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Amy Marie Lyons Usher  
*Loyola University Chicago*

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LOYOLA UNIVERSITY CHICAGO

MEASURES OF EXECUTIVE FUNCTIONING AND THEIR RELATION  
TO FUNCTIONAL OUTCOMES IN A SAMPLE OF YOUTH WITH  
ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (ADHD)

A DISSERTATION SUBMITTED TO  
THE FACULTY OF THE GRADUATE SCHOOL  
IN CANDIDACY FOR THE DEGREE OF  
DOCTOR OF PHILOSOPHY

PROGRAM IN CLINICAL PSYCHOLOGY

BY  
AMY M. LYONS USHER  
CHICAGO, ILLINOIS  
AUGUST 2012

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## ABSTRACT

The current study examined two commonly used neuropsychological assessments of executive functioning in a sample of children and adolescents with attention-deficit/hyperactivity disorder (ADHD). The Test of Everyday Attention for Children (TEA-Ch) is a performance-based, objective measure of executive functioning, and the Behavior Rating Inventory of Executive Functioning (BRIEF) is a subjective, parent-report measure. Confirmatory factor analysis (CFA) was used to establish the factor structures of these measures to determine their appropriateness with a sample of youth with ADHD. The association of these assessment tools with functional outcomes (academic achievement, social functioning) was examined to establish their ecological and incremental validity.

A three-factor model for the TEA-Ch and a two-factor model with modifications for the BRIEF emerged as the best fitting models for each measure. Regarding ecological validity, the Behavioral Regulation factor of the BRIEF was positively associated with social difficulties, and the Switching factor of the TEA-Ch was positively related to achievement in math, written expression, and math fluency. No support for the incremental validity of executive functioning measures was provided. Results have implications for researchers, clinicians, and educators who study, assess, treat, and educate youth with ADHD experiencing executive dysfunction and associated difficulties.

## CHAPTER ONE

### INTRODUCTION

Executive functioning is an overarching term used to describe higher-order cognitive functions necessary for independent, purposeful, goal-directed behavior (Lezak, 1995). Such capacities include initiation, inhibition, switching, working memory, attention, planning, problem-solving, self-regulation, and utilization of feedback, among others (Alvarez & Emory, 2006; Anderson, 2002; Barkley, 2000; Lezak, 2004).

Executive functions have typically been associated with the frontal lobes of the brain, particularly the dorsolateral prefrontal cortex (Barkley, 1997a; Brocki & Bohlin, 2004; Casey, Giedd, & Thomas, 2000; Tranel, Anderson, & Benton, 1994; Welsh, Pennington & Groisser, 1991). Because the development of the frontal lobes continue into early adulthood, executive functions appear to have a prolonged developmental course, with evidence that executive processes emerge in infancy and develop throughout childhood into early adulthood (Anderson, 2002; Diamond & Taylor, 1996; Espy, 1997; Gerstadt, Hong, & Diamond, 1994; Vriezen & Pigott, 2002; Welsh et al., 1991). Individuals with executive function deficits may experience cognitive, behavioral, emotional, and personality changes as a result (Anderson, Anderson, Northam, Jacobs, & Mikiewicz, 2002). Therefore, executive dysfunction often leads to a reduced capacity to successfully engage in important activities of daily life, including academic pursuits, social activities, and self-care (Slick, Lautzenhiser, Sherman, & Eyrl, 2006).

Traditionally, executive functions were considered a unitary construct (Della Sala, Gray, Spinnler, & Trivelli, 1998; Shallice, 1990); however, it more recently has been conceptualized as a set of interrelated processes that work in conjunction (Alexander & Stuss, 2000). Debate around the unity or diversity of executive functions has led to variable definitions of executive functioning and, subsequently, measurement of this construct (Hughes & Graham, 2002). Concerns have also been raised about the validity of neuropsychological measures of executive functioning (Silver, 2000), particularly ecological validity (Cripe, 1996). Ecological validity generally refers to the degree to which test performance corresponds to real-world performance (Slick et al., 2006), and tests of executive functioning are notorious for having poor ecological validity (Chaytor & Schmitter-Edgecombe, 2003). This is problematic because it tells us little about the functional implications of those with executive dysfunction (Barkley, 2001).

Two measures purported to assess executive functioning that attempt to address this problem of ecological validity are the Test of Everyday Attention for Children (TEA-Ch; Manly, Nimmo-Smith, Watson, Anderson, Turner, & Robertson, 2001) and the parent report of the Behavior Rating Inventory of Executive Functioning (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000). The TEA-Ch is considered a performance-based, objective measure because it requires the child to perform tasks that aim to measure executive functioning, and it achieves ecological validity by using tasks simulating real-world attentional demands (i.e., competing demands for auditory and visual attention similar to a classroom setting; Anderson, Fenwick, Manly, & Robertson, 1998). The BRIEF is considered a subjective report because it asks parents to report on their

appraisals of difficulties the child is having that are supposedly caused by executive functioning deficits (Gioia et al., 2000). This measure attempts to improve ecological validity by assessing parents' report of their child's behavioral manifestations of executive functioning in everyday life (Gioia & Isquith, 2004). While these newer measures of executive functioning are considered a significant advance in neuropsychological assessment, the TEA-Ch and the BRIEF have not received much statistical scrutiny in order to test their factor structures and related underpinning constructs (i.e., through Confirmatory Factor Analysis; Gioia, Isquith, Retzlaff, & Espy, 2002; Heaton et al., 2001).

Examining the factor structure of these measures in a sample of children and adolescents with attention-deficit/hyperactivity disorder (ADHD) is particularly important because of the significant deficits in executive functioning typically exhibited by this population. ADHD is characterized by persistent and developmentally inappropriate symptoms of inattention and/or hyperactivity and impulsivity (American Psychiatric Association, 2000). Executive functioning deficits are regarded as a crucial component of understanding ADHD (Barkley, 2006) and are often measured in clinical settings (Gioia et al., 2002; Heaton et al., 2001). Thus far, no studies have examined the factor structure of the BRIEF or the TEA-Ch using a sample of children and adolescents diagnosed with ADHD.

The literature has demonstrated that distinct methods of assessment may provide unique information about an individual, which is one explanation for the low to moderate correlations often found between seemingly similar constructs (Meyer et al., 2001). Given their differences in terms of measurement method (objective, performance based

versus subjective, parent report), the TEA-Ch and the BRIEF may be measuring unique or distinct aspects of executive functioning. No studies have examined their association with functional outcomes despite the value such research would have in helping to establish the ecological and incremental validity of these tools (Heaton et al., 2001). Establishing the validity of these tools could have a positive impact on the practice of neuropsychological assessment by providing more scientific support for and practitioner and public confidence in their use. This positive impact would be amplified for the population of youth with ADHD since it is considered primarily a disorder of executive functioning and is associated with a variety of adverse outcomes, including social impairment, peer relationship difficulties, peer rejection (Bagwell, Molina, Pelham, & Hoza, 2001; Greene et al., 2001), and academic underachievement (Erhardt & Hinshaw, 1994).

The current study assessed two neuropsychological assessments of executive functioning in a sample of children and adolescents with ADHD. The main goal of this study was to establish the factor structure of these measures using Confirmatory Factor Analysis (CFA) in order to determine its appropriateness with a sample of youth with ADHD. The current study also examined the association of these two assessment tools with outcomes (academic achievement, social skills) for youth with ADHD to establish its ecological and incremental validity. Further, this study accomplished these aims while controlling for demographic characteristics (e.g., age, sex) and other variables that may impact results (e.g., IQ, previously diagnosed learning disorders).

The following section presents a review of the literature. First, a description of executive functioning and the neuropsychological assessments used to measure executive

functioning is presented. An overview of ADHD and the difficulties associated with the disorder is reviewed next. Finally, a summary of the literature is presented, followed by the aims and hypotheses of the current study.

## CHAPTER TWO

### LITERATURE REVIEW

#### *Executive Functioning*

Executive functions have been defined as distinct, higher-order cognitive functions that work together to enable a person to engage successfully in independent, purposive, self-serving behavior (Anderson, 2008; Gioia, Isquith, Kenworthy, & Barton, 2002; Lezak, 1995). It is an umbrella term that includes all supervisory or self-regulatory functions which organize and direct cognitive activity, emotional response, and behavior (Gioia, et al., 2002; Hughes & Graham, 2002). Executive functioning has received a tremendous amount of attention in the past decade, likely because of its importance to everyday human functioning and the significant impairments that may occur for individuals with executive dysfunction.

Despite growing research and clinical interest in executive functioning, there is little consensus on how to define this cognitive domain (Welsh, 2002). Individual components of executive functioning, however, are widely agreed upon and include capacities such as initiation, the ability to maintain a behavior (Lezak, 2004), inhibition, switching, working memory, sustained and selective attention (Alvarez & Emory, 2006), the ability to inhibit inappropriate responses and delay responding (Goulden & Silver, 2009), planning, goal-directed action, problem-solving, strategy development, selection,

monitoring, self-awareness across time (Barkley, 2000), anticipation, self-regulation, and utilization of feedback (Anderson, 2002).

### Components

Traditionally, executive functioning has been conceptualized as a single construct, responsible for multi-modal processing and higher-level cognitive skills (Della Sala et al., 1998; Shallice, 1990). However, executive functioning has also been conceptualized as multiple process-related systems that are interrelated, interdependent, and function in conjunction (Alexander & Stuss, 2000). The latter framework is likely more accurate given that global executive dysfunction is rare, specific executive functions have been found to be associated with distinct frontal systems, and executive skills demonstrate variable developmental profiles.

Nonetheless, debate around the unity or diversity of executive functions persists (Ardila, 2008; Gioia et al., 2002). For example, researchers arguing a unitary structure of executive functioning suggest that behavioral inhibition may be responsible for successful performance in executive tasks (Barkley, 1997b) or in combination with working memory (Pennington & Ozonoff, 1996). Rabbitt (1997) suggests that there may be one underlying process given that various executive functions can be observed behaviorally in different tasks and situations, indicating an overlap of functions. In contrast, several leading theorists emphasize the multi-component nature of executive processes (e.g., Baddeley, 1984; Burgess, 1997; Shallice & Burgess, 1991; Stuss & Levine, 2002). Moreover, correlations among executive tests are typically moderate or low, suggesting diverse components of executive functioning (Friedman, Miyake, Corley,

Young, DeFries, & Hewitt, 2006). Due to this discrepancy, Ardila (2008) described executive functions as “separable but moderately correlated constructs,” suggesting that both unitary and non-unitary components exist. Additionally, it may be that the executive profiles of some populations (e.g., youth with ADHD) appear more unitary than others given the developmental nature of executive functions.

### Executive Dysfunction

Executive functions are essential for goal-directed behavior and are required in novel or difficult situations which involve planning, decision-making, problem-solving, or the need to overcome a habitual response (Hughes & Graham, 2002). This cognitive domain affects many aspects of a person’s behavior, and research demonstrates that impaired executive functioning can lead to significant disruption in everyday life even when other cognitive functions are relatively intact (Damasio, 1994). Because the primary purpose of executive functioning is to solve real-world problems, difficulty separating and prioritizing the elements of ambiguous problems may be the source of dysfunction in everyday life (Goulden & Silver, 2009).

Executive dysfunction often leads to a reduced capacity to successfully engage in important activities of daily life, including academic pursuits, social activities, and self-care (Slick et al., 2006). Because it is not a uniform disorder (Gioia, Isquith, & Guy, 2001), a diverse array of deficits is possible, resulting in a variety of potential presentations (Anderson et al., 2002). Cognitive, behavioral, and personality changes may all occur as a result of executive dysfunction. Individuals may experience difficulty developing problem-solving plans, regulating behavior appropriately, or shifting mental

or behavioral sets (Goulden & Silver, 2009). Behavioral problems and personality traits associated with executive dysfunction include reduced self-regulation, adjustment difficulties, low self-esteem, apathy, reduced motivation, inadequate self-control, and limited self-awareness (Anderson et al., 2002). Social difficulties often result due to poor interpersonal skills, inefficient communication skills, inappropriate social interactions, and poor social judgment. In fact, according to Barkley's (2001) evolutionary perspective of executive functioning, the ultimate function of this system is maximizing the long-term versus short-term social outcomes for individuals. Therefore, "social devastation" may occur for those with executive deficits.

### *Executive Dysfunction in Youth*

Similar problems are common in children and adolescents with executive dysfunction (Goulden & Silver, 2009). Cognitively, children may exhibit poor impulse control, difficulties monitoring or regulating behavior, planning and organizational problems, poor reasoning ability, difficulties generating or implementing strategies, perseverations and mental inflexibility, poor utilization of feedback, and reduced working memory (Anderson, 2002). Behavioral and emotional manifestations of executive dysfunction may impact mood, affect, energy level, initiative, and moral and social behavior (Anderson, Bechara, Damasio, Tranel, & Damasio, 1999; Barrash, Tranel, & Anderson, 2000; Grattan & Eslinger, 1991). Children exhibiting executive dysfunction may present as apathetic, unmotivated, and unresponsive, whereas others may be impulsive and argumentative (Anderson, 2002). Like adults, youth may exhibit social difficulties as a result of executive impairments. They may ask socially inappropriate

questions, exhibit difficulty appreciating humor, disregard the consequences of actions, and ignore social rules and conventions (Anderson, 2002). Inflexibility and rigidity is also common, and may be manifested by a resistance to change activities, an inability to modify previously learned behaviors, and a failure to learn from mistakes. As a result, many children and adolescents with executive dysfunction display poor interpersonal skills and experience difficulties maintaining meaningful social relationships. Although intelligence is typically preserved in individuals exhibiting executive dysfunction, it is clear that an important aspect of cognition and behavior is dependent on this part of the brain (Pennington & Ozonoff, 1996).

The cognitive and behavioral difficulties described above are similar to those displayed by children with a variety of developmental and acquired neuropsychological disorders (Barkley, 2006; Levin et al., 1997; Mahone et al., 2002). Thus, many of these difficulties can be attributed to impaired executive functioning.

### History of Executive Functioning

Deficits in executive functioning and its resulting cognitive and behavioral presentations have been observed for many years. During the late 19<sup>th</sup> and early 20<sup>th</sup> centuries, diverse behavioral disorders in cases of frontal pathology were first documented (Ardila, 2008). Feuchtwanger (1923) conceptualized “frontal lobe syndrome” through correlation of frontal pathology to behaviors that were not related to overt speech, memory, or sensorimotor deficits. Personality changes in motivation, affective dysregulation, and the capacity to regulate and integrate other behaviors were emphasized. In 1944, Goldstein expanded the capacity of frontal lobe behaviors to

include “the abstract attitude,” initiation, and mental flexibility. Luria (1966, 1969) then related prefrontal lobe activity with a variety of behaviors and responses, including abstracting, problem-solving, verbal regulation of behavior, programming motor behavior, inhibiting immediate responses, temporal integration of behavior, personality integrity, and consciousness. During the 1970s, 1980s, and 1990s, a number of books focused on the prefrontal cortex were published (e.g., Fuster, 1989; Levin, Eisenberg, & Benton, 1991; Pribram & Luria, 1973). These works typically assumed that “frontal” or “prefrontal” syndrome was synonymous with executive dysfunction (Ardila, 2008). Over time, it became apparent that “prefrontal syndrome” and executive functioning were not synonymous, and that the prefrontal cortex plays a key monitoring role in executive functioning, but other brain areas are also involved (Elliott, 2003). Despite these advances, continued debate about how to define and assess executive functions remains.

#### Neuroanatomical Correlates of Executive Functioning

As stated above, executive functioning has historically been associated with frontal or prefrontal pathology (i.e., “frontal metaphor”), meaning that the behavior resembles that exhibited by patients with well-documented frontal lesions (Pennington & Ozonoff, 1996). The most classical example of prefrontal lobe pathology and accompanying disturbances in executive functioning is the case of Phineas Gage, a reliable foreman who endured significant personality and behavioral changes following an injury to his frontal lobe (Ardila, 2008). Since that time, an association between the constructs of executive functioning and impairment in the frontal lobes has been similarly found with patients with frontal lobe lesions or patients with disorders affecting the

frontal lobes (Stuss & Benton, 1984). Functional neuroimaging studies highlight this association through results demonstrating significant activation within the prefrontal cortex in individuals performing executive functioning tests (e.g., Baker et al., 1996; Morris, Ahmed, Syed, & Toone, 1993).

### *Frontal Lobes*

Research indicates that the frontal lobes play an important role in synthesizing information from other areas of the brain and for the generation, implementation, and correction of adaptive strategies for living (Goldberg, 2001). Damage to this area may lead to one or more changes in cognitive, behavioral, personality, and emotional functioning (Stuss & Benson, 1984). Cognitive processes that have been attributed to the prefrontal cortex include working memory, response inhibition, and attention (Casey et al., 2000). Other changes that may occur include deficits in social judgment, reduced affective responsiveness, poor self-regulation, diminished self-awareness, and poor impulse control (Anderson et al., 2002). Although the behaviors disrupted by frontal lesions are somewhat varied in their surface characteristics, they all require goal-directed behavior, usually in novel contexts with competing response alternatives (Pennington & Ozonoff, 1996).

Three main areas of the frontal lobes have demonstrated a reasonable degree of functional specificity: dorsolateral, orbital, and medial areas (Manchester, Priestley, & Jackson, 2004). The dorsolateral prefrontal cortex is most often implicated in the executive functions (Barkley, 1997b; Brocki & Bohlin, 2004; Casey et al., 2000; Tranel et al., 1994; Welsh et al., 1991). This brain region has been associated with the

manipulation of information held “on line” and is therefore associated with working memory (D’Esposito, Postle, & Rypma, 2000). Other executive functions associated with this area include verbal and design fluency, set-shifting abilities, planning, response inhibition, organizational skills, reasoning, problem-solving, and abstract thinking (Alvarez & Emory, 2006). Results from neuroimaging studies have corroborated these associations through consistent findings that the dorsolateral prefrontal cortex is involved with executive functioning tasks, particularly during verbal fluency (Baldo, Shimamura, Delis, Kramer, & Kaplan, 2001; Lezak, 1982) and working memory tasks (Conklin, Luciana, Hooper, Yarger, 2007; Haut, Kuwabara, Leach, & Arias, 2000). Orbitofrontal damage may result in impulsive, poorly controlled, emotional, and socially inappropriate behavior, as well as inattention and distractibility (Malloy, Bahrle, Duffy, & Cimino, 1993). Finally, damage to the medial prefrontal area is associated with motivation and attention deficits (Manchester et al., 2004).

#### *Related Circuitry*

Although the association between the frontal lobe and executive functioning has been well-documented, current views acknowledge the contribution of other brain regions in producing executive dysfunction (Alvarez & Emory, 2006; Tranel et al., 1994). The neural systems underpinning executive functions are numerous, complex, and interrelated (Anderson et al., 2002). The prefrontal region is an association area with extensive connections with almost all other brain regions, including the brain stem, occipital, temporal, and parietal lobes, as well as limbic and subcortical regions (Anderson et al., 2002; Stuss & Benson, 1984). Because the frontal lobe regions have

multiple connections with other brain regions outside of the frontal lobes, the areas that may be involved in the executive functions are greatly expanded. In addition to providing connections to other brain regions, the prefrontal cortex integrates information from other brain areas, such as parietal and temporal regions of the central cortex and the limbic system (Nauta, 1971); therefore, disruptions occurring along these pathways could result in executive functioning impairments. Taken together, executive dysfunction may be result of prefrontal pathology or may be related to network disconnections, such as white matter damage or impairment to other brain regions (Alexander & Stuss, 2000; Eslinger & Grattan, 1993). The frontal lobes should therefore be considered as “one aspect of an executive system involving many structures of the central nervous system” (Duffy & Campbell, 2001, p. 116).

The development of the frontal lobes extends into adulthood (Hudspeth & Pribram, 1990; Thatcher, 1991), with the dorsolateral prefrontal cortex being one of the last brain regions to mature (Casey et al., 2000). Studies of the degree of myelination also indicate that the prefrontal cortex is among the last areas to develop (Yakovlev, 1962). It is important to examine the functional development of the prefrontal cortex and its related circuitry in the context of cognitive development because of the development of these brain regions and cognitive processes throughout childhood (Casey et al., 2000). The prolonged development and organization of prefrontal cortex throughout childhood and adolescence may suggest an important parallel between brain development and cognitive development (Casey et al., 2000).

## Development of Executive Functioning

Although the frontal lobes are not fully developed until early adulthood, components of executive functioning reach functional maturity throughout childhood and adolescence (Golden, 1981). This is evidenced through neuroimaging studies which have shown prefrontal activation in infancy (Bell & Fox, 1992; Chugani, Phelps, & Mazziotta, 1987), and neuropsychological studies that have demonstrated developmental changes on tests of executive functioning throughout childhood (Levin et al., 1991; Welsh et al., 1991). Therefore, executive functioning appears to have a prolonged developmental course, with evidence that executive processes emerge in infancy and develop throughout childhood into early adulthood (Anderson, 2002; Diamond & Taylor, 1996; Espy, 1997; Gerstadt et al., 1994; Vriezen & Pigott, 2002; Welsh et al., 1991).

Despite these findings, the developmental profile of executive functions remains unclear (Anderson, 2002). As basic executive functions mature, the processing capacity in the prefrontal cortex increases, setting the stage for the development and maturation of more advanced executive skills that may require input from or the coordination of multiple executive functions (DeLuca & Leventer, 2008). The progression of executive functions is not necessarily linear, but may occur in spurts, creating a complex developmental trajectory (Anderson, 2002). Furthermore, different developmental trajectories of executive functions have emerged depending on the type of executive function studied (Anderson, 2002; Brocki & Bohlin, 2004). Because some of the behaviors exhibited by those with executive dysfunction may be normative at certain age

ranges (e.g., infancy or early childhood; Anderson, 2002), it is critical that developmental expectations of executive processes are well understood.

### *Infancy, Toddlerhood, and Preschoolers*

One of the first executive functions to emerge and mature is working memory and attentional control (Senn, Epsy, & Kaufmann, 2004). Without these two basic functions, more complex ones cannot develop. Research indicates that these begin to emerge within the first year of life, specifically between seven and twelve months of age (Anderson, 2002). By twelve months, most infants can inhibit certain behaviors and shift to a new response set (Diamond & Doar, 1989). As children mature into toddlerhood, they begin to demonstrate gains in response inhibition, although they continue to make perseverative errors (DeLuca & Leventer, 2008; Diamond & Taylor, 1996; Espy, 1997). Between three and four years of age, children develop the ability to switch rapidly between two simple response sets, but they exhibit difficulty switching when rules become more complex (Espy, 1997). Response speed, verbal fluency, simple planning, and the generation of new concepts are observed in children between three and five years of age (Espy, 1997; Gerstadt et al., 1994; Welsh et al., 1991). After the development of basic executive skills, more complex executive functions can develop and tend to do so in three stages of maturation: early childhood (6-8 years), middle childhood (9-12 years) and adolescence.

### *Early Childhood*

In early childhood, simple planning and organized visual search appear to have developed by six years of age (Welsh et al., 1991), and children begin to exhibit improvements in speed and accuracy on impulse control tasks (Diamond & Taylor,

1996). Nonverbal working memory develops around age eight (Brocki & Bohlin, 2004), and the ability to cope with multi-dimensional switching tasks improves greatly (Anderson, Anderson, Northam, & Taylor, 2000). Research also indicates that perseverative behavior begins to decline during this period (Levin et al., 1991; Welsh et al., 1991).

### *Middle Childhood*

In middle childhood, planning and organizational skills develop rapidly between seven and ten years of age (Anderson, Anderson, & Lajoie, 1996) and strategic behavior and reasoning abilities become more organized and efficient (Anderson, Anderson, & Garth, 2001; Levin et al., 1991). Children aged nine exhibit adequate ability to monitor and regulate their actions (Anderson et al., 2000), and by age ten, set maintenance, hypothesis testing, and impulse control appear to have developed (Chelune & Baer, 1986; Chelune & Thompson, 1987; Welsh et al., 1991). Additionally, cognitive flexibility, selective attention, response inhibition (Klimkeit, Mattingly, Sheppard, Farrow, & Bradshaw, 2004), and goal direction (Luciana & Nelson, 2002) all develop during this period. Processing speed and fluency continues to improve during middle childhood (Anderson et al., 2000; Welsh et al., 1991), with significant gains in processing speed observed between nine to ten years and eleven to twelve years (Kail, 1986).

### *Adolescence*

Throughout adolescence, many executive functions continue to emerge and mature and the ability to coordinate executive capacities to direct behavior demonstrates a dramatic improvement (DeLuca & Leventer, 2008). Complex planning, motor

sequencing, verbal fluency (Welsh et al., 1991), organization, and working memory (DeLuca & Leventer, 2008) all reach adult levels by adolescence. This period of development demonstrates improvement in efficiency and fluency (Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001; Kail, 1986; Levin et al., 1991), as well as refinement of strategies and improved decision-making (Anderson et al., 2001; Levin et al., 1991).

In sum, executive functioning appears to have a prolonged developmental course, from infancy until early adulthood (Anderson, 2002; Diamond & Taylor, 1996; Espy, 1997; Gerstadt et al., 1994; Vriezen & Pigott, 2002; Welsh et al., 1991). The developmental progression of executive skills has been confirmed using factor analysis, with results demonstrating that executive capacities develop at different rates, which highlight the possibility that executive functions may be fluid constructs (Huizinga, Dolan, & van der Molen, 2006).

### Models of Executive Functioning

Although no one model of executive functioning has been widely accepted, neuropsychological models are important because they provide a theoretical framework for the assessment of cognitive domains (Anderson, 2008). Some existing models focus on a specific executive domain (i.e., self-regulation; Barkley 1997b), whereas other models are developmentally oriented (Anderson, 2002). The discrepancies between models are a result of differing underlying assumptions and rationales for creating these models; for example, Barkley's model was initially created to explain ADHD (Anderson, 2008). Following is a brief overview of current models of executive functioning.

### *Supervisory Activating System (SAS) Model*

The “supervisory activating system” (SAS) was first proposed by Norman and Shallice (1986) in a model about the role of attention in active behaviors. The model differentiates between automatic actions and those that require “deliberate attentional resources” (Anderson, 2008). Automatic actions refer to those that are performed without awareness, whereas deliberate attentional resources require planning, decision-making, troubleshooting, a novel sequence of actions, overcoming prepotent responses, or situations that are dangerous or difficult. Norman and Shallice (1986) proposed two complementary processes to cope with these two levels of action: contention scheduling and SAS. Contention scheduling is used with responses that are implemented automatically. It works by scheduling well-formed schemata and inhibiting conflicting schemata when completing an automatic action. However, for novel or difficult tasks such as those involving executive functions, schemata may not exist. In these situations, additional attentional control is needed, which is the role of the SAS.

This initial model was expanded, and the supervisory system is now viewed as an integrated system performing a variety of processes carried out by different subsystems (Anderson, 2008). It is comprised of three stages and multiple processes, all of which involve the prefrontal cortex. The supervisory system is utilized under several conditions: when no established solution to a problem exists, when selection between schemata is necessary, when the inhibition of inappropriate schemata is required, and when weakly activated schemata are suggested. Five supervisory processes are proposed: (1) activation of target schemata, (2) inhibition of inappropriate schemata, (3) adjustment of contention

scheduling (i.e., ensures that one schemata is not more active and inhibiting the behavior of other less activated schemata), (4) monitoring schemata activity, and (5) control of “if-then” logical processes (i.e., uses monitored feedback to maintain and alter processes). This model has several advantages in that it takes into account most processes associated with executive functioning, it explains impairments in attentional control tasks, and attempts have been made to determine the neural networks underlying the supervisory system (Shallice & Burgess, 1991). However, it does not easily translate into clinical practice, particularly assessment methodologies.

#### *Working Memory Model*

The working memory model is a second theoretical model of executive functioning and was proposed by Baddeley in 1996. In this model, working memory is defined as “a limited capacity system allowing the temporary storage and manipulation of information necessary for such complex tasks as comprehensions, learning, and reasoning” (Baddeley, 2000). Working memory consists of a limited capacity attentional system (central executive) and two secondary systems (phonological loop, visuo-spatial sketch pad; Anderson, 2008). Functions of the central executive consist of selective attention, coordination of two or more concurrent activities, switching attention, and retrieval from long-term memory (Baddeley, 2002). The phonological loop maintains and manipulates verbal information in the short-term, whereas the visuo-spatial sketch pad holds and manipulates visual-spatial information (Anderson, 2008). The central executive has four functions: (1) selectively attending to one stream of information while ignoring irrelevant information, (2) enabling multiple tasks to be completed concurrently by

coordinating working memory resources across tasks, (3) switching attention and response set within a task that requires mental flexibility, and (4) activating representations from long-term memory in order to respond to environmental demands. This model has undergone extensive research and is considered a well-validated model of executive functioning; however, it is not inclusive of all executive impairments.

### *Self-Regulatory Model*

Barkley's (1997b) self-regulatory model of executive functioning suggests that inhibition is central to effective executive functioning. This theory posits that behavioral inhibition (i.e., inhibition of responses, interference control) fundamentally contributes to the functioning of other executive capacities because it provides a delay period necessary for executive processes to occur (Anderson, 2008). Executive capacities include working memory (i.e., capacity to refer the present situation to previous events, retention of information to generate and retain future-oriented goals), self-regulation of affect, motivation and arousal, internalization of speech, and reconstitution (i.e., analysis and synthesis of components of situations). Unlike other models of executive functioning, Barkley's model considers behavioral inhibition as a system that is hierarchically superior to the systems controlling executive processes.

The model was originally formulated to understand attention in ADHD; however, it is also relevant in understanding normal development (Anderson, 2008). Barkley (1997b) speculated that a progressive development of inhibitory functioning co-occurs with the development of the prefrontal regions of the brain. According to this theory, typically developing younger children should be less efficient in behavioral inhibition,

and therefore executive functions, compared to older children. Although Barkley (1997b) acknowledges that further validation is needed, it is possible that this model applies to other populations with frontal pathology or executive dysfunction.

#### *Problem-Solving Model*

Zelazo, Carter, Reznick, and Frye (1997) proposed a problem-solving framework that describes the “distinct phases” of executive function. This framework is referred to as a “macroconstruct” to illustrate the way in which executive processes operate in an integrative manner to solve problems or achieve a goal (Anderson, 2008). This model includes four phases: (1) problem representation (i.e., acknowledge and understand the problem), (2) planning (i.e., select actions in a sequence from alternatives), (3) execution (i.e., maintain sequence of steps in memory to guide the appropriate actions and perform the steps), and (4) evaluation (i.e., error detection and correction). Therefore, this model emphasizes an integrative approach in which higher-order functions are composed of various subprocesses and subsystems that work together to achieve a goal.

#### *Executive Control System Model*

Another model of executive functioning is the executive control system model (Anderson, 2002). This model conceptualizes executive functions as four distinct domains: (1) attentional control, (2) informational processing, (3) cognitive flexibility, and (4) goal setting. The attentional control domain includes the ability to selectively attend to specific stimuli and inhibit responses, as well as the capacity for prolonged focused attention. Deficits in this area may result in impulsivity, lack of self-control, failure to complete tasks, uncorrected mistakes, and inappropriate responses. Components

included in the domain of information processing include fluency, efficiency, and speed of output, and difficulties associated with this domain include reduced output, delayed responses, and slowed reaction times. The cognitive flexibility domain encompasses the ability to shift, learn from mistakes, develop alternative strategies, divide attention, and process multiple sources of information at the same time. Perseverative behavior may result from impairment in this domain. Finally, the goal setting domain refers to the ability to develop new initiatives and concepts, plan in advance, and approach tasks efficiently and strategically. Poor problem-solving abilities are associated with deficits in this domain, and may manifest as insufficient planning, disorganization, inefficient strategies, reliance on previously learned strategies, and poor conceptual reasoning.

The domains within this model are considered separate functions related to specific frontal systems that operate in an integrative manner in order to perform certain tasks (Anderson, 2002). Together, they can be conceptualized as an overall control system. The attentional control domain plays an executive role in that processes within this domain influence the functioning of other executive domains. In contrast, information processing, cognitive flexibility, and goal setting domains are interrelated and interdependent.

#### *Lezak's Model*

Lezak (1995) conceptualized executive functioning as consisting of four domains: (1) volition, (2) planning, (3) purposive action, and (4) effective performance. Volition refers to the conscious decision to perform an action or carry out goal-directed behavior and requires the capacity to generate goals (Anderson, 2008). Deficits in this area are

characterized by difficulty initiating activities despite the ability to solve abstract problems and complete tasks. Planning refers to the ability to identify a sequence of steps needed to solve a problem or achieve a goal. Impulse control, working memory, and sustained attention are all necessary cognitive processes in this domain. Purposive action includes the initiation and maintenance of the steps involved in the plan, as well as the ability to modify or discontinue the planned actions as needed (i.e., mental flexibility). Finally, effective performance refers to the ability to monitor, self-correct, and regulate behavior. According to this model, each domain consists of a distinct set of behaviors, and impairment in any of these domains may result in executive dysfunction. Although this framework is useful for providing a structure for the assessment of specific executive skills, it neglects some important executive skills (e.g., working memory) and has not been validated empirically.

In summary, the aforementioned models of executive functioning provide a good working framework to guide clinical and research endeavors; however, many lack empirical support (Anderson, 2008). Research indicates that executive functioning is a construct with subcomponents that demonstrate a developmental progression that is supported by corresponding neuroanatomical changes. Nonetheless, many questions remain as to the definition of executive functioning and as to how executive functions can be measured (Vriezen & Pigott, 2002). The lack of a unitary construct or model has resulted in various measurement approaches.

*Neuropsychological Assessment of Executive Functioning*

The measurement of executive functions has become a core feature of neuropsychological assessment due to the negative impact that executive dysfunction can have on everyday functioning (Manchester et al., 2004). Assessment batteries are used to identify the presence of impaired executive functions and their real-world implications (Manchester et al., 2004). This is essential because early and accurate identification and subsequent appropriate interventions (e.g., school accommodations, behavior modification, medication management) may minimize the potential negative consequences of executive dysfunction (Anderson et al., 2002).

Despite differences in the measurement of executive functioning, common executive skills measured include selective and sustained attention, response inhibition, working memory, organization, and planning of complex behaviors (Lezak, 1995). Executive functions are typically activated in novel or complex tasks because they require the individual to formulate new strategies and monitor their effectiveness (Shallice, 1990). Therefore, commonalities among tasks include those that require planning future actions, holding those plans on-line until executed, and inhibiting irrelevant actions (Pennington & Ozonoff, 1996). For children and adolescents, measurement of executive functioning typically includes pencil-and-paper tests of planning and problem-solving that may also include inhibition or switching tasks (Goulden & Silver, 2009). These performance-based tests assess how well a child performs in a structured testing session, with distractions and influences at a minimum

## Measurement Issues

### *Definition of Executive Functioning*

It has been recognized by leaders in the field that the measurement of executive functioning is inherently challenging for several reasons (Burgess, 1997; Gioia et al., 2002). The first issue concerns the definition of executive functioning. Consistent with the models discussed earlier, executive functioning has only a theoretical, rather than operational, definition (Hughes & Graham, 2002). Because of this problem, there is not one assessment tool in which all individuals with executive dysfunction fail (Burgess, 1997). This is evident in the fact that while many individuals with frontal lesions and problems with executive functioning perform poorly on tests designed to be sensitive to executive functions, many do not (Cripe, 1996; Eslinger & Damasio, 1987; Shallice & Burgess, 1991).

### *Assessment Environment*

The actual testing environment is an additional concern related to measurement because it may be poorly conducive for eliciting executive functioning deficits (Cripe, 1996; Lezak, 1982). Testing is typically conducted in a quiet room, free of distractions and with a clinician coordinating test administration, explaining rules, setting goals, and prompting and stopping behaviors (Lezak, 1982). Additionally, multi-tasking or prioritizing are often not needed as the clinician informs the individual of tasks that need to be completed and in the order in which to do so (Manchester et al., 2004). Therefore, core deficits inherent in executive functioning (e.g., starting, stopping, switching) may be avoided by the instructions of the examiner and the non-distracting environment. Because

affective arousal is carefully controlled for in the testing environment, this variable that is typically of importance to decision-making and behavioral regulation in everyday life is generally eliminated from the assessment process. Finally, patients with executive dysfunction may perform well within the normal range on neuropsychological testing but be exhausted in doing so, which is not reflected in performance.

#### *Performance-Based Tests*

A third issue in the neuropsychological assessment of executive skills relates to the measurement problems that exist in laboratory or clinical performance tests, which is the primary means by which this cognitive domain is assessed (Pennington & Ozonoff, 1996; Rabbitt 1997). Performance-based tests tap individual components of executive functioning over a short period of time rather than the integrated, multidimensional decision-making that is necessary during novel or complex situations in which executive functions are needed (Goldberg & Podell, 2000; Shallice & Burgess, 1991). Many of the types of situations in which executive skills are necessary are difficult to translate directly into standardized tests; thus, critical aspects of executive functioning may go completely unmeasured (Lezak, 1995; Sbordone, 2000). Therefore, reliance on performance-based types of tests alone may be inadequate in assessing executive functions because they attempt to separate integrated functions into component parts (Burgess, 1997) and can yield an incomplete and limited assessment (Bodnar, Prahme, Cutting, Denckla, & Mahone, 2007; Gioia & Isquith, 2004).

*Ecological Validity*

Finally, concerns have been raised about the validity of neuropsychological measures of executive functioning, particularly ecological validity, because neuropsychological assessment typically occurs in a structured testing environment unlike the environment encountered in everyday life (Cripe, 1996; Silver, 2000). The concept of ecological validity was first introduced into the psychological literature by Brunswik in 1955, and he used the term to describe conditions under which one could generalize from results of controlled, systematic experiments to naturally occurring events in the real world. In general, ecological validity refers to the degree to which test performance corresponds to real-world performance (Slick et al., 2006).

This concept received little attention in the neuropsychological literature until the late 1980s because prior to this time the primary purpose of neuropsychological assessment was detecting and localizing neuropathology (Spooner & Pachana, 2006). However, this need has diminished over time as neuroimaging techniques have become more widely available and more definitive information about the location and extent of brain injury for diagnostic purposes is available (Johnstone & Frank, 1995). Therefore, a new emphasis on the functional implications of neuropsychological test results has emerged (Spooner & Pachana, 2006). This translates into concern about the ecological validity of neuropsychological assessments, as the field of neuropsychology has moved away from descriptive, diagnostic endeavors toward treatment-oriented assessments (Chaytor & Schmitter-Edgecombe, 2003). Although it is important to demonstrate that neuropsychological tests have ecological validity in order to answer questions related to

patients' everyday functioning, limited research exists on the ecological validity of neuropsychological tests (Spooner & Pachana, 2006; Vriezen & Pigott, 2002).

Tests of executive functioning specifically are notorious for having poor ecological validity, as existing measures tell little about the functional implications of those with executive dysfunction (Barkley, 2001; Chaytor & Schmitter-Edgecombe, 2003). Further, ecological validity data for most measures of executive functioning are lacking for children (Slick et al., 2006). This is evident in the low-order correlations of executive functioning tasks with ratings by patients and caregivers of their apparent executive functioning in natural settings, with shared variance between such measurement approaches often below 10% (Burgess, Alderman, Evans, Ernslie, & Wilson, 1998). One explanation for this low correlation is that no objective measure of executive functioning taps into the ability to coordinate cognition and emotion, thereby preventing significant ecological validity (Ardila, 2008). Additionally, subjective parent report of child difficulties has further problems, including under- or over-reporting of symptoms (Kroner-Herwig, Morris, Heinrich, Gassmann, & Vath, 2009) or difficulties reflecting and monitoring due to the potential nature of heritable executive dysfunction.

There is a need for more ecologically valid executive functioning measures (Burgess et al., 1998; Cripe, 1996; Sbordone, 1996). Two approaches to addressing the problem of ecological validity of assessment instruments include verisimilitude and veridicality (Chaytor & Schmitter-Edgecombe, 2003). Verisimilitude refers to the degree in which the cognitive demands of a test are theoretically similar to the cognitive demands in the environment with the aim of identifying those who exhibit difficulty

performing real-world tasks (Franzen & Wilhelm, 1996). Veridicality refers to the degree to which existing tests are empirically related to measures of everyday functioning. Findings from studies that have been conducted generally indicate that the relationship between traditional measures and everyday functioning is poor (e.g., Higginson, Arnett, & Voss, 2000; Nadolne & Stringer, 2001). When patients fail on traditional neuropsychological tests, the assumption is made that the individual is likely to experience difficulties in the real-world comparable to the difficulties they experience in the test situation (Burgess et al., 1998). However, the validity of this assumption is rarely examined in empirical research; thus, there is a need to investigate the veridicality of tests of executive functioning.

### Measures of Executive Functioning

Measures initially used to assess executive functioning were limited largely to tests developed prior to the 1950s and the revolution of contemporary neuropsychology (Delis, Kaplan, & Kramer, 2001). Consequently, many assessment tools were adapted from measures used to assess other domains (e.g., intellectual functioning, memory) and were not developed explicitly for the assessment of executive functioning (Shunk, Davis, & Dean, 2006). Thus, measures were not theoretically-driven and lacked a conceptual model in which assessments were to be based. For example, the Wisconsin Card Sorting Test (WCST) was constructed in 1948 by Grant and Berg and was based partly on sorting test methods to assess abstract reasoning and set-shifting in humans and animals (Alvarez & Emory, 2006). Milner (1963) adapted the procedure and this version became the model of the current standard administration of the WCST, which eventually became a popular

neuropsychological test used by over 70% of neuropsychologists (Butler, Retzlaff , & Vanderploeg, 1991).

Whereas the original use for many tests of executive functioning (e.g., WCST) was to detect neuropathology, newer measures are being used to address various real-world outcomes, which represent a pivot towards making tests ecologically valid. However, these newer measures of executive functions must undergo psychometric scrutiny, particularly their factor structures, in order to better understand the construct of executive functioning and its use in neuropsychological assessment. Confirmatory Factor Analysis (CFA) allows for an inferential comparison of alternative models of executive function that are specified a priori (Gioia et al., 2002) and was used in the current study. Described below are two recently developed tests of executive functioning designed to enhance ecological validity. One measure focuses more specifically on one executive skill (i.e., attention), whereas the other measure captures executive functions more broadly. Thus, these measures assess different types of executive skills.

#### *Test of Everyday Functioning for Children (TEA-Ch)*

A relatively new measure of executive functioning is the TEA-Ch, which represents an effort to overcome some of the limitations (e.g., poor ecological validity) of prior measures (Manly et al., 2001). The TEA-Ch is a performance-based, objective measure of executive functioning with a specific focus on attention used with children ages six to sixteen that consists of nine “game-like” subtests: Sky Search, Score!, Creature Counting, Sky Search DT, Map Mission, Score DT, Walk, Don’t Walk, Opposite Worlds, and Code Transmission. The subscales of this theory-based measure

were developed based on previous studies of executive and attentional processes which delineated a three-factor model of attention (Shapiro, Morris, Morris, Flowers, & Jones, 1998). The development of the TEA-Ch fills an important gap in the assessment of executive functioning because of its use of tasks that more closely resembles real-world demands of attention (Heaton et al., 2001). It attempts to measure attentional skills similar to those experienced in the child's environment (Gioia et al., 2002). Additionally, this measure uses multiple sensory modalities (e.g., visual, auditory, motor) throughout testing, which is similar to demands encountered in everyday life (e.g., listening to teacher instructions while completing work; Heaton et al., 2001). Because the TEA-Ch uses tasks simulating real-world attentional demands, this measure is thought to be more ecologically valid than previous executive functioning measures (Anderson et al., 1998).

### Advantages

Not only does the TEA-Ch address ecological validity concerns, it possesses a number of additional advantages. First, it was developed based on theory and model-based domains of attention (i.e., selective, sustained, switching), thus providing both research and clinical utility (Heaton et al., 2001). The TEA-Ch includes multiple components of attention, which differs from previous measures of attention (e.g., Continuous Performance Test, WCST) that typically examines only one component at a time (Heaton et al., 2001). Because it is an objective measure, it is less susceptible to biased report (Heaton et al., 2001). Finally, the TEA-Ch accounts for other cognitive domains that may be required in testing by minimizing demands on memory, reasoning,

task comprehension, motor speed, verbal ability, and perceptual acuity (Manly et al., 2001).

#### Factor structure

The factor structure of the TEA-Ch has been examined using CFA. Manly and colleagues (2001) conducted a study using CFA on a normative sample of 293 children ages six to 16, and results supported their theoretical model of attention. In total, three latent variables emerged: Sustained Attention (Score!, Code Transmission, Walk, Don't Walk, Score DT, Sky Search DT), Selective Attention (Sky Search, Map Mission), and Attentional Control/Switching (Creature Counting, Opposite Worlds), providing a good fit of the patterns of performance observed in a large group of children. A single factor model was rejected, indicating that this executive functioning construct is not a unitary factor. CFA was also conducted on the Chinese version of the TEA-Ch with a sample of 232 children ages six to 15 (Chan, Wang, Ye, Leung, & Mok, 2008). Results demonstrated that a three-factor solution (Sustained Attention, Selective Attention, Attentional Control/Switching) was a good fit and a one-factor model was rejected, confirming the results from Manly and colleagues (2001). Because these are the only known studies to examine the factor structure of this measure, replication is required in order to validate this theoretical model of attention.

Replication of the factor structure of the TEA-Ch is particularly needed with a sample of children and adolescents diagnosed with ADHD due to the characteristic executive impairment often exhibited in this population (Heaton et al., 2001). Results from a study examining the pattern of performance of children with ADHD on the TEA-

Ch suggest that divided attention may comprise a separate factor for this population (Heaton et al., 2001), unlike previous factor analyses indicating three factors for control children.

*Behavior Rating Inventory of Executive Functioning (BRIEF)*

A second test of executive functioning designed to overcome shortcomings of existing measures is the parent report of the BRIEF (Gioia et al., 2000). Whereas the TEA-Ch focuses more specifically on attentional capacities, the BRIEF examines executive skills more broadly. This assessment tool is considered a subjective measure because it asks parents to report on their appraisals of difficulties the child is having that are purportedly caused by executive functioning deficits (e.g., “When given three things to do, remembers only the first or last”). The BRIEF was formulated using a multidimensional model of executive functioning consisting of eight subscales (i.e., Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Organization of Materials, Monitor) that were developed based on the theoretical assumption that these functions are distinct in a clinically meaningful way, yet related within an overarching executive system (Gioia et al., 2002). The BRIEF offers strong veridicality through assessing parents’ report of their children’s everyday executive behaviors in natural settings (Gioia et al., 2002). It does so by understanding their real-world needs relative to test performance in a clinic-based setting by providing reliable reports from parents regarding the child’s everyday behavioral manifestations of executive impairments. Thus, its ecological validity is enhanced compared to previous executive functioning measures.

## Advantages

In addition to its attempt in representing a more ecologically valid tool, the BRIEF has several other benefits. It attempts to measure the behavioral and emotional aspects of executive functioning in children, focuses on real-life behavior, possesses a capacity to tap into developmental appropriateness (Anderson et al., 2002), can be used with a wide range of childhood disorders (Donders, 2002), and is not correlated with IQ (Mahone et al., 2002). In addition, the BRIEF augments traditional performance-based measures, which typically only assesses cognition, through its assessment of additional components of executive functioning (e.g., behavior, emotion) (Bodnar et al., 2007; Donders, 2002; Vriezen & Pigott, 2002). Although obtaining parent report of child behaviors has been criticized for its lack of agreement with youth report (e.g., Kroner-Herwig et al., 2009), previous research indicates that self-report of everyday cognitive performance is a weaker measure than report by a clinician or other informants (Chaytor & Schmitter-Edgecombe, 2003). Therefore, the parent report nature of the BRIEF may be an additional benefit by providing more accurate and relevant information of youths' behavioral and emotional difficulties associated with executive functioning that may not be captured by traditional performance-based measures (Bodnar et al., 2007). This highlights the importance of including multi-method, multi-informant assessments while measuring a particular construct.

## Factor structure

The BRIEF has been submitted to factor analysis in several studies to examine its factor structure. Gioia and colleagues (2000) conducted an exploratory factor analysis of

the eight scales comprising the BRIEF with parent and teacher ratings for both normative and clinical groups, and a two-factor structure was identified: a three-scale (Inhibit, Shift, Emotional Control) Behavioral Regulation factor and a five-scale (Initiate, Working Memory, Plan/Organize, Organization of Materials, Monitor) Metacognition factor. However, it was later proposed that the Monitor subscale of the BRIEF may reflect two dimensions, monitoring of task-related activities and monitoring of personal behavioral activities. Gioia and colleagues (2002) investigated this hypothesis through CFA with a sample of 374 children ages five to 18 with a variety of diagnoses, including ADHD, learning disorders, autism spectrum disorders, Tourette's syndrome, affective disorders, and seizure disorders. Based on current theories arguing one-dimensional versus multidimensional models of executive functioning, four models of executive functioning were examined using the nine subscales (i.e., with the Monitor subscale divided into two scales). Results of this study indicated that a three-factor model was the most appropriate structure for the nine scales: Emotional Regulation (Shift, Emotional Control), Behavioral Regulation (Self-Monitor, Inhibit), and Metacognition (Initiate, Working Memory, Plan/Organize, Organization of Materials, Task-Monitor). However, a more recent factor analysis using a sample of 80 children and adolescents with epilepsy did not support this factor structure (Slick et al., 2006). Findings from this study indicated that a two-factor model (i.e., Metacognition, Behavioral Regulation) provided the best fit. Moreover, Bodnar and colleagues (2007) examined the factor analysis of the BRIEF subscales with the Continuous Performance Test (CPT), a performance-based measure of attention, using a mixed clinical group of 109 youth ages six to 18. Using Exploratory

Factor Analysis, results indicated that the BRIEF subscales load on a single separate factor from any of the CPT scales, suggesting that the method of assessment rather than the construct accounts for more shared variance.

Further investigation of the BRIEF is needed. The validity of the underlying structure of the BRIEF subscales must be explored (Gioia et al., 2002). The use of this measure in combination with performance-based measures of executive functioning among different clinical populations also must be examined to determine its validity, sensitivity, and specificity (Bodnar et al., 2007). Examining the BRIEF within specific samples will help determine whether disorder-specific executive profiles arise from disorder-specific underlying executive function structures (Gioia et al., 2002). Additionally, it may provide useful information on the generality and specificity of the model's executive function.

Rating scales like the BRIEF are often used clinically in conjunction with objective measures to provide an ecological perspective during neuropsychological assessment. However, previous research suggests modest relationships between these two types of assessments (Burgess et al., 1998). For example, Mahone and colleagues (2002) examined results from the BRIEF with objective, clinic-based measures of executive functioning (Controlled Oral Word Association Test, Tower of London), and results indicated low to moderate correlations (.17-.43). These findings demonstrate that the different assessment methods (i.e., parent versus child report, objective versus subjective) may be measuring unique or distinct aspects of executive functioning (Anderson et al., 2002; Bodnar et al., 2007). It is not uncommon in the assessment literature to find

relatively low to moderate associations between independent methods of assessing similar constructs because each assessment method may be providing useful data not available from other sources (Meyer et al., 2001). This may be even more common in the measurement of executive functioning given its lack of a clear definition and conceptualization (i.e., unitary versus multi-component). It is considered the “gold standard” in child assessment to include multi-informant, multi-method approaches of assessment (Johnston & Murray, 2003) because it is assumed that these diverse sources of data will optimize the predictive accuracy (i.e., incremental validity) of the outcome variable of interest (e.g., academic performance). However, this assumption is rarely empirically evaluated in the executive functioning literature (Bodnar et al., 2007; McCandless & O’Laughlin, 2007).

In sum, both the TEA-Ch and the BRIEF represent measures of executive functioning that may be more ecologically valid than extant assessment tools. Unlike previous measures, these two assessments are theoretically-driven using current models of executive functioning (Gioia et al., 2002; Shapiro et al., 1998). However, similar to other measures of executive functioning, the constructs underpinning these assessment tools require further investigation through statistical scrutiny (i.e., CFA; Gioia et al., 2002; Heaton et al., 2001). This is particularly necessary for samples characterized by executive impairments, such as ADHD, because of the frequent use of executive functioning measurement in clinical settings and the real-world implications of this assessment. Thus far, no studies have examined the factor structure of the BRIEF or the TEA-Ch using a sample of youth diagnosed with ADHD (see Table 1 for a review).

Table 1 Factor Analyses of the TEA-Ch and the BRIEF

Measure	Study	EFA vs. CFA	Sample	Models Tested	Factors Found
<b>TEA-Ch</b>					
	Manly et al. (2001)	CFA	Normative (N=293) ages 6-16	Two: 1-factor and 3-factor	Three-factor model: Selective Attention, Sustained Attention, Attentional Control/Switching
	Chan et al. (2008)	CFA	Normative (N=158) ages 6-15	Two: 1-factor and 3-factor	Three-factor model: Selective Attention, Sustained Attention, Attentional Control/Switching
<b>BRIEF</b>					
	Gioia et al. (2000)	EFA	Normative (N=1,419) and mixed clinical group (N=852) ages 6-16	N/A	Two-factor model: Behavioral Regulation and Metacognition
	Gioia et al. (2002)	CFA	Mixed clinical group (N=374) ages 5-18	Four: 1-factor, 2-factor, 3-factor, 4-factor	Three-factor model: Emotional Regulation, Behavioral Regulation, and Metacognition
	Slick et al. (2006)	EFA	Epilepsy (N=80) ages 5-17	N/A	Two-factor model: Behavioral Regulation and Metacognition
	Bodnar et al. (2007)	EFA	Mixed clinical group (N=109) ages 6-18	N/A	All scales loaded on one factor

Note. If CFA was run, the model that received the most support is reported. If EFA was run, the number of factors in which subscales loaded on is reported.

### *Attention-Deficit/Hyperactivity Disorder (ADHD)*

ADHD is a developmental disorder characterized by persistent and developmentally inappropriate symptoms of inattention and/or hyperactivity and impulsivity (American Psychiatric Association, 2000). To warrant a diagnosis, the symptoms must cause impairment to normal functioning and be evident in multiple settings (e.g., home, school, social relationships). The prevalence of ADHD ranges from three to 10%, with an approximate referral rate of 30-40% in child guidance clinics (Barkley, 1997a). The gender ratio is approximately 3:1, with more males being affected than females (American Psychiatric Association, 2000). However, some researchers believe that these ratios are biased due to underdiagnosis of ADHD in females (e.g., Gaub & Carlson, 1997; Hynd & Hooper, 1995) or represent referral biases by parents, teachers, and health professionals (e.g., Swanson, Sergeant, Taylor, Sonuga-Barke, Jensen, & Cantwell, 1998; Taylor, 1994). ADHD is a chronic disorder (Pennington & Ozonoff, 1996) characterized by both cognitive (e.g., working memory, speed, processing deficits) and behavioral (e.g., inattention, hyperactivity, impulsivity) symptoms (Brassett-Harknett & Butler, 2007).

#### Subtypes

The DSM-IV identifies three subtypes of ADHD: (1) inattentive, (2) hyperactive/impulsive, and (3) combined (inattentive and hyperactive/impulsive; American Psychiatric Association, 2000). Symptoms of inattention reflect an inability to sustain attention or persist at tasks, remember and follow through with directions, and ignore distractions (Barkley, 2003). Hyperactivity symptoms include excessive activity

level, fidgetiness, limited ability to remain seated when required to do so, greater touching of objects, moving about, talking excessively, acting impulsively, interrupting others' activities, and difficulty waiting in line or taking turns in games. Symptoms of hyperactivity appear to decline with age, whereas inattention difficulties remain relatively stable during elementary years, eventually declining during adolescence although never reaching typical levels.

Epidemiological and clinical studies have documented that the behavioral, emotional, and social characteristics of ADHD subtypes are quite different (Barkley, Fisher, Edelbrook, & Smallish, 1991; Lockwood, Marcotte, & Stern, 2001). For example, research demonstrates that children diagnosed with ADHD-Combined Type show a greater proclivity to exhibit externalizing behaviors, such as aggression, self-destructiveness, and antisocial behavior (King & Young, 1982), and seem to be predictive of conduct disorder and substance use and abuse (Molina, Smith, & Pelham, 1999). In contrast, youth with ADHD-Inattentive Type have a greater tendency to display internalizing behaviors (e.g., social withdrawal, anxiety, self-consciousness, apathy; Lahey, Schaugency, Hynd, Carlson, & Nieves, 1987), and are predictive of academic underachievement (DuPaul, Power, Anastopoulos, & Reid, 1998; Fischer, Barkley, Fletcher, & Smallish, 1993; Weiss & Hechtman, 1993). No cognitive differences have been found on IQ and academic measures between ADHD subtypes (Faraone, Biederman, Weber, & Russell, 1998).

### Etiology

ADHD can manifest itself in a variety of ways and has a variety of causes, making it a very complex condition to understand (Brassett-Harknett & Butler, 2007; Hill

& Taylor, 2001). Research investigating the etiology of ADHD has implicated environmental, biochemical, genetic, and neurological factors.

#### *Environmental Factors*

Environmental research has examined the family context in which ADHD children are raised, and results suggest that parents of children with ADHD are more likely to exhibit mental health problems, such as anxiety disorders and substance abuse (Egeland, Kalkoske, Gottesman, & Erickson, 1990; Russo & Beidel, 1994). Research has also indicated greater family conflict, marital discord, and psychosocial problems in families with a child with ADHD (Edwards, Schultz, & Long, 1995; Peris & Hinshaw, 2003; Thunstrom, 2002). However, it must be noted that the direction of influence has yet to be determined, and it is likely that family difficulties may be a consequence of ADHD rather than a cause. Parental characteristics (e.g., poor management of children, overstimulating parenting approach) have also been examined for their role in the development of ADHD, but they have not received much support (Barkley, 2003). It is more likely that parental factors impact the severity of symptoms, the continuity of symptoms over development, the types of comorbid disorders that develop, and peer relationship problems that may arise rather than the actual development of the disorder.

Research has also investigated the role of environmental experiences during pregnancy, delivery, and infancy. Some evidence exists to suggest that fetal distress may selectively damage the brain regions associated with ADHD (e.g., Gillberg, Carlstrom, & Rassmussen, 1983), but possibly only for certain groups (e.g., comorbid, non-familial; Sprich-Bruchminster, Beiderman, Milberger, Faraone, & Lehman, 1993). Maternal behaviors during pregnancy have also been linked with ADHD, including maternal

bleeding, smoking, and illicit drug use (Milberger, Biederman, Faraone, Guite, & Tsuang, 1997; Thaper et al., 2003). Other evidence suggests the impact of low birth weight (Breslau et al., 1996; Whitaker et al., 1997), premature birth (Bhutta, Cleves, Casey, Cradock, & Anand, 2002), and sleep problems in infancy (Thunstrom, 2002) on the development of ADHD in children.

Other factors that have been examined for their relation with ADHD include food dyes, preservatives, and environmental toxins (e.g., lead); however, research indicates that there is no evidence for this association (e.g., Mattes & Gittelman, 1981; Needleman et al., 1979).

### *Biochemical Factors*

Biochemical causes of ADHD have implicated several neurotransmitters for their role in the development of symptoms. Dopamine, a neurotransmitter used by the brain with a central role in psychomotor activity and reward-seeking behavior, has been associated with ADHD and may be manifested in the characteristic symptoms of impulsivity and hyperactivity (e.g., Cook et al., 1995; Dougherty, Bonab, Spencer, Rauch, Madras, & Fischman, 1999; Malone, Kershner, & Swanson, 1994). Other transmitters, such as norepinephrine, have also been implicated (e.g., Heilman, Voellar, & Nadeau, 1991; Shen & Wang, 1984). The role of these two neurotransmitters is evident in the fact that many children respond well to stimulants, which act by increasing the availability of dopamine and by producing some effects on the noradrenergic pathways (DuPaul, Barkley, & Connor, 1998).

### *Genetic Factors*

Although ADHD may result from a variety of pathologies, a genetic susceptibility seems to be the most common (Hill & Taylor, 2001; Pennington & Ozonoff, 1996). Twin, adoption, and family studies provide evidence of a genetic component, with heritability estimates ranging from .50 to .98 in monozygotic twins and concordance rates ranging from .80 to .98 (Faraone & Doyle, 2000; Gjone, Stevenson, & Sundet, 1996; Levy, Hay, McStephen, Wood, & Waldman, 1997; Pennington & Ozonoff, 1996). Twin studies consistently find little effect of shared environmental experiences on the traits of ADHD, providing evidence of the strong genetic component of this disorder (Barkley, 2003). Further, ADHD clusters significantly among the biological relatives of children or adults with the disorder, and adoption studies demonstrate that children with ADHD are more likely to resemble their biological parents than their adoptive parents in hyperactivity levels.

Several genes have been linked to ADHD (e.g., Segman et al., 2002); however, research has produced conflicting results (Brassett-Harknett & Butler, 2007). Future research must focus on the mode of transmission, larger sample sizes, and families in which genes are exerting the largest risk (e.g., chronic symptoms) in order to determine specific genetic influences (Faraone & Doyle, 2000).

### *Neurological Factors*

Evidence from studies of neuroanatomy, neuroimaging, neurochemistry, and stimulant medication has led many researchers to view ADHD as a disorder of frontal lobe dysfunction (Barkley, 1997a; Castellanos, 1997; Tannock, 1998), with some agreement that frontal abnormalities are more pronounced in the right hemisphere

(Barkley, Grodzinsky, & DuPaul, 1992). Right prefrontal function in adults has been associated with several executive functions (e.g., sustained attention, response inhibition) that are characteristic deficits in children with ADHD (Barkley 1997a; Cohen, Semple, Gross, King, & Nordahl, 1992; Garavan, Ross, & Stein, 1999). Research examining the brains of individuals with ADHD using brain imaging techniques has demonstrated differences in morphology (Barry, Johnstone, & Clarke, 2003). For example, single photon emission computed tomography (SPECT) reports show hypoperfusion of striatal and frontal brain regions (about 10% lower than normal) and hyperperfusion of occipital brain areas in individuals with ADHD (Lou, Henriksen, & Bruhn, 1984; Lou, Henriksen, Bruhn, Borner, & Nielson, 1989). Magnetic resonance imaging (MRI) scans demonstrate slightly larger right frontal lobes than left in control children; however, children with ADHD lack this asymmetry (Hynd, Semrud-Clikeman, Lorys, Novey, & Eliopoulos, 1991).

Children with ADHD also demonstrate decreased blood flow to the frontal lobes (Grodzinsky & Diamond, 1992; Lou et al., 1984), as well as to pathways connecting these regions with the limbic system via the striatum and the caudate, and with the cerebellum (Gustafsson, Thernlund, Ryding, Rosen, & Cederblad, 2000). Therefore, researchers have concluded that the characteristic psychological deficits of those with ADHD have been linked to several specific brain regions (i.e., the frontal lobe, its connections to the basal ganglia, and their relation to the central aspects of the cerebellum) that exhibit less electrical activity and reactivity to stimulation, as well as smaller areas of brain matter and less metabolic activity of this brain matter.

In conclusion, the etiology of ADHD continues to be controversial, implicating a variety of environmental, biochemical, genetic, and neurological causes. Nonetheless, considerable evidence suggests that this is a highly heritable disorder with frontal lobe dysfunction common in individuals with ADHD.

### Comorbidity

Comorbidity is common in children diagnosed with ADHD, with estimates of comorbid diagnoses up to 44% in community-based samples (Szatmari, Offord, & Boyle, 1989) and 87% in clinic-referred children (Kadesjo & Gillberg, 2001). Comorbid diagnoses include disruptive disorders, learning disabilities, mood disorders, and tic disorders (Angold, Costello, & Erkanli, 1999), with the most common being oppositional defiant disorder (ODD) and, to a lesser extent, conduct disorder (CD; August, Braswell, & Thuras, 1998; Faraone, Biederman, & Monuteaux, 2000; Lavigne, Cicchetti, Gibbons, Binns, Larsen, & DeVito, 2001). In fact, research indicates that up to 50% of youth with ADHD meet criteria for ODD (American Academy of Child and Adolescent Psychiatry, 1997), with more males being affected than females (Carlson, Tamm, & Gaub, 1997).

Several developmental and learning disorders have also been found to be associated with ADHD, including Tourette's syndrome, dyslexia, dysgraphia, dyscalculia, and dyspraxia (Barkley, 1990; Biederman, Newcorn, & Sprich, 1991; Peterson, Pine, Cohen, & Brook, 2001; Rabiner & Coie, 2000). Specifically, approximately 19-26% of children with ADHD meet criteria for a learning disorder (American Academy of Child and Adolescent Psychiatry, 1997), with inattentive symptoms being more closely associated with reading disabilities (Wilcutt, Pennington, & DeVries, 2000).

Other comorbid conditions reported to exist with ADHD include anxiety (e.g., obsessive compulsive disorder) and mood disorders (e.g., depression, bipolar disorder; Biederman et al., 1991; Lavigne et al., 2001), with estimates up to 20-25% for an anxiety disorder and 15-20% for an affective disorder (American Academy of Child and Adolescent Psychiatry, 1997). High comorbidity rates, coupled with the impairment associated with symptoms of ADHD, often produce negative, long-lasting consequences affecting adjustment, including behavioral, social, and academic functioning (DuPaul & Stoner, 1994).

### Executive Dysfunction

Research indicates that the frontal lobe dysfunction associated with ADHD generally results in impairment in executive functioning for children and adolescents diagnosed with this disorder. Halperin and Schulz's (2006) review of neuropsychological and neuroimaging research provides considerable evidence for the association between prefrontal and basal ganglia function and the behavioral manifestations of ADHD. Researchers generally conclude that ADHD is a relative inability to regulate and organize behavior, which is associated with an impairment of the executive functions that are primarily controlled by the frontal lobes of the brain (Barkley, 1997a; Barkley et al., 1992; Brown, 2000). Deficits observed in executive functions are consistent with structural brain-imaging studies showing that children with ADHD have smaller volumes in various brain regions including the dorsolateral prefrontal cortex, which is typically associated with executive functions (Seldman, Valera, & Makris, 2005). Additionally, there is an association between the right frontal lobe and measures of sustained attention, which has theoretical relevance to ADHD (Pennington & Ozonoff, 1996).

### *ADHD Models and Executive Functioning*

Some researchers believe that specific executive functioning domains contribute to the symptoms of ADHD, such as response inhibition (Barkley, 1997a), working memory (Pennington & Ozonoff, 1996), or a more general weakness in executive control (Castellanos & Tannock, 2002). For example, a widely accepted view is Barkley's (1997a) theory that the central impairment in children with ADHD is behavioral inhibition, which serves as a trigger for secondary effects in various executive functions. Thus, the model linking executive functioning deficits to the behavioral symptoms of ADHD is that the three fundamental symptoms (i.e., hyperactivity, distractibility, impulsivity) are due to a deficit in the executive function of inhibition. This conceptualization corresponds with neuroanatomical research in that both the frontal lobe and basal ganglia may mediate the inhibitory deficit in ADHD (Sergeant, Geurts, & Oosterlaan, 2002). In contrast, Brown (2000) conceptualized ADHD as a model in which the executive functions implicate abilities in goal-oriented processes, including initiation and maintenance of efficient strategies, programming and planning of motor behavior skills, learning and applying contingency rules, abstract reasoning, problem-solving, and sustaining attention and concentration. Despite the conceptualization of ADHD used, strong evidence for executive dysfunction exists even after statistical adjustment for demographic variables (e.g., gender, age, IQ, SES; Biederman et al., 2004).

### *Evidence from Neuropsychological Assessment*

Neuropsychological assessment of executive functioning in youth with ADHD corroborates these findings and provides additional evidence for the specific impairments associated with this disorder. Pennington and Ozonoff (1996) conducted a meta-analysis

of eighteen studies investigating the association between executive impairments and ADHD, and findings demonstrated that children with ADHD performed significantly worse than controls on 67% of a total of 60 measures. Moreover, they did not perform significantly better than controls on any of the executive functioning measures, providing evidence for the presence of executive dysfunction in this population. More recently, Wilcutt, Doyle, Nigg, Faraone, and Pennington (2005) performed a review of the literature which demonstrated significant differences between individuals with ADHD and those without on all thirteen executive functioning tasks, with the most consistent findings of impairment being on measures of response inhibition, vigilance, spatial working memory, and some measures of planning.

#### Specific executive functioning tasks

While individuals with ADHD generally exhibit deficits in executive functioning, research examining performance on specific executive functioning tasks has yielded inconsistent results, suggesting considerable variability in ADHD samples (Grodzinsky & Diamond, 1992; Sergeant et al., 2002; Toplak, Bucciarelli, Jain, & Tannock, 2009). Deficits in executive functioning domains that have been identified include strategic flexibility, planning, monitoring behavior (Cepeda, Cepeda, & Kramer, 2000; Clark & Rutter, 1981; Manly et al., 2001), working memory (Cepeda et al., 2000; Clark & Rutter, 1981; Manly et al., 2001; Mariani & Barkley, 1997; Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005; Muir-Broaddus, Rosenstein, Medina, & Soderberg, 2002), response inhibition (Mahone, Pillion, Hoffman, Hiemenz, & Denckla, 2005; Mostofsky, Newschaffer, & Denckla, 2003; Muir-Broaddus et al., 2002; Pennington & Ozonoff, 1996), and impulsivity (Stins et al., 2005). Conversely, consistent findings of impairment

in sustained attention has been demonstrated (Cepeda et al., 2000; Clark & Rutter, 1981; Harris et al., 1995; Levy & Hobbes, 1997; Manly et al., 2001; Mirsky, Pascualvaca, Duncan, & French, 1999; Muir-Broaddus et al., 2002). Divided attention has not been fully examined; thus, there is inconclusive evidence on the performance of individuals with ADHD for this executive domain (Heaton et al., 2001). Overall, these findings may be indicative of more specific executive functioning deficits rather than global ones (Grodzinsky & Diamond, 1992).

#### Specific executive functioning measures

Because the assessment tools used to measure executive functions vary by function of the definition used, it is also important to examine the pattern of performance on specific tests of executive functioning. Barkley and colleagues (1992) conducted a review of previously used tests of executive functioning, and results indicated significant differences in performance between children with ADHD and controls on a test of set-shifting ability (i.e., WCST), the Stroop test, and on a measure of sustained attention (i.e., Continuous Performance Test). Other neuropsychological tests (e.g., verbal fluency, Rey-Osterrieth Complex Figure Test, Trail Making Test) demonstrated variable performance with some studies reporting significant differences between groups and others not. Results from a prospective single-blind study demonstrated that children with ADHD performed significantly worse than age-, grade-, and gender-matched controls on errors of omission during the Continuous Performance Test (CPT), WCST, and tests of verbal list learning (i.e., Wide Range Assessment of Memory and Learning; Seidman et al., 1995). In a continuation of this study, significant deficits were replicated on the Stroop, WCST, Wide Range Assessment of Memory and Learning list learning, and auditory

CPT omissions (Seidman, Biederman, Faraone, Weber, & Ouellette, 1997), suggesting stability of findings. Further, a number of studies demonstrate relatively poorer performance on the CPT, indicating more consistent findings using this test (Mirsky et al., 1999).

Despite the considerable evidence of executive dysfunction in children and adolescents with ADHD, very little is known about the clinical implications of these deficits (Biederman et al., 2004). Impairments on tests of executive functioning are often assumed to relate to real-world functioning; however, the ecological validity of impairment on such tests and in ADHD has yet to be determined.

#### Associated Difficulties

Apart from an increased risk for comorbid psychiatric disorders, children and adolescents with ADHD are more likely to experience a variety of developmental, health, social, and academic difficulties. Two of the most prominent (i.e., social difficulties and academic underachievement), which were examined in the current study, are discussed below.

##### *Social Skills*

Impairment in social interactions is central to the problems associated with ADHD and is present in a variety of social settings and relationships. Children with ADHD exhibit difficulty with taking turns, interrupting others in games, conversations and classroom discussions, talking excessively, and appearing not to listen when spoken to (American Psychiatric Association, 2000). They seem to process social and emotional cues from others in a more limited and error-prone fashion as if they are not attentive to emotional information provided by others (Barkley, 2003). These difficulties affect the

interactions of children with their parents, and reciprocally, the way in which parents respond to their children (Johnston & Mash, 2001). Increased conflict with siblings relative to typically developing peer-sibling dyads has also been demonstrated (Mash & Johnston, 1983; Taylor, Sandberg, Thorley, & Giles, 1991).

In addition to social difficulties within the home, poor interaction with others also occurs with teachers (Whalen, Henker, & Dotemoto, 1980) and peers (Clark, Cheyne, Cunningham, & Siegel, 1988; DuPaul, McGoey, Eckert, & VanBrakle, 2001). Research demonstrates that children with ADHD have lower levels of social competence, are less liked by their peers, have fewer friends, and experience peer rejection as a consequence of their social difficulties (e.g., Bagwell et al., 2001; Barkley et al., 1991; Blachman & Hinshaw, 2002; Erhardt, & Hinshaw, 1994). Specifically, it is estimated that approximately 50-60% of children with ADHD experience rejection by their peers (Barkley, 1990), compared to 13-16% of children in elementary school classrooms being rejected (Terry & Coie, 1991).

Although the general consensus is that all ADHD subtypes are at risk for peer rejection (Carlson & Mann, 2000), some symptoms of ADHD and comorbid behaviors may place children at greater risk for poor social functioning, specifically aggression, disruptive behavior disorders, and hyperactive-impulsive symptoms (Rich, Loo, Yang, Dang, & Smalley, 2009). Thus, it is not surprising that children with the hyperactive/impulsive type have an increased likelihood of being rejected by peers than children with the inattentive type (Milich, Balentine, & Lynam, 2001). Gender may also be an important factor, as evidenced by previous studies demonstrating that young males with ADHD often fail to achieve peer acceptance (Melnick & Hinshaw, 1996) and show

low levels of social competence (Campbell, 1994). When symptoms of ADHD are greater, research shows higher levels of peer dislike in girls (Diamantopoulou, Henricsson, & Rydell, 2005). Given that social skills difficulties in youth with ADHD are likely to be chronic, with approximately 50-80% experiencing problems in adolescence (Barkley, 1990), and may lead to later delinquency (Kupersmidt, Cole, & Dodge, 1990), it is important to examine potential predictors of these difficulties.

#### Role of executive functioning

Neuropsychological function is often seen as a causal mediator in childhood for the development of psychopathology (Rutter, 1987); therefore, executive functioning deficits have been proposed as one potential predictor of social difficulties (e.g., McGann, Werven, & Douglas, 1997). Some neuropsychological literature points to executive functioning as a necessary component for social competence (Lezak, 2004), and social information processing theory suggests that executive functioning skills are necessary for social interaction (Crick & Dodge, 1994). Crick and Dodge's (1994) theory proposes that social problem-solving involves six steps: (1) encoding of internal and external cues, (2) interpretation of cues, (3) clarification of goals, (4) response access or construction (i.e., generating or accessing possible responses), (5) response decision, and (6) behavioral enactment. At any point in this process, executive dysfunction may interfere with an individual's ability to follow through with the step, thereby impacting social interactions. For example, executive functioning is necessary during the fourth step in order to generate alternative solutions and in the sixth step to modulate a response. Therefore, the executive functioning impairments and social difficulties that are characteristic of ADHD may be related or causal in nature. It may be that children with

ADHD have limited ability to generate strategies and to organize their thoughts and guide their behavior in social situations (Clark, Prior, & Kinsella, 2002) or that an impulsive behavioral style adversely affects social maturity and interpersonal adaptation (Stuss & Alexander, 2000). Because executive dysfunction can interfere with the development of appropriate peer relationships, it is important to understand the relation between neurocognitive functioning and social skills (Schonfeld, Paley, Frankel, & O'Connor, 2006).

*Executive functioning and social skills in other populations.* Previous studies have examined the impact of executive functioning deficits on social skills in various populations, with findings generally supporting a relation between these two aspects of functioning. Results from studies utilizing various pediatric populations have demonstrated a relation between executive functions and aspects of social problem-solving skills (e.g., Dennis, Guger, Roncadin, Barnes, & Schachar, 2001; Ganesalingam, Sanson, Anderson, & Yeates, 2007). For example, executive dysfunction was associated with poor social functioning in a sample of children with fetal alcohol exposure (Schonfeld et al., 2006), developmental disabilities (McEvoy, Rogers, & Pennington, 1993; Warschausky, Argento, Hurvitz, & Berg, 2003), frontal lobe lesions (Clark et al., 2002), and congenital brain dysfunction (Warschausky et al., 2003).

Although the effect of executive functioning on later adjustment has rarely been studied, a community-based sample was examined longitudinally and results indicated modest associations between measures of inhibition at age six and social competencies at age eight (Bates, Bayles, Bennet, Ridge, & Brown, 1991). A more recent longitudinal study was conducted by Nigg, Quamma, Greenberg, and Kusche (1999) with results

suggesting that performance on executive functioning tasks, specifically inhibitory control, predicted social competence two years later in a sample of school-aged children.

*Executive functioning and social skills in ADHD.* The relation between executive functioning and social functioning has also been examined in youth with ADHD. Clark and colleagues (2002) studied adolescents with and without ADHD, and results demonstrated a significant relation between performance scores on executive functioning tests and adolescents' social competence. Executive functioning impairments were also associated with adaptive behavior, including communication and socialization skills, suggesting difficulty organizing and monitoring thoughts efficiently, which may result in misinterpretation during social interactions. Conclusions from this study indicated that the higher-order cognitive deficits associated with poor self-regulation and impaired strategic planning abilities contribute to adjustment difficulties in children with ADHD. Another study examined the relation between executive dysfunction and social skills, and results suggested that the interaction of executive skills deficits and ADHD symptoms was important for some aspects of social functioning, including prosocial behavior (Diamantopoulou, Rydell, Thorell, & Bohlin, 2007). Additionally, high levels of executive dysfunction had a negative impact on peer acceptance for girls. Finally, a study conducted by Tannock, Fine, Heintz, & Schachar (1995) indicated a systematic deficit in the cognitive processes underlying the social use of language by children with ADHD (i.e., executive dysfunction), as well as the accompanying impairment in the social skills of these children.

In contrast, other studies have failed to find a relation between executive functioning deficits and social skills (e.g., Biederman et al., 2004). This may be a result

of the relative inability of traditional neuropsychological test scores to predict social and behavioral outcomes among children with certain disorders (Ganesalingam, Yeates, Sanson, & Anderson, 2007). Nonetheless, research indicates that it is important to incorporate executive functioning tasks in assessments of children with ADHD, not only as a diagnostic tool, but also to better predict these children's social outcomes (Diamantopoulou et al., 2007). Further, it may also be important to keep these neurocognitive impairments in mind when developing interventions to improve social skills for children with ADHD (Schonfeld et al., 2006). Previous research demonstrates successful executive functioning remediation for children with ADHD with social communication impairments (Ylvisaker & DeBonis, 2000).

#### *Academic Achievement*

ADHD has also been associated with poor school achievement (e.g., Barry, Lyman, & Klinger, 2002; Biederman et al., 2004; Erhardt & Hinshaw, 1994). Children with ADHD tend to have higher rates of school failure, grade retention, and poorer grades, as well as increased rates of academic underachievement compared to same-aged and IQ-matched peers (Wilson & Marcotte, 1996). In fact, approximately 30% of children with ADHD do not achieve academically at the level predicted by their age or IQ (Kamphaus & Frick, 1996). Academic underachievement appears to be specific to ADHD rather than associated with comorbid difficulties, such as conduct disorder (Frick et al., 1991). Some research exists to suggest that the severity of ADHD symptoms may impact school performance, with a greater number, severity, and pervasiveness of ADHD symptoms associated with an increased likelihood of academic difficulties (Barry et al., 2002). Although most studies do not suggest any differences on achievement between

ADHD subtypes or percentage diagnosed with learning disorders (Barkley et al., 1992), children diagnosed with inattentive type have demonstrated poorer school performance compared to children with the hyperactive/impulsive type (Milich et al., 2001). Gender appears to play a role in academic difficulties, with boys demonstrating increased diagnoses of learning disabilities and problems at school (Biederman et al., 2002; Graetz, Sawyer, & Baghurst, 2005). The association between ADHD symptoms and academic underachievement appears to be chronic (Brassett-Harknett & Butler, 2007), with difficulties persisting into adolescence (Barkley, 1990; Faraone, Biederman, & Monuteaux, 2002; Rucklidge & Tannock, 2001). The chronic nature of these difficulties may result in negative consequences, including lower educational attainment and delinquency (Preston, Heaton, McCann, Watson, & Selke, 2009). Despite numerous studies describing the association between academic underachievement and ADHD, the specific nature of the relationship remains unclear (Preston et al., 2009).

#### Role of executive functioning

Academic underachievement is generally considered the result of a range of factors, including familial, school, and neuropsychological domains. Because the influence of executive dysfunction on academic performance is unclear, a further research question involves the contribution of this cognitive domain to academic underachievement (Clark et al., 2002). Although many assume that a behavioral contribution (e.g., off-task, incomplete work) is the primary cause of children's inability to achieve potential, it may be that specific cognitive deficits (i.e., executive dysfunction) hinder the learning process (Barry et al., 2002; Preston et al., 2009).

Previous research has examined this possibility. In a normative population of 112 school-aged children, executive functioning deficits independently predicted school functioning (Diamantopoulou et al., 2007). Similar findings have been demonstrated for youth with ADHD. Aylward, Gordon, and Verhulst (1997) found a significant relation between performance on a measure of sustained attention (i.e., CPT) and scores on standardized achievement tests in a large sample of children with ADHD; however, the strength of this relation was small. Many researchers have differentiated between children and adolescents with ADHD symptoms alone and those with ADHD symptoms and executive dysfunction. Overall, results indicate a significant relation between executive functioning deficits and academic underachievement. For example, Biederman and colleagues (2004) found that children with ADHD and poor executive skills were at greater risk for grade retention and academic underachievement compared with children with ADHD and adequate executive functioning while controlling for socioeconomic status (SES), learning disabilities, and IQ. Positive associations between reading scores and executive function tests have also been demonstrated, suggesting that cognitive difficulties rather than behavioral symptoms alone were likely to contribute to a causal pathway from ADHD symptoms to later reading difficulties (Clark et al., 2002). These results suggest that the frequently reported association between ADHD and academic underachievement could be particularly strong in those with associated executive functioning deficits.

The association between executive dysfunction and academic underachievement may be related to specific academic subjects. For example, results from Mahone and colleagues (2002) demonstrated that parent report of executive dysfunction, as measured

by the BRIEF, was significantly associated with math achievement in a sample of children with ADHD and Tourette's syndrome. In another study, findings revealed that children with more severe symptoms of ADHD had lower academic performance in all subjects, whereas children with greater executive dysfunction had lower performance in math only, suggesting that executive dysfunction and ADHD severity are both good predictors independent of one another of overall academic underachievement (Barry et al., 2002). Conversely, Preston and colleagues (2009) found a significant relation between set-shifting abilities (i.e., performance on the TEA-Ch) and several academic areas, including reading, math, and spelling. Results from these studies demonstrate a lack of consistent findings with respect to academic subject.

Despite significant results, one limitation of the aforementioned studies includes a lack of a multidimensional conceptualization of cognitive functioning (Preston et al., 2009). In order to understand how specific executive functioning impairments impact academic achievement, both objective measures of performance and ecologically valid reports from parents or teachers is essential.

In conclusion, children and adolescents with ADHD often experience adverse difficulties that impact social and academic functioning (American Psychiatric Association, 2000; Barry et al., 2002; Biederman et al., 2004; Erhardt & Hinshaw, 1994). Although a variety of factors may contribute to these outcomes (e.g., family, peers, school), executive functioning has been identified as a potential key predictor in the development and maintenance of these difficulties (Barry et al., 2002; Lezak, 2004; McGann et al., 1997; Preston et al., 2009). This relation has been previously investigated, and results demonstrate mixed findings (e.g., Biederman et al., 2004; Clark et al., 2002).

A potential limitation for these results is the lack of use of ecologically valid measures of executive functioning to examine this association.

### *Summary*

The literature presented here highlights the importance of examining the domain of executive functioning given the significant impact of executive dysfunction on everyday life. A lack of research on the validity of recent measures of executive functions, as well as continued debate surrounding the unity or diversity of executive functions, underscore the importance of investigating the factor structure of neuropsychological assessments of executive functioning. Two recent tests have emerged in attempt to overcome limitations associated with ecological validity (i.e., TEA-Ch, BRIEF). However, the constructs underpinning these assessment tools require further investigation through statistical scrutiny (i.e., CFA). This is particularly necessary for samples characterized by executive impairments, such as ADHD, because of the frequent use of executive functioning measurement in clinical settings and the real-world implications of this assessment. Thus far, no studies have examined the factor structure of the BRIEF or the TEA-Ch using a sample of youth diagnosed with ADHD, which was the focus of the current study.

The literature has demonstrated that distinct methods of assessment may provide unique information and often result in low to moderate correlations despite assessing similar constructs. This is particularly salient for executive functioning measures due to a lack of a clear definition and conceptualization of this construct. Therefore, given their differences in measurement (objective, performance based versus subjective, parent report), the TEA-Ch and the BRIEF may be measuring distinct aspects of executive

functioning and/or the deficits associated with executive dysfunction. No studies have examined the association of these measures with outcomes, such as academic achievement and social functioning, despite the need to do so in order to determine the ecological and incremental validity of these tools. This is particularly relevant for children and adolescents diagnosed with ADHD due to difficulties in executive functioning, academic achievement, and social skills that they typically face.

### *Current Study*

The current study addressed several of the limitations in the literature. First, this study examined the construct and assessment of executive functioning with a sample of youth diagnosed with ADHD due to their characteristic executive functioning deficits. Second, the current study examined two assessments of executive functioning designed to enhance ecological validity (i.e., TEA-Ch, BRIEF). Each tool underwent CFA in order to establish its factor structure in a sample of youth with ADHD. Third, given the need for executive functioning tests to provide information regarding the functional implications of those with executive dysfunction, the association of these tools with outcomes (e.g., academic achievement, social skills) was examined. Finally, the two measures of executive functioning were examined for their incremental validity in predicting academic achievement and social skills.

### Hypotheses

#### *Factor Structure of Executive Functioning*

##### **Hypothesis 1**

The first hypothesis predicted that a measurement model consisting of three factors would provide a good fit to the data for the TEA-Ch. The three factors included:

Sustained Attention (Score!, Code Transmission, Walk Don't Walk, Score DT, Sky Search DT), Selective Attention (Sky Search, Map Mission), and Attentional Control/Switching (Creature Counting, Opposite Worlds). Results were analyzed using CFA, and maximum likelihood estimation with oblique and orthogonal rotations were used to test the factor structure of this model. Specifically, it was hypothesized that:

- a. The three-factor model would provide a good fit to the data as determined by  $\chi^2$  values and four measures of goodness of fit: root mean square error of approximation ( $RMSEA \leq .10$ ), standardized root mean square residual ( $SRMR \leq .08$ ), non-normed fit index ( $NNFI \geq .9$ ), and comparative fit index ( $CFI \geq .9$ ; see Figure 1).*
- b. The three-factor model would provide a better fit to the data than a one-factor model (see Figure 2) as determined by a chi-square differences test.*
- c. The three-factor oblique model would provide a better fit than a three-factor orthogonal model (see Figure 3) as determined by a chi-square differences test.*

### Hypothesis 2

The second hypothesis predicted that a measurement model consisting of two factors would provide a good fit to the data for the BRIEF. The two factors included: Behavioral Regulation (Inhibit, Shift, Emotional Control) and Metacognition (Initiate, Working Memory, Plan/Organize, Organization of Materials, Monitor). Results were analyzed using CFA, and maximum likelihood estimation with oblique and orthogonal rotations were used to test the factor structure of this model. Specifically, it was hypothesized that:

- a. The two-factor model would provide a good fit to the data as determined by  $\chi^2$  values and four measures of goodness of fit: root mean square error of approximation*

Figure 1 TEA-Ch Three-Factor Oblique Model

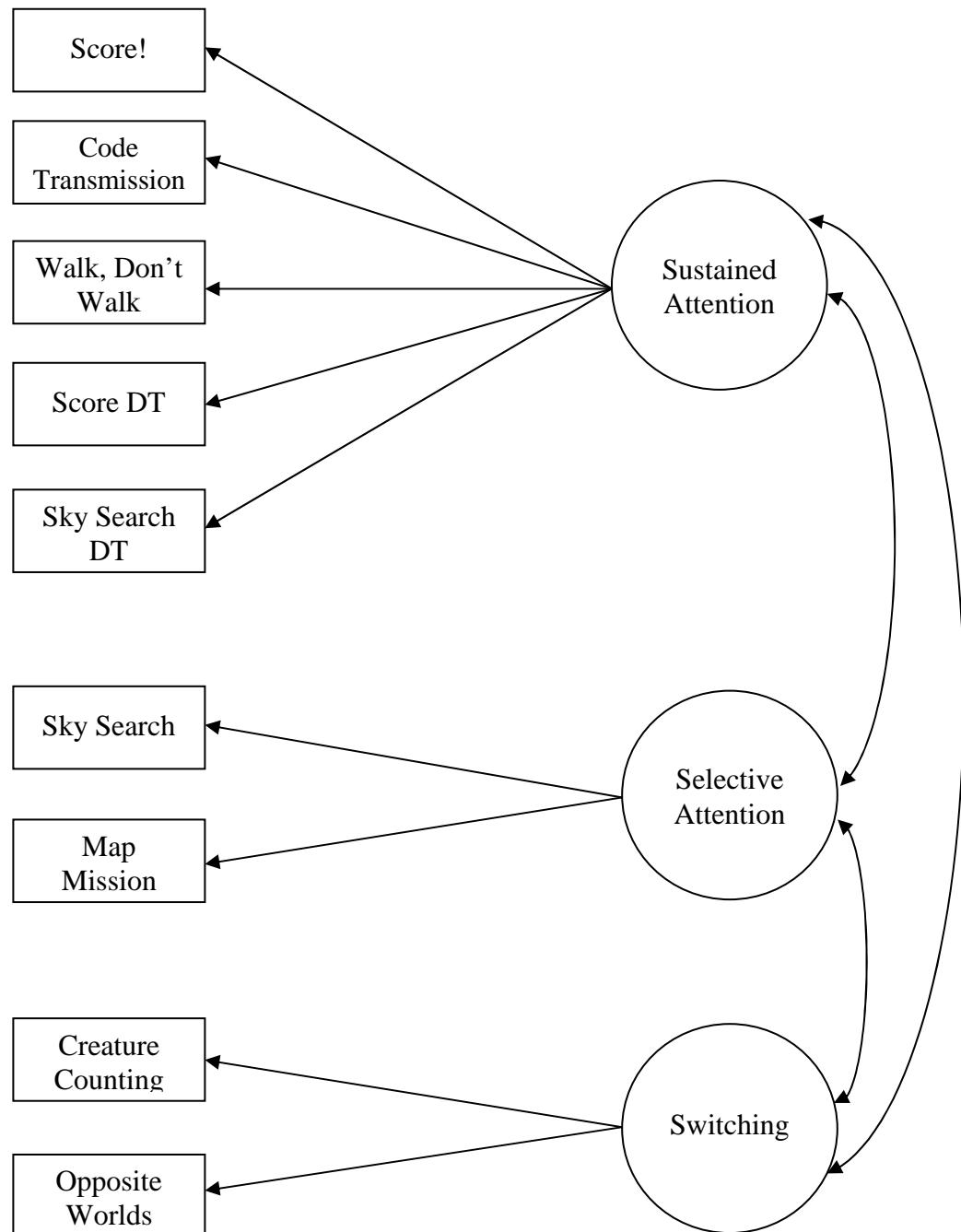


Figure 2 TEA-Ch One-Factor Model

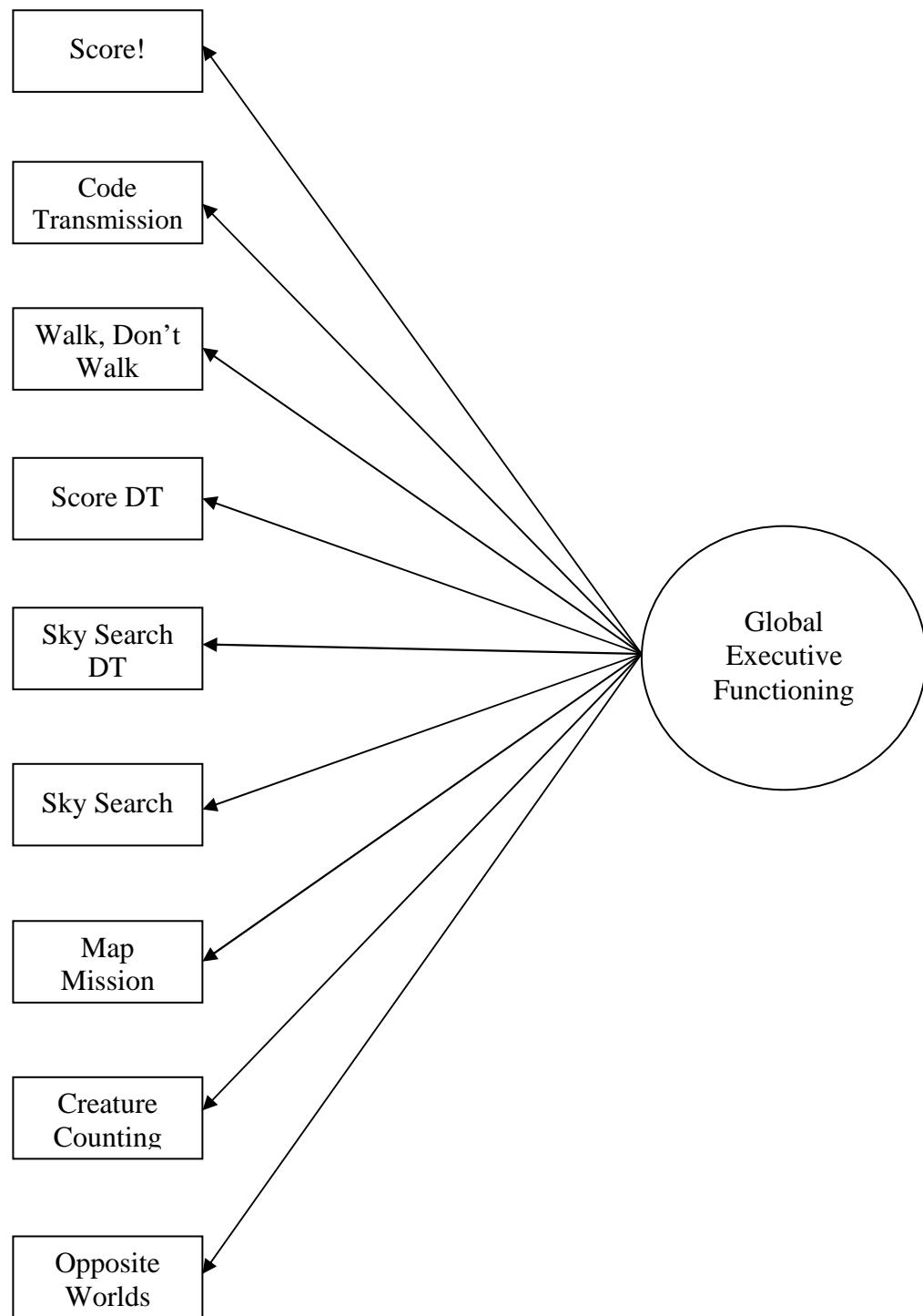
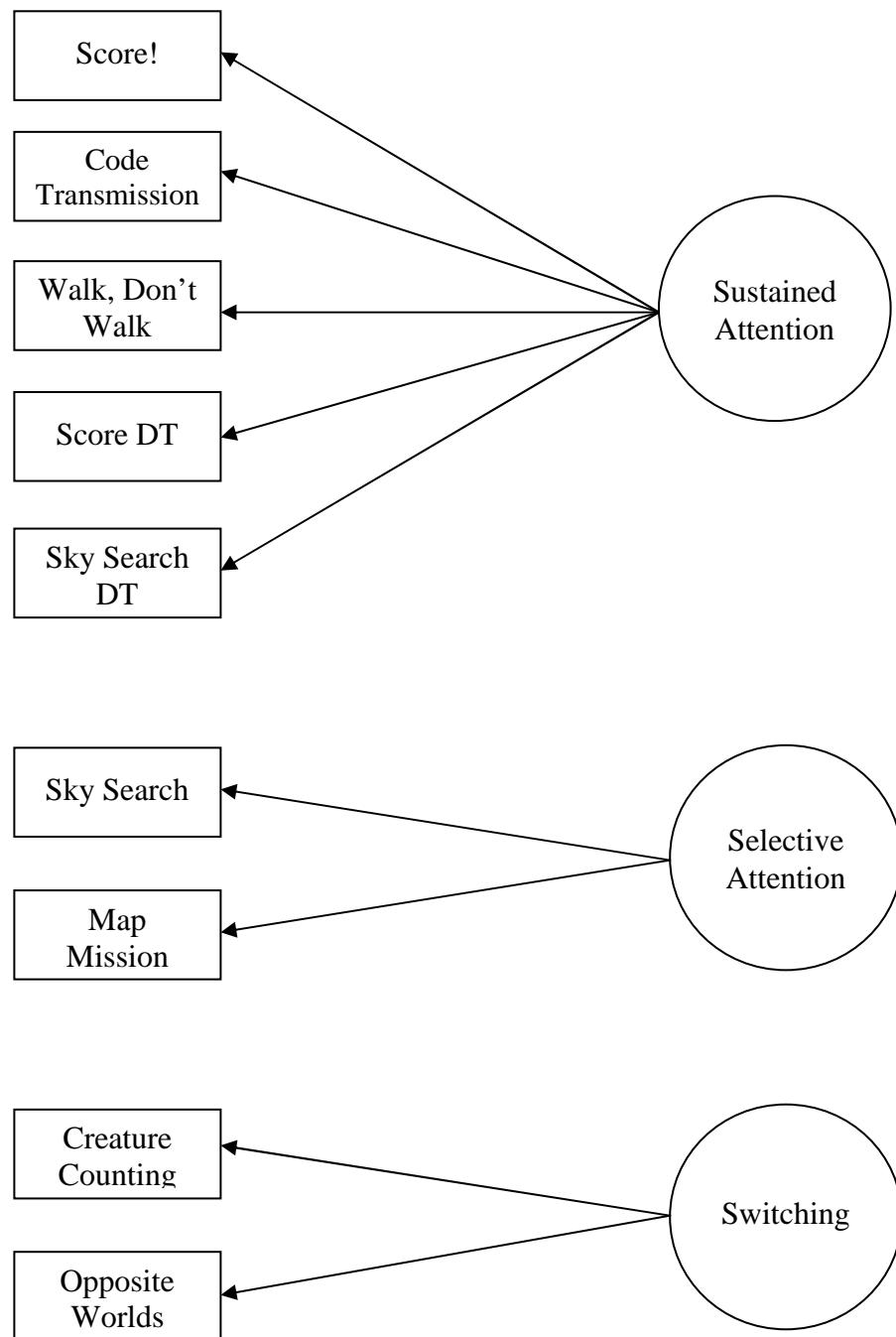


Figure 3 TEA-Ch Three-Factor Orthogonal Model



*(RMSEA $\leq$ .10), standardized root mean square residual (SRMR $\leq$ .08), non-normed fit index (NNFI $\geq$ .9), and comparative fit index (CFI $\geq$ .9; see Figure 4).*

*b. The two-factor model would provide a better fit to the data than a one-factor model (see Figure 5) as determined by a chi-square differences test.*

*c. The two-factor oblique model would provide a better fit than a two-factor orthogonal model (see Figure 6) as determined by a chi-square differences test.*

#### *Ecological Validity of Executive Functioning Measures*

##### Hypothesis 3

Hypothesis three predicted that executive functioning scores were related to social difficulties on the Child Behavior Checklist (CBCL) – Social Problems domain while controlling for Full Scale IQ, age, and gender (see Figure 7). Specifically, it was hypothesized that:

*a. The Selective Attention factor of the TEA-Ch would be negatively related to social difficulties (i.e., worse performance on selective attention tasks associated with greater social difficulties) given the need for cognitive efficiency and inhibition in social interactions (Bates et al., 1991; Nigg et al., 1999; Warschausky et al., 2003).*

*b. The Behavioral Regulation factor of the BRIEF would be positively associated with social difficulties (i.e., greater behavioral regulation difficulties related to greater social problems) due to its measure of behavioral inhibition, which has demonstrated significant relations with social skills (Bates et al., 1991; Nigg et al., Schonfeld et al., 2006; Warschausky et al., 2003).*

Figure 4 BRIEF Two-Factor Oblique Model

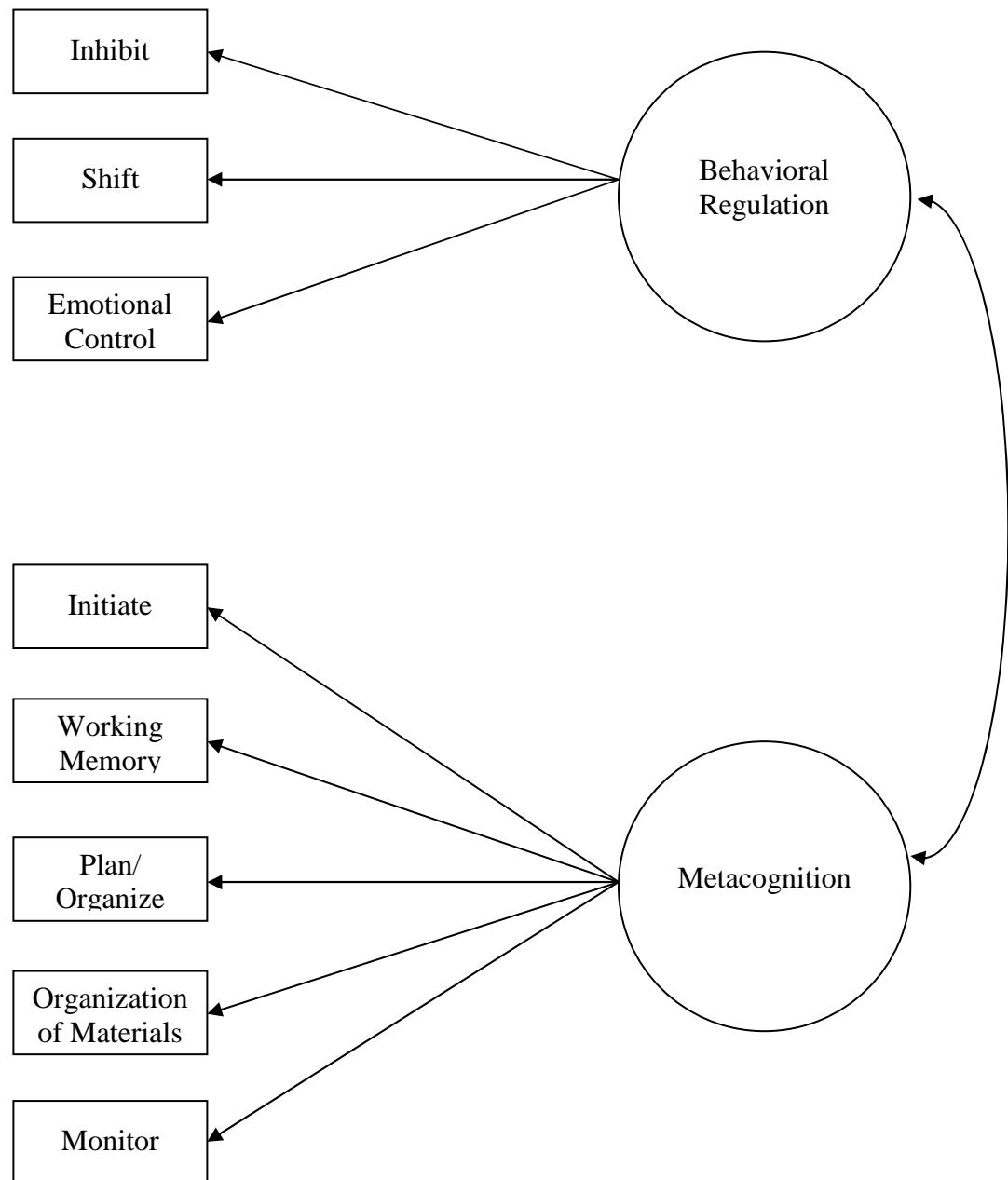


Figure 5 BRIEF One-Factor Model

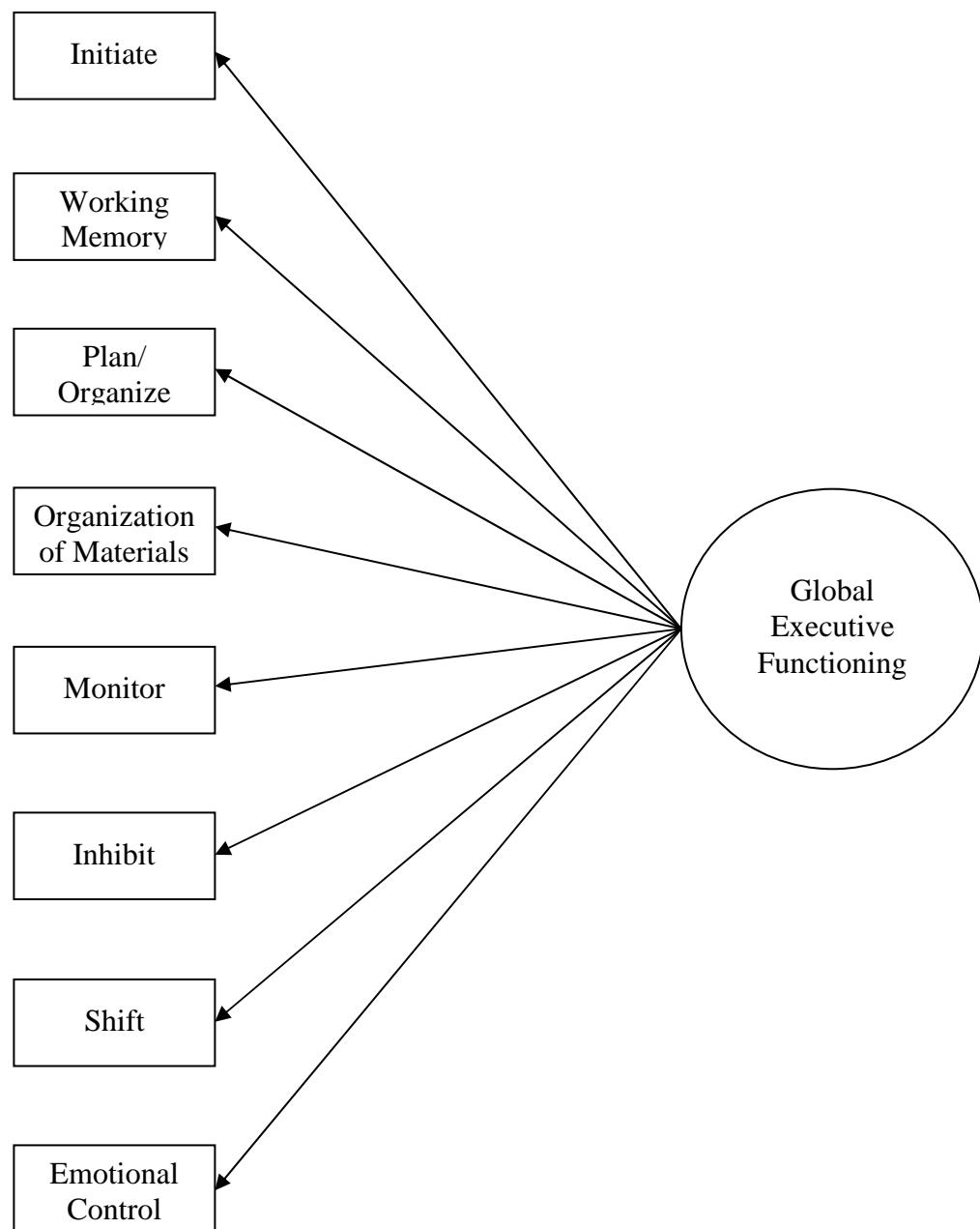


Figure 6 BRIEF Two-Factor Orthogonal Model

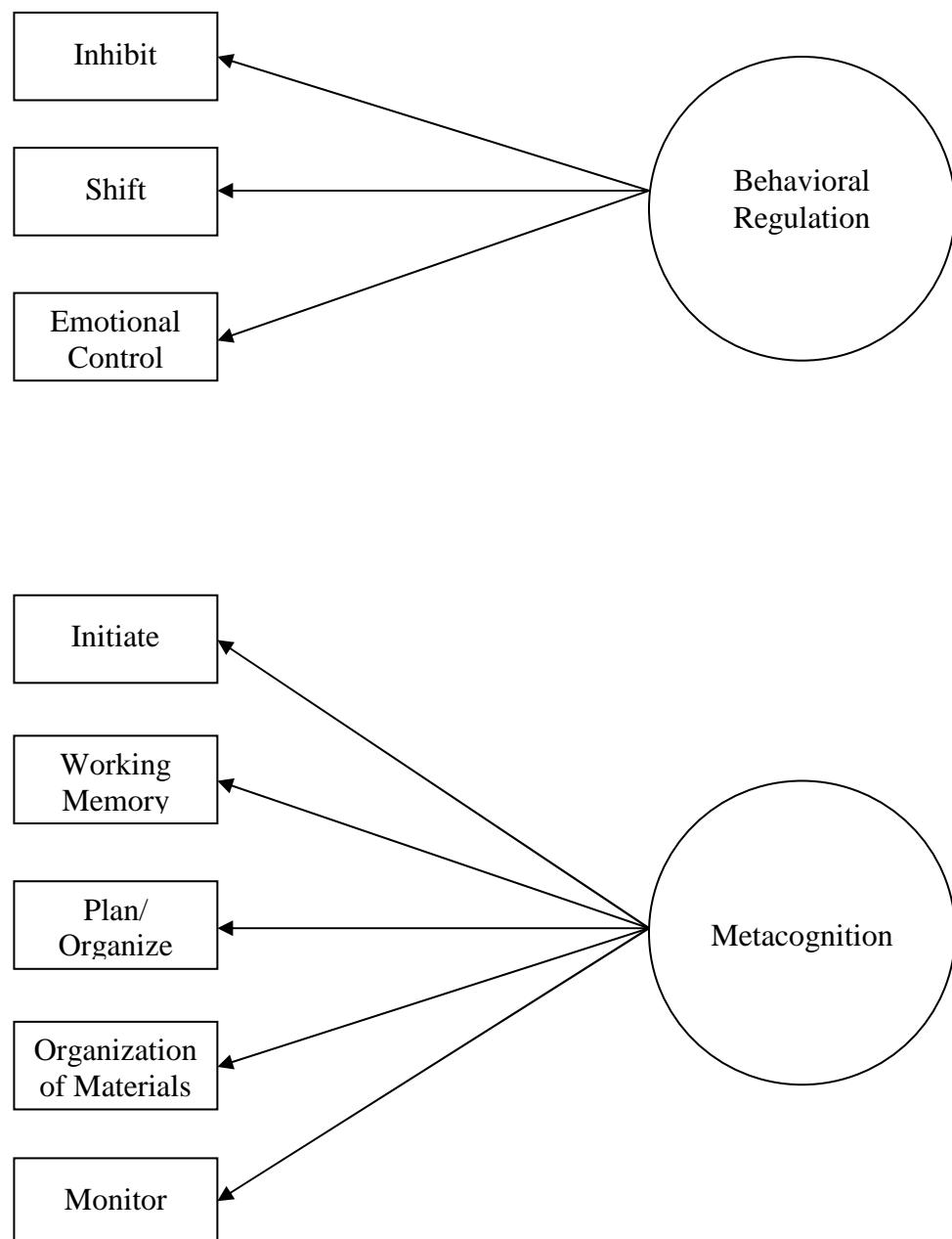
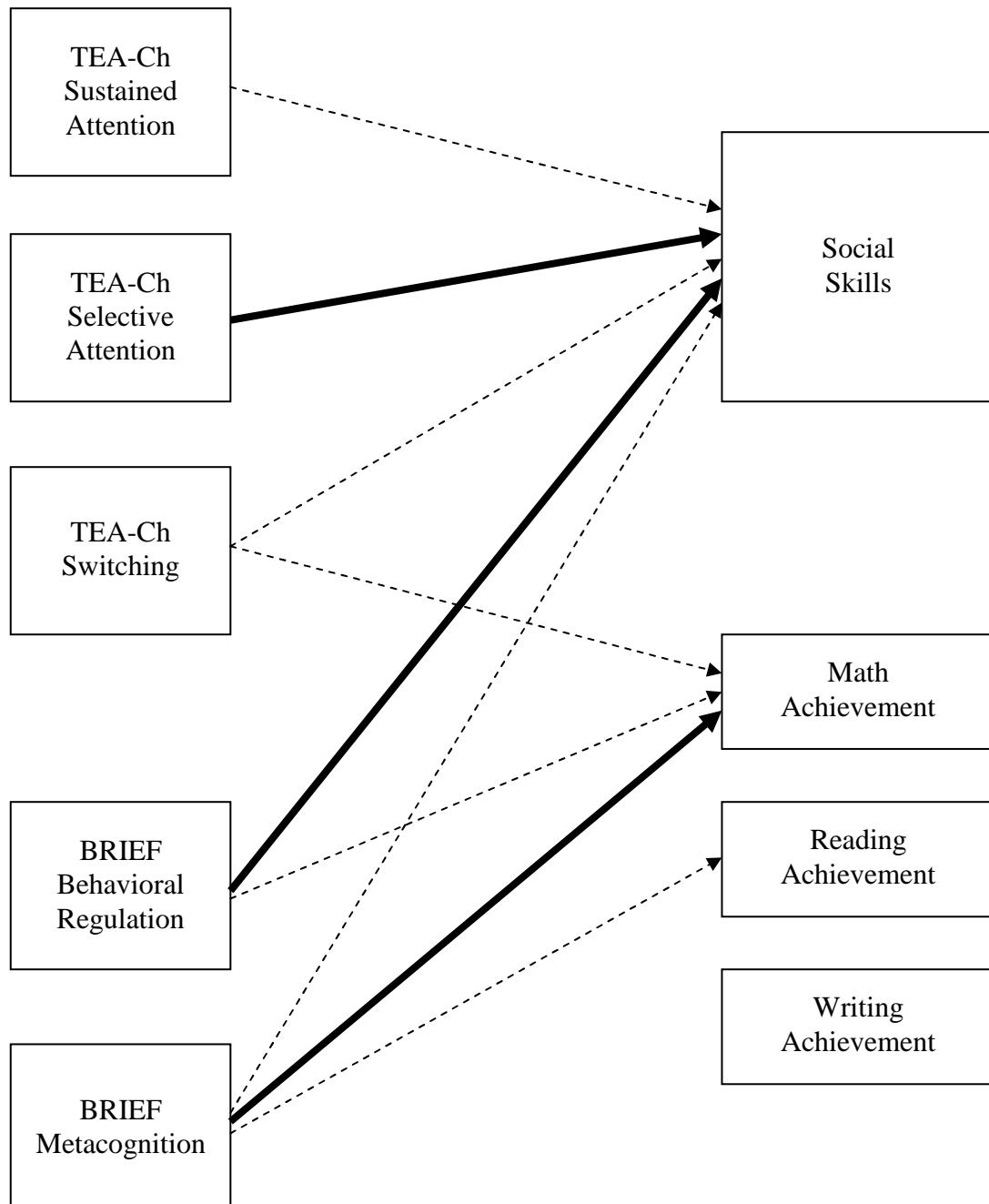


Figure 7 Hypothesized Relations between Factors of Executive Functioning Measures and Functional Outcomes



Note. Bold lines represent the strongest hypothesized relationships.

#### Hypothesis 4

Hypothesis four predicted that performance on measures of executive functioning would be related to academic achievement scores as measured by the Woodcock Johnson-III (WJ-III) while controlling for Full Scale IQ, age, and gender (see Figure 7). Specifically, it was hypothesized that:

*a. The Metacognition factor of the BRIEF would be negatively related to math achievement (i.e., greater metacognition difficulties associated with lower math achievement scores) based on previous studies showing this relation (Barry et al., 2003; Mahone et al., 2002).*

In exploratory analyses, it was predicted that the relation between executive functioning and academic achievement would be particularly strong for the fluency subtests of the WJ-III due to the increased demand for executive abilities during timed tests.

#### *Incremental Validity of Executive Functioning Measures*

#### Hypothesis 5

Hypothesis five predicted that the combination of the TEA-Ch and the BRIEF would explain a greater amount of variation in social skills and academic achievement than either measure alone due to their unique measurement of executive functions.

## CHAPTER THREE

### METHOD

#### *Participants*

This study was part of a larger, ongoing data collection process of clinically-referred children seen for a neuropsychological evaluation in a university-based outpatient neuropsychology clinic in a large urban city. Participants included children and adolescents diagnosed with ADHD (ages 6-16) and their parents. Youth were diagnosed with ADHD following a comprehensive neuropsychological battery by a licensed clinical psychologist and board certified neuropsychologist. Diagnosis was established using objective test data, subjective parent report (e.g., Conners Rating Scales), and corroboration from a third party (i.e., teachers). Exclusionary criteria included a full scale IQ less than 75 or a diagnosis of a neurological condition (e.g., seizures) as these could impact neuropsychological test performance. A total of 181 youth were included in the current study. None of the participants declined to have their data used anonymously. Demographic data for the sample are presented in Table 2. The majority of the sample was male (73%), Caucasian (56%), and had at least one other comorbid diagnosis (53%). Approximately half of the sample was diagnosed with ADHD Combined type (48%) and 44% were diagnosed with Inattentive type.

Table 2 Sample Characteristics (N=181)

	Mean	Standard Deviation
	N	Percent of Sample
Age	10.32	2.67
Gender		
Male	132	72.9
Female	49	27.1
Race/Ethnicity		
Caucasian	102	56.4
African American	34	18.8
Latino/Latina	16	8.8
Biracial	14	7.7
Asian	2	1.1
Missing	13	7.2
ADHD Subtype		
Combined	87	48.1
Inattentive	79	43.6
Hyperactive/Impulsive	3	1.7
NOS	1	0.6
Missing	11	6.1
Comorbid Diagnosis		
Learning Disorder	70	38.7
Mood Disorder	26	14.4
Anxiety Disorder	18	9.9
Disruptive Behavior Disorder	7	3.9
Other	4	2.2

*Measures*

## Executive Functioning

*TEA-Ch*

The TEA-Ch (Manly, Robertson, Anderson, & Nimmo-Smith, 1999) is a children's version of the Test of Everyday Attention (TEA; Robertson, Ward, Ridgeway, & Nimmo-Smith, 1996) consisting of nine subtests reported to assess attentional capacities (Sustained Attention, Selective Attention, and Attentional Control/Switching), which are an important executive skill. Specifically, sustained attention is the ability to keep one's mind focused to achieve a goal without necessarily being interested in the task. Selective attention is the ability to resist distraction, to sort through information, and to discriminate elements that are important to the task at hand. Attentional switching is the ability to efficiently switch the focus of attention between one thing and another.

The TEA-Ch adopts a game-like format in order to increase participant motivation, and the test attempts to reduce the demands placed upon memory, verbal comprehension, motor speed, and perceptual acuity (Manly et al., 1999). It has been standardized and validated for children and adolescents ages six to 16. Test-retest reliability for the clinical subtests ranged from .64-.92. The authors of the TEA-Ch have presented a structural equation model of TEA-Ch performance to give support for its validity, with the three-factor model providing a close fit to the data. The TEA-Ch also demonstrated good convergent validity, with results demonstrating significant correlations with other measures of attention and executive functioning (e.g., Trails A and B, Matching Familiar Figures Test, Stroop test).

## Factors

*Sustained attention.* The Sustained Attention domain is comprised of Score!, Sky Search DT, Score DT, Walk, Don't Walk, and Code Transmission subtests (Manly et al., 1999). This domain contains subtests assessing the capacity to self-maintain attention to a task, goal, or behavior despite little stimulation to do so. The Score! subtest is a 10-item tone-counting measure in which children are asked to silently count tones and to provide the total at the end of the task. If children are to keep count, they must actively maintain their own attention on the task. The Sky Search DT subtest is a dual task where participants are asked to simultaneously identify visual targets among distracters while counting tones on an audiotape. This task requires children to sustain attention while incorporating both auditory and visual information. Score DT is a dual task combining the Score! subtest with another listening task that requires the child to listen for an animal name during a news report. After each of the 10 trials, the child must report the number of tones counted and the animal name. This subtest measures the ability to sufficiently maintain attention on the less engaging aspect of the task (i.e., counting tones) in the face of a more interesting task (i.e., listening to a news report). The Walk, Don't Walk subtest is a 20-item task in which children are asked to mark steps along a paper path each time they hear a target sound on the audiotape but refrain from marking a step if the tone is immediately followed by a second sound. The rate the tones are presented increases as the child progresses through the items. This subtest emphasizes sustained attention to one's own actions and intentions. Because the task encourages an automatic form of responding, it also provides information related to the child's impulsivity because it requires the child to inhibit a response. Code Transmission is a subtest in which children

are asked to listen to a long, monotonous series of numbers and listen for two five's in a row. When the child hears two fives in a row, they must report the number immediately preceding the first five. This subtest was designed to be non-engaging so that children must actively sustain their attention on the task.

*Selective attention.* The Selective Attention domain of the TEA-Ch includes the Sky Search and Map Mission subtests (Manly et al., 1999). Tasks within this domain intend to assess the efficiency with which information can be filtered to detect relevant information and inhibit irrelevant or distracting information. The Sky Search task requires children to find target spaceships on a large sheet filled with similar distracter spaceships. Motor control is measured by asking the child to find the target spaceships without any distracter ones so that the ability to find the targets are less confounded with motor speed. This subtest requires the child to find the targets in the shortest time possible through the use of an effective search strategy and impulse control. The Map Mission subtest is a similar task that asks children to locate small target symbols on a large map with an array of distracter symbols in one minute.

*Attentional control/switching.* The Attentional Control/Switching subtest of the TEA-Ch is composed of the Creature Counting and Opposite Worlds subtests (Manly et al., 1999). The subtests included in this domain assess the capacity to switch attention either from one task to another or changing task performance and is generally associated with a small delay before optimal levels of performance are achieved. Creature Counting requires children to repeatedly switch between counting forward and backward in response to visual target stimuli. This subtest is considered a simple measure of the ability to switch from one task to another because of the relatively simple demand of the

task (i.e., counting) and its explicit instruction of the need to switch. The Opposite Worlds subtest asks children to say “one” when they see a two and say “two” when they see a one. Prior to this part of the task, children are asked to name digits “one” and “two” aloud scattered along a path. The additional time needed during the latter part of the task reflects the time needed to produce the non-routine verbal response. Therefore, this subtest requires children to approach a task in a novel way due to the need to inhibit a prepotent response.

#### *BRIEF*

The BRIEF (Gioia et al., 2000; see Appendix A) is an 86-item parent report questionnaire designed to assess executive functioning in children ages 5-18. Parents rate if their child’s behavior is “never,” “sometimes,” or “often” a problem, with higher ratings indicative of greater perceived impairment. The BRIEF is composed of eight clinical scales (Initiate, Working Memory, Plan/Organize, Organization of Materials, Monitor, Inhibit, Shift, Emotional Control) that generate two broad indices: Metacognition Index and Behavior Regulation Index. An overall score is obtained (Global Executive Composite) from the raw scores of the Metacognition Index and the Behavioral Regulation Index. It also has two validity scales to identify the informants’ response styles. The BRIEF was normed on 1,419 control children and 852 children from referred clinical groups. Adequate test-retest reliability, internal consistency, content and construct validity, and convergent and discriminant validity has been demonstrated (Pizzitola, 2002). Specifically, test-retest reliability statistics range from .79 to .88 during a two-week period and internal consistency is reported as ranging from .80 to .98 (Gioia et al., 2000).

## Factors

*Behavioral regulation.* The Behavioral Regulation Index includes the Inhibit, Shift, and Emotional Control subscales (Gioia et al., 2000). This factor contains items that intend to assess the ability to use appropriate inhibitory control to shift cognitive set and modulate emotions and behavior. Specifically, the Inhibit scale measures the child's ability to control impulses and appropriately stop behavior when necessary (e.g., *gets out of seat at the wrong times*). The Shift subscale includes items assessing the capacity to flexibly solve problems, transition, and move freely from one situation, activity, or aspect of a problem to another as the situation demands. Lastly, the ability to appropriately modulate emotional responses is assessed within the Emotional Control subscale (e.g., *overreacts to small problems*).

*Metacognition.* The Metacognition Index is comprised of the following subscales: Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor (Gioia et al., 2000). Overall, this factor represents the ability to use working memory to initiate, plan, organize, and sustain future-oriented problem-solving. The Initiate subscale measures a child's ability to begin a task or activity and independently generate ideas (e.g., *has trouble getting started on homework or chores*). The child's ability to hold information in mind for the purpose of completing a task and to persist with an activity is captured within the Working Memory subscale. The Plan/Organize scale was designed to assess the capacity to anticipate future events, set goals, develop appropriate steps to carry out associated tasks or actions, and to understand and communicate key concepts (e.g., *becomes overwhelmed by large assignments*). Organization of Materials refers to the child's ability to keep work space, play areas, and materials neat and orderly. Finally,

the Monitor subscale measures the child's ability to examine his or her own behavior, such as in checking work, assessing performance during or after finishing a task to ensure attainment of a goal, and keeping track of the effect of one's behavior on others.

### Intellectual Functioning

#### *Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV)*

The WISC-IV (Wechsler, 2003) is a commonly used, well-normed measure of intellectual functioning consisting of ten subtests (Block Design, Similarities, Picture Concepts, Digit Span, Coding, Vocabulary, Letter-Number Sequencing, Matrix Reasoning, Comprehension, Symbol Search). Subtest scores yield four domain scores (Verbal Comprehension, Perceptual Reasoning, Working Memory, Processing Speed) and an overall measure of intellectual functioning (Full Scale IQ). The WISC-IV was nationally standardized with a representative sample of 2,200 children ages 6-16, and it has demonstrated good psychometric properties. Good reliability has been demonstrated, with internal consistency coefficients ranging from .88 to .97 and test-retest coefficients ranging from .72 to .93 (Williams, Weiss, & Rolfus, 2003). Good validity has also been shown, with factor analysis confirming the four-factor model and significant associations with other measures of intellectual ability being demonstrated.

### Social Skills

#### *Child Behavior Checklist-Social Problems (CBCL)*

The Social Problems subscale of the CBCL (Achenbach, 1991; see Appendix B) is an 118-item parent report of child behavioral and emotional difficulties which are scored on a 3-point Likert scale ranging from "not true" to "very often true" of the child. The following subscales are included: Withdrawn/Depressed, Somatic Complaints,

Anxious/Depressed, Social Problems, Thought Problems, Attention Problems, Rule-Breaking Behavior, and Aggressive Behavior. The CBCL was normed on 2,368 children, and scales were validated with 4,455 clinically referred children. Research indicates good reliability and validity, with test-retest reliability reported to be .88 for girls and .90 for boys and significant associations between the CBCL and other outcome measures being demonstrated. The Social Problems subscale was only used in the current study, and it has demonstrated internal consistency coefficients from .72 to .74.

#### Academic Achievement

##### *Woodcock-Johnson-III Tests of Achievement (WJ-III)*

The WJ-III (Woodcock, McGrew, & Mather, 2001) measures academic achievement for individuals ages six to 90. Subtests assess achievement in a variety of academic domains and include both timed and untimed tests. The present study used the following untimed subtests in analyses to measure math, reading, and writing achievement: Math Calculation, Passage Comprehension, and Writing Samples. The Math Calculation subtest assesses math skills ranging from simple addition facts to calculus. Reading comprehension skills are measured within the Passage Comprehension subtest, which requires children to read a short passage and supply a key missing word. Writing Samples is a test in which children are asked to write sentences in response to a series of demands that increases in difficulty. The following timed tests were also used in the current study in exploratory analyses: Math Fluency, Reading Fluency, and Writing Fluency. The Math Fluency subtest requires rapid calculation of single-digit addition, subtraction, and multiplication facts in a three minute timeframe. Reading Fluency is a test in which children are asked to read and comprehend simple sentences quickly.

Finally, the Writing Fluency subtest requires rapidly formulating and writing simple sentences within a seven minute time limit.

The WJ-III was nationally standardized with a representative sample of 8,818 individuals, and it has demonstrated good reliability and validity. Reliability coefficients range from .81 to .94 and test-retest reliability coefficients are .80 and above. Additionally, the validity has been confirmed with confirmatory factor analysis, and the content of the test has been demonstrated to be similar to other achievement tests in subject areas and to established practice in schools.

#### *Procedure*

Data collection took place over the course of four years. Parents provided informed consent for assessment and to have their child's clinical data de-identified and used for research purposes (see Appendix C). For children ages twelve and over, they provided assent in addition to parent consent. Demographic information was collected from parents through their completion of a child neuropsychology history questionnaire (see Appendix D) and a clinical interview conducted by a licensed clinical neuropsychologist. Children and adolescents with ADHD completed a neuropsychological test battery to assess intelligence, academic achievement, and executive functioning. This battery took approximately four hours to complete. Parents of participants completed measures of their perception of their child's executive functioning and social skills which took about one hour to complete. All procedures were supervised by a licensed clinical neuropsychologist and approved by the university's institutional review board.

### *Analyses*

#### Factor Structure of Executive Functioning

1. The TEA-Ch was assessed using maximum likelihood confirmatory factor analysis (CFA) via LISREL 8.80 following suggestions by Bryant and Baxter (1997). To establish fit,  $\chi^2$  values and four measures of goodness of fit (RMSEA, SRMR, NNFI, CFI) were used for each of the a priori models. Three competing models were examined for the TEA-Ch (see Figures 1, 2, and 3). CFA requires large sample sizes to produce reliable models. Researchers suggest using a sample size that has five to ten participants per estimated parameter (Floyd & Widaman, 1995). The three-factor oblique model of the TEA-Ch required the most parameters of any model this study. This model had 24 parameters ( $9\lambda + 12\delta + 3\varphi$ ) multiplied by 5 participants per parameter, requiring a sample size of at least 120.

2. The BRIEF was assessed using maximum likelihood confirmatory factor analysis (CFA) via LISREL 8.80 following suggestions by Bryant and Baxter (1997). To establish fit,  $\chi^2$  values and four measures of goodness of fit (RMSEA, SRMR, NNFI, CFI) were used for each of the a priori models. Three competing models were examined for the BRIEF (see Figures 4, 5, and 6).

#### Ecological Validity of Executive Functioning Measures

##### *Social Skills*

3. To evaluate the ecological validity of executive functioning measures, hierarchical regression analyses were conducted using a stepwise procedure with CBCL-Social Problems functioning as the dependent variable. Using the forward selection

technique, covariates (gender, age) were entered in the first block and Full Scale IQ was entered in the second block. Latent factors that emerged from the CFA on executive functioning measures (i.e., TEA-Ch, BRIEF) were entered in the third block using the enter technique.

#### *Academic Achievement*

4. To evaluate the ecological validity of executive functioning measures, hierarchical regression analyses were conducted using a stepwise procedure with WJ-III academic achievement (Math Calculation, Passage Comprehension, Writing Samples) as the dependent variable. In the first block, covariates (gender, age) were entered using a forward selection technique. Full Scale IQ and the presence of a learning disorder diagnosis were entered in the second block also using a forward selection technique. Using the enter technique, latent factors that emerged from the CFA on executive functioning measures (i.e., TEA-Ch, BRIEF) were entered in the third block.

#### Incremental Validity: Relation between Executive Functioning and Functional Outcomes

##### Incremental Validity of Executive Functioning Measures

5. To evaluate the incremental validity of executive functioning measures, hierarchical regression analyses were conducted with each outcome measure. Guidelines for establishing incremental validity were followed. Specifically, covariates (gender, age) were entered in the first block and Full Scale IQ was entered in the second block using the forward selection technique. Latent factors that emerged from the CFA on the TEA-Ch were entered in the third block using the enter technique, and factors that emerged from the CFA on the BRIEF were entered in the fourth block with the enter technique.

Analyses were then conducted with factors from the BRIEF in the third block and factors from the TEA-Ch in the fourth block.

## CHAPTER FOUR

### RESULTS

#### *Descriptive Analyses*

Descriptive data for the sample is presented in Table 3. WISC Full Scale IQ (FSIQ) ranged from below average to superior and was overall in the average range (mean Standard Score=97.88,  $SD=12.17$ ). Scores on the TEA-Ch ranged from the very low to very superior range, and the means of subtests were within the low average to average range. Twenty-five to 62% of scores on BRIEF subscales were in the clinical range (T-scores of 65 or greater), with the greatest problems reported in the Working Memory subscale (62% in the clinical range). The average CBCL Social Problems T-score was 59.66 ( $SD=8.37$ ), indicating symptoms in the high average range, with 31% of scores in the clinically significant range. Scores on the WJ-III ranged from the very low to very superior range, and the means of subtests were generally average. Correlations between measures are presented in Table 4.

#### *Factor Structure of Executive Functioning*

##### Identifying and Handling Missing Data

As discussed previously, CFA measures relatively more parameters than other types of statistical techniques (e.g., exploratory factor analysis), and requires large sample sizes to produce reliable models. The three-factor oblique model of the TEA-Ch required the most parameters of any model this study. This model had 24 parameters ( $9\lambda$

Table 3 Descriptive Characteristics (N=181)

Domain	Mean	SD	Median	Range	% Clinically Elevated*
WISC FSIQ (Standard Score)	97.88	12.17	96	75-126	N/A
TEA-CH (Scaled Score)					
Sustained Attention					
Score	8.04	3.32	7	1-15	N/A
Code Transmission	7.18	3.45	7	1-17	N/A
Walk, Don't Walk	7.55	3.45	8	1-17	N/A
Score DT	8.46	3.35	8	1-17	N/A
Sky Search DT	6.70	4.04	8	1-19	N/A
Selective Attention					
Sky Search	8.56	2.87	8	1-17	N/A
Map Mission	9.36	3.42	9	2-18	N/A
Switching					
Creature Counting	7.61	2.61	8	1-15	N/A
Opposite Worlds	6.91	3.03	7	1-16	N/A
BRIEF (T-Scores)					
Behavioral Regulation Index					
Inhibit	58.97	13.72	57	36-100	33
Shift	58.18	13.58	57	36-95	33
Emotional Control	55.65	12.73	56	35-91	25
Metacognition Index					
Initiate	60.55	11.71	62	35-87	39
Working Memory	68.16	10.82	70	39-93	62
Plan/Organize	64.73	11.61	65	33-89	55
Organization of Materials	59.01	10.03	61	33-76	37
Monitor	62.37	10.90	64	31-91	50
CBCL Social Problems (T-Score)	59.66	8.37	58	50-85	31
WJ-III (Standard Scores)					
Calculation	95.94	14.84	95	50-145	N/A
Passage Comprehension	94.83	12.49	95	55-129	N/A
Writing Samples	98.18	13.16	98	62-140	N/A
Math Fluency	89.77	13.83	88	60-131	N/A
Reading Fluency	97.78	15.54	98	55-146	N/A
Writing Fluency	95.91	13.53	96	55-130	N/A

Note. Clinically elevated scales have T scores  $\geq 65$ .

Table 4 Correlations between Measures

	1	2	3	4	5	6	7	8	9	10	11	12	13
1 WISC	1.00												
2 Score	.162*	1.00											
3 Code Trans	.342**	.409**	1.00										
4 Walk, Don't	.237*	.240**	.300**	1.00									
5 Score DT	.325**	.453**	.495**	.310**	1.00								
6 Sky DT	.151*	.338**	.285**	.244**	.264**	1.00							
7 Sky Search	.249**	.026	.124	-.005	.047	.007	1.00						
8 Map Mission	.216**	.222**	.313**	.011	.131	.204**	.242**	1.00					
9 Creature	.227**	.385**	.290**	.152*	.246**	.355**	.210**	.271**	1.00				
10 Opp World	.267**	.239**	.355**	.272**	.233**	.324**	.261**	.260**	.451**	1.00			
11 Inhibit	.049	.098	.149*	.111	.005	.195**	.098	.206**	.195**	.178*	1.00		
12 Shift	-.018	.109	.110	.072	.016	.125	.071	.196**	.040	.139	.530**	1.00	
13 Emot Cont	.002	.095	.109	.027	-.055	.098	.060	.191*	-.008	.129	.537**	.648**	1.00
14 Initiate	-.037	.067	-.025	.030	.042	.109	.043	.074	-.003	-.004	.288**	.492**	.387**
15 Work Mem	.032	-.023	-.047	.010	-.026	-.025	-.004	.019	-.128	-.071	.236**	.335**	.231**
16 Plan/Org	.002	.076	.006	.092	.032	-.021	.130	.037	-.029	.007	.238**	.402**	.262**
17 Organize	.129	.065	.038	.087	.019	-.026	.152*	.051	.051	-.028	.277**	.261**	.216**
18 Monitor	.089	.171*	.115	.125	.115	.096	.138	.189*	.102	.058	.533**	.469**	.417**
19 Social Prob	-.098	.035	-.042	-.032	-.061	.049	-.020	.037	-.047	-.062	.370**	.522**	.488**
20 Calculation	.549**	.121	.198**	.146	.111	.132	.157*	.164*	.286**	.254**	.096	-.055	.086
21 Passage	.624**	.168*	.240**	.203**	.338**	.192**	.129	.064	.226**	.207**	.099	-.069	.045
22 Writing	.585**	.213**	.356**	.196**	.325**	.173*	.164*	.151*	.303**	.324**	.009	-.042	.000
23 Math Flu	.364**	.165*	.247**	.062	.137	.074	.187*	.361**	.426**	.347**	.147*	.135	.093
24 Read Flu	.519**	.146*	.228**	.111	.247**	.158*	.093	.234**	.306**	.197**	.213**	.103	.098
25 Writing Flu	.572**	.265**	.326**	.162*	.239**	.144	.089	.291**	.308**	.270**	.088	.045	.050

	14	15	16	17	18	19	20	21	22	23	24	25
14 Initiate	1.00											
15 Work Mem	.658**	1.00										
16 Plan/Org	.650**	.718**	1.00									
17 Organization	.459**	.540**	.635**	1.00								
18 Monitor	.575**	.510**	.679**	.576**	1.00							
19 Social Prob	.354**	.208**	.260**	.288**	.410**	1.00						
20 Calculation	-.072	-.001	-.067	.113	.039	-.071	1.00					
21 Passage	.033	.078	.057	.203**	.152*	.000	.524**	1.00				
22 Writing	.043	.067	.045	.149*	.103	-.122	.465**	.713**	1.00			
23 Math Flu	.001	-.019	-.064	.074	.090	-.056	.468**	.267**	.283**	1.00		
24 Reading Flu	.069	.056	.054	.224**	.238**	.041	.454**	.695**	.528**	.519**	1.00	
25 Writing Flu	-.022	.021	.004	.156*	.129	-.036	.468**	.517**	.597**	.455**	.667**	1.00

Note. \*\*Correlation is significant at the 0.01 level (2-tailed). \*Correlation is significant at the 0.05 level (2-tailed).

$+ 12\delta + 3 \phi$ ) multiplied by 5 participants per parameter (the minimum number suggested by Floyd & Widaman, 1995), requiring a sample size of at least 120. This study had an original sample size of 193. Seven participants were not included in analyses because they were missing the entire 86-item BRIEF measure, and five more were excluded due to missing more than half of the TEA-Ch measure (i.e., five out of nine subtests), reducing the sample size to 181. An additional 30 cases were missing at least one item from the TEA-Ch, with 12 subjects missing one item, three subjects missing two items, 11 subjects missing three items, and four subjects missing four items. Therefore, 67 out of 1,629 pieces of data were missing, representing 4% of the data. Due to the small proportion of missing data, data imputation via PRELIS 2.80 in LISREL 8.80 was used to maintain an adequate sample size for the CFA analyses. The nine TEA-Ch subtest scores, age, and FSIQ were used to impute the data. Correlations between data prior to imputation and after imputation were conducted, and all subtests had a correlation of 1.00, indicating little difference in data following imputation.

#### Analysis Strategy

The factor structure of executive functioning measures was examined using CFA via LISREL 8.80. As required by CFA, the model specified which items were expected to load on which factors, how these factors intercorrelate, and the relations among unique-error terms for the observed indicators. In these models, items were forced to have a single loading, factors were standardized (i.e., variances fixed at one), and unique errors were considered independent. To establish fit,  $\chi^2$  values and four measures of goodness of fit were used to assess CFA models in the study: (1) the root mean square error of approximation (RMSEA), (2) the standardized root mean square residual (SRMR), (3)

the non-normed fit index (NNFI), and (4) the comparative fit index (CFI). According to Hu and Bentler (1998), the RMSEA measure of absolute fit should be no greater than .10 and the SRMR value should be less than .08. For measures of relative fit, Bentler and Bonett (1980) suggest that values above .90 are indicative of good fit for the NNFI and the CFI. In addition to conventional cutoff values, the fit of a model is also interpreted relative to competing models. In the current study, a first-order CFA was used to evaluate the goodness-of-fit of three competing models for the TEA-Ch, and a second-order CFA was used to examine three competing models for the BRIEF.

### Executive Functioning Models

#### *TEA-Ch*

The first hypothesis posited that a measurement model of the TEA-Ch consisting of three correlated factors (Sustained Attention, Selective Attention, Switching) would provide a better fit to the data than a global one-factor model for this sample of children with ADHD. This hypothesis was supported, as the three-factor model provided good absolute fit,  $\chi^2(24, N=181) = 43.08$ , RMSEA=.07, SRMR=.06, and good relative fit (NNFI=.94, CFI=.96; see Table 5). A test of the one-factor model of executive functioning provided mixed findings of absolute fit,  $\chi^2(27, N=181) = 69.29$ , RMSEA=.10, SRMR=.07 and relative fit (NNFI=.88, CFI=.91), indicating overall poor model fit and support for hypothesis 1b that the three-factor model provides better fit than a one-factor model,  $\Delta\chi^2(3) = 26.21$ ,  $p < .001$ . Finally, hypothesis 1c was also supported, as the three-factor oblique model provided a better fit than the three-factor orthogonal model,  $\Delta\chi^2(3) = 73.71$ ,  $p < .001$ . The three-factor orthogonal model demonstrated poor

Table 5 Goodness of Fit Statistics for TEA-Ch Factor Models

Factor Model	$\chi^2$	Df	$\Delta\chi^2$	$\Delta df$	p<	Measures of Fit			
						RMSEA	SRMR	NNFI	CFI
1 One global factor	69.29	24			.001	.10	.07	.88	.91
<b>2 Three oblique factors</b>	<b>43.08</b>	<b>27</b>	<b>26.21</b>	<b>3</b>	<b>.001</b>	<b>.07</b>	<b>.06</b>	<b>.94</b>	<b>.96</b>
3 Three orthogonal factors	116.79	24	73.71	3	.001	.13	.17	.74	.81

Note.  $\chi^2$ =chi-square test statistic,  $df$ =degrees of freedom,  $\Delta\chi^2$ =change in chi-square test statistic,  $\Delta df$ =change in degrees of freedom, RMSEA=root mean square error of approximation, SRMR=standardized root mean square residual, NNFI=non-normed fit index, CFI=comparative fit index. Bolded model provided the best fit to the data.

absolute fit,  $\chi^2(27, N=181) = 116.79$ , RMSEA=.13, SRMR=.17 and poor relative fit (NNFI=.74, CFI=.81).

As expected given the large sample size, chi-square statistics for all models were significant, although the chi-square value was the lowest for the three-factor oblique model. Inspection of the inter-factor correlations from this three-factor model demonstrated that the Switching factor was highly intercorrelated with both the Sustained Attention (0.70) and Selective Attention (0.74) factors, whereas the Sustained Attention and Selective Attention factors were moderately intercorrelated (0.45; see Table 6).

#### *BRIEF*

The first hypothesis stated that a measurement model of the BRIEF consisting of two correlated factors (Behavioral Regulation, Metacognition) would provide a better fit to the data than a global one-factor model for this sample of children with ADHD. A test of the one-factor model of executive functioning provided poor absolute fit,  $\chi^2(20, N=181) = 200.27$ , RMSEA=.24, SRMR=.12, as well as poor relative fit (NNFI=.78, CFI=.84; see Table 7). The oblique two-factor model fit the data better than the one-factor model,  $\Delta\chi^2(1) = 110.79$ ,  $p < .001$ , providing support for hypothesis 1b; however, the overall model was unacceptable. The SRMR was less than .08 and NNFI and CFI values were greater than .90, indicating good model fit. However, the RMSEA value was greater than .10, suggesting poor model fit. Finally, hypothesis 1c was supported as the two-factor oblique model provided a better fit than the two-factor orthogonal model,  $\Delta\chi^2(1) = 24.06$ ,  $p < .001$ , which provided overall poor fit across all indices.

Due to overall poor fit of the two-factor oblique model and previous literature suggesting that the Monitor subscale may be related to both factors (e.g., Gioia et al.,

Table 6 Correlations between TEA-Ch Factors for Best Fitting Model

	1	2	3
1 Sustained Attention	1.00		
2 Selective Attention	0.45	1.00	
3 Switching	0.70	0.74	1.00

Table 7 Goodness of Fit Statistics for BRIEF Factor Models

Factor Model	$\chi^2$	Df	$\Delta\chi^2$	$\Delta df$	p<	Measures of Fit			
						RMSEA	SRMR	NNFI	CFI
1 One global factor	200.27	20			.001	.24	.12	.78	.84
2 Two oblique factors	89.48	19	110.79	1	.001	.14	.07	.91	.94
3 Two orthogonal factors	133.12	20	24.06	1	.001	.16	.23	.86	.90
4 Two oblique factors with Monitor subscale loading on both factors	69.56	18	131.83	2	.001	.12	.06	.93	.95
<b>5 Two oblique factors with Monitor subscale loading on both factors and Monitor measurement error correlated with Inhibit subscale</b>	<b>48.93</b>	<b>17</b>	<b>153.06</b>	<b>3</b>	<b>.001</b>	<b>.09</b>	<b>.05</b>	<b>.95</b>	<b>.97</b>

Note.  $\chi^2$ =chi-square test statistic,  $df$ =degrees of freedom,  $\Delta\chi^2$ =change in chi-square test statistic,  $\Delta df$ =change in degrees of freedom, RMSEA=root mean square error of approximation, SRMR=standardized root mean square residual, NNFI=non-normed fit index, CFI=comparative fit index. Bolded model provided the best fit to the data.

2002), a two-factor model with the Monitor subscale loading on both the Behavioral Regulation and Metacognition factors was examined next. This model fit the data better than the one-factor model,  $\Delta\chi^2(2) = 131.83$ ,  $p < .001$ , but still provided poor absolute fit ( $\text{RMSEA}=.12$ ) despite adequate relative fit ( $\text{NNFI}=.93$ ,  $\text{CFI}=.95$ ).

The two-factor oblique model underwent additional modifications in order to improve overall model fit. Previous research investigated the idea that monitoring one's behavior and behavioral inhibition share the need to regulate one's actions and its impact on others, and results indicated that the Monitor and Inhibit subscales were statistically related (Gioia et al., 2002). Therefore, it was expected that these two subscales may share variance over and above what was reflected in the common factors in the model. Thus, a two-factor model that allowed the Monitor subscale to load on both factors (i.e., Behavioral Regulation, Metacognition), as well as allowed the measurement errors for the Monitor and Inhibit subscales to correlate was examined next. This two-factor oblique model provided good absolute fit,  $\chi^2(17, N=181) = 48.93$ ,  $\text{RMSEA}=.09$ ,  $\text{SRMR}=.05$  and good relative fit ( $\text{NNFI}=.95$ ,  $\text{CFI}=.97$ ). Additionally, it provided better fit than a one-factor model,  $\Delta\chi^2(3) = 153.06$ ,  $p < .001$ .

As expected given the large sample size, chi-square statistics for all models were significant; however, the chi-square value was the lowest for the final model. Inspection of inter-factor correlations from this two-factor model demonstrated that the factors were moderately intercorrelated (.50; see Table 8).

Table 8 Correlations between BRIEF Factors for Best Fitting Model

	1	2
1 Behavioral Regulation Index	1.00	
2 Metacognition Index	0.50	1.00

*Ecological Validity of Executive Functioning Measures*

## Social Skills

Multiple regression analysis using a stepwise procedure was used to assess the association of social difficulties to executive functioning measures. Using the forward selection technique, covariates (gender, age) were entered in the first block and FSIQ was entered in the second block. Latent factors that emerged from the CFA on executive functioning measures (i.e., TEA-Ch, BRIEF) were entered in the third block using the enter technique. Although the CFA for the BRIEF in the current study indicated that the Monitor subscale loaded on both factors, the original latent factor structure (i.e., Monitor loading only on the Metacognition factor) was used during the following analysis.

Gender, age, and FSIQ were not significant predictors of difficulties on the Social Problems subscale of the CBCL ( $p>.05$ ). Regarding executive functioning measures, the Behavioral Regulation factor of the BRIEF was a main effect predictor of Social Problems ( $\beta=.57$ ,  $t=7.78$ ,  $p < .001$ ; see Table 9). Specifically, greater reported problems on this BRIEF factor was related to more reported social difficulties, supporting hypothesis 3b. The Selective Attention factor of the TEA-Ch did not yield a significant main effect, which is contrary to the hypothesis that lower scores on the Selective Attention subscale would be associated with greater social difficulties (hypothesis 3a).

Table 9 Standardized Coefficients for CBCL Social Problems Regression Model

	B	T
Gender	.05	.77
Age	.02	.27
FSIQ	-.05	-.73
TEA-Ch Sustained Attention	-.02	-.20
TEA-Ch Selective Attention	-.06	-.68
TEA-Ch Switching	-.09	-.79
BRIEF Behavioral Regulation	.57	7.75**
BRIEF Metacognition	.06	.85

\*\*p<.001

Note. Standardized coefficients were used. Overall model F=18.24, p<.001. Overall adjusted R<sup>2</sup>=.33.

#### Academic Achievement

##### *Math Achievement*

Hierarchical regression analysis using a stepwise procedure was performed to examine the association of math achievement to executive functioning measures. In the first block, covariates (gender, age) were entered using a forward selection technique. FSIQ and a previous diagnosis of a math disorder (i.e., dyscalculia) were entered in the second block also using a forward selection technique. Using the enter technique, latent factors that emerged from the CFA on executive functioning measures (i.e., TEA-Ch, BRIEF) were entered in the third block. Although the CFA for the BRIEF in the current study indicated that the Monitor subscale loaded on both factors, the original latent factor structure (i.e., Monitor loading only on the Metacognition factor) was used during the following analysis.

Results from regression analysis are presented in Table 10. In the first step, gender and age were not significant predictors of math achievement scores (p>.05).

Table 10 Standardized Coefficients for WJ-III Math Achievement Regression Model

	$\beta$	T	$R^2\Delta$
Gender	-.02	-.27	
Age	-.12	-1.94	
FSIQ	.55	8.79**	
			.30
Math Disorder	-.30	-5.01**	
			.09
TEA-Ch Sustained Attention	-.11	-1.33	
TEA-Ch Selective Attention	-.13	-1.45	
TEA-Ch Switching	.28	2.56*	
BRIEF Behavioral Regulation	.07	.93	
BRIEF Metacognition	-.08	-1.11	
			.03

\*p<.05, \*\*p<.001

Note. Standardized coefficients were used. Overall model F=17.77, p<.001. Overall adjusted  $R^2=.40$ .

FSIQ, entered in the second step, was a main effect predictor of Math Calculation ( $p<.001$ ), with higher IQ scores related to higher academic achievement scores. A math disorder diagnosis was also a significant predictor of math achievement ( $p<.001$ ), indicating that the presence of a learning disorder was associated with lower achievement scores. Regarding executive functioning measures, the Metacognition factor of the BRIEF was not related to math ( $\beta=-.08$ ,  $t=-1.11$ ,  $p=.27$ ) as hypothesized (hypothesis 4a). However, the Switching factor of the TEA-Ch was a significant main effect predictor of Math Calculation ( $\beta=.28$ ,  $t=2.56$ ,  $p<.05$ ), suggesting that higher scores on set-shifting subtests was related to better performance on math achievement.

#### *Reading Achievement*

The association of reading achievement to executive functioning measures was examined through hierarchical regression analysis using a stepwise procedure. Covariates

(gender, age) were entered in the first block using a forward selection technique. FSIQ and a previous diagnosis of a reading disorder (i.e., dyslexia) were entered in the second block using a forward selection technique as well. In the third block, latent factors that emerged from the CFA on executive functioning measures (i.e., TEA-Ch, BRIEF) were entered using the enter technique. Although the CFA for the BRIEF in the current study indicated that the Monitor subscale loaded on both factors, the original latent factor structure (i.e., Monitor loading only on the Metacognition factor) was used during the following analysis.

Results from analysis are presented in Table 11. Gender and age were not significant predictors of reading achievement scores ( $p>.05$ ) in the first step. In the second step, FSIQ was a main effect predictor of Passage Comprehension ( $p<.001$ ), with higher IQ scores related to higher reading achievement scores. A diagnosis of a reading disorder was also a significant predictor of reading achievement ( $p<.001$ ). Thus, having a reading disorder was associated with lower achievement scores. No measures of executive functioning were related to reading achievement.

#### *Writing Achievement*

Hierarchical regression analysis using a stepwise procedure was performed to examine the relation of writing achievement to executive functioning measures. In the first block, covariates (gender, age) were entered using a forward selection technique. FSIQ and a previous diagnosis of a writing disorder (i.e., dysgraphia) were entered in the second block also using a forward selection technique. Using the enter technique, latent factors that emerged from the CFA on executive functioning measures (i.e., TEA-Ch,

Table 11 Standardized Coefficients for WJ-III Reading Achievement Regression Model

	B	t	R <sup>2</sup> Δ
Gender	.07	1.18	
Age	-.02	-.36	
FSIQ	.62	10.68**	
			.39
Reading Disorder	-.33	-6.19**	
			.11
TEA-Ch Sustained Attention	.05	.64	
TEA-Ch Selective Attention	-.13	-1.58	
TEA-Ch Switching	.09	.85	
BRIEF Behavioral Regulation	-.08	-1.23	
BRIEF Metacognition	.07	1.17	
			.02

\*\*p<.001

Note. Standardized coefficients were used. Overall model F=26.06, p<.001. Overall adjusted R<sup>2</sup>=.49.

BRIEF) were entered in the third block. Although the CFA for the BRIEF in the current study indicated that the Monitor subscale loaded on both factors, the original latent factor structure (i.e., Monitor loading only on the Metacognition factor) was used during the following analysis.

Results from analysis are presented in Table 12. Gender and age were not significant predictors of writing achievement scores (p>.05) in the first step. In the second step, FSIQ was a main effect predictor of Writing Samples (p<.001), with higher IQ scores related to higher writing achievement scores. A diagnosis of a writing disorder was also a significant predictor of writing achievement (p<.001), indicating that the presence of a learning disorder was associated with lower achievement scores. Regarding executive functioning measures, the Switching factor of the TEA-Ch was a significant main effect predictor of Writing Samples ( $\beta=.22$ ,  $t=2.05$ ,  $p<.05$ ). Therefore, higher scores

Table 12 Standardized Coefficients for WJ-III Writing Achievement Regression Model

	$\beta$	t	$R^2\Delta$
Gender	.12	1.97	
Age	.04	.63	
FSIQ	.59	9.66**	
			.34
Writing Disorder	-.21	-3.58**	
			.04
TEA-Ch Sustained Attention	.10	1.16	
TEA-Ch Selective Attention	-.09	-1.07	
TEA-Ch Switching	.22	2.05*	
BRIEF Behavioral Regulation	-.13	-1.86	
BRIEF Metacognition	.12	1.85	
			.06

\*p<.05, \*\*p<.001

Note. Standardized coefficients were used. Overall model F=19.82, p<.001. Overall adjusted  $R^2=.42$ .

on tasks comprising the Switching factor were related to better performance on writing achievement scores.

#### *Fluency Subtests*

In exploratory analyses, a series of hierarchical regression analyses using a stepwise procedure were used to explore the relation between the fluency subtests of the WJ-III (i.e., Math Fluency, Reading Fluency, Writing Fluency) and executive functioning measures. Gender and age did not predict performance on the fluency subtests ( $p>.05$ ). FSIQ was a significant main effect predictor of Math Fluency ( $p<.001$ ), Reading Fluency ( $p<.001$ ), and Writing Fluency ( $p<.001$ ), with higher IQ scores associated with higher fluency scores. A previous diagnosis of a learning disorder was also a significant predictor of achievement on fluency subtests, suggesting that having a learning disorder

was related to lower fluency scores. Regarding executive functioning measures, the Switching factor of the TEA-Ch was a significant main effect predictor of Math Fluency ( $\beta=.39$ ,  $t=3.27$ ,  $p<.01$ ). Thus, higher scores on tasks of set-shifting abilities were related to better performance on math fluency (see Table 13). No other executive functioning measures were significantly related to the fluency subtests (see Tables 14 and 15).

#### *Incremental Validity of Executive Functioning Measures*

##### Social Skills

Multiple regression analysis using a stepwise procedure was conducted to examine the incremental validity of executive functioning measures in their relation with social problems. Using the forward selection technique, covariates (gender, age) were entered in the first block and FSIQ was entered in the second block. Latent factors that emerged from the CFA on the TEA-Ch were entered in the third block using the enter technique, and factors that emerged from the CFA on the BRIEF were entered in the fourth block with the enter technique. Analyses were then conducted with factors from the BRIEF in the third block and factors from the TEA-Ch in the fourth block. Although the CFA for the BRIEF in the current study indicated that the Monitor subscale loaded on both factors, the original latent factor structure (i.e., Monitor loading only on the Metacognition factor) was used during the following analysis.

Gender, age, and FSIQ were not significant predictors of difficulties on the Social Problems subscale of the CBCL on either regression analysis ( $p>.05$ ). When the TEA-Ch was entered in the third block and the BRIEF was entered in the fourth block, the Behavioral Regulation factor of the BRIEF was a main effect predictor of Social

Table 13 Standardized Coefficients for WJ-III Math Fluency Regression Model

	B	T	R <sup>2</sup> Δ
Gender	.01	.16	
Age	-.04	-.63	
FSIQ	.36	5.23**	
			.13
Math Disorder	-.17	-2.40*	
			.03
TEA-Ch Sustained Attention	-.17	-1.80	
TEA-Ch Selective Attention	.11	1.13	
TEA-Ch Switching	.39	3.27*	
BRIEF Behavioral Regulation	.12	1.63	
BRIEF Metacognition	-.09	-1.26	
			.16

\*p<.01, \*\*p<.001

Note. Standardized coefficients were used. Overall model F=11.61, p<.001. Overall adjusted R<sup>2</sup>=.29.

Table 14 Standardized Coefficients for WJ-III Reading Fluency Regression Model

	B	t	$R^2\Delta$
Gender	.01	1.60	
Age	-.10	-1.61	
FSIQ	.52	8.12**	
			.27
Reading Disorder	-.36	-6.16**	
			.13
TEA-Ch Sustained Attention	-.06	-.73	
TEA-Ch Selective Attention	.02	.20	
TEA-Ch Switching	.11	.99	
BRIEF Behavioral Regulation	.07	1.01	
BRIEF Metacognition	.01	.12	
			.02

\*\*p<.001

Note. Standardized coefficients were used. Overall model F=17.33, p<.001. Overall adjusted  $R^2=.39$ .

Table 15 Standardized Coefficients for WJ-III Writing Fluency Regression Model

	B	t	R <sup>2</sup> Δ
Gender	.10	.16	
Age	-.11	-1.82	
FSIQ	.57	9.32**	
			.38
Writing Disorder	-.16	-2.63*	
			.03
TEA-Ch Sustained Attention	.07	.73	
TEA-Ch Selective Attention	.03	.36	
TEA-Ch Switching	.12	1.01	
BRIEF Behavioral Regulation	.01	.12	
BRIEF Metacognition	.01	.16	
			.03

\*p<.01, \*\*p<.001

Note. Standardized coefficients were used. Overall model F=15.49, p<.001. Overall adjusted R<sup>2</sup>=.36.

Problems ( $\beta=.57$ ,  $t=7.78$ ,  $p<.001$ ), suggesting that greater reported problems on the Behavioral Regulation factor were related to more reported social difficulties (see Table 16). When the BRIEF was entered in the third block and the TEA-Ch was entered in the fourth block, the Behavioral Regulation factor of the BRIEF remained a main effect predictor of Social Problems ( $\beta=.53$ ,  $t=7.37$ ,  $p<.001$ ), with greater problems on this subscale related to greater social difficulties (see Table 17). The inclusion of the BRIEF in the model accounted for 31% of the variance in social difficulties. Although the addition of the TEA-Ch accounted for 33% of the variance, this was not a significant difference ( $p>.05$ ). Therefore, hypothesis five was not supported for social functioning.

Table 16 Standardized Coefficients for CBCL Social Problems Regression Model:  
TEA-Ch in the Third Block and BRIEF in the Fourth Block

	B	T
Gender	.02	.20
Age	.01	.15
FSIQ	-.11	-1.3
TEA-Ch Sustained Attention	.03	.30
TEA-Ch Selective Attention	.08	.73
TEA-Ch Switching	-.14	-.97
BRIEF Behavioral Regulation	.57	7.78**
BRIEF Metacognition	.06	.85

\*\*p<.001

Note. Standardized coefficients were used. Overall model F=18.24, p<.001. Overall adjusted R<sup>2</sup>=.33.

Table 17 Standardized Coefficients for CBCL Social Problems Regression Model:  
BRIEF in the Third Block and TEA-Ch in the Fourth Block

	B	T
Gender	.04	.69
Age	-.02	-.38
FSIQ	-.10	-1.65
BRIEF Behavioral Regulation	.53	7.37**
BRIEF Metacognition	.07	1.01
TEA-Ch Sustained Attention	-.02	-.20
TEA-Ch Selective Attention	-.06	-.68
TEA-Ch Switching	-.09	-.79

\*\*p<.001

Note. Standardized coefficients were used. Overall model F=18.24, p<.001. Overall adjusted R<sup>2</sup>=.33.

#### Academic Achievement

##### *Math Achievement*

The incremental validity of executive functioning measures in their association with math achievement was examined through hierarchical regression analysis using a stepwise procedure. Covariates (gender, age) were entered in the first block using a forward selection technique. FSIQ and a previous diagnosis of a math disorder (i.e., dyscalculia) were entered in the second block using a forward selection technique as well. Using the enter technique, latent factors that emerged from the CFA on the TEA-Ch were entered in the third block, and latent factors that emerged from the CFA on the BRIEF were entered in the fourth block. Analyses were then conducted with factors from the BRIEF in the third block and factors from the TEA-Ch in the fourth block. Although the CFA for the BRIEF in the current study indicated that the Monitor subscale loaded on both factors, the original latent factor structure (i.e., Monitor loading only on the Metacognition factor) was used during the following analysis.

Gender and age were not significant predictors in either regression analysis ( $p>.05$ ). FSIQ was a significant main effect predictor of math achievement ( $\beta=.55$ ,  $t=8.79$ ,  $p<.001$ ), with higher IQ scores associated with better performance on math achievement tasks. Having a math disorder was also a significant predictor of math achievement ( $\beta=-.30$ ,  $t=-5.01$ ,  $p<.001$ ) in both analyses, indicating that a diagnosis of a math disorder was related to lower achievement scores. Regarding executive functioning measures, when the TEA-Ch was entered in the third block and the BRIEF was entered in the fourth block, the Switching factor of the TEA-Ch was a significant predictor of math achievement scores ( $\beta=.29$ ,  $t=2.69$ ,  $p<.01$ ), with better performance on this subscale related to higher math scores (see Table 18). When the BRIEF was entered in the third block and the TEA-Ch was entered in the fourth block, the Switching factor of the TEA-Ch remained a main effect predictor of Math Calculation ( $\beta=.28$ ,  $t=2.56$ ,  $p<.05$ ), with higher scores on set-shifting tasks related to better performance on math achievement (see Table 19). Forty percent of the variance in math achievement performance was accounted for with the inclusion of the TEA-Ch. The addition of the BRIEF did not account for any additional variance; therefore, hypothesis five was not supported for math achievement.

#### *Reading Achievement*

Hierarchical regression analysis using a stepwise procedure was conducted to assess the incremental validity of executive functioning measures in their association with reading achievement. In the first block, covariates (gender, age) were entered using a forward selection technique. FSIQ and a diagnosis of a reading disorder (i.e., dyslexia) were entered in the second block using a forward selection technique as well. Latent

Table 18 Standardized Coefficients for WJ-III Math Achievement Regression Model:  
TEA-Ch in the Third Block and BRIEF in the Fourth Block

	B	T	$R^2\Delta$
Gender	-.00	-.01	
Age	-.14	-2.19	
FSIQ	.55	8.79**	
			.30
Math Disorder	-.30	-5.01**	
			.09
TEA-Ch Sustained Attention	-.12	-1.37	
TEA-Ch Selective Attention	.13	1.43	
TEA-Ch Switching	.29	2.69*	
			.03
BRIEF Behavioral Regulation	.07	.93	
BRIEF Metacognition	-.08	-1.11	
			.01

\*p<.01, \*\*p<.001

Note. Standardized coefficients were used. Overall model F=17.77, p<.001. Overall adjusted  $R^2=.40$ .

Table 19 Standardized Coefficients for WJ-III Math Achievement Regression Model:  
BRIEF in the Third Block and TEA-Ch in the Fourth Block

	B	T	$R^2\Delta$
Gender	-.00	-.01	
Age	-.14	-2.19	
FSIQ	.55	8.79**	
			.30
Math Disorder	-.30	-5.01**	.09
BRIEF Behavioral Regulation	.08	1.13	
BRIEF Metacognition	-.10	-1.42	
			.01
TEA-Ch Sustained Attention	-.11	-1.33	
TEA-Ch Selective Attention	.13	1.45	
TEA-Ch Switching	.28	2.56*	
			.02

\*p<.05, \*\*p<.001

Note. Standardized coefficients were used. Overall model F=17.77, p<.001. Overall adjusted  $R^2=.40$ .

factors that emerged from the CFA on the TEA-Ch were entered in the third block, and latent factors that emerged from the CFA on the BRIEF were entered in the fourth block using the enter technique. Analyses were then conducted with factors from the BRIEF in the third block and factors from the TEA-Ch in the fourth block. Although the CFA for the BRIEF in the current study indicated that the Monitor subscale loaded on both factors, the original latent factor structure (i.e., Monitor loading only on the Metacognition factor) was used during the following analysis.

Results from regression analyses are presented in Tables 20 and 21. Gender and age were not significant predictors of reading achievement scores ( $p>.05$ ). FSIQ was a significant main effect predictor of Passage Comprehension ( $\beta=.62$ ,  $t=10.68$ ,  $p<.001$ ), with higher IQ scores associated with better performance on reading achievement. The

Table 20 Standardized Coefficients for WJ-III Reading Achievement Regression Model:  
TEA-Ch in the Third Block and BRIEF in the Fourth Block

	B	T	$R^2\Delta$
Gender	.07	1.18	
Age	-.02	-.36	
FSIQ	.62	10.68**	
			.39
Math Disorder	-.33	-6.19**	
			.11
TEA-Ch Sustained Attention	.05	.64	
TEA-Ch Selective Attention	-.14	-1.69	
TEA-Ch Switching	.08	.75	
			.01
BRIEF Behavioral Regulation	-.08	-1.23	
BRIEF Metacognition	.07	1.17	
			.01

\*p<.01, \*\*p<.001

Note. Standardized coefficients were used. Overall model F=26.06, p<.001. Overall adjusted  $R^2=.49$ .

Table 21 Standardized Coefficients for WJ-III Reading Achievement Regression Model:  
BRIEF in the Third Block and TEA-Ch in the Fourth Block

	B	T	$R^2\Delta$
Gender	.07	1.18	
Age	-.02	-.36	
FSIQ	.62	10.68**	
			.39
Reading Disorder	-.33	-6.19**	.11
BRIEF Behavioral Regulation	-.09	-1.38	
BRIEF Metacognition	.07	1.06	
			.01
TEA-Ch Sustained Attention	.05	.64	
TEA-Ch Selective Attention	-.13	-1.58	
TEA-Ch Switching	.09	.85	
			.01

\*p<.01, \*\*p<.001

Note. Standardized coefficients were used. Overall model F=26.06, p<.001. Overall adjusted  $R^2=.49$ .

presence of a reading disorder was also a significant predictor of reading achievement ( $\beta=-.33$ ,  $t=-6.19$ ,  $p<.001$ ) in both analyses, indicating that a reading disorder diagnosis was associated with lower achievement scores. No executive functioning measures were related with reading achievement in either analysis; therefore, no support was provided for the hypothesis that multiple methods of executive functioning measurement would account for greater variance in reading achievement than either measure alone (hypothesis five).

#### *Writing Achievement*

The incremental validity of executive functioning measures in their association with writing achievement was examined through hierarchical regression analysis using a

stepwise procedure. Covariates (gender, age) were entered in the first block using a forward selection technique. FSIQ and a previous diagnosis of a writing disorder (i.e., dysgraphia) were entered in the second block using a forward selection technique. Using the enter technique, latent factors that emerged from the CFA on the TEA-Ch were entered in the third block, and latent factors that emerged from the CFA on the BRIEF were entered in the fourth block. Analyses were then conducted with factors from the BRIEF in the third block and factors from the TEA-Ch in the fourth block. Although the CFA for the BRIEF in the current study indicated that the Monitor subscale loaded on both factors, the original latent factor structure (i.e., Monitor loading only on the Metacognition factor) was used during the following analysis.

Gender and age were not significant predictors in either regression analysis ( $p>.05$ ). FSIQ was a significant main effect predictor of writing achievement ( $p<.001$ ), with higher IQ scores associated with better performance on writing achievement tasks. Having a diagnosis of a writing disorder was also a significant predictor of writing achievement ( $\beta=-.21$ ,  $t=-3.58$ ,  $p<.001$ ) in both analyses, with the presence of a learning disorder associated with lower writing achievement scores. When the TEA-Ch was entered in the third block and the BRIEF was entered in the fourth block, no executive functioning measures were associated with writing achievement (see Table 22). However, when the BRIEF was entered in the third block and the TEA-Ch was entered in the fourth block, the Switching factor of the TEA-Ch was a significant predictor of writing achievement scores ( $\beta=.22$ ,  $t=2.05$ ,  $p<.05$ ), with better performance on this subscale related to higher writing scores (see Table 23). The addition of both the TEA-Ch and the BRIEF accounted for 42% of the variance in writing achievement performance,

Table 22 Standardized Coefficients for WJ-III Writing Achievement Regression Model:  
TEA-Ch in the Third Block and BRIEF in the Fourth Block

	B	T	$R^2\Delta$
Gender	.12	1.97	
Age	.04	.63	
FSIQ	.59	9.66**	
			.34
Writing Disorder	-.21	-3.58**	
			.04
TEA-Ch Sustained Attention	.10	1.17	
TEA-Ch Selective Attention	-.10	-1.20	
TEA-Ch Switching	.21	1.90	
			.04
BRIEF Behavioral Regulation	-.13	-1.86	
BRIEF Metacognition	.12	1.85	
			.02

\*\*p<.001

Note. Standardized coefficients were used. Overall model F=19.82, p<.001. Overall adjusted  $R^2=.42$ .

Table 23 Standardized Coefficients for WJ-III Writing Achievement Regression Model:  
BRIEF in the Third Block and TEA-Ch in the Fourth Block

	B	T	$R^2\Delta$
Gender	.12	1.97	
Age	.04	.63	
FSIQ	.59	9.66**	
			.34
Writing Disorder	-.21	-3.58**	
			.04
BRIEF Behavioral Regulation	-.09	-1.30	
BRIEF Metacognition	.10	1.46	
			.01
TEA-Ch Sustained Attention	.10	1.16	
TEA-Ch Selective Attention	-.09	-1.07	
TEA-Ch Switching	.22	2.05*	
			.05

\*p<.05 \*\*p<.001

Note. Standardized coefficients were used. Overall model F=19.82, p<.001. Overall adjusted  $R^2=.42$ .

compared to 41% of the variance with the TEA-Ch alone. Therefore, hypothesis five was not supported for writing achievement because the inclusion of both executive functioning measures did not explain significantly more of the variance than either measure alone ( $p>.05$ ).

## CHAPTER FIVE

### DISCUSSION

The current study examined two measures of executive functioning and the ecological and incremental validity of these measures through their relation with functional outcomes (social skills, academic achievement) in a sample of children and adolescents diagnosed with ADHD. This section highlights the key findings from each hypothesis, and Table 24 displays results related to the hypotheses explored in this study. Finally, limitations of the present study and future directions for research are presented.

#### *Factor Structure of Executive Functioning*

A lack of research on the validity of recent measures of executive functioning, as well as continued debate surrounding the unity or diversity of executive functions, underscored the importance of investigating the factor structure of neuropsychological assessments of executive skills (Hughes & Graham, 2002; Silver 2000). The constructs underpinning the TEA-Ch and the BRIEF required further investigation through statistical scrutiny (i.e., CFA) with an ADHD sample given the executive dysfunction that typically exist within this population, as well as the frequent use of executive functioning measurement in clinical settings (Gioia et al., 2002; Heaton et al., 2001). Thus, analyses were completed to assess the factor structure for each measure using a sample of children and adolescents diagnosed with ADHD.

Table 24 Support for Hypotheses

Hypothesis	Finding
<i>Hypothesis 1a:</i> A measurement model consisting of three factors (Selective Attention, Sustained Attention, Switching) will provide a good fit to the data for the TEA-Ch as determined by the goodness of fit indices	Supported
<i>Hypothesis 1b:</i> The three-factor model will provide a better fit to the data than a one-factor model as determined by a chi-square differences test	Supported
<i>Hypothesis 1c:</i> The three-factor oblique model will provide a better fit than a three-factor orthogonal model as determined by a chi-square differences test	Supported
<i>Hypothesis 2a:</i> A measurement model consisting of two factors will provide a good fit to the data for the BRIEF as determined by the goodness of fit indices	Supported
<i>Hypothesis 2b:</i> The two-factor model will provide a better fit to the data than a one-factor model as determined by a chi-square differences test	Supported
<i>Hypothesis 2c:</i> The two-factor oblique model will provide a better fit than a two-factor orthogonal model as determined by a chi-square differences test	Supported
<i>Hypothesis 3a:</i> The Selective Attention factor of the TEA-Ch will be negatively related to the CBCL Social Problems subscale	Not Supported
<i>Hypothesis 3b:</i> The Behavioral Regulation factor of the BRIEF will be positively associated with the CBCL Social Problems subscale	Supported
<i>Hypothesis 4:</i> The Metacognition factor of the BRIEF will be negatively related to WJ-III math achievement	Not Supported
<i>Hypothesis 5:</i> The combination of the TEA-Ch and the BRIEF will explain a greater amount of variation in social skills and academic achievement than either measure alone	Not Supported

## Executive Functioning Models

### *TEA-Ch*

A total of three factor analyses were completed for the TEA-Ch. A one-factor model and a three-factor oblique model of executive functioning were hypothesized based on previous research and theoretical assumptions (i.e., unitary versus diversity of executive functions). A three-factor orthogonal model was also examined. CFA revealed that the three-factor oblique model provided the best fit to the data. This model included a Sustained Attention factor, a Selective Attention factor, and a Switching factor, and the three factors were correlated. This model provided a better fit than a one-factor, global model of executive functioning, as well as a three-factor model in which factors were not correlated.

This three-factor model is consistent with previous findings reported by Manly and colleagues (2001) using a normative sample, as well as with findings from Chan and colleagues (2008) using a normative sample with the Chinese version of the TEA-Ch. Therefore, results from the current study suggest that a three-factor model of executive functioning for the TEA-Ch is appropriate for use with a sample of children and adolescents diagnosed with ADHD. Replication of the factor structure of the TEA-Ch in an ADHD sample was particularly important because of the significant deficits in executive functioning typically exhibited by this population (Barkley 1997a; Barkley et al., 1992; Brown, 2000). Heaton and colleagues (2001) highlighted this need after results from their study indicated poorer performance on divided attention tasks in an ADHD population. However, no support for a separate divided attention factor was provided in the current study, as a model with three factors provided a good fit to the data.

Additionally, the Sustained Attention, Selective Attention, and Switching factors of the TEA-Ch were moderately to highly correlated, providing evidence of a model of executive functioning in which constructs are related but distinct.

#### *BRIEF*

A total of five factor analyses were completed for the BRIEF. It was hypothesized that a two-factor oblique model of executive functioning would provide a good fit to the data compared to a one-factor model and a two-factor orthogonal model. A one-factor model and a two-factor orthogonal model were both rejected. A two-factor oblique model provided better fit than the former two models; however, it did not provide adequate fit overall (i.e., good relative fit but poor absolute fit).

Additional model modifications were conducted, and a two-factor oblique model in which the Monitor subscale loaded equally on both factors (i.e., Behavioral Regulation, Metacognition) and the measurement errors for the Monitor and Inhibit subscales were allowed to correlate provided good fit for the data. This two-factor model is consistent with previous research indicating that the Monitor subscale reflects two dimensions (i.e., monitoring of task-related activities and monitoring of personal behavioral activities) and thus loads on multiple factors (Gioia & Isquith, 2004; Slick et al., 2006). Gioia and colleagues (2002) previously explored this hypothesis through CFA with the Monitor subscale separated into two components, and results indicated that a three-factor model provided the best fit to the data for a mixed clinical group.

Nonetheless, the two-factor model with modifications as indicated in the current study is the most appropriate factor structure since proper administration and scoring of the BRIEF in clinical settings only produces eight subscales. Additionally, parsimony would

d dictate that the two-factor model is superior to a three-factor model. In the current model, the measurement errors for the Monitor and Inhibit subscales were allowed to correlate, which is consistent with previous research indicating that these two subscales were statistically related (Gioia et al., 2002) given their shared ability to regulate one's actions and its impact on others.

Previous literature indicated a need for factor replication of the BRIEF within specific clinical groups (e.g., ADHD) in order to elucidate the generality or specificity of executive functioning models (Gioia et al., 2002). The current study provides support for the use of a two-factor model of executive functions for the BRIEF for youth diagnosed with ADHD. In addition, the Behavioral Regulation and Metacognition factors within this model were moderately correlated, suggesting that these factors are related but separate, and consistent with a multi-dimensional theory of executive functioning.

#### *Ecological Validity of Executive Functioning Measures*

##### Social Skills

The third hypothesis examined the relation between executive functioning measures (i.e., TEA-Ch, BRIEF) and social difficulties. It was hypothesized that the Selective Attention factor of the TEA-Ch would be negatively related to social problems (i.e., worse performance on selective attention tasks associated with greater social difficulties), whereas the Behavioral Regulation factor of the BRIEF would be positively associated with social difficulties (i.e., greater behavioral regulation difficulties related to greater social problems) given the need for cognitive efficiency and inhibition in social interactions (Bates et al., 1991; Nigg et al., 1999; Schonfeld et al., 2006; Warschausky et al., 2003).

The efficiency with which information can be filtered to detect relevant information and inhibit irrelevant or distracting information as measured by the Selective Attention factor of the TEA-Ch was found to be unrelated to social difficulties. The lack of significant findings may be a result of the focus on the efficiency with which the child completes the task on the TEA-Ch (i.e., the timing component) rather than inhibition alone. These other components (i.e., efficiency) may be less important in social interactions, resulting in a lack of significant findings. Another possibility for this insignificant relation is the difference in measurement between the executive functioning assessment tool and the social problems measure, as the TEA-Ch is a performance-based task and the measure of social functioning used in the current study is based upon parent report. These assessment tools may be measuring unique aspects of the child's functioning and not fully capturing the entire picture, therefore, limiting the ability to reveal significant findings (Meyer et al., 2001). Conversely, the lack of significant findings may be a result of the difficulty in predicting social and behavioral outcomes using traditional neuropsychological test scores (Ganesalingam et al., 2007). Finally, it may be that the current study did not have enough statistical power to detect this proposed relation and larger sample sizes may reveal a significant relation.

The Behavioral Regulation factor of the BRIEF, which assesses the child's ability to use appropriate inhibitory control to shift cognitive set and modulate emotions and behavior, was significantly related to social difficulties in the present study, with greater reported problems in behavioral regulation associated with greater reported social problems. This finding is consistent with previous research implicating executive functions in social interactions. Longitudinal studies have demonstrated modest

associations between early executive functioning skills, particularly inhibitory control, and social competency (Bates et al., 1991; Nigg et al., 1999). Cross-sectional research has confirmed these findings, with the important role of inhibition and self-regulation highlighted in these studies (e.g., Clark et al., 2002; Schonfeld et al., 2006; Warschausky et al., 2003). In fact, one study found the Behavioral Regulation factor of the BRIEF in particular to predict the effectiveness of a social skills intervention (Schonfeld et al., 2006).

The relation between behavioral regulation and social skills is especially salient in youth with ADHD, as researchers generally conclude that ADHD is a relative inability to regulate and organize behavior (Barkley, 1997a; Barkley et al., 1992; Brown, 2000). It may be that children with ADHD have limited ability to generate strategies and to organize their thoughts and guide their behavior in social situations (Clark et al., 2002) or that an impulsive behavioral style adversely affects social maturity and interpersonal adaptation (Stuss & Alexander, 2000). Thus, the current study lends support of the unique and important role of inhibition and behavioral regulation in social interactions for children and adolescents with ADHD.

In addition to previous research suggesting an association between behavioral regulation and social skills, current models of social functioning also implicate the role of executive functioning in social skills development. Crick and Dodge's (1994) social information processing theory suggests that executive skills are necessary for social interaction, and behavioral regulation is a crucial component in several steps within this model. For example, behavioral regulation is necessary during the fourth step (i.e., response decision process) in order to generate alternative solutions and in the sixth step

(i.e., enactment process) to modulate a response. Therefore, executive dysfunction may interfere with an individual's ability to follow through with the step and negatively impact social interactions. A more recent model of the development of social skills proposed by Beauchamp and Anderson (2010) highlights the important role of behavioral regulation (i.e., attentional control) that includes such abilities as self-monitoring, response inhibition, and self-regulation in the development of social skills. They propose that these cognitive skills interact dynamically with other components (e.g., temperament, personality, SES, culture) to determine an individual's level of social competence. For example, children who are unable to take turns, appropriately enter groups of children at play, or manage social conflict, all which require behavioral regulation skills, attract negative peer responses that impact social interactions.

The role of behavioral regulation in social functioning is also evidenced in prevention programs and interventions aimed at promoting social-emotional competence in children and adolescents. Previous research has focused on promoting behavioral regulation skills, such as inhibiting impulsive behavior, regulating emotions, accurately perceiving others' perspectives, correctly identifying problems, and generating solutions to improve social interactions (Zins, Elias, Greenberg, & Weissberg, 2000), which allows children to modify and integrate behaviors, actions, and emotions to cope with social interactions (Weissberg, Caplan, & Sivo, 1989). Interventions focusing on the development of behavioral regulation skills have demonstrated improved social competence in school-aged children (Greenberg, 2006; Riggs, Greenberg, Kusche, & Pentz, 2006). Remediation of executive skills has also been successfully used with

children with ADHD with social communication impairments (Ylvisaker & DeBonis, 2000).

The findings from this hypothesis have important implications for researchers and clinicians who assess and treat children and adolescents with ADHD, particularly those experiencing social difficulties. First, researchers should examine longitudinally the role of behavioral regulation and inhibition in social functioning to determine the causal relationship between these variables. Clinicians assessing youth with ADHD should include measures of executive functioning tasks, particularly those assessing behavioral regulation, as a diagnostic tool and to target children who may be at risk for social difficulties (Beauchamp & Anderson, 2010; Diamantopoulou et al., 2007). This is particularly important because social problems tend to be chronic (Barkley, 1990) and may lead to later delinquency (Kupersmidt et al., 1990), psychological distress, social isolation, and reduced self-esteem (Beauchamp & Anderson, 2010). Those providing treatment to youth with ADHD who exhibit social difficulties may utilize interventions tailored to the child's neurocognitive difficulties (i.e., behavioral regulation, inhibition) to enhance social interactions (Schonfeld et al., 2006). For example, the use of repetition, visual cues, step-by-step commands, and behavioral rehearsal may be helpful in coping with difficulties in inhibition or modulating emotion and behavior.

#### Academic Achievement

The fourth hypothesis assessed the relation between executive functioning and academic achievement (i.e., math, reading, writing). Specifically, it was posited that the Metacognition factor of the BRIEF would be negatively related to math achievement as a result of previous studies demonstrating this relation (Barry et al., 2003; Mahone et al.,

2002). In other words, greater difficulties within the Metacognition factor would be associated with lower scores on math achievement.

The Metacognition factor of the BRIEF assesses the ability to use working memory to initiate, plan, organize, and sustain future-oriented problem-solving, and this was found to be unrelated to math achievement in the current study. These findings are in contrast to Mahone and colleagues' (2002) study which demonstrated a significant relation between parent report of executive functions using the BRIEF and math achievement in children with ADHD and Tourette's syndrome. However, this study included math reasoning abilities rather than math calculation alone, which may require greater use of language and executive functioning skills (Fuchs et al., 2006; Keith, 1999; Mahone et al., 2002). Thus, it may be that the executive skills measured by the Metacognition factor of the BRIEF (e.g., working memory, planning, problem-solving) are more related to applied problems and complex problem-solving than math computation. Barry and colleagues (2002) also demonstrated a significant association between executive functions and math achievement; however, this study utilized an executive functioning composite score which included other skills such as set-shifting and cognitive flexibility. It may be that a broader range of executive skills are needed for math achievement than those captured within the Metacognition factor of the BRIEF alone (Gersten, Jordan, & Flojo, 2005; Keith, 1999). Another possibility for the lack of significant findings in the present study is that a larger sample size is needed to increase statistical power for detecting effects.

Although not hypothesized, results from the current study demonstrated a significant positive relation between the Switching factor of the TEA-Ch and math

achievement, with higher scores on the TEA-Ch associated with better performance on math achievement. This finding remained significant even after controlling for a previously diagnosed math disorder; therefore, these results may account for the prevalence of children diagnosed with ADHD without a learning disorder who continue to exhibit academic difficulties (Barkley et al., 2002). Results from the current study is consistent with previous research indicating the important role of set-shifting abilities in math achievement (Bull & Scerif, 2001; Clark, Pritchard, & Woodward, 2010; Mazzocco & Kover, 2007; Preston et al., 2009; van der Sluis, de Jong, & van der Leij, 2007). In fact, one study found significant associations between the TEA-Ch Switching factor and several academic areas, including word reading, math, and spelling (Preston et al., 2009). Clark and colleagues (2010) examined this association longitudinally, and results indicated that increased efficiency on measures of set-shifting and inhibitory control were associated with higher math achievement two years later. Furthermore, van der Sluis and colleagues (2007) found that the role of set-shifting in math achievement performance was uniquely related to math, as results indicated no relation with reading performance. This finding is particularly important since math and reading achievement are often associated and there is a need to determine whether executive functions independently contribute to math achievement (Clark et al., 2010). Thus, the current study adds support to the unique contribution of set-shifting abilities in math achievement.

This finding suggests that the primary difficulty for children and adolescents with low math achievement is inhibiting a learned strategy and switching to a new strategy. For successful mathematical learning, strategy development is a key process that “involves changes in the mix of existing strategies as well as the construction of new

ones and abandonment of old ones" (Siegler & Jenkins, 1989, p. 27). Research demonstrates that children use a mix of strategies characterized by the declining use of less efficient strategies and the increasing use of the most efficient strategies when solving arithmetic problems (Wu et al., 2008). For example, children with typical achievement generally progress from the use of immature strategies (e.g., counting) to more mature ones (e.g., memory-based processes) during elementary school years. However, children with low math achievement demonstrate the use of immature strategies longer and exhibit difficulties in the use of memory-based processes (Geary, Hoard, Byrd-Craven, & DeSoto, 2004; Geary & Brown, 1991). Executive functions, including cognitive flexibility and set-shifting abilities, are critical components in strategy development (Wu et al., 2008). Children who utilize cognitive flexibility to effectively analyze math problems and apply correct strategies are able to build up a knowledge base of core mathematical facts (Geary, 1993; Sweller, van Merriënboer, & Paas, 1998). They are then more likely to transfer correct information to long-term memory and advance more quickly in math learning. Results from the present study provide evidence for the unique role of set-shifting and cognitive flexibility in math achievement, as well as the use of the Switching factor of the TEA-Ch in predicting difficulties in math performance.

The Switching factor of the TEA-Ch was also positively associated with achievement scores in written expression, with better performance on set-shifting tasks related to higher writing scores. This finding remained significant after controlling for a previously diagnosed writing disorder. It has been suggested that neuropsychological functions are influential in the development and quality of written expression and may

impact many aspects of the writing process from translating ideas into text, correcting grammatical or spelling errors, or monitoring the overall product (Hooper, Swartz, Wakely, de Kruif, & Montgomery, 2002; Kellogg, 1996).

Levine and colleagues (1993) were one of the first to suggest the importance of a variety of neuropsychological functions, including memory, attention, graphomotor output, sequential processing, higher order cognition, language, and visual-spatial functions, in the writing process. More recently, the role of executive functions in written expression has been proposed and examined empirically (Berninger, 1999; Hooper et al., 2002; Kellogg, 1996; Lea & Levy, 1999), with results indicating the importance of executive functions in writing achievement (e.g., Altemeier, Jones, Abbott, & Berninger, 2006; Graham & Harris, 2003). For example, Hooper and colleagues (2002) found that initiation and set-shifting abilities in particular differentiated good and poor writers, with poor writers performing worse on these executive tasks. In addition, interventions have targeted executive functions to improve writing skills in school-aged children (Graham, 1997). Therefore, findings from the current study are consistent with previous research suggesting set-shifting abilities as an important aspect of written expression.

These findings have important implications for researchers, clinicians, and educators who work with children and adolescents with ADHD experiencing academic difficulties without necessarily being diagnosed with a comorbid learning disorder. First, researchers should focus on longitudinal studies examining the role of set-shifting abilities and cognitive flexibility in academic achievement to elucidate the causal nature of this relationship. Second, clinicians treating youth with ADHD should target deficits in cognitive flexibility (i.e., the capacity to switch attention from one task to another or

changing task performance), which may result in improved academic performance (Preston et al., 2009). With proper intervention and support, children with ADHD can succeed academically.

Finally, these results also have implications for the education curriculum. In addition to regular instruction in academic subject areas, results from the present study suggest that it would be beneficial to include instruction tailored to developing skills within the attentional control/switching domain (e.g., set-shifting, inhibition, working memory) to enhance learning for those with deficits. Currently, most interventions target the consequences of poor executive functions rather than the development of these skills (Diamond, Barnett, Thomas, & Munro, 2007; Dowsett & Livesey, 2000). However, programs intended to enhance children's executive skills prior to school entry may be particularly helpful in preventing academic difficulties (Clark et al., 2010). For example, results from a study investigating the impact of a preschool program demonstrated that improving executive functioning skills may have increasing benefits over time in improving the academic performance of these children (Diamond et al., 2007). This may have larger societal impacts, including a reduction in special education and costs associated with delinquent behavior. Because children exhibiting difficulty knowing when to utilize a strategy may impulsively apply the same strategy to a variety of problems without effective regulation, educators may need to be more explicit in their teaching and scaffolding of executive skills (Clark et al., 2010). Interventions such as mnemonic strategies, direct strategy instruction, and strategy notebooks may be particularly helpful for these children.

Exploratory analyses of the fluency subtests indicated that executive functions played a small role in performance. Specifically, the Switching factor of the TEA-Ch was related to math fluency, with better performance on set-shifting tasks related to higher math fluency scores. Thus, abilities comprising the Switching factor are related to the efficiency of completing academic tasks. This finding also has implications for the education curriculum in that many school-aged children are required to complete timed tasks; therefore, children with difficulties in shifting attention may be at a disadvantage when asked to complete tasks quickly. It may be beneficial for these children to obtain accommodations to reduce or eliminate these types of demands in order to succeed academically.

Overall, previous research and results from the current study demonstrate that executive functions play an important role in academic achievement for children and adolescents with ADHD. The Switching factor of the TEA-Ch, which assesses the capacity to switch attention either from one task to another or changing task performance, appears to be particularly important across several domains of academic performance, including math, written expression, and math fluency. Set-shifting abilities are a critical aspect of problem-solving (Hooper et al., 2002), and both mathematics and writing have been described as a problem-solving process (Geary, 1993; Hooper et al., 2002). For example, conceptual models of written expression (e.g., Hayes & Flowers, 1980; Ellis, 1983) suggest the need for strong problem-solving abilities to be present for competent writing to be generated. Similarly, children with math disabilities and low math achievement tend to be less skilled in monitoring problem-solving (Butterfield & Ferretti, 1987) and use immature problem-solving longer than expected (Wu et al., 2008).

Because set-shifting abilities relate to problem-solving efficiency, cognitive flexibility, and self-monitoring (Hooper et al., 2002), it is likely that this executive function has a unique role compared to other executive functions in the development of math and writing skills. Although the aforementioned findings apply more generally to all school-age children with math and writing difficulties, the role of set-shifting abilities in academic achievement may be even more pronounced in children and adolescents with ADHD since overall executive dysfunction is common in this population (Barkley 1997a; Barkley et al., 1992; Brown, 2000), and it has been suggested that these children may have limited ability to generate strategies in particular (Clark et al., 2002). Therefore, this aspect of executive functioning may be a crucial aspect of the learning process for youth with ADHD and may be specifically targeted for those with academic difficulties.

#### *Incremental Validity of Executive Functioning Measures*

The fifth hypothesis posited that the combination of executive functioning measures (i.e., TEA-Ch, BRIEF) would explain a greater amount of variation in social functioning (i.e., CBCL Social Problems) and academic achievement (i.e., math, reading, writing) than either measure alone due to their unique measurement of executive functions. This hypothesis was based upon literature indicating that different assessment methods (i.e., parent versus child report, objective versus subjective) may be measuring distinct aspects of executive functioning (Anderson et al., 2002; Bodnar et al., 2007), and that these diverse sources of data will optimize the predictive accuracy (i.e., incremental validity) of the outcome variable of interest.

This hypothesis was not supported in the current study, as the inclusion of both a parent report (i.e., BRIEF) and a performance-based measure (i.e., TEA-Ch) of executive

functioning did not account for significantly more variance in outcomes than the use of either measure alone. For example, the BRIEF was useful in predicting social difficulties, but the inclusion of the TEA-Ch did not significantly account for more variance in this prediction when it was added to the model. Similarly, the TEA-Ch explained a significant proportion of the variance in predicting math and writing achievement, but adding the BRIEF to the model did not significantly improve the amount of variance accounted for in performance. These results are somewhat surprising, but may be due to a lack of a clear definition and conceptualization of executive functioning (i.e., unitary versus multi-component), resulting in measurement difficulties (e.g., Ardila, 2008; Gioia et al., 2002). Additionally, correlations among executive tests are typically moderate or low, suggesting diverse components of executive functioning (Friedman et al., 2006). Therefore, the TEA-Ch and the BRIEF may be measuring distinctive aspects of executive functioning that are not always applicable in predicting specific outcomes. It is also possible that the present study did not have a large enough sample size to detect effects; thus, studies with increased samples are needed to explore this hypothesis.

The lack of significant findings from this hypothesis has important implications for both researchers and clinicians. First, research should continue to include both types of assessment methods in predicting outcomes to determine the necessity of measures in neuropsychological assessment. Although both assessment tools were not needed to predict each individual outcome in the present study, each tool uniquely predicted a different outcome. Therefore, for clinicians developing assessment batteries for children and adolescents with ADHD, both performance-based measures of executive functioning

and parent report may want to be considered given their unique association with outcomes.

#### *Limitations and Directions for Future Research*

Although this study provides important information about the measurement of executive functioning and its association with social skills and academic achievement in a sample of youth with ADHD, there are several limitations that need to be acknowledged.

First, there were limitations related to the sample used. The sample was heterogeneous in terms of ADHD subtype with approximately half of the sample being diagnosed as Inattentive type and the other half diagnosed with Combined type. Future research should obtain adequate sample size to compare findings between subtypes to determine whether the factor structure of measures of executive functioning is similar among groups and if the impact of executive functions on functional outcomes differs between groups. A second limitation to the current study was that the sample used was primarily male (73%). Nonetheless, this sample is similar to the gender ratio of 3:1, with more males being affected with ADHD than females (American Psychiatric Association, 2000).

Another limitation of the sample was the rate of comorbidity, with 53% having been diagnosed with at least one other disorder. Although this limits the specificity of results for ADHD, it increases generalizability. In fact, this rate of comorbidity is consistent with community samples that demonstrate comorbidity rates up to 44% (Szatmari et al., 1989) and rates near 87% in clinic-referred children (Kadesjo & Gillberg, 2001). Comparison of samples of youth diagnosed with ADHD only and with samples of youth with ADHD combined with other comorbid diagnoses may be helpful

in future research to clarify the specific impact of executive functions on outcomes without potential confounding variables (i.e., the impact of anxiety or depression on academic achievement). Finally, the overall sample size was relatively small despite being adequate for analysis. Future research using larger samples of children and adolescents with ADHD is warranted.

This study was also limited in terms of measurement. The use of multiple methods of assessment (i.e., subjective parent report, objective performance-based) when examining the impact of executive functions on outcomes confounded the results because it was unclear whether these findings were the result of the type of method used. There is likely to be some portion of the variance from the variables that is shared as a result of the specific method rather than as a result of the construct of interest (LaGrange & Cole, 2008). For example, the parent report of executive functioning (i.e., BRIEF) was related to the parent report of social difficulties (i.e., CBCL), and the performance-based executive functioning measure (i.e., TEA-Ch) was related to the performance-based academic achievement measure (i.e., WJ-III). Nonetheless, only one of the factors of the BRIEF (i.e., Behavioral Regulation) was related to social difficulties, providing support that it was not just the method used that contributed to these findings. Additionally, it is considered the “gold standard” in child assessment to include multi-informant, multi-method approaches of assessment (Johnston & Murray, 2003) because it is assumed that these diverse sources of data will optimize the predictive accuracy of the outcome variable of interest. It would be beneficial for future research to examine the relation between executive functions and outcomes using multiple methods of executive functioning similar to the current study, as well as multiple measures of academic

achievement and social skills. This approach to assessment provides a more complete representation of the characteristics of the construct that each measure intends to assess (Meyer et al., 2001). Another limitation of the current study was the measure of social functioning used. The Social Problems subscale of the CBCL is a parent report of social difficulties. Future research should employ a more comprehensive measure of social functioning, such as performance-based measures or natural based measures (e.g., peer nominations).

Finally, the cross-sectional design of the current study is a significant limitation. Cross-sectional studies do not determine the causality of relationships. The causal relation of executive functioning and outcomes cannot be determined in the present study; therefore, it is unclear whether executive dysfunction exacerbates social or learning difficulties or causes them. Future research should utilize longitudinal designs to determine the cause of social difficulties and academic underachievement with this population. For example, a longitudinal study following the academic performance of youth with and without executive impairments would illuminate the relation between executive functions and academic achievement.

In summary, the ideal study to examine measures of executive functioning and its relation to social skills and academic achievement is to assess a large sample of youth with ADHD utilizing a multi-trait, multi-method longitudinal design. The study would include large samples of children to compare findings between ADHD subtypes and between those diagnosed with ADHD only and those with comorbid diagnoses. Measures would include both objective, performance-based measures of executive functioning, social skills, and academic achievement, as well as subjective, parent and/or teacher

report of executive functioning, social skills, and academic performance to eliminate the possibility of shared method variance when interpreting findings. Finally, the ideal study would be longitudinal to determine the causality of results.

### *Conclusions*

Despite the aforementioned limitations, the present study makes several important contributions to the literature. First, it provides support for the existing factor structure of the TEA-Ch and the BRIEF through its replication of the factor structure using CFA. These findings also support a model of executive functioning that is comprised of multiple but inter-related components. Second, it provides evidence for the use of the existing factor structure of the TEA-Ch and the BRIEF with a sample of children and adolescents with ADHD. This is particularly important given the characteristic executive functioning impairments that often co-occur with ADHD and the need to adequately assess executive functions in neuropsychological assessment with this population.

The present study also provides evidence of the ecological validity of the TEA-Ch and the BRIEF in predicting outcomes. The Behavioral Regulation factor of the BRIEF is particularly important in predicting social difficulties, whereas the Switching factor of the TEA-Ch is predictive of math and writing achievement scores. These results are important because the neurocognitive underpinnings of math and written expression have been less studied than other academic domains (Hooper et al., 2002). This has limited the empirical base from which teachers can make instructional decisions about writing interventions specific to a student's neurocognitive profile (Hooper, Wakely, de Kruif, & Swartz, 2006), as well as few empirically established intervention programs to support students with math difficulties (Clark et al., 2010). Therefore, the current study provides

useful data related to the neuropsychological factors involved in these less-studied academic domains. Finally, the lack of significant findings related to the incremental validity of executive functioning measurement highlights the need for further research examining the inclusion of multiple measures within an assessment battery. Because the BRIEF and the TEA-Ch were associated with different outcomes, it provides support for the use of a full assessment battery if the goal of neuropsychological assessment is to examine a range of outcomes.

**APPENDIX A**

**BRIEF**

On the following pages is a list of statements that describe children. We would like to know if your child has had problems with these behaviors over the past 6 months. Please answer all the items the best that you can. Please DO NOT SKIP ANY ITEMS. Think about your child as you read each statement and circle your response: "N" if the behavior is never a problem, "S" if the behavior is sometimes a problem, or "O" if the behavior is often a problem. For example, if your child never has trouble completing homework on time, you could circle "N" for this item: *has trouble completing homework on time*. If you make a mistake or want to change your answer, DO NOT ERASE. Draw an "X" through the answer you want to change, and then circle the correct answer. Before you begin answering the items, please fill in your child's name, gender, grade, age, birth date, your name, your relationship to the child, and today's date in the spaces provided at the top of the next page.

1. Overreacts to small problems
2. When given three things to do, remembers only the first or last
3. Is not a self-starter
4. Leaves playroom a mess
5. Resists or has trouble accepting a different way to solve a problem with schoolwork, friends, chores, etc.
6. Becomes upset in new situations
7. Has explosive, angry outbursts
8. Tries the same approach to a problem over and over even when it does not work
9. Has a short attention span
10. Needs to be told to begin a task even when willing
11. Does not bring home homework, assignment sheets, materials, etc.
12. Acts upset by a change in plans
13. Is disturbed by change of teacher or class
14. Does not check work for mistakes
15. Has good ideas but cannot get them on paper
16. Has trouble coming up with ideas for what to do in play or free time
17. Has trouble concentrating on chores, schoolwork, etc.
18. Does not connect doing tonight's homework with grades
19. Is easily distracted by noises, activity, sights, etc.
20. Becomes tearful easily
21. Makes careless errors
22. Forgets to hand in homework, even when completed
23. Resists change of routine, foods, places, etc.
24. Has trouble with chores or tasks that have more than one step
25. Has outbursts for little reason
26. Mood changes frequently
27. Needs help from an adult to stay on task
28. Gets caught up in details and misses the big picture
29. Keeps room messy
30. Has trouble getting used to new situations (classes, groups, friends)
31. Has poor handwriting

32. Forgets what he/she was doing
33. When sent to get something, forgets what he/she is supposed to get
34. Is unaware of how his/her behavior affects or bothers others
35. Has good ideas but does not get job done (lacks follow-through)
36. Becomes overwhelmed by large assignments
37. Has trouble finishing tasks (chores, homework)
38. Acts wilder or sillier than others in groups (birthday parties, recess)
39. Thinks too much about the same topic
40. Underestimates time needed to finish tasks
41. Interrupts others
42. Does not notice when his/her behavior causes negative reactions
43. Gets out of seat at the wrong times
44. Gets out of control more than friends
45. Reacts more strongly to situations than other children
46. Starts assignments or chores at the last minute
47. Has trouble getting started on homework or chores
48. Has trouble organizing activities with friends
49. Blurts things out
50. Mood is easily influenced by situation
51. Does not plan ahead for school assignments
52. Has poor understanding of own strengths and weaknesses
53. Written work is poorly organized
54. Acts too wild or “out of control”
55. Has trouble putting the brakes on his/her actions
56. Gets in trouble if not supervised by an adult
57. Has trouble remembering things, even for a few minutes
58. Has trouble carrying out the actions needed to reach goals (saving money for special item, studying to get a good grade)
59. Becomes too silly
60. Work is sloppy
61. Does not take initiative
62. Angry or tearful outbursts are intense but end suddenly
63. Does not realize that certain actions bother others
64. Small events trigger big reactions
65. Talks at the wrong time
66. Complains there is nothing to do
67. Cannot find things in room or school desk
68. Leaves a trail of belongings wherever he/she goes
69. Leaves messes that others have to clean up
70. Becomes upset too easily
71. Lies around the house a lot (“couch potato”)
72. Has a messy closet
73. Has trouble waiting for turn
74. Loses lunch box, lunch money, permission slips, homework, etc.
75. Cannot find clothes, glasses, shoes, toys, books, pencils, etc.

- 76. Tests poorly even when knows correct answers
- 77. Does not finish long-term projects
- 78. Has to be closely supervised
- 79. Does not think before doing
- 80. Has trouble moving from one activity to another
- 81. Is fidgety
- 82. Is impulsive
- 83. Cannot stay on the same topic when talking
- 84. Gets stuck on one topic or activity
- 85. Says the same things over and over
- 86. Has trouble getting though morning routine in getting ready for school

**APPENDIX B**

**CBCL**

Below is a list of items that describe children and youths. For each item that describes your child now or within the past 6 months, please circle the 2 if the item is very true or often true of your child. Circle the 1 if the item is somewhat or sometimes true of your child. If the item is not true of your child, circle the 0. Please answer all items as well as you can, even if some do not seem to apply to your child.

1. Acts too young for his/her age
2. Drinks alcohol without parents' approval
3. Argues a lot
4. Fails to finish things he/she starts
5. There is very little he/she enjoys
6. Bowel movements outside toilet
7. Bragging, boasting
8. Can't concentrate, can't pay attention for long
9. Can't get his/her mind off certain thoughts; obsessions
10. Can't sit still, restless, or hyperactive
11. Clings to adults or too dependent
12. Complains of loneliness
13. Confused or seems to be in a fog
14. Cries a lot
15. Cruel to animals
16. Cruelty, bullying, or meanness to others
17. Daydreams or gets lost in his/her thoughts
18. Deliberately harms self or attempts suicide
19. Demands a lot of attention
20. Destroys his/her own things
21. Destroys things belonging to his/her family or others
22. Disobedient at home
23. Disobedient at school
24. Doesn't eat well
25. Doesn't get along with other kids
26. Doesn't seem to feel guilty after misbehaving
27. Easily jealous
28. Breaks rules at home, school, or elsewhere
29. Fears certain animals, situations, or places, other than school
30. Fears going to school
31. Fears he/she might think or do something bad
32. Feels he/she has to be perfect
33. Feels or complains that no one loves him/her
34. Feels others are out to get him/her
35. Feels worthless or inferior
36. Gets hurt a lot, accident-prone
37. Gets in many fights
38. Gets teased a lot
39. Hangs around with others who get in trouble

- 40. Hears sounds or voices that aren't there
- 41. Impulsive or acts without thinking
- 42. Would rather be alone than with others
- 43. Lying or cheating
- 44. Bites fingernails
- 45. Nervous, highstrung, or tense
- 46. Nervous movements or twitching
- 47. Nightmares
- 48. Not liked by other kids
- 49. Constipated, doesn't move bowels
- 50. Too fearful or anxious
- 51. Feels dizzy or lightheaded
- 52. Feels too guilty
- 53. Overeating
- 54. Overtired without good reason
- 55. Overweight
- 56. Physical problems
  - a) Aches or pains (not stomach or headaches)
  - b) Headaches
  - c) Nausea, feels sick
  - d) Problems with eyes (not if corrected by glasses)
  - e) Rashes or other skin problems
  - f) Stomachaches
  - g) Vomiting, throwing up
  - h) Other
- 57. Physically attacks others
- 58. Picks nose, skin, or other parts of body
- 59. Plays with own sex parts in public
- 60. Plays with own sex parts too much
- 61. Poor school work
- 62. Poorly coordinated or clumsy
- 63. Prefers being with older kids
- 64. Prefers being with younger kids
- 65. Refuses to talk
- 66. Repeats certain acts over and over; compulsions
- 67. Runs away from home
- 68. Screams a lot
- 69. Secretive, keeps things to self
- 70. Sees things that aren't there
- 71. Self-conscious or easily embarrassed
- 72. Sets fires
- 73. Sexual problems
- 74. Showing off or clowning
- 75. Too shy or timid
- 76. Sleeps less than most kids

77. Sleeps more than most kids during day and/or night
78. Inattentive or easily distracted
79. Speech problem
80. Stares blankly
81. Steals at home
82. Steals outside the home
83. Stores up too many things he/she doesn't need
84. Strange behavior
85. Strange ideas
86. Stubborn, sullen, or irritable
87. Sudden changes in mood or feelings
88. Sulks a lot
89. Suspicious
90. Swearing or obscene language
91. Talks about killing self
92. Talks or walks in sleep
93. Talks too much
94. Teases a lot
95. Temper tantrums or hot temper
96. Thinks about sex too much
97. Threatens people
98. Thumb-sucking
99. Smokes, chews, or sniffs tobacco
100. Trouble sleeping
101. Truancy, skips school
102. Underactive, slow moving, or lacks energy
103. Unhappy, sad, or depressed
104. Unusually loud
105. Uses drugs for nonmedical purposes (don't include alcohol or tobacco)
106. Vandalism
107. Wets self during the day
108. Wets the bed
109. Whining
110. Wishes to be of opposite sex
111. Withdrawn, doesn't get involved with others
112. Worries

**APPENDIX C**  
**INFORMED CONSENT**



**University of Illinois Medical Center**

Changing medicine, for good.

**UIMC Consent for Treatment and Authorization**

Patient Addressograph Label

1. **CONSENT TO TREAT:** For myself, or as a legal guardian of the patient in question, I hereby voluntarily and knowingly agree and do give my express consent to the University of Illinois Medical Center (UIMC), operated by the Board of Trustees of the University of Illinois, to perform such procedures, medical or surgical, take such x-rays, administer such drugs or injections and draw such blood as may be considered necessary or desirable for diagnosis and treatment by the physician in attendance. I understand that I will be asked to give separate consent for any contemplated procedure believed to involve any substantial risk. I understand that admission to the UIMC shall include participation in its clinical training programs and hereby voluntarily consent to said participation. This consent implies that at various times I might be interviewed, examined, observed, or have diagnostic or therapeutic procedures performed on me by resident physicians, medical students, or other authorized students of the health professions. Such participation shall be appropriate to their level of training and under adequate supervision when needed. I am aware that the practice of medicine and surgery is not an exact science and I acknowledge that no guarantees have been made to me as to results of any diagnosis, treatment, surgery, test, or examination conducted or performed. I declare that I have provided or will provide financial, family, and medical history information requested to the best of my knowledge, and believe that such information already given is true, correct, and complete.
2. **PERSONAL BELONGINGS:** I assume full responsibility for all items of personal property, including, but not limited to eyeglasses, hearing aids, dentures, jewelry, currency, and all other valuables. I understand that the hospital maintains a safe where valuable may be kept upon my request and hereby release the hospital of responsibility and liability for those valuables and items of personal property which are not deposited with the hospital for safe keeping.
3. **RESPONSIBILITY FOR PAYMENT:** In consideration for services to be rendered at the hospital, the undersigned agrees, as patient or guarantor for patient, to pay the hospital for all services, facilities, and supplies provided to me or the patient at the established rates, including any deductible, co-payment, or charges not covered by third party payors. I accept responsibility for any cost, including attorneys' fees, incurred in the collection of these charges. I understand that if I do not consent to release medical records or later revoke such consent, I am fully responsible for payment of all charges for diagnosis and treatment received, if such refusal results in denial of payment by my insurance company. I certify that the information given by me for purposes of payment for this hospital treatment is, to the best of my knowledge, complete and accurate.
4. **ASSIGNMENT OF BENEFITS:** I hereby assign and instruct my insurance company(ies) to pay the UIMC and the treating physician(s) the accrued benefits for any inpatient or outpatient hospital services rendered or to be rendered by UIMC.
5. **MEDICARE PAYMENT AND ASSIGNMENT OF BENEFITS (if applicable):** I request that payment of authorized Medicare benefits be made on my behalf for hospital and physician services furnished to me at the hospital and I assign such benefits to the hospital and the physicians providing same. I certify that the information given by me in applying for such benefits is correct and that I have completed a Medicare questionnaire. I authorize any holder of medical or other information about me to release to the Centers of Medicare and Medicaid Services (CMS) and its agents any information needed for payment of such benefits. I authorize the Social Security Administration to release information about my entitlement to benefits to the hospital and physicians providing services to me. If I am an inpatient Medicare beneficiary I acknowledge receipt of the message from the University of Illinois Medical Center regarding my rights as a Medicare patient. My signature does not waive any of my rights to request a review or make me liable for any payment.
6. **CLINIC BILLING:** Many of our outpatient offices bill for services as "provider-based" clinics. In addition to a bill for your doctor's fee, the hospital owns the office and charges a facility fee for each visit. This means that you will receive either:
  - \* a single bill from the hospital that contains charges for the professional services provided by your doctor and the facility fee charged by the hospital, OR
  - \* separate bills: one from your doctor's billing service for professional fees and one from the hospital for the facility charges

Many insurance plans pay for health care services provided in a hospital clinic differently than they pay for a private doctor's office. Your plan may have different deductible and co-insurance requirements for a hospital clinic than a doctor's office. Please check with your insurance company or your employer's benefits office if you have questions about your plan's coverage for provider based clinic charges.



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University of Illinois Medical Center

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**UIMC Consent for Treatment and Authorization****Patient Addressograph Label**

**7. NOTICE OF PRIVACY PRACTICES:** The University of Illinois Medical Center's Notice of Privacy Practices has been made available to me. I grant permission for the University of Illinois Medical Center and its agents to contact me by telephone at any number that I provide through any means of contact including, but not limited to direct voice, autodialed, and prerecorded message calls.

**8. DIRECTORY INFORMATION:** I grant permission to the University of Illinois Medical Center to use and disclose my name, the location at which I am receiving care, my condition in general terms, and my religious affiliation in the facility directory. I further understand that all of this information, except religious affiliation, will be disclosed to people that ask for me by name, including media. The University of Illinois Medical Center will only provide my religious affiliation to clergy, even if they do not ask for me by name. If I decide to restrict my information from being used and disclosed in the facility directory, I understand I must inform the Admitting Department and complete the form on Restriction to Use and Disclose Patient Information Form for UIMC In-patient Directory. Further, I understand that if I restrict my information out of the directory, florists and other visitors may not be able to find my room or contact me.

**9. RELEASE OF MEDICAL RECORDS:** I understand that my medical records are protected under federal and state law and may be disclosed without my written consent for the purposes of treatment, payment, and healthcare operations. I further understand that the specific type of information to be disclosed may include diagnosis, prognosis, treatment for physical and psychiatric illness, treatment for alcohol or substance abuse, or Acquired Immune Deficiency Syndrome (AIDS) or AIDS virus (HIV) testing. I hereby authorize the hospital and any physician or other healthcare provider who may treat me to release any and all pertinent information contained in my medical record to; entities involved in billing and collection for the hospital, physicians, and ambulance/paramedic services and third party payors responsible for payment of patient charges (including but not limited to insurance companies, health benefit plans, employers involved in approval of benefit claims, government agencies, or intermediaries representing any of the above); any organization or government agency authorized to license or accredit the hospital or to review quality, utilization, or cost of care rendered; any person or organization involved in discharge planning; referring and follow-up health care providers after a hospitalization or emergency room visit. I understand my treating physicians, nurses, and other health care providers have access to any of my prior medical records in the custody of the Medical Center as needed to render care during my stay/visit. I specifically authorize the hospital and any physician or other health care providers who may treat me for mental health, drug or alcohol abuse, or HIV and related diseases, to release any and all information contained in my past or current medical records to the persons and organization for the purposes stated above. I agree that the specific consent contained in this paragraph shall apply even if I am diagnosed and/or treated for one of the above conditions after I have signed consent for the current Medical Center visit/stay. For the purpose of treatment, payment, healthcare operation, and to facilitate continuity of care, an electronic version of the medical records may be shared with employees and physicians of entities of University of Illinois Medical Center and its affiliates.

**10. REVOKING CONSENT:** This consent may be revoked in writing by me at any time, except to the extent of actions that have been taken in reliance on the consent given.

Patient Name (Please Print)

Signature of patient/person authorized to consent for patient

Witness \_\_\_\_\_

Relationship \_\_\_\_\_

Date \_\_\_\_\_

Time \_\_\_\_\_

Street Address (if different from that of patient)

City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_

**(IF PATIENT IS UNABLE TO CONSENT OR IS A MINOR, COMPLETE THE FOLLOWING)**

Patient named above is a minor, \_\_\_\_\_ years of age.

Patient named above is unable to sign because: \_\_\_\_\_

**ADMINISTRATIVE USE ONLY**

<input type="checkbox"/> Telephone Consent	Consent Witnessed By: _____	
<input type="checkbox"/> Mother	Date/Time: _____ / _____ : _____ AM PM	
<input type="checkbox"/> Father	(needed with Administrative Consent)	
<input type="checkbox"/> Legal Guardian	(needed with Administrative Consent)	
<input type="checkbox"/> Administrative Consent	Attending MD: _____	

UIC UNIVERSITY OF ILLINOIS AT CHICAGO Name \_\_\_\_\_  
DEPARTMENT OF PSYCHIATRY  
MR# \_\_\_\_\_

Consent for Mental Health Treatment

This written consent must be obtained before mental health assessment unless the client is in crisis or the assessment is court ordered.

I hereby give my consent for mental health and / or addictions treatment at the University of Illinois at Chicago, Department of psychiatry. This consent will be valid as long as my registration with the University of Illinois Hospital and Clinics remains current.

Signatures:

Client Signature

Date

Witness Signature

Date

If the patient is under 12:

Parent/Guardian Signature

Date

**APPENDIX D**  
**CHILD NEUROPSYCHOLOGY HISTORY QUESTIONNAIRE**

**CHILD NEUROPSYCHOLOGICAL HISTORY QUESTIONNAIRE<sup>\*</sup>***Confidential*

Patient's Name: \_\_\_\_\_

[Completed By: \_\_\_\_\_ Relationship to Child: \_\_\_\_\_]

Today's Date: \_\_\_\_\_

Current Age: \_\_\_\_\_

Child's Date of Birth: \_\_\_\_\_

Grade: \_\_\_\_\_

Gender:       Female       MaleHandedness:       Right       Left       BothEthnicity:       African-American     Hispanic     Caucasian     Native American  
                   Asian       Other: \_\_\_\_\_Primary Language:  English       Other: \_\_\_\_\_Address: \_\_\_\_\_ Day Phone: \_\_\_\_\_  
                  \_\_\_\_\_ Evening Phone: \_\_\_\_\_**Referral Information**

Person who referred for testing:	_____
Address:	_____
Phone:	_____
Fax:	_____

What is your understanding of why this evaluation was requested?

_____
_____
_____

Has your child ever had psychological or neuropsychological testing done before?  Yes  
 No

If Yes, by whom:	
Date(s):	
Test(s):	
Outcome:	

Is this case involved in any litigation, or do you intend to pursue litigation in the future?  Yes  No

If Yes, please describe:	

#### Presenting Problems/Symptoms

Please describe what symptoms or problems are of most concern to you:


Please describe when and how you first became aware of these difficulties and whether they have gotten worse over time:


Do both parents agree about the nature of your child's problems?  Yes  No

Mother's Education: \_\_\_\_\_ Occupation: \_\_\_\_\_

Father's Education: \_\_\_\_\_ Occupation: \_\_\_\_\_

Please list all of members of family (that is, parents & siblings):

Name	Age	Relationship	Current health	How is the relationship?

Please list any members of your family who are left-handed:


#### Current Symptom Checklist

Please check each of the following symptoms or problems that your child is experiencing. Briefly describe each symptom checked (for example, intensity, how long it has been experienced, and how frequent it is):

##### Describe

<input type="checkbox"/> Headaches	
<input type="checkbox"/> Dizziness	
<input type="checkbox"/> Coordination problems	
<input type="checkbox"/> Balance problems	
<input type="checkbox"/> Tremors or shakiness	
<input type="checkbox"/> Concentration problems	
<input type="checkbox"/> Visual problems	
<input type="checkbox"/> Hearing difficulties	
<input type="checkbox"/> Loss of feeling, tingling, or numbness	
<input type="checkbox"/> Difficulty pronouncing words clearly	
<input type="checkbox"/> Getting tired easily	
<input type="checkbox"/> Sensitivity to noise	
<input type="checkbox"/> Sensitivity to light	
<input type="checkbox"/> Pains	
<input type="checkbox"/> Difficulty remembering the right word	
<input type="checkbox"/> Being easily distractible	
<input type="checkbox"/> Poor concentration for extended periods of time	

## ... Symptom Checklist continued

Describe

<input type="checkbox"/> Difficulty reading or writing	
<input type="checkbox"/> Difficulty thinking clearly and efficiently	
<input type="checkbox"/> Difficulty planning and organizing things	
<input type="checkbox"/> Difficulty following through on thinking things	
<input type="checkbox"/> Personality changes	
<input type="checkbox"/> Apathy, lack of interest in things	
<input type="checkbox"/> Difficulty starting tasks	
<input type="checkbox"/> Black-out spells	
<input type="checkbox"/> Irritability	
<input type="checkbox"/> Restlessness	
<input type="checkbox"/> Temper outbursts	
<input type="checkbox"/> Mood swings, quick emotional shifts	
<input type="checkbox"/> Getting bored easily	
<input type="checkbox"/> Getting lost	
<input type="checkbox"/> Anxiety/tension	
<input type="checkbox"/> Troubling thoughts that are difficult to keep out of mind	
<input type="checkbox"/> Depression	
<input type="checkbox"/> Loneliness	
<input type="checkbox"/> Loss of confidence	
<input type="checkbox"/> Feelings of guilt	
<input type="checkbox"/> Changes in appetite	
<input type="checkbox"/> Nightmares	
<input type="checkbox"/> Difficulty telling right from left	
<input type="checkbox"/> Forgetting appointments	
<input type="checkbox"/> Forgetting conversations and people's names	
<input type="checkbox"/> Forgetting the date and time	
<input type="checkbox"/> Increased suspiciousness of others	
<input type="checkbox"/> Feeling slowed down	
<input type="checkbox"/> Sleep disturbance; change in sleep pattern	
<input type="checkbox"/> Hallucinations	
<input type="checkbox"/> Difficulty making/keeping friends	
<input type="checkbox"/> Daydreaming	

**Developmental History****Pregnancy and Birth History:**

Age of mother at delivery: \_\_\_\_\_ Birth weight (pounds &amp; ounces): \_\_\_\_\_

Delivery was:  Vaginal  Cesarean  spontaneous  inducedBaby was born:  Full term  Premature at \_\_\_\_\_ weeks gestation  Post term at \_\_\_\_\_ weeks  
 Forceps used  Vacuum extraction used

Apgar scores: \_\_\_\_\_ 1 minute \_\_\_\_\_ 5 minute

Were there any problems during the pregnancy or delivery?  Yes  No

If yes, please describe: \_\_\_\_\_

Did mother use any medications, alcohol, drugs smoke or have x-rays during pregnancy?

 Yes  No

If yes, please describe: \_\_\_\_\_

**Childhood History:**

Please check each of the following conditions that describe behaviors or emotions your child has ever experienced and briefly describe:

<input type="checkbox"/> Delay learning to walk	<input type="checkbox"/> Act young for age
<input type="checkbox"/> Delay learning to talk	<input type="checkbox"/> Frustrated easily
<input type="checkbox"/> Delay learning to read	<input type="checkbox"/> Excitable
<input type="checkbox"/> Behavioral problems at home	<input type="checkbox"/> Stubborn
<input type="checkbox"/> Behavioral problems at school	<input type="checkbox"/> Poor coordination
<input type="checkbox"/> Bedwetting	<input type="checkbox"/> Hyperactive
<input type="checkbox"/> Nail-biting	<input type="checkbox"/> Blank or staring spells
<input type="checkbox"/> Difficulty paying attention	<input type="checkbox"/> Difficulty making friends
<input type="checkbox"/> Memory problems	<input type="checkbox"/> Impulsivity
<input type="checkbox"/> Depressed	<input type="checkbox"/> Disorganized
<input type="checkbox"/> Aggressive	<input type="checkbox"/> Difficulty controlling emotions
<input type="checkbox"/> Shy	<input type="checkbox"/> Daydream often
<input type="checkbox"/> Tantrums	<input type="checkbox"/> Easily distracted
<input type="checkbox"/> Nightmares	<input type="checkbox"/> Trouble sitting still
<input type="checkbox"/> Poor self-esteem	<input type="checkbox"/> Difficulty finishing projects
<input type="checkbox"/> Unpredictable behavior	<input type="checkbox"/> Attention wanders
<input type="checkbox"/> Cry easily and often	<input type="checkbox"/> Fidgety
<input type="checkbox"/> Speech or language problems	<input type="checkbox"/> Alcohol/drug use
<input type="checkbox"/> Acts without thinking	

**Milestones:**Age: 1<sup>st</sup> word \_\_\_\_\_ 2-3 word sentence \_\_\_\_\_ crawled \_\_\_\_\_ walked \_\_\_\_\_

Has your child had any contact with the law?

 Yes     No

(If yes, explain (incidence dates and nature of the incidents):


Has the child or anyone in the family received any of the following diagnoses:

	Child			Family		
	Y	N	UK	Y	N	UK
Language delay or difficulty	Y	N	UK	Y	N	UK
Autism /PDD/Aspergers	Y	N	DK	Y	N	DK
Hyperactive	Y	N	DK	Y	N	DK
Attention Deficit Hyperactivity Disorder	Y	N	DK	Y	N	DK
Learning Disabled	Y	N	DK	Y	N	DK
Depression	Y	N	DK	Y	N	DK
Schizophrenia	Y	N	DK	Y	N	DK
Conduct Disorder	Y	N	DK	Y	N	DK
Any psychiatric diagnosis	Y	N	DK	Y	N	DK
Maturation lag/ developmental delay	Y	N	DK	Y	N	DK
Emotional / behavior problems	Y	N	DK	Y	N	DK

(If yes, please describe):


Please list any special talents, interests, or hobbies that your child has:


**Educational History**

Current School: \_\_\_\_\_

Primary Teacher: \_\_\_\_\_

Placement:  regular special ed

(Please describe type of service): \_\_\_\_\_

Does child have an IEP? \_\_\_\_\_ If yes, what category? \_\_\_\_\_

Has your child ever skipped or repeated a grade in school?  Yes  No  
 If yes, explain: \_\_\_\_\_  
 \_\_\_\_\_

Has your child taken any special courses or summer school?  Yes  No  
 If yes, explain: \_\_\_\_\_  
 \_\_\_\_\_

Has your child ever received any special education testing?  Yes  No  
 If yes, explain: \_\_\_\_\_  
 \_\_\_\_\_

Has your child ever had an individual IQ test?  Yes  No  
 If yes, what was the name or the test, reason, and results? \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Has your child ever received additional services at school?  Yes  No  
 (e.g., remedial classes, learning or emotional support, tutoring, gifted program, special education, etc.)  
 If yes, explain: \_\_\_\_\_  
 \_\_\_\_\_

Did your child have any difficulties learning to read or write?  Yes  No  
 If yes, explain: \_\_\_\_\_  
 \_\_\_\_\_

Any problems learning addition, subtraction, multiplication or division?  Yes  No  
 If yes, explain: \_\_\_\_\_  
 \_\_\_\_\_

[ ] On average, how would you describe your child's grades:

_____
_____
_____

□

Please list any standardized academic tests or proficiency exams taken and approximate scores: (or provide copies of previous tests)

Test	Date	Score

#### Medical History

Please list all illnesses, surgeries, and hospitalizations that your child has experienced:

Illness/Condition	Date	Treatment

Has your child ever had a head injury with loss of consciousness or being "dazed"?  Yes

No

If Yes, please describe:

Type of Head Injury	Date	Loss of Consciousness?	Outcome

Please list any neurological tests such as MRI, CT, spinal tap, or EEG, including dates and hospitals:

Test(Hospital)	Date	Results

Check if your child has ever experienced the following and briefly describe (for example, dates, frequency):

<input type="checkbox"/> Head injury	
<input type="checkbox"/> Seizures, convulsions, epilepsy	
<input type="checkbox"/> Chronic headaches	
<input type="checkbox"/> Chronic ear infections	
<input type="checkbox"/> Fainting spells	

<input type="checkbox"/> Pneumonia
<input type="checkbox"/> Asthma
<input type="checkbox"/> Diabetes
<input type="checkbox"/> Irregular heart rhythm
<input type="checkbox"/> Repetitive movements (e.g. hand flapping)
<input type="checkbox"/> Change in sense of smell or taste
<input type="checkbox"/> Hearing problems
<input type="checkbox"/> Vision problems
<input type="checkbox"/> Electric shock
<input type="checkbox"/> Exposure to toxic chemicals
<input type="checkbox"/> Hallucinations

Please list your child's current medications:

Medication	Amount	Taking Since?	Reason

Please list your child's past medications:

Medication	Amount	How Long?	Reason for stopping

Please list any known allergies:	

Please indicate if anyone in the family has had the following conditions by checking the box and putting their relationship to your child in the space provided:

<input type="checkbox"/> Diabetes		<input type="checkbox"/> Epilepsy	
<input type="checkbox"/> Hypertension		<input type="checkbox"/> Multiple Sclerosis	
<input type="checkbox"/> Heart Disease		<input type="checkbox"/> Parkinson's	
<input type="checkbox"/> Stroke		<input type="checkbox"/> Alzheimer's	
<input type="checkbox"/> Cancer		<input type="checkbox"/> Alcoholism	

Please indicate if anyone in the family has the following and indicate their relationship to your child:

<input type="checkbox"/> Depression		<input type="checkbox"/> Attention-Deficit Disorder	
<input type="checkbox"/> Schizophrenia		<input type="checkbox"/> Bipolar (Manic-Depressive)	
<input type="checkbox"/> Anxiety		<input type="checkbox"/> Other	

Please describe any other family history of psychiatric problems:


Please add any additional information that you feel may be useful:


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## VITA

Amy Lyons Usher was born and raised in Louisville, Kentucky where she graduated from Assumption High School. She attended the University of Kentucky and graduated summa cum laude with a Bachelor of Arts degree in psychology in 2005. She then entered the clinical psychology program at the University of Dayton in Dayton, Ohio where she completed a thesis examining stress and coping in parents with a child diagnosed with an autism spectrum disorder. She graduated with a Masters degree in clinical psychology from the University of Dayton in 2007.

Amy continued her education at Loyola University Chicago in the clinical psychology program where she joined the laboratory of Dr. Scott Leon. Her research and clinical training focused primarily on neuropsychological assessment, particularly with children and adolescents. She completed a predoctoral internship with a focus on pediatric neuropsychology at Children's Hospitals and Clinics of Minnesota. After graduating with her doctoral degree in clinical psychology from Loyola University Chicago in 2012, she began a postdoctoral fellowship in pediatric neuropsychology at Loyola University Medical Center in Chicago, Illinois. She plans on focusing her career on pediatric neuropsychological assessment in a hospital setting.