</td>
<td>2.023</td>
</tr>
<tr>
<td>IQ</td>
<td>M</td>
<td>10.950</td>
<td>11.000</td>
<td>11.040</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>1.947</td>
<td>2.273</td>
<td>2.189</td>
</tr>
</tbody>
</table>

* Ins/Rul = Instruction and Rule condition

The last demographic variable of concern was the
estimated level of intelligence. The average vocabulary
subtest score for the children without ADHD was 11 with a
standard deviation of 2. Scores ranged between 8 for a low
and 18 for a maximum. Scores for the boys with ADHD were a
mean of 10 (SD = 2). The range was between 7 and 15. The overall analysis of variance was not significant. $F(1, 96) = 1.860, p = 0.175$. The results suggest that there were no significant differences between the children with ADHD and the normal children on age, father’s education, mother’s education, or the child’s level of intelligence; therefore, there was no need to include these variables as covariates in future analyses. All remaining statistical analyses used the analysis of variance procedures.

Ratings on the Hyperactivity Index of the Revised Conners Parent Rating Scales indicated that the children were significantly different on this factor. The mean score on the Hyperactivity Index for the boys with ADHD was 2.02 with a standard deviation of 0.38. Scores ranged between 1.5 and 2.9, with the mean score for the boys without ADHD being .51 having a standard deviation of 0.29. Scores ranged between a low of 0 and 1.1. Mean scores for the two groups were compared using the t statistic, $t = 21.9, p < .005$) Results from the other Conners factors are reported in Tables 6 and 7 in Appendix E.

**Research Question One**

The research questions provided the framework for the remaining levels of statistical analyses. The first question concerned the ability of the children without ADHD and with ADHD to use the five problem solving steps. The WCST provided three overall measures of the child’s ability
to use the five steps, total number of errors, total number of correct responses, and the number of categories completed. Their responses also provide information concerning the types of problem solving strategies or response sets used by the children.

Each of the WCST measures were submitted to statistical analysis. All analyses included group (non-ADHD vs. ADHD) and level of feedback (verbal only vs. instruction and rule) as independent variables. Table 2 contains the means and standard deviations for the WCST measures.

Table 2

<table>
<thead>
<tr>
<th>WCST Measures of Problem Solving Means and Standard Deviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measure</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Errors</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Correct</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Category</td>
</tr>
<tr>
<td>Achieved</td>
</tr>
</tbody>
</table>

\(^a\) In/Ru = Instruction and Rule condition

**Hypothesis one-A.** Hypothesis one-A, which stated the children with ADHD in the verbal only condition would make significantly more total errors on the WCST than would
children without ADHD in the instruction and rule condition, was rejected (see Table 2). F statistics are reported in Table 8 (Appendix E). The analysis found that both groups made a similar number of total errors.

**Hypothesis one-B.** Hypothesis one-B, which stated there would be no significant differences between the children with ADHD in the instruction and rule condition and children without ADHD in verbal only condition on the total errors, was accepted (see Table 2). F statistics are reported in Table 8 (Appendix E). The analysis indicated that both groups made an equal number of errors.

**Hypothesis one-C.** Hypothesis one-C, which stated the children without ADHD in the instruction and rule condition would have a significantly higher rate of correct responses on the WCST than will children with ADHD in verbal only condition, was rejected (see Table 2). F statistics are reported in Table 9 (Appendix E). The analysis found that children made a similar number of correct responses.

**Hypothesis one-D.** Hypothesis one-D, which stated that there would be no significant differences between the children with ADHD in the instruction and rule condition and children without ADHD in verbal only condition on the total number of correct responses on the WCST, was accepted (see Table 2). F statistics are reported in Table 9 (Appendix E). The analysis found that the children made a similar number of correct responses.
Hypothesis one-E. Hypothesis one-E, which stated that children without ADHD in the instruction and rule condition would achieve a significantly higher number of categories than would children with ADHD in the verbal only condition, was accepted (see Table 2). F statistics are reported in Table 10 (Appendix E). The analysis found that children in both conditions completed a comparable number of categories.

Hypothesis one-F. Hypothesis one-F, which stated that there would be no significant differences between the the children with ADHD in the instruction and rule condition and children without ADHD in verbal only condition on the number of categories achieved on the WCST, was accepted (see Table 2). F statistics are reported in Table 10 (Appendix E). The analysis found that children in both groups completed a similar number categories.

Hypothesis one-G. Hypothesis one-G, which stated that children without ADHD in the instruction and rule condition would have a significantly lower percentage of hypothesis bias or position bias scores than would children without ADHD in the verbal only condition, was accepted. Table 3 presents the means and standard deviations for the position and hypothesis bias scores.

The analysis of variance for the position bias score was not significant (see Table 11, Appendix E); however, there was a trend in the scores ($F = 3.392, p = 0.069$). While the analysis of the hypothesis bias scores was
significant \( F = 4.164, p = .044 \) An inspection of the means suggests that the children without ADHD in the instruction and rule condition were less likely to respond according to a position or hypothesis bias than were children without ADHD in the verbal only condition (see Table 12, Appendix E).

Table 3

**Position and Hypothesis Difference Scores Means and Standard Deviations**

<table>
<thead>
<tr>
<th>Measure</th>
<th>ADHD Verbal</th>
<th>ADHD Ins/Rul$^a$</th>
<th>Normal Verbal</th>
<th>Normal Ins/Rul$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypoth</td>
<td>M</td>
<td>46.625</td>
<td>36.961</td>
<td>35.208</td>
</tr>
<tr>
<td>Ideal$^b$</td>
<td>SD</td>
<td>20.064</td>
<td>20.323</td>
<td>19.805</td>
</tr>
<tr>
<td>Position</td>
<td>M</td>
<td>49.20</td>
<td>38.384</td>
<td>37.541</td>
</tr>
<tr>
<td>Ideal$^b$</td>
<td>SD</td>
<td>20.890</td>
<td>21.401</td>
<td>21.075</td>
</tr>
</tbody>
</table>

$^a$ Ins/Rul = Instruction and Rule condition.

$^b$ Hypoth Ideal = Hypothesis ideal.

**Hypothesis one-H.** Hypothesis one-H, which stated that children with ADHD in the instruction and rule condition would have a significantly lower percentage of hypothesis bias or position bias scores than would children with ADHD in the verbal only condition, was accepted. Table 3 presents the means and standard deviations for the position and hypothesis bias scores. The analysis of variance found no significant differences on the position difference scores.
between the two groups of ADHD children (see Table 11, Appendix E); however, there was a trend in the scores ($F = 3.392, p = 0.069$): the analysis of the means and standard deviations for the hypothesis difference scores found a significant condition effect (see Table 12, Appendix C). Boys with ADHD in the instruction and rule condition were less likely to respond according to a particular stimulus dimension than children in the verbal only condition ($F = 4.164, p = 0.044$). Furthermore, the scores for the two groups children were compared. The analysis indicated that children without ADHD were significantly less likely to respond according to a particular stimulus dimension than were children with ADHD ($F = 4.820, p = 0.031$).

**Research Question Two**

The second research question evaluated the children's ability to attend to and discriminate among the stimulus dimensions on the WCST.

**Hypothesis two.** Hypothesis two, which stated that a significantly higher percentage of children without ADHD would attend to and sort cards to each of the stimulus dimensions of the WCST than will children with ADHD, was rejected. The analysis of the responses found that 100 percent of the boys with ADHD sorted according to the three stimulus dimensions. This compares to 98 percent for the boys without ADHD. One boy without ADHD in the verbal only
condition failed to sort any cards to the number dimension.

Research Question Three

The last stage of analysis concerned research question three. The ability of the children to respond appropriately to feedback was compared. Four variables from the WCST measure the child’s ability to respond to feedback were analyzed first. The WCST measures were number of perseverative errors, number of perseverative responses, number of nonperseverative errors, and failure to maintain set. Scores for rejecting or maintaining a hypothesis that received positive feedback, along with scores for maintaining or rejecting a hypothesis that received negative feedback were also analyzed.

**Hypothesis three-A.** Hypothesis three-A, which stated that the children without ADHD in the instruction and rule condition would have significantly fewer perseverative errors, perseverative responses, nonperseverative errors, and failure to maintain set than would children with ADHD in the verbal only condition, was rejected. The means and standard deviations for each of the variables are found in Table 4. F statistics are reported in Tables 13 through 16 (Appendix E). The analyses of these variables suggest that children in both conditions responded appropriately to feedback.

**Hypothesis three-B.** Hypothesis three-B, which stated that there would be no significant differences between
children without ADHD in the verbal only condition and children with ADHD in the instruction and rule condition on the number of perseverative errors, perseverative responses, nonperseverative errors, and failure to maintain set, was accepted. The means and standard deviations for each of the variables are presented in Table 4. F statistics are reported in Tables 13 through 16 (Appendix E).

Hypothesis three-C. Hypothesis three-C, which stated that the percentage of trials that a confirmed hypothesis is maintained would be significantly higher for children without ADHD in the instruction and rule condition than for children with ADHD in the verbal only condition, was rejected. Means and standard deviations for responding to positive feedback are presented in Table 5. F statistics are reported in Tables 17 and 18 (Appendix E). The analyses suggest that children in both groups maintained hypotheses that received positive feedback.

Hypothesis three-D. Hypothesis three-D, which stated that there would be no significant differences between the children without ADHD in the verbal only condition and for the children with ADHD in the instruction and rule condition on the percentage of trials that a confirmed hypothesis was maintained, was accepted. Means and standard deviations for responding to positive feedback are presented in Table 4. F statistics are reported in Tables 17 and 18 (Appendix E).
The findings suggest that both groups of children maintained hypotheses that received positive feedback.

Hypothesis three-E. Hypothesis three-E, which stated that the percentage of trials that a disconfirmed hypothesis was maintained would be significantly higher for children with ADHD in the verbal only condition than for children without ADHD in the instruction and rule condition, was rejected. Means and standard deviations for responding to positive feedback are presented in Table 5. F statistics are reported in Tables 17 and 18 (Appendix E).

Hypothesis three-F. Hypothesis three-F, which stated that there would be no significant differences between children without ADHD in the verbal only condition and for children with ADHD in the instruction and rule condition on the percentage of trials that a disconfirmed hypothesis was maintained, was accepted. An analysis of the means and standard deviations suggest that children in both conditions rejected hypotheses that received negative feedback (see Table 5).

Further analysis of the means revealed condition differences on rejecting an incorrect hypothesis (F (1,96) = 6.832, p = .010). The findings suggest that boys in the verbal only condition were more likely to maintain an incorrect hypothesis on subsequent trials. F statistics are reported in Tables 19 and 20 (Appendix E).
Table 4

WCST Measures of Responding to Feedback Means and Standard Deviations

<table>
<thead>
<tr>
<th>Measure</th>
<th>ADHD Verbal</th>
<th>ADHD Ins/Rul</th>
<th>Normal Verbal</th>
<th>Normal Ins/Rul</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persev Errors</td>
<td>M</td>
<td>22.080</td>
<td>18.840</td>
<td>17.840</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>12.193</td>
<td>12.263</td>
<td>16.926</td>
</tr>
<tr>
<td>Persev Response</td>
<td>M</td>
<td>22.080</td>
<td>18.840</td>
<td>17.840</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>12.193</td>
<td>12.263</td>
<td>16.926</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>13.301</td>
<td>8.131</td>
<td>8.107</td>
</tr>
<tr>
<td>Fail to Main Set</td>
<td>M</td>
<td>0.960</td>
<td>0.480</td>
<td>0.600</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>1.172</td>
<td>0.963</td>
<td>1.118</td>
</tr>
</tbody>
</table>

Ins/Rul = Instruction and Rule condition.

Persev Errors = Perseverative errors.

Persev Response = Perseverative Response.

NonPer Errors = Nonperseverative Errors.

Fail to Main Set = Failure to maintain set.
Table 5

Correct Hypotheses Maintained and Rejected Wrong Hypotheses

Maintained and Rejected Means and Standard Deviations

<table>
<thead>
<tr>
<th></th>
<th>ADHD Verbal</th>
<th>ADHD Ins/rul&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Normal Verbal</th>
<th>Normal Ins/rul&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>CorHyp Maint&lt;sup&gt;b&lt;/sup&gt;</td>
<td>M</td>
<td>73.600</td>
<td>69.240</td>
<td>69.880</td>
</tr>
<tr>
<td>Maint&lt;sup&gt;c&lt;/sup&gt;</td>
<td>SD</td>
<td>12.823</td>
<td>8.496</td>
<td>11.293</td>
</tr>
<tr>
<td>CorHyp Reject&lt;sup&gt;d&lt;/sup&gt;</td>
<td>M</td>
<td>36.320</td>
<td>28.360</td>
<td>27.240</td>
</tr>
<tr>
<td>WrongHyp SD</td>
<td>20.676</td>
<td>19.380</td>
<td>20.563</td>
<td>15.227</td>
</tr>
<tr>
<td>WrongHyp M</td>
<td>23.800</td>
<td>18.840</td>
<td>26.360</td>
<td>14.000</td>
</tr>
<tr>
<td>WrongHyp M</td>
<td>81.120</td>
<td>75.240</td>
<td>75.400</td>
<td>77.080</td>
</tr>
<tr>
<td>Reject&lt;sup&gt;e&lt;/sup&gt;</td>
<td>SD</td>
<td>14.093</td>
<td>13.071</td>
<td>18.097</td>
</tr>
</tbody>
</table>

<sup>a</sup> Ins/Rul = Instruction and Rule condition.

<sup>b</sup> CorHyp Maint = Correct hypothesis maintained.

<sup>c</sup> CorHyp Reject = Correct hypothesis rejected.

<sup>d</sup> WrongHyp Maint = Wrong hypothesis maintained.

<sup>e</sup> WrongHyp Rejected = Wrong hypothesis rejected.
The purpose of this research was to present an overview of the Attention-deficit Hyperactivity Disorder literature with a specific focus on studies that evaluated the hypothesis testing abilities of children with ADHD on a concept learning task. Hypothesis testing theory suggests that problem solving and concept learning requires at least five steps: (a) selective attention, (b) stimulus differentiation, (c) response generation, (d) response execution, and (e) responding appropriately to feedback. These steps were used to generate a series of questions and hypotheses concerning the problem solving abilities of normal children and children with ADHD.

Hypotheses and Research Questions

The first question evaluates the use of the five problem solving steps by the normal children and children with ADHD. The WCST provides three measures of the child's ability to use the five steps, number of errors, number of correct responses, and the number of categories completed.

The results from the WCST in this study contrast to those of other researchers (Boucugnani & Jones, 1989; Chelune and Baer, 1986; Chelune et al., 1986; Chelune & Thompson, 1987; Parry, 1973) and are consistent with the
findings of Loge, Staton, and Beatty (1990), Fischer, Barkley, Edelbrock, and Smallish (1990), Gorenstein et al., (1989), and Peoples (1989). Parry (1973) found that the hyperactive children in her study made more errors than the children without hyperactivity. Chelune et al. (1986) reported similar results. In their study, the children with ADHD made significantly more errors than the children in the control group. Furthermore, the children in their control group achieved more categories than did the children with ADHD.

On the other hand, Gorenstein et al. (1989) reported that the children in the ADHD group completed as many categories and total errors as their control group. Loge et al. (1990) reported the same general findings. Loge et al. found no differences between their children with ADHD and the children without ADHD. Similarly, Fischer et al. (1990) found no differences in the number of categories or total errors in their study of ADHD adolescents. Possible reasons for the differences in findings will be presented after the other WCST variables are discussed.

The last aspect of concern in this section is the problem solving strategies and response sets used by the children. No previous studies reported the types of problem-solving strategies or response sets used by children on the WCST. The present study found that the performance of normal children improved after they learned a problem
solving strategy. The children in the instruction and rule condition learned to not perseverate on a particular stimulus dimension. The current study suggests that the children with ADHD were significantly more likely to respond according to a particular stimulus dimension than were children without ADHD; however, children with ADHD in the instruction and rule condition learned to not respond according to a stimulus preference or position preference.

The findings from this study are consistent with those reported by Parrill-Burnstein (1978) and Parrill-Burnstein (1979, cited by Gholsen, 1980), and Parrill-Burnstein and Baker-Ward (1979) using normal and children with learning disabilities. Results from previous studies and the current study suggest that children can learn to overcome developmental tendencies and focus on one particular stimulus dimension or position; however, given the scores on the other WCST measures, the tendency to respond according to a position or hypothesis bias did not significantly impair the performance of the children with ADHD or children in the verbal only condition. The tendency to respond according to a particular stimulus dimension or position is therefore, not very strong in the present group of children with ADHD.

The second area of concern was whether some of the differences noted by researchers in the past were due to the children with ADHD not attending to or differentiating among
the stimulus dimensions. None of the previous studies specifically report whether the children attended to and differentiated among the stimulus dimensions. Results from previous studies, however provide information for comparison. Parry (1973) reported that one-third of her subjects did not notice or sort to one stimulus dimension. Freibergs and Douglas (1969) suggested that their hyperactive children had no difficulty attending to the different stimulus values. Parry and Douglas (1983) also used a variety of different concepts in their study of feedback and reinforcement. They found that their hyperactive children were equally able to sort to different concepts. Taken together, the results from these studies and the current study suggest that ADHD children did not have more difficulty attending to and differentiating among the stimulus dimensions; therefore, the deficits noted on previous studies using the WCST may not be the result of the children with ADHD not attending to or differentiating among the stimulus dimensions.

Measures discussed thus far correspond to four of the five problem solving steps as described by hypothesis testing theory. The children with ADHD in this study had no difficulty with (a) selective attention, (b) stimulus differentiation, (c) response generation, and lastly, (d) response execution. The focus now shifts to the last step of problem solving, responding appropriately to feedback.
The last question concerned the ability of the children with ADHD and the children without ADHD to respond appropriately to feedback. When completing the WCST, two types of responses are appropriate. If the feedback is positive, then the same hypothesis should be maintained. If the feedback is negative, then another hypotheses should be attempted. The WCST has four measures that reflect the persons' ability to respond to feedback including number of perseverative errors, number of perseverative responses, number of nonperseverative errors, and failure to maintain set. A second source of information concerning feedback is the child's ability to respond to positive feedback and to negative feedback.

Several researchers reported results consistent with the findings of the present study. A dissertation by Peoples (1989) found no differences between a group of children with ADHD and a matched group of children without ADHD on perseverative errors or failure to maintain set. Fischer et al. (1990) found no differences between their group of children with ADHD and their control children on the number of perseverative responses, perseverative errors, nonperseverative errors, or failure to maintain set. Loge et al. (1990) reported the same general findings. These results contrast with the findings Boucugnani and Jones (1989), Chelune et al., (1986), Gorenstein et al., (1989). Chelune et al. (1986) reported that children with ADHD made
significantly more perseverative errors and failed to maintain set more than did the children in the control group. Similarly, Boucugnani and Jones (1989) found that their group of children with ADHD made significantly more perseverative responses and perseverative errors than the group of children without ADHD.

As reflected in the above analysis, research findings are inconsistent using the WCST. There are several possible explanations for these differences. One possible difference among the studies is the severity of the hyperactive symptoms. Most of the studies used the Revised Conners’ Parent Rating Scales or the Revised Conners’ Teacher Rating Scales to assess hyperactive symptoms. A comparison of the scores from the Conners’ scales suggests that the scores were within the same range. This analysis suggests that the differences are not due to the level of severity of the hyperactive symptoms.

Another factor may have influenced the performance of the children on the WCST. In their review, Shaywitz and Shaywitz (1988) suggest that the performance of children with ADHD improves when tasks are more salient or challenging and less boring, when consistent feedback is provided, and when the child sets the pace of the task. The administration of the WCST requires that the child is given feedback after each card and the child determines how quickly he or she sorts the cards; however, Chelune and Baer
(1986) suggest that as the test progresses, children tend to become bored and may pay less attention. The resulting boredom and decreased attention would possibly result in more errors. The salience of the task or the child's motivation was possibly increased in the present study by the promise of a reward when finished.

Another explanation is that children with ADHD do not reliably have deficits in the areas measured by the WCST. For example, the ability to develop concepts or ideas as measured by the number of categories achieved may not be problematic for children with normal levels of intelligence. Additionally, the failure to maintain set or perseverative error scores may not be sensitive enough to measure these behaviors in children with ADHD.

Another factor is that both groups of children in this study tended to score better than the 6 to 12 year-old children in the norms reported by Chelune and Baer (1986). These discrepancies may be due to sample differences, but may also reflect developmental differences among 6 to 9 year-old children. Until additional normative studies are completed, the exact explanations will not be known.

The last area of concern is the child's ability to respond to positive and negative feedback. Previous studies report the score for failure to maintain set as measure of responding to feedback. The present study divided the feedback into two categories: the child's response to
positive and negative feedback. Results from the present study suggest that neither group of children had problems responding to positive feedback. This would suggest that they used the positive feedback information in an appropriate manner.

The problem solving task also requires the person to respond appropriately to negative feedback. The present study found that children who received the additional feedback during training were less likely to maintain a hypothesis that received negative feedback. This suggests that the children in the verbal only condition did not search for a new hypothesis as quickly as their peers in the instruction and rule condition. This type of response style is efficient, as more trials are necessary to solve the problem. Reasons for the tendency to maintain an incorrect response may be related to perseverative tendencies noted by other researchers. Another possible explanation is that children with ADHD become accustomed to receiving negative feedback from parents and teachers; therefore, they fail to change their behavior or response style when they receive negative feedback.

Implications

The results from the present study have implications for clinicians, parents and teachers. The current study found no major differences in the types of strategies that the children with ADHD used to solve concept learning tasks;
however, there was a tendency for the children with ADHD to respond in a stereotypical response style. This did not translate into significantly more perseverative responses as measured by the WCST, but suggests that children with ADHD may respond to a problem solving situation in an idiosyncratic manner. Children with ADHD may require additional time or attempts to complete an activity; therefore, parents and teachers need to remember that children with ADHD may need additional information or feedback to successfully complete an activity.

A second implication of the present research involves the child’s ability to respond appropriately to negative feedback. Children in the verbal only condition learned to respond to negative feedback in a less appropriate manner. The results of this study suggest that children can learn to effectively use problem solving strategies. After training, the children were better able to respond to negative feedback; therefore, one aspect of education or treatment could focus on training children to respond appropriately to feedback, but specifically negative feedback.

Summary

To summarize the discussion of the hypotheses, the results of this study seem to suggest that children with ADHD do not have more deficits in problem solving as measured by the WSCT than do children without ADHD. Both groups of children responded appropriately to feedback and noticed and
utilized different stimulus dimensions. Thus, the major WCST measures were nonsignificant. There was a tendency for the children with ADHD to respond according to position or a specific hypothesis. Similarly, children in the verbal only condition tended to respond to feedback less appropriately than did children in the instruction and rule condition. These tendencies, however, did not appear to hinder performance as measured by the WCST.

Limitations

The present research has limitations which should be considered in future research. The first limitation of this research is that the group of children with ADHD included boys who met the criteria for other DSM-III-R disorders. A second factor was the inclusion of children taking medications. A third limitation is the lack of adequate WCST norms for normal children and for children with ADHD. A fourth and final limitation is that all children in the ADHD group were not diagnosed by the same pediatricians and psychologists. As a result, variations in diagnostic interpretation may have resulted in the inclusion of children who did not actually meet the necessary criteria.

Future Studies

The present study found few differences between children with ADHD and children without ADHD on a concept learning task. It is presently unknown whether differences would be found in other types of problem solving. One
possible area of interest is that of social skills, as the same types of problem solving abilities are necessary for the development of social skills. Barkley (1989) Douglas (1983) and Henker and Whalen (1989) suggest that social skills deficits are critical in the long development of children with ADHD; therefore, research could focus on identifying the problem solving steps that present difficulty to the child with ADHD and then train more appropriate social skills strategies.
APPENDIX A

DSM-III-R CRITERIA

ATTENTION-DEFICIT HYPERACTIVITY DISORDER
DSM-III-R CRITERIA

ATTENTION-DEFICIT HYPERACTIVITY DISORDER*

Note: Consider a criterion met only if the behavior is considerably more frequent than that of most people of the same mental age.

A. A disturbance of at least six months during which at least eight of the following are present:

(1) often fidgets with hands or feet or squirms in seat (in adolescents, may be limited to subjective feelings of restlessness)

(2) has difficulty remaining seated when required to do so

(3) is easily distracted by extraneous stimuli

(4) has difficulty awaiting turn in game or group situations

(5) often blurts out answers to questions before they have been completed

(6) has difficulty following through on instructions from others (not due to oppositional behaviors or failure of comprehension), e.g., fails to finish chores

(7) has difficulty sustaining attention in tasks or play activities

(8) often shifts from one uncompleted activity to another

(9) has difficulty playing quietly
(10) often talks excessively
(11) often interrupts or intrudes on others, e.g., butts into other children’s games
(12) often does not seem to listen to what is being said to him or her
(13) often loses things necessary for tasks or activities at school or at home (e.g., toys pencils, books, assignments)
(14) often engages in physically dangerous activities without considering possible consequences (not for purpose of thrill-seeking), e.g., runs into street without looking

Note: The above items are listed in descending order of discriminating power based on data from a national field trial of the DSM-III-R criteria for Disruptive Behavior Disorders.

B. Onset before the age of seven.
C. Does not meet the criteria for a Pervasive Developmental Disorder.

APPENDIX B

PARENT RECRUITING LETTER
Dear Parents:

If you have a son between the ages of 6 and 9, then I need your help. I need 100 boys for my Ph.D. dissertation and would like to invite you and your son to participate.

We are conducting a research project designed to study the strategies that children use to solve concept learning tasks. We request permission for your child to participate. The study consists of one session that will last approximately one and one-half hours. Breaks will be provided at natural stopping points.

The study involves having the children sort a series of cards into different stacks according to categories. The goals of the study are to assess the types of strategies that the children use to solve the concept learning task and to see if pretraining on a similar task improves their performance. Children usually enjoy these types of activities, so we expect that children will be interested and enthusiastic about participating. In addition, the boys get several prizes for helping. We would also like for you to complete a questionnaire concerning your child's behavior and a developmental history.

This study is part of the requirements for completing my Ph.D. in Psychology at the University of North Texas in Denton, Texas. I have recently completed an internship at the Johns Hopkins University School of Medicine and am employed in the Department of Behavioral Psychology at the Kennedy Krieger Institute.

If you and your child would be interested in participating, please phone me at the Department of Behavioral Psychology, The Kennedy Krieger Institute (301) 550-9455 or at (410) 391-0286 during the evenings.

Sincerely,

Sidney R. Epperson M.S.
Clinical Specialist II
Department of Behavioral Psychology

THIS PROJECT HAS BEEN REVIEWED BY THE UNIVERSITY OF NORTH TEXAS COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS (Phone: 817-565-3940) AND BY THE OFFICE OF THE JOINT COMMITTEE ON CLINICAL INVESTIGATION AT THE JOHNS HOPKINS UNIVERSITY SCHOOL OF MEDICINE (Phone: 955-3008).
APPENDIX C

PARENT AND CHILD CONSENT FORMS
PURPOSE OF STUDY:
This study investigates the strategies that children with Attention-deficit hyperactivity disorder and without any known disorder use to solve concept learning tasks. You and your son are being asked to participate in this study because your son is between the ages of six and nine and is in the indicated study groups: 1) Attention-deficit hyperactivity disorder, or 2) normal control.

PROCEDURES:
If you agree to join this research study a one and one-half hour session, conducted at the Department of Behavioral Psychology in the Kennedy Institute will be necessary. Your son will be asked to take two standardized tests: Vocabulary Subtest of the Weschler Intelligence Test for Children-Revised and the Wisconsin Card Sorting Test. Prior to taking the Wisconsin Card Sorting Task, the children will receive pretraining on five concept learning tasks. The Wisconsin and the pretraining tasks require the child to sort a series of cards into categories. While your son completes these tasks you will be asked to complete two questionnaires and possibly a brief interview, depending upon responses to the questionnaire. After all the tasks are completed the investigator will debrief you on the precise experimental questions. All questions that you may have will be answered at that time or you may contact me, Sidney Epperson at 550-9455, if you have questions later.

RISKS AND DISCOMFORTS:
There are no known risks involved in this study. Unforeseeable risks are similar to those found in a typical academic activity.

BENEFITS:
Your son will receive a reward from a grab bag for participating. The assessment may be of some value to your therapist for the diagnosis and treatment of Attention-deficit hyperactivity disorder.

ALTERNATIVES TO PARTICIPATION:
If you choose not to participate in this study your therapist may decide to do part of the assessment described above to ensure the proper diagnosis and treatment of your child. This information will not be considered as part of the study. Choosing to not participate will not influence or reduce your access to services through the Department of Behavioral Psychology.
If you sign this form, you are willing to join the research project described to you on the other side of this page. Your doctors, or the investigators, did explain the other kinds of treatment that are available to you and to others. You should ask the principal investigator listed below any questions you may have about this research study. You may ask him/her questions in the future if you do not understand something that is being done. The investigators (or doctors) will share with you any new findings that may develop while you are participating in this study.

The records from this research study will be kept confidential and will not be given to anyone who is not helping on this study, unless you agree to have the records given out. If the study uses a new drug or device that is under the jurisdiction of the Food and Drug Administration (FDA), the FDA government officials may look at the relevant part of your medical records as part of their job to review new drug and device studies.

If you want to talk to anyone about this research study because you think you have not been treated fairly, or think you have been hurt by joining the study, or you have any other questions about the study, you should call the principal investigator, ______________________________ at __________________________, or call the Office of the Joint Committee on Clinical Investigation at 955-3008 or call The Francis Scott Key Medical Center Institutional Review Board for Human Research at 550-1853. Either the investigator or the people in the Committee office or IRB office will answer your questions and/or help you to find medical care for an injury you feel you have suffered. The Johns Hopkins University, The Johns Hopkins Hospital, The Francis Scott Key Medical Center, ______________________________ and the Federal Government do not have any program to provide compensation to you if you experience injury or other bad effects which are not the fault of the investigators.

You may withdraw from the research study at any time. Even if you do not want to join the study, or if you withdraw from it, you will still have the same quality of medical care available to you at Johns Hopkins or the Francis Scott Key Medical Center.

If you agree to join this study, please sign your name below.

NOTE: Signed copies of this consent form must be a) retained on file by the Principal Investigator; b) deposited in the patient's medical record; and c) given to the patient.

Revised: 5/91
I volunteer my child, ______________, and I to participate in the research project designed to study the strategies that children use to solve concept learning tasks. I am aware that this project involves research in order to fulfill the requirements for a doctoral dissertation in School/Child Clinical Psychology. The study will take approximately one and a half hours. I agree to complete the Revised Conners Parent's Questionnaire. I understand that additional information about my child's developmental history and behavior will be sought in an individual and confidential interview. I am aware that I may examine these materials before I agree to participate. My child has my permission to take the following standardized tests: Vocabulary Subtest of the Weschler Intelligence Test for Children-Revised and the Wisconsin Card Sorting Test. I am aware that there are no costs or fees involved nor any monetary reward for participation.

There are no known risks in participating in these procedures. The benefits include receiving on my request information concerning 1) the problem solving strategies used by my child and 2) the effects of the pretraining on my child's concept learning abilities. It has been explained to me that there may be some unforeseeable risks in participating. If any new knowledge becomes available which may affect my willingness to participate, the investigator will inform me so that I may make a knowledgeable decision.

I have been informed that all information obtained in this study will be recorded with a code number that will allow Mr. Epperson to determine my identity. At the conclusion of this study the key that relates my name with my assigned code number will be destroyed. I understand that all information that I give will be anonymous and for research or educational purposes only. If the investigation is published my name and my child's name will not be used. I understand that any information obtained as a result of our participation in this research will be kept as confidential as legally possible.

I understand that I may refuse to participate in this research project and that I will not be penalized for not participating. I am free to withdraw my consent and discontinue participation in this study at any time. A decision to withdraw from the study will not result in penalty or loss of benefits that I or my child are entitled.
If I have any questions or problems that arise in connection with my or my child's participation in this study, I should contact Mr. Epperson, the project director at The Kennedy Institute, 707 N. Broadway, Room 205, Baltimore, MD., (301) 550-9455. If I have a question about my rights as a human subject I may call the Institutional Review Board at 817-565-3940.

This project has been explained to my child in my presence, in language that he can understand. He has been encouraged to ask questions, both now and in the future, about the research study.

I volunteer to participate in this study. I have received a copy of this consent form.

______________  ____________
Parent Signature   Date

______________  ____________
Sidney R. Epperson M.S.  Date
Project Director

THIS PROJECT HAS BEEN REVIEWED BY THE UNIVERSITY OF NORTH TEXAS COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS (Phone: 817-565-3940) AND BY THE OFFICE OF THE JOINT COMMITTEE ON CLINICAL INVESTIGATION AT THE JOHNS HOPKINS UNIVERSITY SCHOOL OF MEDICINE (Phone: 955-3008)
I, __________________________ volunteer to participate in a research project designed to study the strategies that children use to solve concept learning tasks. It will take me about one and one half hours. I understand that I will take the following standardized tests: Vocabulary Subtest of the Wechsler Intelligence Test for Children-Revised and the Wisconsin Card Sorting Test. I understand that I will be dividing a series of cards into different categories. I understand that I can stop at any time I want without anyone getting angry. I am aware that it will not hurt me to take part in this study. I understand that after I finish helping, I will get the chance to pull a reward from a grab bag. I have had the chance to ask questions about the project and what I should do. My questions have been answered by the investigator, who is Mr. Sid Epperson.

If have any more questions I can contact Mr. Epperson at The Kennedy Institute, 707 N. Broadway, Room 205, Baltimore, MD., (301) 550-9455.

__________________________
Child's Signature

__________________________ Date
Parent Signature

__________________________ Date
Sidney R. Epperson M.S.
Project Director

THIS PROJECT HAS BEEN REVIEWED BY THE UNIVERSITY OF NORTH TEXAS COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS (Phone: 817-565-3940) AND BY THE OFFICE OF THE JOINT COMMITTEE ON CLINICAL INVESTIGATION AT THE JOHNS HOPKINS UNIVERSITY SCHOOL OF MEDICINE (Phone: 955-3008)
APPENDIX D

CHILD HISTORY QUESTIONNAIRE
### Child History

<table>
<thead>
<tr>
<th>Child's Name</th>
<th>Birth Date</th>
<th>Age</th>
<th>Sex</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Home Address</th>
<th>Home Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Street</td>
<td>City</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Child's School</th>
<th>Name</th>
<th>Address</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Grade</th>
<th>Repeated grade(s)</th>
</tr>
</thead>
</table>

Present illnesses for which the child is being treated

Medications the child is currently taking

Child is presently living with:

- [ ] Natural Mother
- [ ] Natural Father
- [ ] Stepmother
- [ ] Stepfather
- [ ] Adoptive Mother
- [ ] Adoptive Father
- [ ] Foster Mother
- [ ] Foster Father
- [ ] Other (Specify)

### Parents

**Mother's Name**

<table>
<thead>
<tr>
<th>Age</th>
<th>Occupation</th>
<th>Business Phone</th>
</tr>
</thead>
</table>

Age at time of pregnancy with child

School: Highest grade completed

- Learning problems
- Attention problems
- Behavior problems

Medical Problems:

Have any of your blood relatives experienced problems similar to those your child is experiencing? If so, describe

**Father's Name**

<table>
<thead>
<tr>
<th>Age</th>
<th>Occupation</th>
<th>Business Phone</th>
</tr>
</thead>
</table>

School: Highest grade completed

- Learning problems
- Attention problems
- Behavior problems

Medical Problems:

Have any of your blood relatives experienced problems similar to those your child is experiencing? If so, describe
Siblings

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>Medical, social or school problems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Developmental and Medical Information

If you or your child had problems in the following areas please describe below:
- Pregnancy
- Delivery
- Medical

If you can recall, record the age at which your child reached the following developmental milestones. If you cannot recall exactly, check item at right.

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Age</th>
<th>Early</th>
<th>Normal</th>
<th>Late</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sat without support</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crawled</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stood without support</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walked without assistance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spoke first words</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Said sentences</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toilet trained</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Peer Relationships

- Does your child seek friendships with peers?
- Is your child sought by peers for friendship?
- Does your child play with children primarily his or her own age? younger? older?
School

Does your child's teacher describe any of the following as significant classroom problems?

Doesn't sit still in his or her chair ___
Frequently gets up and walks around the classroom ___
Shouts out. Doesn't wait to be called on ___
Won't wait his or her turn ___
 Doesn't cooperate well in group activities ___
Typically does better in a one to one relationship ___
 Doesn't respect the rights of others ___
Doesn't pay attention during storytelling or show and tell ___

Home Behavior

All children exhibit, to some degree, the behaviors listed below. Check those that you believe your child exhibits to an excessive or exaggerated degree when compared to other children his or her own age.

Fidgets with hands, feet or squirms in seat ___
Has difficulty remaining seated when required to do so ___
Easily distracted by extraneous stimulation ___
Has difficulty awaiting turn in games or group situation ___
Blurts out answers to questions before they have been completed ___
Has problems following through with instructions ___
Has difficulty paying attention during tasks or play activities ___
Shifts from one uncompleted activity to another ___
 Has difficulty playing quietly ___
Interrupts or intrudes on others (impulsively) ___
Does not appear to listen to what is being said ___
Loses things necessary for tasks or activities at home ___
Boundless energy and poor judgement ___
Impulsivity (poor self control) ___
Frustrates easily ___
History of temper tantrums ___
Temper outbursts ___
Frustrates easily ___
Sloppy table manners ___
Sudden outbursts of physical abuse of other children ___
Acts like he or she is driven by a motor ___
Wears out shoes more frequently than siblings ___
Excessive number of accidents ___
Doesn't seem to learn from experience ___
Poor memory ___
APPENDIX E

CONNERS PARENT QUESTIONNAIRE RESULTS, WCST RESULTS, AND ANALYSES OF VARIANCE
Table 6

Conners Parent Z-Scores Means and Standard Deviations

<table>
<thead>
<tr>
<th>Conners Factor</th>
<th>ADHD Verbal</th>
<th>ADHD Ins/Rul</th>
<th>Normal Verbal</th>
<th>Normal Ins/Rul</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduct</td>
<td>1.317</td>
<td>1.074</td>
<td>0.454</td>
<td>0.400</td>
</tr>
<tr>
<td></td>
<td>0.716</td>
<td>0.448</td>
<td>0.309</td>
<td>0.334</td>
</tr>
<tr>
<td>Learning</td>
<td>1.980</td>
<td>1.810</td>
<td>0.510</td>
<td>0.480</td>
</tr>
<tr>
<td></td>
<td>0.641</td>
<td>0.496</td>
<td>0.411</td>
<td>0.450</td>
</tr>
<tr>
<td>Psychosomatic</td>
<td>0.413</td>
<td>0.400</td>
<td>0.070</td>
<td>0.132</td>
</tr>
<tr>
<td></td>
<td>0.411</td>
<td>0.346</td>
<td>0.135</td>
<td>0.222</td>
</tr>
<tr>
<td>Impulse/Hyper</td>
<td>2.111</td>
<td>2.050</td>
<td>0.690</td>
<td>0.840</td>
</tr>
<tr>
<td></td>
<td>0.579</td>
<td>0.468</td>
<td>0.574</td>
<td>0.461</td>
</tr>
<tr>
<td>Anxiety</td>
<td>0.830</td>
<td>0.700</td>
<td>0.550</td>
<td>0.420</td>
</tr>
<tr>
<td></td>
<td>0.529</td>
<td>0.625</td>
<td>0.421</td>
<td>0.286</td>
</tr>
<tr>
<td>Hyper/Index</td>
<td>2.104</td>
<td>1.948</td>
<td>0.556</td>
<td>0.481</td>
</tr>
<tr>
<td></td>
<td>0.408</td>
<td>0.354</td>
<td>0.334</td>
<td>0.249</td>
</tr>
</tbody>
</table>

Note. *Ins/Rul = Instruction and Rule condition
Table 7

Conners Parent T-Scores Means and Standard Deviations

<table>
<thead>
<tr>
<th>Conners Factor</th>
<th>ADHD Verbal</th>
<th>ADHD Ins/Rul</th>
<th>Normal Verbal</th>
<th>Normal Ins/Rul</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduct</td>
<td>M 70.720</td>
<td>64.200</td>
<td>48.840</td>
<td>47.920</td>
</tr>
<tr>
<td></td>
<td>SD 17.978</td>
<td>10.716</td>
<td>7.925</td>
<td>8.684</td>
</tr>
<tr>
<td>Learning</td>
<td>M 79.120</td>
<td>76.560</td>
<td>46.880</td>
<td>46.240</td>
</tr>
<tr>
<td></td>
<td>SD 13.106</td>
<td>10.548</td>
<td>8.805</td>
<td>9.413</td>
</tr>
<tr>
<td>Psychosomatic</td>
<td>M 61.720</td>
<td>61.200</td>
<td>49.440</td>
<td>49.440</td>
</tr>
<tr>
<td></td>
<td>SD 16.999</td>
<td>15.069</td>
<td>9.417</td>
<td>9.417</td>
</tr>
<tr>
<td>Impulse/Hyper</td>
<td>M 70.920</td>
<td>68.880</td>
<td>47.440</td>
<td>48.600</td>
</tr>
<tr>
<td></td>
<td>SD 9.451</td>
<td>7.656</td>
<td>10.544</td>
<td>7.627</td>
</tr>
<tr>
<td>Anxiety</td>
<td>M 56.960</td>
<td>52.400</td>
<td>51.320</td>
<td>48.600</td>
</tr>
<tr>
<td></td>
<td>SD 10.494</td>
<td>16.065</td>
<td>8.640</td>
<td>5.730</td>
</tr>
<tr>
<td>Hyper/Index</td>
<td>M 81.160</td>
<td>77.840</td>
<td>47.320</td>
<td>45.600</td>
</tr>
<tr>
<td></td>
<td>SD 8.807</td>
<td>7.825</td>
<td>7.443</td>
<td>5.545</td>
</tr>
</tbody>
</table>

Note. a Ins/Rul = Instruction and Rule condition
Table 8

**Number Errors: Analysis of Variance**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Group</td>
<td>1</td>
<td>2.586</td>
<td>0.111</td>
</tr>
<tr>
<td>Feedback Level</td>
<td>1</td>
<td>2.149</td>
<td>0.146</td>
</tr>
<tr>
<td>Child Group X Feedback</td>
<td>1</td>
<td>0.543</td>
<td>0.463</td>
</tr>
</tbody>
</table>
Table 9

Number Correct: Analysis of Variance

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Group</td>
<td>1</td>
<td>0.321</td>
<td>0.572</td>
</tr>
<tr>
<td>Feedback Level</td>
<td>1</td>
<td>0.024</td>
<td>0.878</td>
</tr>
<tr>
<td>Child Group X Feedback</td>
<td>1</td>
<td>0.606</td>
<td>0.438</td>
</tr>
</tbody>
</table>
Table 10

Categories Achieved: Analysis of Variance

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Group</td>
<td>1</td>
<td>1.654</td>
<td>0.202</td>
</tr>
<tr>
<td>Feedback Level</td>
<td>1</td>
<td>1.005</td>
<td>0.319</td>
</tr>
<tr>
<td>Child Group X Feedback</td>
<td>1</td>
<td>0.501</td>
<td>0.481</td>
</tr>
</tbody>
</table>
Table 11

Position Difference Scores: Analysis of Variance

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Group</td>
<td>1</td>
<td>3.792</td>
<td>0.054</td>
</tr>
<tr>
<td>Feedback Level</td>
<td>1</td>
<td>3.392</td>
<td>0.069</td>
</tr>
<tr>
<td>Child Group X Feedback</td>
<td>1</td>
<td>0.884</td>
<td>0.350</td>
</tr>
</tbody>
</table>
Table 12

**Hypothesis Difference Scores: Analysis of Variance**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Group</td>
<td>1</td>
<td>4.820</td>
<td>0.030</td>
</tr>
<tr>
<td>Feedback Level</td>
<td>1</td>
<td>4.164</td>
<td>0.044</td>
</tr>
<tr>
<td>Child Group X Feedback</td>
<td>1</td>
<td>0.692</td>
<td>0.408</td>
</tr>
</tbody>
</table>
Table 13

Perseverative Errors: Analysis of Variance

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Group</td>
<td>1</td>
<td>3.005</td>
<td>0.572</td>
</tr>
<tr>
<td>Feedback Level</td>
<td>1</td>
<td>1.889</td>
<td>0.878</td>
</tr>
<tr>
<td>Child Group X Feedback</td>
<td>1</td>
<td>0.017</td>
<td>0.438</td>
</tr>
</tbody>
</table>
Table 14

Perseverative Responses: Analysis of Variance

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Group</td>
<td>1</td>
<td>3.654</td>
<td>0.059</td>
</tr>
<tr>
<td>Feedback Level</td>
<td>1</td>
<td>2.362</td>
<td>0.127</td>
</tr>
<tr>
<td>Child Group X Feedback</td>
<td>1</td>
<td>0.074</td>
<td>0.785</td>
</tr>
</tbody>
</table>
Table 15

Nonperseverative Errors: Analysis of Variance

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Group</td>
<td>1</td>
<td>1.316</td>
<td>0.254</td>
</tr>
<tr>
<td>Feedback Level</td>
<td>1</td>
<td>1.665</td>
<td>0.200</td>
</tr>
<tr>
<td>Child Group X Feedback</td>
<td>1</td>
<td>2.084</td>
<td>0.152</td>
</tr>
</tbody>
</table>
Table 16

Failure to Maintain Set: Analysis of Variance

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Group</td>
<td>1</td>
<td>0.195</td>
<td>0.660</td>
</tr>
<tr>
<td>Feedback Level</td>
<td>1</td>
<td>0.017</td>
<td>0.896</td>
</tr>
<tr>
<td>Child Group X Feedback</td>
<td>1</td>
<td>1.818</td>
<td>0.181</td>
</tr>
</tbody>
</table>
### Table 17
Correct Hypothesis Maintained: Analysis of Variance

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Group</td>
<td>1</td>
<td>0.088</td>
<td>0.767</td>
</tr>
<tr>
<td>Feedback Level</td>
<td>1</td>
<td>0.386</td>
<td>0.536</td>
</tr>
<tr>
<td>Child Group X Feedback</td>
<td>1</td>
<td>2.109</td>
<td>0.150</td>
</tr>
</tbody>
</table>
Table 18

Correct Hypothesis Rejected: Analysis of Variance

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Group</td>
<td>1</td>
<td>3.145</td>
<td>0.079</td>
</tr>
<tr>
<td>Feedback Level</td>
<td>1</td>
<td>2.232</td>
<td>0.139</td>
</tr>
<tr>
<td>Child Group X Feedback</td>
<td>1</td>
<td>0.319</td>
<td>0.574</td>
</tr>
</tbody>
</table>
Table 19

Wrong Hypothesis Maintained: Analysis of Variance

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Group</td>
<td>1</td>
<td>0.118</td>
<td>0.731</td>
</tr>
<tr>
<td>Feedback Level</td>
<td>1</td>
<td>6.832</td>
<td>0.010</td>
</tr>
<tr>
<td>Child Group X Feedback</td>
<td>1</td>
<td>1.247</td>
<td>0.267</td>
</tr>
</tbody>
</table>
Table 20

Wrong Hypothesis Rejected: Analysis of Variance

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Group</td>
<td>1</td>
<td>0.480</td>
<td>0.490</td>
</tr>
<tr>
<td>Feedback Level</td>
<td>1</td>
<td>0.563</td>
<td>0.455</td>
</tr>
<tr>
<td>Child Group X Feedback</td>
<td>1</td>
<td>1.829</td>
<td>0.180</td>
</tr>
</tbody>
</table>
REFERENCES


