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Executive Functioning Deficits in Children with Attention Deficit/Hyperactivity Disorder, Reading Disorder, and Both Disorders

Valentina Libra

EXECUTIVE FUNCTIONING DEFICITS IN CHILDREN WITH ATTENTION DEFICIT/HYPERACTIVITY DISORDER, READING DISORDER, AND BOTH DISORDERS

DISSERTATION

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by
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ABSTRACT

EXECUTIVE FUNCTIONING DEFICITS IN CHILDREN WITH ATTENTION DEFICIT/HYPERACTIVITY DISORDER, READING DISORDER, AND BOTH DISORDERS

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Barry University, 2011

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Purpose

Research indicates that executive functioning (EF) is a multidimensional construct, and may be a common deficit in many developmental and learning disorders, such as attention deficit hyperactivity disorder (ADHD) and reading disorder (RD) (Welsh & Pennington, 1988). However, limited research has been done to explore specific patterns of EF deficits with both co-occurring disorders (ADHD/RD). The purpose of the study was to compare the patterns of EF deficits in children with RD-only, ADHD-only, and ADHD/RD-combined, as measured by the Behavioral Regulation Inventory of Executive Functioning (BRIEF), and as reported by parents and teachers. Additionally, the relationship among the BRIEF scores and other measures of EF, such as the Conners' Continuous Performance Test (CCPT), and the Digit Span (DS) subtest from the WISC-IV, was explored.

Method

The sample in the study included archival data from 112 children ages 6.0-16.0, who received a psycho-educational battery in a private clinical setting between July 2007 and December 2010. The participants were divided into three diagnostic groups: RD-only

($n = 19$), ADHD-only ($n = 66$), and ADHD/RD-combined ($n = 27$). Statistical analyses included MANOVA, paired sample *t*-tests, and Pearson *r* correlations.

Major Findings

Parent ratings of EF indicated a significant effect for the disability diagnosis (Wilks' $\lambda = .71$, $p = .03$). Children in the ADHD-only and ADHD/RD-combined groups demonstrated greater EF deficits than children in the RD-only group for the Inhibit, Monitor, and Working Memory scales.

Comparisons of parent and teacher ratings revealed significant differences in three scales (Initiate, Organization of Materials, and Working Memory) and one index scale (Metacognition). Teacher ratings of EF deficits were higher for every scale, as well as for one index score (with *t* values ranging from 2.8 to 3.8, $p < .05$). It was also noted that parent ratings of EF suggested a significant positive correlation between the Metacognition Index of the BRIEF and the Digit Span subtest of the WISC-IV ($r = .21$, $p < .05$). Overall, children with ADHD have more pervasive deficits in EF than children with RD. However, it was found that EF deficits were not exclusive to ADHD.

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CHAPTER I
THE PROBLEM

Introduction

While definitions of *executive function* vary slightly and the concept is still evolving, there is some consensus among researchers, psychologists, and other experts. Most researchers would agree that the term could be used to refer to brain circuits that prioritize, integrate, and regulate other cognitive functions. Executive function is often compared to the conductor of a symphony orchestra, coordinating and managing many cognitive functions (Brown, 2006).

> Regardless of how well the musicians in a symphony orchestra may play their instruments, they are not likely to produce very good symphonic music if they do not have a competent conductor to select what piece is to be played, to start their playing together, to keep them in time, to modulate the pace and volume of each section, to introduce or fade out various instruments at appropriate times, and so forth. Although each musician may play his or her instrument skillfully, the subtle, dynamic integrated functioning of the orchestra depends crucially on the coordinating and managing functions of the conductor. (p. 36-37)

Executive Functioning

Research on brain functioning and executive functioning can be traced back to the theoretical and empirical work of the Soviet psychologist Alexander Luria (1902–1977). Luria's theory of brain functioning can be described as one of the most influential theories in the history of neuropsychology. Luria's model changed the way clinicians conceptualize and assess humans' brain functioning (Hughes & Ensor, 2007).

Luria's brain functioning theory described the building blocks of intelligence, which he labeled *units.* These units are associated with specific areas of the brain and basic functions. The first unit includes the brain stem and regulates the arousal of the cortex. The second unit involves the occipital, parietal and temporal lobes, and is responsible for encoding, processing, and storing information. The third unit, which is located in the frontal lobe, is responsible for programming, regulating and verifying human behavior (Luria, 1973).

The terms "executive function" or "executive functioning" (EF) are usually associated with the pre-frontal cortex (PFC) (Hughes & Ensor, 2007). EF includes the ability to plan, organize information, and mentally manipulate information to solve a problem. It also involves self-monitoring to change or modify one's behavior (Semrud-Clikema, Pliszka, & Liotti, 2008).

According to Chan, Shum, Toulopoulou, and Chen (2008), EF is an umbrella term that comprises:

> … a wide range of cognitive processes and behavioral competencies which include verbal reasoning, problem-solving, planning, sequencing, the ability to sustain attention, resistance to interference, utilization of feedback, multitasking, cognitive flexibility, and the ability to deal with novelty. (p. 201)

Research has shown that EF deficits have devastating effects on people's everyday life activities, including the ability to learn, to function independently, and to develop and maintain appropriate social relations (Chan et al., 2008). Cognitive theorists explain that EF is involved in all areas of learning, thus making it of particular significance for school and clinical psychologists (Denckla, 1996). Research has shown that EF deficits are prevalent in different psychological and learning disorders, such as attention deficit hyperactivity disorder (ADHD) (Pennington, Groisser, & Welsh, 1993; Willcutt et al., 2001), specific learning disability (SLD) (Kolligian & Sternberg, 1987; Semrud-Clikema et al., 2008), Tourette syndrome (Verte, Geurts, Roeyers, & Oosterlaan, 2006), and pervasive developmental disorder (Griffith, Pennington, Wehner, & Rogers, 1999; Verte et al., 2006). Therefore, the study of the EF deficits is beneficial in remediating and strengthening academic, as well as behavioral difficulties.

A large number of studies have revealed the presence of EF deficits in children with ADHD and in children with reading related disorders (Cutting, Materek, Cole, Levine, & Mahone, 2009; Marzocchi et al., 2008; Pennington et al., 1993; Sesma, Mahone, Levine, Eason, & Cutting, 2009; Willcutt et al., 2001). However, there has been limited research that has explored the specific patterns of EF deficits in children with both co-occurring disorders, ADHD and reading disorder (RD) (Semrud-Clikema et al., 2008). It is the aim of this study to more closely examine the different profiles of EF in children with attentional and/or reading related disorders.

Executive functioning in children with attention deficit hyperactivity disorder. ADHD is defined as a neurodevelopmental disorder characterized by persistent patterns of inattention and/or hyperactivity – impulsivity accompanied by social impairment (American Psychiatric Association, 2000). ADHD is one of the most prevalent chronic disorders of childhood with some epidemiological studies estimating that approximately one to six per cent of children in the United States are affected (Burd, Kulg, Coumbe, & Kerbeshian, 2003). Children with ADHD are typically characterized by symptoms of inattention, hyperactivity, and/or impulsivity (American Psychiatric Association, 2000). Following the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) (APA, 2000), ADHD can be divided into three sub-types: ADHD-Predominantly Inattentive, ADHD-Predominantly Hyperactive/Impulsive, and ADHD-Combined (American Psychiatric Association, 2000).

In addition, a growing body of research suggests that ADHD is associated with a core deficit in EF (Marzocchi et al., 2008; Pennington et al., 1993; Willcutt et al., 2001). Children with ADHD frequently have difficulties in the areas of emotional control, behavioral regulation, planning and organizing, and working memory. Furthermore, such children have fluctuating attention on tasks requiring vigilance and have difficulty shifting from one cognitive set to another. Finally, children with ADHD often experience difficulties self-monitoring their behavior, and inhibiting their impulses (Pennington et al., 1993).

Executive functioning in children with reading disorders. As reported by Kibby, Marks, Morgan, and Long (2004), children with RD experience an unexpected difficulty in learning to read despite average intellectual abilities, adequate educational opportunities, and intact sensory functioning. A large body of research has shown that children with RD usually demonstrate deficits in phonological processing (Kibby et al., 2004). Children who have difficulty understanding how the letters in a word are related to phonemes have difficulty becoming proficient decoders, which negatively impacts their reading comprehension. There is little debate that children who have phonological weaknesses will experience reading difficulties. However, of greater controversy is the possible impairment of other non-language neuropsychological skills in this population, such as non-verbal reasoning and EF (Frye, Landry, Swank, & Smith, 2009; Kibby et al., 2004; Sesma et al., 2009).

According to Sesma, Mahone, Levine, Eason, and Cutting (2009), adequate reading comprehension depends on other cognitive skills beyond word decoding, reading fluency, and language comprehension, such as those that fall under the umbrella of EF. Specifically, research has shown that children with RD are less efficient at strategy usage, tend to have poorer self-regulation, and often have difficulty coordinating and integrating information in order to effectively process written material (Kibby et al., 2004; Sesma et al., 2009).

Executive functioning in children with ADHD and RD. ADHD and RD are two of the most common childhood disorders and they frequently co-occur. Research estimates the comorbidity of specific learning disabilities (SLD) and ADHD between approximately 20 - 40%, with the most frequent co-morbidity observed specifically in the area of reading deficits. Overlapping neuropsychological deficits may provide insight into the factors contributing to the frequent co-occurrence of both disorders (ADHD and RD); whereas the non-overlapping deficits may assist clinicians in the diagnostic process and treatment planning (Bental & Tirosh, 2007; De Jong et al., 2009).

Assessment of Executive Functioning

As stated above, EF deficits are characteristic features of a variety of medical, psychological, and learning disorders. Therefore, there has been an increased need for neuropsychological measures to assess this domain; however, due to its dynamic essence, the clinical assessment of EF deficits represents a challenge for clinicians and practitioners (Chan et al., 2008; Gioia, Isquith, & Guy, 2001).

The highly-structured nature of any clinical setting does not necessarily encourage novel problem-solving abilities, in part because the examiner imposes structure (Gioia et al., 2001; Mahone et al., 2002). The conditions under which a typical assessment occurs may reduce the demands on EF, and therefore, reduce the opportunity to observe critical behaviors associated with EF. In this type of setting, clinicians provide the structure, organization, guidance, and plan necessary for optimal performance by the child, thus, serving as that child's external executive control (Gioia et al., 2001). As a result, many children with EF deficits who have difficulty making simple real-life decisions may perform appropriately on many performance-based measures of EF.

Many research studies have demonstrated inconsistencies between adequate performance in cognitive tests contrasting with profound deficits in EF in daily life activities (Chevignard, Mariller, Abada, Pradat-Diehl, & Laurent-Vannier, 2009; Gioia et al., 2001). As Gioia et al. explained, a child who fails to complete a set of math problems in the classroom that requires strategically modifying his/her approach to solve it, may yet be able to perform appropriately on the Wisconsin Card Sorting Test, an EF test that requires flexibility in problem-solving. According to the authors, when assessing EF in children it is important to remember that "*the absence of evidence is not evidence of absence*." In other words, clinicians may not be collecting the relevant data to assess the full essence of strengths and weaknesses in terms of EF (Gioia et al., 2001).

An additional challenge in the assessment of the EF in children is that it is often assessed with tests that were developed originally for use with an adult population. As a result, they fail to take into consideration the developmental progression of executive skills in children (Chevignard et al., 2009; Gioia et al., 2001). For example, the Brown Attention-Deficit Disorder Scales for Children is an adaptation of the adult and adolescent version, which was designed to assess critical executive aspects of cognitive functioning in adults (Brown, 2001). There is a need for the creation of instruments that are sensitive to developmental effects. Research in cognitive psychology has demonstrated changes in strategic behavior and knowledge from infancy through adolescence. Therefore, recognition of these developmental effects in the assessment of EF in children is of critical importance. Adapting adult neuropsychological tests is not always suitable for use with infants and young children (Chevignard et al., 2009; Gioia et al., 2001).

Research is now showing that deficits in EF are easily observed in the child's home and school environments. Observations by parents and teachers offer an ecologically-valid method of documenting problems within these domains (Gioia et al., 2001). As a result, behavior rating scales can provide a valid and reliable evaluation technique that has been shown to document a range of emotional, behavioral, and learning problems. Observations from the child's behavior at home and at school provide an essential source of information in the assessment of EF (Chevignard et al., 2009; Gioia et al., 2001). In this order of ideas, the Behavior Rating Inventory of Executive Function (BRIEF) is one step toward fulfilling this need.

Theoretical Framework

Luria's theory of brain functioning provides a theoretical framework for this study. His theory significantly changed the way clinicians comprehend and evaluate humans' behavior and information processing (Luria, 1973). Stemming from Luria's work, the term EF was described as part of cognitive theory and has become the focus of widespread interest in research ever since (Denckla, 1996; Van der Sluis, De Jong, & Van der Leij, 2007; Willcutt et al., 2001). Cognitive psychologists postulated that our brain has an executive system by which behaviors are monitored (Just & Carpenter, 1992).

Statement of the Problem

This study compared the patterns of EF deficits in children with RD-only, ADHD-only, and ADHD/RD-combined. The goal of the study was to assess which of the indexes and scales of the BRIEF, as reported by parents, best discriminate children with RD-only from children with ADHD-only, and those with both conditions (ADHD/RD-combined). This study also attempted to compare parent and teacher ratings of EF deficits as measured by the BRIEF. A secondary analysis attempted to explore the relationship between the BRIEF scores and other performance-based measures of EF. Specifically, this study included the Conners' Continuous Performance Test (CCPT), and the Digit Span (DS) subtest from the WISC-IV as two performance-based EF measures.

As research has demonstrated, many empirical studies on EF included clinical tests that the examiner administered to the child, which did not provide a valid assessment of the child's EF deficits. The BRIEF provides an ecologically valid, comprehensive, and psychometrically sound means of assessing these abilities. It assesses two indexes: Behavioral Regulation and Metacognition, and eight clinical scales: Initiate, Monitor, Inhibit, Shift, Plan/Organize, Organization of Materials, Working Memory, and Emotional Control (Gioia et al., 2001). Additionally, this study explored the relationship between BRIEF indexes and scales and other performance-based EF measures, specifically the CCPT and DS.

Significance of the Present Study

The present study has implications for the literature and for practitioners. As reported earlier in this chapter, prevalence studies have demonstrated that ADHD and RD are two of the most common disabilities, and they frequently co-occur (Bental & Tirosh, 2007). In fact, some studies have demonstrated how the co-morbid group (ADHD/RD) is more impaired when compared with groups exhibiting the two exclusive disorders (either ADHD or RD) (Bental & Tirosh, 2007). This study investigated the profile of EF in a sample of children with ADHD-only, RD-only and ADHD-RD-combined. Additionally, when studying ADHD, it is important to investigate the contribution RD can have to the findings in order to establish what deficits are an ADHD phenomenon, an RD phenomenon, as well as a combined disorder phenomenon. Only the inclusion of both disorders in the same study will allow practitioners to determine the unique contribution each has to the underlying deficit.

In addition, it is important for parents and teachers to understand what executive skills are, how they develop in children, and how they impact school performance of children with specific disabilities so they can better help them hone these skills. With knowledge of children's EF strengths and weaknesses, the clinician is in a far better position to develop a treatment plan that targets the necessary skills.

Furthermore, the results of the present study can help parents, educators, and health care providers to make decisions about the type of interventions that will best accommodate the child's needs, as well as to implement behavioral and academic interventions prior to the onset of any learning, social, or behavioral problems.

Research Questions

In essence, deficits in EF are characteristic of many disorders of childhood, including attentional and reading related difficulties. Therefore, the present study attempted to answer the following questions regarding EF deficits in children with RD-only, ADHD-only and ADHD-RD-combined:

1. Are there significant differences among the BRIEF scale and index scores of the RD-only group, ADHD-only group, and ADHD/RD-combined group as described by parents?
2. Are there significant differences among the BRIEF scale and index scores of the three ADHD sub-types (Predominantly Inattentive Type, Predominantly Hyperactive-Impulsive Type, and Combined Type) as described by parents?
3. Are there significant differences among the BRIEF scale and index scores as predicted by parents and teachers?
4. Are there significant differences among the BRIEF scale and index scores of the RD-only group as predicted by parents and teachers?
5. Are there significant differences among the BRIEF scale and index scores of the ADHD-only group as predicted by parents and teachers?
6. Are there significant differences among the BRIEF scale and index scores of the ADHD/RD-combined group as predicted by parents and teachers?

7. Is there a significant relationship between the BRIEF scale scores and other performance-based measures of executive functioning, specifically the Conners' Continuous Performance Test (CCPT) and the Digit Span subtest (DS), as rated by parents and teachers?

Definition of Terms

Attention Deficit/Hyperactivity Disorder (ADHD). Symptoms of inattention and/or hyperactivity/impulsivity that have persisted for at least six months to a degree that is maladaptive and inconsistent with developmental level (American Psychiatric Association, 2000).

Behavioral Regulation Index (BRI). Measures the "child's ability to shift cognitive set and modulate emotions and behavior via appropriate inhibitory control" (Gioia, Isquith, & Kenworthy, 2000, p. 20).

Behavior Rating Inventory of Executive Functioning (BRIEF). This is an 86-item rating inventory completed by parents or teachers. It enables professionals to assess executive functioning of a broad range of children, ages 5 to 18 years. The BRIEF items form eight theoretically and empirically derived clinical scales that measure different aspects of EF: Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor (Gioia et al., 2000).

Emotional control scale. Refers to the "individual's emotional stability or control through manifestations of executive functions" (Gioia et al., 2000, p. 18).

Executive functioning. Refers to an umbrella term for functions such as planning, working memory, inhibition, mental flexibility, as well as the initiation and monitoring of action (Chan et al., 2008, p. 201).

Inhibit scale. Refers to a "child's ability to resist or to avoid acting upon an impulse, and to control ones' behavior when appropriate" (Gioia et al., 2000, p. 17).

Initiate scale. "Requires an individual to initiate a task or activity and individually create ideas and/or problem solve" (Gioia et al., 2000, p. 18).

Metacognition Index (MI). Represents "the child's ability to initiate, plan, organize, and sustain future-oriented problem solving in working memory" (Gioia et al., 2000, p. 20).

Monitor scale. Reflects the "child's ability to check for goal attainment during the completion of a task and after" (Gioia et al., 2000, p. 20).

Plan/Organize scale. "Involves predicting the needed steps to completing a task and creating a plan to execute the task" (Gioia et al., 2000, p. 19).

Organization of materials scale. Refers to the "child's ability to maintain order and organization of ones' things in several settings including school work, while playing, and personal space" (Gioia et al., 2000, p. 20).

Shift scale. Measures the "child's ability to move from one task to another, to alter situations, and change a strategy based on demands" (Gioia et al., 2000, p. 18).

Reading Disability (RD). Defined by the Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition Text Revision (DSM-IV-TR) as a "reading achievement score falling significantly below expected performance based on the child's age, intellectual functioning, and education" (American Psychiatric Association, 2000, p. 50).

Working memory scale. This scale assesses an "individual's short-term memory by measuring the ability to hold information in memory while manipulating it" (Gioia et al., 2000, p. 19).

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

The aim of this chapter was to provide a solid foundation in the basic concepts of EF and its relationship with two of the most prevalent disorders in childhood psychopathology, ADHD and RD. In order to achieve this goal, a thorough review of the educational and psychological literature was conducted, and the information obtained was then segmented into six main areas.

The literature review begins with a case study that seeks to enlighten the reader on the impact that EF deficits have in the daily life of any child. Second, the theoretical framework for the study is discussed. Given the vast literature that evidences Luria's impact on neuropsychology, his theory was used as a theoretical framework for the present study. Luria played a major role in defining neuropsychology as it is practiced today. The major themes of his theory of brain functioning are reviewed, particularly the third unit, the prefrontal cortex (PFC), which is usually associated with EF.

The third major segment of the literature review includes an overview of the development of the frontal cortex. As research has shown, this part of the brain is one of the last regions to reach maturity during the developmental phases (Anderson, 2002). This research has also shown that the frontal cortex develops rapidly in early childhood, with important changes occurring at particular ages, and then continues to develop into adulthood (Anderson, 2002).

The fourth major section reviews the clinical manifestations of EF deficits, particularly as it relates to ADHD and RD. This discussion includes a review of the incidence, prevalence, and characteristics of each disability. This section also reviews the latest research on ADHD and RD and its relationship with EF.

The fifth section of the literature review focuses on issues related to the assessment of EF in children. This section addresses not only the major trends but also the challenges clinicians face when attempting to test this complex construct. Finally, the last major section reviews the main instrument for this research, the BRIEF. Results obtained in different research projects are described as they relate to the BRIEF.

Case Study

> Phillip is a 14-year-old boy referred for evaluation to assist in understanding poor academic performance and motivation. His parents report that he is apathetic towards school, and he is failing most of his classes. Phillip reports that it has nothing to do with his ability to understand the work, but it is more a problem with completing work, starting work at the last minute, or being poorly organized with his work. Phillip actually completes about half of his homework as assigned but often does not turn it in or cannot find it. He complains that he is bored at school and cannot tolerate sitting in class. In his haste to complete work, he often makes careless errors that go unchecked. When his parents try to help him, he quickly becomes angry and insists on doing the work his own way, regardless of the cost. He often attempts to solve problems via trial and error rather than strategically. He often forgets to

> write down homework assignments or loses the assignment sheets. Phillip has received different diagnoses throughout his childhood. He is a good athlete and plays lacrosse and football. (Gioia et al., 2001, p. 2-3)

Phillip demonstrates difficulties within many of the sub-domains of EF, including difficulties with sustaining performance, inhibiting competing thoughts and actions, shifting his problem-solving approach, organizing complex information and his environment, initiating tasks, planning, and self-monitoring his performance. These weaknesses have a severe impact on his academic performance and overall functioning. The assessment challenge is to determine the severity and nature of his difficulties in order to develop appropriate intervention strategies (Gioia et al., 2001).

This case study clearly illustrates the complex assessment picture presented by children with neurological impairments. At the present time, interest in EF is an expanding area of interest for neuropsychologists, psychologists, and educators (Gioia et al., 2001).

Definition of Executive Functioning

According to Boonstra, Kooij, Oosterlaan, Sergeant, and Buitelar (2010), current literature reports as many as 33 different definitions for the construct of EF. The study of EF is particularly challenging due to the inconsistencies with respect to definition and operationalization of the construct, as well as the rapidly developing status of these skills throughout childhood. However, most authors would agree that EF is an umbrella term for a collection of interrelated functions that are responsible for purposeful, goal-directed, problem-solving behavior (Bennetto & Pennington, 2003; Boonstra et al., 2010; Brown, 2006; Chan et al., 2008; Gioia et al., 2001; Mahone et al., 2002; Semrud-Clikema et al., 2008; Verte et al., 2006).

One promising definition of EF is that of Welsh and Pennington (1988), in which EF is described as “the ability to maintain an appropriate problem solving set for the attainment of a future goal” (p. 201). Later in 1996, Pennington and Ozonoff included other domains into the definition such as fluency (the ability to generate different solutions for a specific problem), planning (the ability to plan the steps needed to reach a solution for a problem), working memory (the ability to keep information online while performing), inhibition (the ability to withhold one’s actions), and set shifting (the ability to shift to another action or problem-solving set when necessary) (Pennington & Ozonoff, 1996).

In sum, EF is a term generally used to refer to self-regulatory behaviors necessary to select and sustain actions and guide behavior within the context of goals and rules. It entails developing and implementing an approach to performing a task that is not habitually performed. Overall, the crucial elements of the EF definition are initiation, planning, shifting of thought or attention, organization, inhibition of inappropriate thought or behavior, and efficiently sustained and sequenced behavior (Mahone et al., 2002).

Due to the complexity and multifaceted nature of the construct of EF, several different definitions have been formulated. However, few attempts have been made to pull them all together, which has resulted in the lack of a single theory of EF (McCloskey, Perkins, & Van Divner, 2009). One of the most influential theories on EF was developed by Alexander Luria.

Theoretical framework

Luria's theory of brain functioning. Research on EF can be traced back to the theoretical and empirical work of the Soviet psychologist Alexander Luria (1902–1977). According to Luria's theory of brain functioning, all complex human behavior is the result of the successful interaction of these three basic brain systems (MacNeil, 1987). "Each form of conscious activity is always a complex functional system and takes place through the combined working of all three brain units, each making its own contribution" (Luria, 1973, p.99).

Luria's theory of brain functioning identified three functional units, each one localized in a specific part of the human brain and each one being responsible for different mental activities (Chan et al., 2008; Luria, 1973; MacNeil, 1987). These units are responsible for regulating cortical tone or waking; for obtaining, processing, and storing information arriving from the outside world; and for programming, regulating, and verifying mental activity. According to Luria (1973), each of these units is "hierarchical in structure and consists of at least three cortical zones built one above the other" (p. 43). A primary "projection" area receives impulses from or sends impulses to the periphery. A secondary "projection-association" area is where incoming information is processed and programmed for projection to efferent pathways (impulses pass from the brain to the different muscles, organs, or glands). The tertiary "zones of overlapping" area is last to develop and is responsible for complex forms of mental activity, which requires the integrated participation of many cortical structures. These three units and zones, when functioning properly, work together to regulate all human behaviors, from waking and sleeping, to hearing and seeing, and thinking and problem solving (Luria, 1973).

According to Luria, the first unit regulates tone, waking and mental states. It is responsible for regulating the arousal, selective attention, tone and wakefulness of the human's mind (Chan et al., 2008; Luria, 1973; MacNeil, 1987). This unit lies below the cerebral cortex and is commonly known as the reticular activating system (RAS). This unit has a dual relationship with the cortex in that the RAS both influences the tone of the cortex, and also experiences a regulatory influence. Therefore, the first functional unit not only changes the tone of the cortex, but is also under the control of the cortex, allowing the RAS to help the nervous system to respond and adapt to perceived changes in the environment. Any disruption in the ascending or descending RAS pathways, or damage to the processes and structures which activate this functional unit, will result in an insufficient state of waking or cortical tone, which in turn results in an organism which can not sufficiently interact with its environment (Luria, 1973).

The second unit controls the reception, integration, and analysis of sensory information from the internal and external environments (Chan et al., 2008; Luria, 1973; MacNeil, 1987). This unit plays a vital part in bringing visual, auditory, gustatory, olfactory, vestibular, and general sensory information into the cortex. With respect to neuroanatomy, this unit consists of the temporal, parietal, and occipital lobes. The structures comprising this unit consist of isolated groups of neurons in parts of the cortex that receive impulses and relay impulses to other neurons. Any damage to the structures forming the second functional unit can result in decreased efferent impulses to orient the first functional unit, or incomplete information being transmitted to the third functional unit (Luria, 1973).

Finally, the third unit entails planning, executing, and verifying behavior, and is located in the frontal lobe of the brain. This unit is responsible for executive planning and is useful for such activities as planning, organizing, programming, regulating, monitoring, and verifying activity (Chan et al., 2008; Luria, 1973; MacNeil, 1987). Forming plans and intentions, regulating behaviors, monitoring progress towards goals, and correcting mistakes are all activities associated with this third functional unit. Neural activity passes through this unit to the motor cortex, where impulses are transmitted into motor routines and speech patterns. These impulses are projected to the pre-motor areas of the frontal region. It is within this pre-motor area that neural activity is transmitted to systematically organized movements (such as grasping movements of the hands, turning the head and eyes, or forming words and sentences instead of individualized twitches of muscles). Afferent impulses from all areas of the brain are synthesized in the prefrontal structures and organized for efferent projection, thus inhibiting or activating behaviors controlled by the afferent areas. Damage to the third functional unit can alter this regulatory control by impairing the ability of the prefrontal area to synthesize and organize these impulses. In addition, damage to the prefrontal area can alter the reciprocal relationship between cortex and the RAS, so that the brain may not be sufficiently aroused for complex behaviors requiring sustained attention (Luria, 1973).

According to Luria (1973), in order to perform a voluntary movement, the systems of the first unit provide the muscle tone, the systems of the second unit provide afferent feedback as to the status of the movement, while the third unit regulates the movement by synthesizing the neural activity and coordinating and adjusting the movement toward the goal. Similar scripts can be outlined for virtually any act of perception, verbalization, audition, motion, etc. However, when this complex functional system is damaged by injury to any or all of the units, the cohesion of the system is disrupted, resulting in a system which functions in a manner markedly different than before the disruption (Luria, 1973). An important implication of Luria's theory of human brain functioning is the concept of syndrome analysis. Basically, the disruption of any individual component of the functional system may prevent the accomplishment of the behavioral goal (MacNeil, 1987).

Within the third unit, the prefrontal cortex (PFC) is considered by Luria as a superstructure that regulates or control mental activity and behavior. Damage to the frontal lobes, and in particular the prefrontal cortex, is expected to disrupt complex behavioral programmes and a person's ability to verify or regulate behavioral outcomes. Consequently, it can lead to the replacement of these complex programmes by more basic behavior or stereotypical behavior that is either illogical, irrelevant, or inappropriate (Chan et al., 2008; Verte et al., 2006).

There is evidence indicating that the development of EF is a multi-stage process, reflected behaviorally already in the first year of life. EF develops during childhood and over the course of the lifespan (Welsh & Pennington, 1988).

Developmental Course of Executive Functions

The developmental path of the EF across childhood has been a fascinating area of study for many years. A key aspect of its developmental course is that it follows the same evolutionary process as other cognitive functions but in a more prolonged pattern

(Anderson, 2002; Isquith, Gioia, & Andrews, 2004). The development of attentional control, future-oriented intentional problem-solving, and self-regulation of emotion and behavior can be observed as early as in infancy, and continues through the preschool and school-age years (Anderson, 2002; Isquith et al., 2004).

According to McCloskey et al. (2009), EF begins to develop in early childhood, with important changes occurring at particular ages (at the end of the first year of life, between three and six years, and around puberty), and then continues to develop into adulthood. Research has also shown that EF deteriorates with aging, suggesting an inverted U-shaped curve when discussing the development of EF across the life span (Zelazo, Craik, & Booth, 2003).

The first signs of EF as a conscious effort to control thought, action, and/or emotion begin to emerge as early as the end of the first year of life. At the age of eight months, babies can usually be encouraged to search for hidden objects after a brief delay, a form of “hide and seek game.” This behavior by itself suggests some degree of EF. The baby needs to keep the object on his/her mind and performs one action (remove the blocking object) in order to perform another action (retrieve the toy). Even at this age, babies are able to perform an action to achieve a goal. However, infants’ emerging EF is still very fragile and easily disrupted. Literature has shown that infants are largely stimulus-bound, reacting immediately to events near them, and oriented to the present (Zelazo, Craik, & Booth, 2003).

As children grow, preschoolers may think about the past and plan for the future, consider several options and then select one. However, preschoolers’ abilities to consciously control their thoughts, actions, and emotions are still severely limited, and quite often their knowledge about what they should do surpasses their ability to actually do it (Zelazo et al., 2003).

As teenagers mature, EF start to reflect easily initiated, well-planned, organized, and flexible thought processes that can be sustained over long periods of time. Teenagers can now consider multiple possibilities, inhibit the inappropriate actions, and select the appropriate ones in pursuit of an established goal, while monitoring the adequacy and efficiency of the process (Zelazo et al., 2003).

Clinical Manifestations of Executive Function Disorders

After reviewing the developmental course of EF, it is important to discuss how deficits in EF may present as clinical symptoms or disorders, or contribute to other disorders (Gioia et al., 2001). Research has shown that EF deficits are a prevalent characteristic of a variety of clinical disorders in children such as Attention Deficit Hyperactivity Disorder (ADHD) (Pennington et al., 1993; Willcutt et al., 2001), reading disorder (RD) (Kolligian & Sternberg, 1987; Semrud-Clikema et al., 2008), and pervasive developmental disorder (PDD) (Griffith et al., 1999; Verte et al., 2006). Additionally, research has shown that impairments in EF may have devastating effects on people’s everyday life activities, including their ability to work and attend school, function independently at home, or develop and maintain appropriate social relations (Chan et al., 2008).

Attention deficit hyperactivity disorder (ADHD) and executive functioning (EF). Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most common psychiatric disorders of childhood and is one of the most prevalent chronic health conditions affecting school-aged children. Although estimates vary from a low of 2% to a high of 5-7% (Polderman et al., 2009), differences in estimates are thought to reflect different methodologies across studies, the changing diagnostic criteria for ADHD, and the use of various sampling methods. More boys than girls are identified as meeting the diagnostic criteria for ADHD, with an approximate 6 to 1 ratio in clinically referred samples and an approximate 3 to 1 ratio in non-referred samples (Kronenberger & Meyer, 2001).

ADHD is defined as a neurodevelopmental disorder characterized by persistent patterns of inattention and/or hyperactivity – impulsivity accompanied by social impairment. The current diagnostic classification of ADHD relies predominantly on the presence of symptoms associated with these three behavioral constructs (Mares, McLuckie, Schwartz, & Saini, 2007; Polderman et al., 2009). Current diagnostic criteria require that these symptoms begin in childhood (by the age of 7 years), occur across settings such as home and school, cause functional impairment, and are not attributable primarily to another disorder such as depression or anxiety (Kronenberger & Meyer, 2001).

Three sub-types of ADHD are defined by the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV-TR) (APA, 2000): Predominantly Inattentive type (ADHD-I), predominantly Hyperactive/Impulsive type (ADHD-HI), and Combined type (ADHD-C). Each subtype is identified by the number of criteria met within its category. For example, a child who exhibits six of nine symptoms of inattention would be diagnosed with ADHD-I. A child who exhibits six of nine hyperactive/impulsive symptoms, but not inattentive symptoms would be diagnosed with ADHD-HI, while a child who exhibits 6 of each symptom category would meet criteria for ADHD-C (Kronenberger & Meyer, 2001).

However, the current classification system fails to recognize many of the cognitive and affective deficits experienced by individuals with this disorder. Children diagnosed with ADHD are reported to exhibit impairments with emotional control, behavioral regulation, planning and organizing, and working memory. These impairments are associated with reduced capacity in the executive system that consists of EF (Mares et al., 2007).

In 2005, Willcutt, Doyle, Nigg, Faraone, and Pennington conducted a meta-analysis of 83 studies that explored EF deficits in children with and without ADHD. Results indicated that children with ADHD exhibited significant impairment on neuropsychological measures of response inhibition, vigilance, working memory, and planning. Effect sizes from meta-analytic analyses of these studies were generally in the medium range (0.46–0.49). According to the authors, their results clearly show that EF weaknesses are significantly associated with ADHD. However, they do not support the hypothesis that EF deficits are the single necessary and sufficient cause of ADHD in all individuals with the disorder (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005).

In 2009, Alloway et al. (2009) utilized the BRIEF and the Conners' Continuous Performance Test (CCPT) to study EF and working memory deficits in a sample of children diagnosed with ADHD. The goal of the study was to explore whether behavioral inhibition deficits would serve as a trigger for working memory weaknesses. The study included three groups. The first group consisted of 46 children previously diagnosed with ADHD. The second and third groups were control groups. The authors explained that before conducting the study, approximately 1,000 typically developing children were screened on a measure of verbal working memory. This measure included the listening recall and backwards digit recall from the Automated Working Memory Assessment (AWMA). Children who obtained a standard score of 86 or lower on the AWMA would be included in Group 2 (working memory-impaired [WMI] group), while those children who obtained a standard score of 90 or higher would be included in the comparison group. After the screening, Group 2 consisted of 25 children, while Group 3 included 20 children (Alloway et al., 2009).

In terms of the BRIEF, results indicated that this instrument was able to successfully discriminate children in the ADHD group and WMI group from the control group. Additionally, the BRIEF was also able to discriminate between children in the ADHD group and WMI group. Specifically, children with ADHD demonstrated greater deficits with inhibition, shifting and controlling emotions, while children in the WMI group exhibited greater difficulties with working memory, planning and organization (Alloway et al., 2009).

With respect to CCPT results, the authors indicated that children with ADHD made significantly more errors of commission (a measure of impulsivity) than the other two groups. However, the errors of omission variable (a measure of inattention) was not able to discriminate the three groups. According to Alloway et al. (2009), while omission errors is a standard measure of inattention, approximately 30-50% of clinically-diagnosed children with ADHD are not detected by CCPT performance (Alloway et al., 2009).

Difference among ADHD sub-types and executive functioning. As was mentioned previously, ADHD can be divided into three sub-types: ADHD-I, ADHD-HI, ADHD-C (Geurts, Verte, Oosterlaan, Roeyers, & Sergeant, 2005).

According to Barkley's theoretical model (1990), children with ADHD-C and ADHD-HI, but not ADHD-I, demonstrate pervasive EF deficits due to a primary deficit in inhibitory control. However, research on this topic has yielded inconsistent findings. Therefore, it remains unclear whether deficits in EF are specifically related to ADHD-C and ADHD-HI or are also present in children with ADHD-I (Geurts et al., 2005).

In their study, Geurts, Verte, Oosterlaan, Roeyers, and Sergeant (2005) attempted to investigate Barkley's model that ADHD-C and ADHD-I are two qualitatively different disorders in terms of EF. The results obtained were not in line with the expectations based on Barkley's model. In fact, the ADHD-C and ADHD-I groups did not differ from each other on any of the EF domains. The only significant difference between the two diagnoses was observed on a visual short-term memory task. Results indicated that both groups, ADHD-C and ADHD-I, exhibited inhibition deficits. According to the authors, symptoms of inattention, but not symptoms of hyperactivity/impulsivity, accounted for the deficit in response inhibition in ADHD-I. However, this does not suggest that the ADHD-C and ADHD-I types cannot be differentiated from each other on other cognitive measures (Geurts et al., 2005).

Research has also shown that ADHD is associated with reading disability (RD) (Bental & Tirosh, 2007; Marzocchi et al., 2008). In fact, estimates of co-morbidity of ADHD and specific learning disability (SLD) range from 10% to 50%; most frequently, co-morbidity is observed in the area of reading (Bental & Tirosh, 2007; De Jong et al., 2009). Likewise, research has demonstrated that children with RD also show EF deficits (Bental & Tirosh, 2007; Kibby et al., 2004).

Reading disability (RD) and executive functioning (EF). Reading disability (RD) is generally defined "as an unexpected difficulty in learning to read despite at least average intelligence, adequate educational background, and intact sensory functioning" (Kibby et al., 2004, p. 349). Literature on this topic has demonstrated that the underlying deficit evidenced by children with RD entail weaknesses in phonological processing and verbal short-term memory. However, recent research is indicating possible deficits in EF (Kibby et al., 2004).

According to Kibby et al. (2004), children with specific learning disabilities (SLD) do not employ efficient and appropriate rehearsal or organizing strategies in a goal-directed manner. Children diagnosed with SLD tend to have poor regulation skills in terms of planning, monitoring, and revising during learning or problem solving. Additionally, although children with SLD may have intact phonics or orthographic skills, they have difficulty coordinating the multiple processes involved in reading, which leads to reading deficits (Kibby et al).

In 2004, Kibby et al. conducted a study to investigate EF deficits in children with RD. The authors hypothesized that children with RD would demonstrate reduced central executive functioning when compared to typically developing children. To answer the research question, Kibby et al. included two groups of children: 20 with RD and 20 without RD. Both groups were comparable on age, gender, general intelligence, socioeconomic status, and history of prior diagnosis of ADHD. Children with ADHD were included in the study due to the high comorbidity between these two diagnoses. EF was measured by asking children to perform two tasks simultaneously. In the no-load condition, children were only asked to complete the verbal or nonverbal memory task without performing any concurrent task. In the load condition, children were asked to complete the verbal or nonverbal memory task, in addition to a motor sequential task. The authors expected that children with RD would experience significantly greater difficulty than children without RD when engaged in a dual task performance, regardless of whether they were learning visual or verbal information, due to a deficit in EF. This hypothesis was not supported. Children with RD performed comparably to children without RD, which questions the idea of EF deficits in children with RD. As an important point, the authors highlighted that none of the participants demonstrated moderate or severe ADHD symptoms. Therefore, EF deficits may be related to the severity of the ADHD symptoms (Kibby et al., 2004).

Relationship between ADHD and RD, and executive functioning. As highlighted by Kibby et al. (2004), RD and ADHD are two of the most common disorders of childhood, each occurring in approximately 5% of the population. Additionally, research has shown that ADHD and RD also co-occur significantly, that is, more frequently than expected by chance (Kibby et al.).

In 2008, Marzocchi et al. conducted a study to explore if ADHD and RD could be discriminated by their EF deficits. The aim of the study was to determine the EF deficits of ADHD and RD participants in contrast to one another and typically developing children. The participants in this study included 30 controls (6 females, 24 males), 35 with ADHD (only males and all combined type) and 22 with RD. Several EF and non-EF measures were included in the study.

Results indicated that children with ADHD showed deficits in planning, working memory, set-shifting, and letter fluency as compared to children with RD. However, they did not show a generalized inhibitory control deficit. In other words, ADHD children did not differ in inhibitory processing from RD children. On the other hand, children with RD performed more poorly than controls on both the letter fluency task and on the set-shift measures (Marzocchi et al., 2008).

In 2001, Willcutt et al. conducted a study to explore the cognitive profile of children with RD and ADHD on different measures of phonological awareness (PA) and executive functioning (EF). EF tasks involved three major components: inhibition, set-shifting, and verbal working memory. The authors used a 2 (RD vs. no RD) x 2 (ADHD vs. no ADHD) factorial design to compare the performance of children with RD and ADHD. The sample of the study consisted of children ages eight to 16, who were divided into four groups: children with reading disability (RD; $n = 93$), children with attention-deficit/hyperactivity disorder (ADHD; $n = 52$), children with RD and ADHD ($n = 48$), and children with neither RD nor ADHD ($n = 121$) (Willcutt et al., 2001).

Children with ADHD scored significantly lower on the inhibition measures than those without ADHD. Additionally, there were no significant differences between the ADHD and no ADHD groups on measures of set-shifting and working memory composites. In other words, deficits in working memory or set-shifting obtained in previous studies of ADHD may be restricted to those children who also have RD and may not be associated with ADHD per se (Willcutt et al., 2001).

With respect to the RD group, the authors reported that children with RD demonstrated greater deficits in PA than children without RD, providing additional evidence that a deficit in PA or other measures of phonological processing represent the core deficit in RD. Children with RD showed impairments in verbal working memory. According to the authors, it is still possible that deficits in working memory associated with RD may be attributable to a deficit in auditory processing (Willcutt et al., 2001).

Willcutt et al. (2001) also indicated that the RD + ADHD group was most impaired on virtually all EF and PA measures. Additionally, the present results are consistent with a double dissociation model between RD and ADHD on measures of PA and inhibition. Specifically, ADHD was associated with inhibition deficits, but was not associated with PA deficits when Full Scale Intellectual Quotient (FSIQ) was co-varied. In contrast, RD was associated with PA deficits, but was not associated with deficits in inhibition when FSIQ was controlled. With respect to the other EF dimensions, neither RD nor ADHD was associated with a significant deficit on the set-shifting measures after controlling FSIQ. However, RD was significantly associated with impairment in verbal working memory, even when controlling FSIQ (Willcutt et al., 2001).

In order to further investigate EF deficits in children with ADHD and RD, Bental and Tirosh (2007) conducted a study in a co-morbid sample of boys with ADHD and RD. The aim of the study was to explore the different profiles in terms of attention/control functions and reading domain functions and the nature of their relationship. This study was conducted in Hebrew, a language that has a consistent letter-phoneme mapping, as well a different textual arrangements. The authors hypothesized that the cognitive profile of ADHD + RD showed unique deficits not shared by either one of the pure groups (Bental & Tirosh, 2007).

To test the hypotheses, the authors collected data from 86 boys in grades two to six between the ages of seven and 11. The four groups included: children with ADHD (n = 19), children with RD (n = 17), children with ADHD + RD (n = 27), and control (n = 23). In terms of the EF measures used, the authors included tests of response inhibition, planning, rule abstraction/set-shifting, working memory, and word fluency. Additionally, the authors used different reading and phonological processing measures. Preliminary analyses indicated that all groups were comparable in intellectual, oral language functions, and reading comprehension (Bental & Tirosh, 2007).

Results indicated that the co-morbid group (ADHD + RD) shared primary deficits of both pure clinical groups of RD and ADHD. However, in comparison to both pure clinical groups, the co-morbid group demonstrated a unique deficit in rapid naming and was more severely impaired on measures of verbal working memory (Bental & Tirosh, 2007).

Further, Bental and Tirosh (2007) explained that in the non-ADHD groups (RD and control), word decoding is associated with phonological functions and verbal working memory. On the other hand, in the ADHD groups (ADHD and ADHD + RD), no associations with phonological functions are shown for word decoding accuracy, but instead links with EF in response inhibition/effortful visual search. The current results underscore the need to assess deficits in working memory and rapid naming when evaluating children with RD (Bental & Tirosh, 2007).

As stated by Bental and Tirosh (2007), assessment issues are critical when studying EF in children. Due to the difficulty defining the construct of EF, its measurement has become an even more complex issue. The identification, description, and measurement of EF deficits in children has been a challenge for psychologists and educators. However, in the past few years, there has been increased interest in methods to assess EF. Additionally, there is a need for theory-driven instruments to describe patterns of behavior associated with the various aspects of the EF construct (Mahone et al., 2002).

Assessment of Executive Functioning

Historically, clinical assessment of EF in any age group has been challenging due to the fluid and dynamic nature of the EF construct (Isquith et al., 2004). Research has shown that the main challenge is to assess the functional, real-world impact of EF deficits in everyday activities (Isquith, Crawford, Andrews Espy, & Gioia, 2005). Instruments such as the Developmental Neuropsychological Assessment (NEPSY), the Naglieri and Das, the Cognitive Assessment System, and the Child Category Test, while effective at measuring EF, only provide a picture of the child's functioning in a structured one-on-one setting. Therefore, a great number of studies are being conducted to evaluate the ecological validity of neuropsychological tools, including those designed to measure EF (Isquith et al., 2005). Ecological validity, as defined by Sbordone (1996), is "the functional and predictive relation between the patient's behavior on a set of neuropsychological tests and the patient's behavior in a variety of real-world-settings" (Isquith et al., 2005, p.210).

In this context, studies have demonstrated inconsistencies between performance on traditional measures of EF and real life behavior (Anderson, 2002). As reported by Chan et al. (2008), many individuals with EF deficits do not differ in their performance on traditional neuropsychological tests as compared to controls; however, they report significant difficulties and impairments in everyday life activities (Chan et al., 2008).

The structured nature of the typical individual assessment situation, be it for clinical or research purposes, limits opportunities for observing EF deficits. Typically, neuropsychological tests are administered in well-structured and quiet settings with minimal distractions, and therefore, are unlikely to represent the child's home, classroom, or social environment. Additionally, the examiner provides support and encouragement, and plans and initiates activities, executing all functions of the patient's frontal lobe (Anderson, 2002).

Therefore, if the ability to predict EF deficits using traditional neuropsychological tests is modest, there is a need for other methodologies to assess EF more efficiently (Anderson, 2002; Chan et al., 2008; Isquith et al., 2004). Observations of the child's behavior at home or in school by adult caregivers, such as parents or teachers, provide an essential source of information in the assessment of EF. Reliable reports from parents and/or teachers regarding the child's everyday manifestations of EF deficits increase the ecological validity of the assessment process in terms of their real-world needs as opposed to their test performance in an office setting. Due to the difficulties and complexities involved in the assessment of EF, an ecologically valid system of assessing the everyday self-control behaviors of children is represented with structured behavior rating scales (Anderson, 2002; Gioia et al., 2001; Isquith et al., 2004).

Structured behavior rating scales have been utilized for decades in the assessment of psychological and neuropsychological functions. Specifically, the use of teacher and parent rating scales is a common practice and a well-proven method for the assessment of different domains including social, emotional, and behavioral functioning (Anderson, 2002; Gioia et al., 2001; Isquith et al., 2004).

In addition to the issue of ecological validity, another challenge in the assessment of EF in children is the fact that the majority of the evaluation tools have been developed and validated in adult populations (Chevignard et al., 2009; Gioia et al., 2001). This practice is highly disputed, especially for diagnostic purposes, as adult measures may tap different skills in children. Research is needed to prove that EF deficits in adults can be generalized to children (Anderson, 2002; Isquith et al., 2005).

To address some of these issues, Gioa et al. (2000) developed the Behavior Rating Inventory of Executive Function (BRIEF). This instrument can add valuable information to that obtained with standardized batteries, as they provide behavioral and qualitative information to be collected and interpreted in a standardized format (Anderson, 2002; Gioia et al., 2001).

The Behavior Rating Inventory of Executive Function (BRIEF)

The BRIEF is a parent- and teacher-completed rating scale designed to assess the behavioral manifestations of EF in children ages 5 to 18 years. It has 86 items that are organized in eight, non-overlapping scales (Gioia et al., 2001; Isquith et al., 2004). The individual scales form two broad factor-based indexes: The Behavioral Regulation Index (BRI) includes the Inhibit, Shift and Emotional Control scales, and measures the "child's ability to shift cognitive set and modulate emotions and behavior via appropriate inhibitory control" (Gioia et al., 2000, p. 20). On the other hand, the Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor scales compose the Metacognition Index (MI). This index measures the "child's ability to cognitively self-manage tasks and reflects the child's ability to monitor his or her performance" (Gioia et al., 2000, p. 21). In this study, the BRIEF Parent and Teacher Form was utilized to investigate the patterns in executive functioning that parents and teachers recognize in children with attention problems and reading disabilities.

Mares, McLuckie, Schwartz, and Saini (2007) compared parent and teacher reports of EF, as measured by BRIEF, on a sample of children previously diagnosed with ADHD. The primary hypothesis was that teachers would report more impairments on the BRIEF than would parents. The conditional secondary hypothesis was that teachers' ratings of EF skills could be used as better predictors of symptoms of ADHD than would parents' ratings. Participants in the study included 240 children (190 boys and 50 girls) between the ages of 5 and 15 years who had been previously diagnosed with ADHD and attended an urban Toronto psychiatric program specializing in ADHD. The majority of the sample (n = 151, 63%) met the DSM-IV diagnostic criteria for ADHD-C, while 35% (n = 83) met the criteria for ADHD-I, and 2.5% (n = 6) met the criteria for ADHD-HI.

Results of the Mares et al. (2007) study indicated that teachers, when compared to parents, reported greater levels of EF deficits across all scales of the BRIEF. These results suggest either that teachers may be better able than parents to identify EF deficits in children with ADHD or that children with ADHD may be experiencing more difficulties with their executive functioning at school than at home.

Discrepancies between parent and teacher reports may be the result of cross-situational differences in children's behavior or of differences in raters' perceptions and expectations. The relatively low agreement does not necessarily indicate that one type of informant was providing invalid or unreliable information (Mares et al., 2007).

According to teachers, impairments in inhibition, planning/organizing, and organization of materials are the risk factors for ADHD. Specifically, a deficit in inhibition, as reported by teachers, was found to be the single greatest risk factor. At the same time, parents also indicated inhibition as their main predictor for hyperactivity–impulsivity. The commonality of inhibition as a risk factor across home and school environments suggest that this is both the most recognizable construct and likely the defining impairment associated with ADHD (Mares et al., 2007).

Results attained for the ADHD-I, revealed that parents indicated deficits in planning/organizing, inhibition, and working memory as the key risk factors. Teachers concurred with parents that planning/organizing was a key risk factor for this group of children, but also used the child's organization of workspace and school materials as a predictor (Mares et al., 2007).

McCandless and O'Laughlin (2007) also investigated the validity and clinical utility of the BRIEF to differentiate children diagnosed with ADHD-C, to those diagnosed with ADHD-I and those given no diagnosis of ADHD. The authors hypothesized that children with ADHD-C would score higher on the BRI, while children with ADHD-C and ADHD-I would score higher on the Working Memory scale. Additionally, the authors explored the inter-rater reliability between parent and teachers reports on the BRIEF. The convergent validity between the BRIEF scores and other measures of EF was also examined using other parent/teacher rating scales and a computer-based test of attention (McCandless & O'Laughlin, 2007).

Parents and teachers of 70 children, ages 5 to thirteen, were asked to complete the BRIEF while attending a university-based ADHD clinic. Children were referred to the ADHD clinic by their physicians, and the BRIEF was used as part of the assessment battery. The 70 participants were classified in three groups: ADHD-I (n = 11), ADHD-C (*n* = 34), and no ADHD diagnosis (*n* = 25). The Behavior Assessment System for Children (BASC) and the Intermediate Visual and Auditory Continuous Performance Test (IVA-CCPT) were used to assess the convergent validity of the BRIEF. Findings from the McCandless and O'Laughlin (2007) study revealed that BRIEF scores were significantly associated with both reports of inattention and hyperactivity on the BASC and also with the computer-based test of attention (McCandless & O'Laughlin, 2007).

Overall, the BRIEF scores differed significantly among groups. Results indicated that the MI and associated scales may be most useful in "*ruling in*" a diagnosis of ADHD, while parent ratings on the BRI, particularly the Inhibit scale, may be most useful in determining ADHD sub-type (McCandless & O'Laughlin, 2007).

In terms of the MI, significant differences were observed in teacher and parent ratings on the Working Memory scale. Teacher ratings for both ADHD groups (Inattentive and Combined) were significantly higher than the non-ADHD group. For parents, children in the ADHD-C group were rated as significantly more impaired in working memory when compared to the other two groups. Contrary to predictions, parents did not report significant differences among the ADHD-I and non-ADHD groups. According to the authors, teachers have more opportunities and/or are more observant for working memory deficits than parents (McCandless & O'Laughlin, 2007).

With respect to the BRI, children with ADHD-C obtained higher scores as compared to the ADHD-I and non-ADHD groups. However, this finding was only significant for parents. On a closer clinical analysis, the authors observed that for the ADHD-C group, parents reported significant elevations on the Inhibit and Emotional

Control scales, while teachers only indicated elevations on the Inhibit scale (McCandless & O'Laughlin, 2007).

Finally, findings from the McCandless and O'Laughlin (2007) study indicated that parents and teacher ratings were significantly correlated for three of the eight BRIEF scales (Inhibit, Plan/Organize and Monitor). However, parent-teacher agreement was lowest for the Emotional Control, Organization of Materials, and Initiate scales. According to the authors, this may be due to the different demands in each setting, as well as different opportunities to observe different behaviors associated with these scales (McCandless & O'Laughlin).

In 2002, Mahone et al. conducted a study to explore the convergent and discriminant validity of the BRIEF-Parent Form in a sample of children with ADHD and/or Tourette syndrome (TS). In order to study the psychometric properties of the BRIEF, the authors administered the BRIEF Parent Form along with a selected set of ADHD-specific behavior rating scales, as well as performance-based measures of EF. The sample of the study consisted of 76 children ages six to 16, who were classified into four groups: ADHD-only (n = 18), TS-only group (n = 21), TS+ADHD (n = 17), and controls (n = 20) (Mahone et al.).

According to the authors, the BRIEF-Parent form was significantly and strongly correlated with other parent ratings previously developed for ADHD. Specifically, the BRIEF General Executive Composite (GEC) was significantly correlated with ratings on the CBCL Attention Problems scale (r = .82), DICA-IV ADHD Scale (r = .78) and the ADHD Rating Scale IV (inattention symptoms r = .79; hyperactivity/impulsivity symptoms r = .69). These results provide support for the discriminant validity of the

BRIEF ratings and support the factor structure, as well as the discriminant and convergent validity of the BRIEF ADHD indexes (Mahone et al., 2002).

Further analysis indicated that even though the BRIEF MI was not developed as a measure of inattention, it has a high degree of overlap with the Working Memory scale. At the same time, the BRIEF MI was more strongly correlated with ADHD Rating Scale IV inattention symptoms (r = .85) than with hyperactivity symptoms (r = .59). On the other hand, the BRI, while not developed as a measure of hyperactivity, has a high degree of overlap with the BRIEF Inhibit scale, and both (BRI and Inhibit scale) appeared to have higher relationships with other more direct ratings of hyperactivity (r = .76), compared with ratings of inattention (r = .55) (Mahone et al., 2002).

The authors also explored whether the BRIEF would be more strongly correlated with performance-based measures of EF (given the same construct) than with academic measures. For the performance-based measures of EF, the authors selected different measures of initiation, retrieval, planning, fluency, attention, impulsivity and hyperactivity. To measure academic skills, the authors used the Wechsler Individual Achievement Test (Mahone et al., 2002).

Findings from the study suggested that correlations between the BRIEF and performance-based EF measures were low to moderate (r = . 19 to r = . 43). However, the BRIEF scores were significantly correlated to the WIAT Math Composite score, which is comprised of the Numerical Operations subtest (e.g., calculation) and the Mathematics Reasoning subtest (applied math) (r = -. 37 to r = -. 41). Mahone et al. (2002) explained that math subtests may place a higher demand on the child's executive skills. As reported by the authors, many children with attention problems make math calculation errors due to problems with retrieval and use of procedures associated with attentional deficits. Additionally, word problem tasks demand both language and executive skills, above and beyond what is required for basic calculation procedures. According to the authors, many performance-based EF measures do not have strong reliability coefficients. Therefore, it is not surprising to find a pattern in which rating scale measures, such as the BRIEF, are highly correlated with other well-standardized measures, such as the WIAT (Mahone et al., 2002).

With respect to the ADHD-only and TS+ADHD group, post hoc tests revealed that the ADHD groups were rated higher than the TS-only and control groups on all scales and indexes. In terms of the TS group, results from the Mahone et al. (2002) did not indicate a significant difference between the individuals with TS and controls on four of the five BRIEF scales. Individuals in the TS group only obtained a higher score than control participants on the Working Memory scale. The authors explained that the presence of this disorder added little to the BRIEF ratings over and above what would be expected when IQ scores were controlled for in the groups. This finding is inconsistent with previous studies, and it might be related to the small sample size. The authors also reported that the BRIEF scales might have limited sensitivity to detect more subtle variations that may exist in the TS groups (Mahone et al., 2002).

Most of the research conducted with the BRIEF has been done with children diagnosed with ADHD and LD given their high prevalence in childhood psychopathology. However, a few studies have also explored other diagnostic groups such as Fetal Alcohol Spectrum Disorder (FASD). In 2007, Rasmussen, McAuley, and Andrew examined the performance of children with FASD on the BRIEF. The parents/guardians of 64 children (37 males and 27 females) with FASD completed the BRIEF. Results indicated that children with FASD displayed significant deficits on the BRIEF. Although almost every scale on the BRIEF demonstrated significant elevations, a distinctive pattern of strengths and weaknesses emerged. As reported by their parents, children with FASD showed most difficulty on the Inhibit, Working Memory, and Initiate scales, and least difficulty on the Organization of Materials scale, which represented an area of relative strength for this group of children (Rasmussen et al., 2007).

Other studies, such as the one conducted by Feifer and Rattan (2007), have also used the BRIEF with other diagnostic groups. The authors used the BRIEF-Teacher Form with male students with severe emotional conditions. The sample consisted of 60 students, aged 9 to 12 years old, who were divided into three groups of 20. Group 1 consisted of special education students, who were identified as having an emotional condition and received their education in a restricted setting outside the confines of their home school. Group 2 consisted of students identified as having an emotional condition that received special education services in their home school. Lastly, group 3 was a control group with no diagnosis of emotional disorders. The control group had been evaluated for special education services due to behavioral concerns; however, they did not qualify for special education services. Results indicated that students in group 1 (emotional condition in separate educational facility) and group 2 (emotional condition in regular setting) had greater difficulty shifting their attention from one task to another than students in group 3 (control group) (Shift scale). Additionally, students in group 1 and group 2 had greater difficulty regulating their emotions than students in group 3 (Emotional Control scale). In sum, Feifer and Rattan (2007) recognized two specific attributes of EF (emotional control and shifting attention), as measured by the BRIEF, as being most significant for students with severe emotional conditions.

Significance of the Present Study

As mentioned before, EF deficits are characteristic features of a variety of medical, psychological, and learning disorders. Therefore, there has been an increased need for neuropsychological measures to assess this domain. Until recently, there have been few well-established measures of EF for children, which likely reflect the nature of EF that makes them inherently difficult to assess. The highly structured clinical setting does not necessarily encourage novel problem-solving abilities, in part because the examiner imposes structure. Furthermore, intelligence tests often rely too heavily on previously learned material to be an effective gauge of executive functions (Chan et al., 2008).

Deficits in EF are easily observed in the child's home and school environments. Observations by parents and teachers offer an ecologically-valid method of documenting problems within these domains. Therefore, behavior rating scales provide a valid and reliable evaluation technique that has been shown to document a range of emotional, behavioral, and learning problems (Gioia et al., 2001).

In this order of ideas, the BRIEF is one step toward fulfilling this need (Gioia et al., 2001). This study compared the patterns of EF deficits in children with RD-only, ADHD-only, and ADHD/RD-combined as rated by parents. The goal of this study was to assess which of the scales and indexes of the BRIEF best discriminate children with RD-only from children with ADHD-only, and those with both conditions (ADHD/RD-combined). Additionally, this study compared parent and teacher ratings of EF deficits as measured by the BRIEF. Final analyses in this study also explored the relationship between BRIEF scale and index scores and performance-based EF measures, such as the Conners' Continuous Performance Test and the Digit Span subtest from the WISC-IV.

CHAPTER III

METHOD

Introduction

This chapter describes the methodology that was used to examine the proposed research questions of the current study. Using archival data, the aim of this study was to examine the profile of EF in children with attentional and/or reading disorders using a causal-comparative design.

Research Questions

The researcher attempted to answer the following questions:

1. Are there significant differences among the BRIEF scale and index scores of the RD-only group, ADHD-only group, and ADHD/RD-combined group as described by parents?
2. Are there significant differences among the BRIEF scale and index scores of the three ADHD sub-types (ADHD-I, ADHD-HI, and ADHD-C) as described by parents?
3. Are there significant differences among the BRIEF scale and index scores as described by parents and teachers?
4. Are there significant differences among the BRIEF scale and index scores of the RD-only group as described by parents and teachers?
5. Are there significant differences among the BRIEF scale and index scores of the ADHD-only group as described by parents and teachers?
6. Are there significant differences among the BRIEF scale and index scores of the ADHD/RD-combined group as described by parents and teachers?

7. Is there a significant relationship between the BRIEF scale scores and other performance-based measures of executive functioning, specifically the Conners' Continuous Performance Test (CCPT) and Digit Span subtest (DS), as rated by parents and teachers?

Research Design

This retrospective study used a causal-comparative research design with three contrast groups: (a) Reading Disorder (RD-only), (b) Attention-Deficit/Hyperactivity Disorder (ADHD-only), (c) Combined ADHD and RD (ADHD/RD-combined). The primary analysis of this study was a Multiple Analysis of Variance (MANOVA). A series of MANOVAs were conducted in order to ascertain if children with RD-only, ADHD-only, and ADHD/RD-combined differ in EF deficits as reported by their parents. Furthermore, the same statistical procedure was used to compare parents' and teacher's ratings of EF deficits in each group (RD-only, ADHD-only and ADHD/RD-combined). Finally, additional MANOVAs were conducted to determine if children from the three ADHD sub-types (ADHD-I, ADHD-HI, and ADHD-C) demonstrate different patterns of EF deficits. In cases where the overall *F* was significant, means were compared using the Scheffé test ($p < .05$), as this is the most conservative test.

A secondary analysis was conducted to address the third and seventh research questions noted above. In order to explore the relationship between parent and teacher ratings of EF, as measured by the BRIEF, a paired sample *t*-test was conducted. A paired sample *t*-test was used to determine whether there is a significant difference between parent and teacher ratings. Additionally, a Pearson *r* correlation was calculated to estimate the strength of the relationship between the BRIEF scale and index scores and other performance-based measures of EF, such as the Conners' Continuous Performance Test and the Digit Span subtest from the WISC-IV.

The independent variables for the present study were: a) the type of disability, which was determined by using the diagnostic criteria of the Diagnostic and the Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV-TR, 2000) (RD-only, ADHD-only and ADHD/RD-combined); b) gender (boy or girl); and c) grade level (lower elementary: grades first through third; elementary/middle school: grades fourth through seventh; and middle/high school: grades eighth through tenth). The dependent variables under consideration for the present study were: a) the BRIEF-Parent/Teacher scores (two indexes: Behavioral Regulation and Metacognition, and eight clinical scales: Initiate, Inhibit, Shift, Plan/Organize, Organization of Materials, Monitor, Emotional Control, and Working Memory); and b) the scores for the two performance-based EF measures (Conners' Continuous Performance Test, and Digit Span subtest from the WISC-IV).

Participants

In this study, archival data were obtained from 112 children between the ages of 6.0 and 16.0 years of age. Participants received a comprehensive psycho-educational assessment battery in a private clinical setting between July 2007 and December 2010. The clinical setting is located in south Florida, and specializes in the diagnosis and treatment of different childhood disorders. The majority of the children were referred to the clinical setting because of educational and/or attentional problems. Secondary problems included social, emotional, and/or behavioral concerns. Data were collected for only those students whose parents agreed to release their child's information.

In terms of the demographic characteristics of the participants, most of the families that attend this clinical setting come from private schools. Therefore, limitations inherent in the design and collection of the current data may limit generalizability of the results.

Assessments included a developmental history and a semi-structured parent interview, a review of prior records, and psychological/psycho-educational testing. The standard battery of psychological testing consisted of a comprehensive assessment of the child's intellectual functioning, academic skills, cognitive processing (attention, language, visual/nonverbal processing, learning and memory, motor and sensory functions, and phonological processing), and social/emotional/behavioral functioning. Test batteries were administered by licensed school and clinical psychologists who specialize in school neuropsychology. Participants who fulfill the selection criteria for this study were divided into three groups: RD-only, ADHD-only, and ADHD/RD-combined.

The RD-only group included children who meet the diagnostic criteria for a reading disorder, as established by the DSM–IV-TR. According to the DSM-IV-TR, children with a reading disorder demonstrate a reading achievement, as measured by individually administered standardized tests of reading accuracy or comprehension, substantially below what is expected given the child's measured intelligence (American Psychiatric Association, 2000).

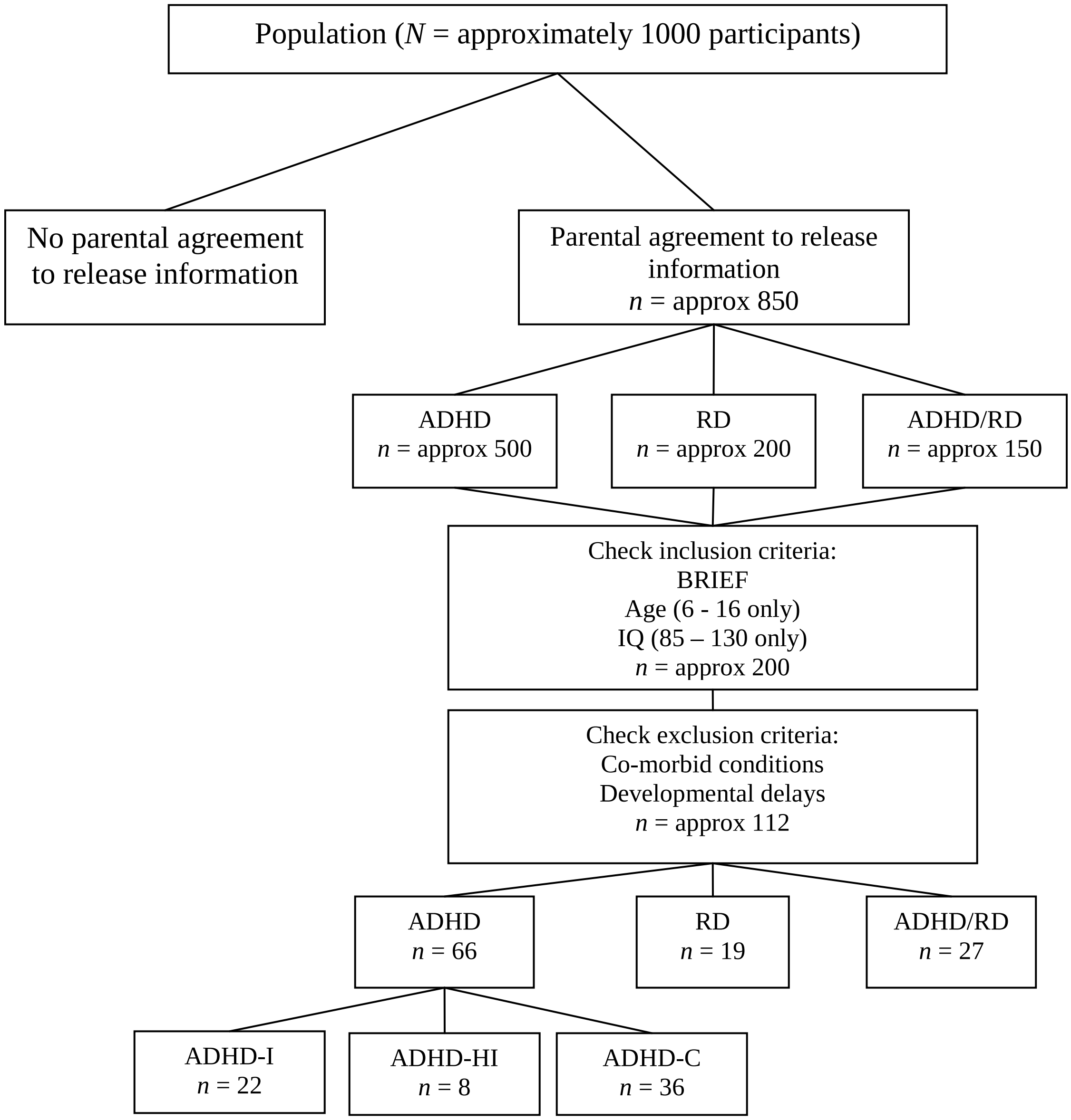
The ADHD-only group consisted of children who meet the diagnostic criteria, as established by the DSM–IV-TR, for ADHD. According to the DSM-IV-TR, children with ADHD exhibit six or more symptoms of inattention, and/or six or more symptoms of hyperactivity-impulsivity for at least six months. Children in the ADHD-only group were then classified based on their sub-type as being: ADHD-I, ADHD-HI, and ADHD-C (American Psychiatric Association, 2000).

The third group, ADHD/RD-combined group, included participants who meet diagnostic criteria for both disorders: ADHD and RD (ADHD/RD-combined group). In other words, children in this group exhibited reading deficits, which would have qualified them for the RD group, and exhibited symptoms of inattention and/or hyperactivity/impulsivity, which would have qualified them for the ADHD group.

Inclusion/Exclusion Criteria

For the purposes of the present study, only data regarding children ages six to 16 years of age with the DSM-IV-TR diagnoses of RD-only, ADHD-only, or both ADHD/RD-combined were included in the sample. With respect to exclusionary criteria, data were not included if any of the two main Indexes (Verbal Comprehension or Perceptual Reasoning) or the Full Scale IQ was too low (less than 85) or too high (higher than 130). Additionally, children were not included in the study if they met the criteria for any psychiatric disorder or had experienced traumatic brain injury or any significant developmental delays. Figure 1 displays the procedural steps that were followed for the selection of the sample (see Figure 1).

Figure 1. Sample Selection



Data Collection Instruments

As part of the comprehensive school neuropsychological assessment battery, parents and teachers completed the BRIEF-Parent and Teacher Rating Form. The BRIEF is a measure of EF, specifically evaluating inhibition, shift, emotional control, working memory, and planning organization skills necessary for learning.

The BRIEF consists of two rating forms, a parent questionnaire and a teacher questionnaire, designed to assess EF in the home and school environments. It also includes a self-report questionnaire, in which the child serves as the informant.

On the BRIEF, raw scores on each of the scales and indexes are converted to *T*-scores with a mean of 50, and a standard deviation of 10. Higher *T*-scores are indicative of higher deficits. More specifically, *T*-scores higher than or equal to 65 are considered clinically significant, and suggest a possible deficit.

In addition to the BRIEF-Parent Form (BRIEF-PRS), the BRIEF-Teacher Rating Form (BRIEF-TRS) was included for secondary analysis. The BRIEF-TRS is not part of the comprehensive school neuropsychological assessment battery that children receive in the clinical setting. Therefore, the BRIEF-TRS scores were included in the study for those participants that had the information available.

The BRIEF-PRS and -TRS are comprised of a demographic sheet and 86 three-point Likert scale items. The items are behavioral descriptors of children, and are rated 1 (Never), 2 (Sometimes), or 3 (Often). The 86 items create two index scales and eight clinical scales.

The two index scales include the Behavioral Regulation Index (BRI) and the Metacognition Index (MI). The BRI includes the Shift, Inhibit and Emotional Control scales, while the MI includes the Initiate, Shift, Plan/Organize, Organization of Materials, Monitor, and Working Memory scales (see Figure 2). The BRIEF also includes two validity scales that measure negativity and inconsistency of responses. Table 1 shows some sample items for each scale.

Figure 2. BRIEF Indexes and Scales

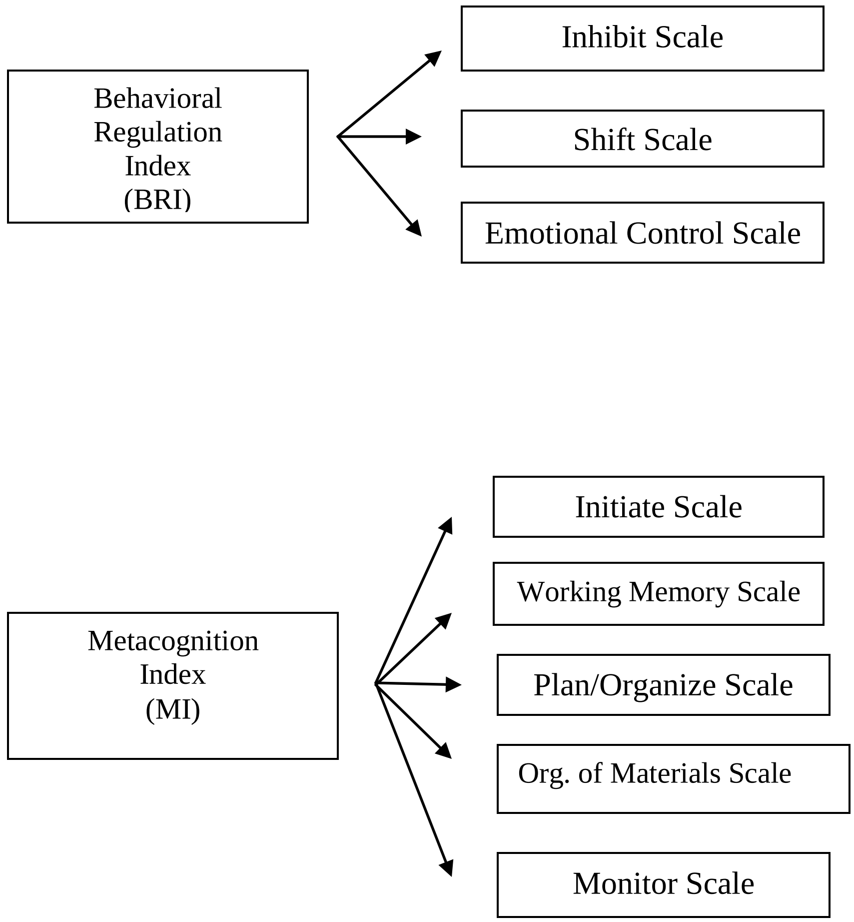


Table 1

BRIEF Scales and Sample Items

Scale	Sample Items
Initiate	Is not a self-starter
	Does not take initiative
Inhibit	Acts too wild or "out of control"
	Interrupts others
Shift	Becomes upset with new situations
	Resists change of routine, foods, places, etc
Plan/Organize	Does not bring home homework, assignments sheets
	Becomes overwhelmed by large assignments
Organization of Materials	Keeps room messy
	Cannot find things in room or school desk
Monitor	Makes careless errors
	Work is sloppy
Emotional Control	Overreacts to small problems
	Mood changes frequently
Working Memory	Has a short attention span
	Needs help from an adult to stay on task

In creating the BRIEF, the authors reviewed the literature on EF in children, and conducted several studies to explore the psychometric properties of the instrument. With respect to reliability, internal consistency was high ranging from .80 to .98 (Gioia et al., 2000). In addition, test-retest reliability was examined for a clinical and a nonclinical sample. Test-retest reliability coefficients ranged from .76 to .85 over an average interval of two weeks. In terms of the correlations between parent and teacher ratings, Gioia et al. indicated moderate coefficients ($r = .32$). Additionally, the authors reported even lower correlations for the Initiate scale ($r = .18$) and Organization of Materials scale ($r = .15$) (Gioia et al., 2000).

With regard to validity, the authors conducted several studies to explore the content and construct validity of the BRIEF. As a measure of content validity, agreement was sought among several pediatric neuropsychologists. The clinicians were asked to indicate which domain of EF each item best exemplified. Items with poor agreement were eliminated from the final instrument. As a measure of construct validity, although the BRIEF could not be correlated with existent rating scales of EF (none are available), the BRIEF was compared to more general measures of behavioral functioning (Gioia et al., 2000).

In addition to the BRIEF scores, two performance-based EF measures were included as part of the secondary analysis. These measures included: a) Conners' Continuous Performance Test, and b) Digit Span subtest from the WISC.

Conners' Continuous Performance Test (CCPT): the CCPT is a computerized test that measures sustained attention and impulsive control. Children are required to press the space bar of a keyboard when any letter, except for the letter X, is displayed on the screen. There are six blocks, each with three sub-blocks of 20 trials. Each trial is a letter presentation, either the letter X or others. The number of errors and reaction time are two frequently reported indicators provided by the CCPT program. For purposes of this study, only omission and commission errors were included in the study. Omission errors are those in which the child fails to respond to the letter X (inattention). Commission errors entail the number of times in which the child responds to the letter X (impulsivity) (Conners, 2002). According to Epstein et al. (2003), the test-retest reliability of the CCPT has been well documented, ranging from .79 for hyperactive-impulsive symptoms to .82 for symptoms of inattention.

Digit Span subtest from the WISC-IV: this subtest measures the child's short-term auditory memory and attention, and requires the child to repeat a series of digits that are read aloud. Digit Span is a reliable subtest (r = .87) (Sattler & Dumont, 2004).

Data Collection Procedures

The present study reviewed an archival data sample of a clinical setting located in south Florida. The clinical setting used is a large child development private practice located in Weston, Florida, which has over 15 clinicians providing services across Dade, Broward, and Palm Beach counties.

Prior to conducting the study, the researcher met with the two senior psychologists at the clinical setting to review the aims of the study and their participation in the study. After obtaining consent from the senior psychologists to conduct the study, the researcher met and coordinated with the Operations Manager at the clinical setting to discuss all the details regarding the study. In order to assure anonymity, the Operations

Manager was responsible for accessing each child's folder and collecting all the required information.

The researcher explained the Procedural Steps (See Appendix A) to the Operations Manager. The Procedural Steps outlines the specific steps the Operations Manager followed when reviewing each folder. First, the Operations Manager reviewed the "Permission to Treat and Custody Form" used by the clinical setting (see Appendix B). This form asked parents/guardians if their child's data could be used in the future for research purposes. Data were collected for only those students whose parents agreed to release their child's information.

Once the Permission to Treat and Custody Form had been checked, the Operations Manager was instructed to get the required information from the child's folder using the Archival Data Form (see Appendix C). This form was developed by the researcher to obtain all the information required for the present study. In order to assure anonymity and confidentiality, numerical identifiers were placed at the top of each Archival Data Form. Completed Archived Data Forms were given to the researcher for statistical analysis.

After collecting all the Archival Data Forms, the information was entered into the Statistical Package for the Social Sciences Program (SPSS-19) to be analyzed. Demographic information included: a) gender (boy or girl); b) age (6.0 to 16.0); c) intellectual functioning (85 to 130); d) diagnosis (RD-only, ADHD-only or ADHD/RD-combined group); e) ADHD subtype when applicable (ADHD-I, ADHD-HI, and ADHD-C); f) BRIEF- PRS scores (indexes: Behavioral Regulation and Metacognition, and scales: Initiate, Inhibit, Shift, Plan/Organize, Organization of Materials, Monitor, Emotional Control, and Working Memory); g) BRIEF- TRS scores (indexes: Behavioral Regulation and Metacognition, and scales: Initiate, Inhibit, Shift, Plan/Organize, Organization of Materials, Monitor, Emotional Control, and Working Memory); and h) Performance-based EF measures: Conners' Continuous Performance Test scores (omissions and commissions) and Digit Span subtest.

A series of Multiple Analysis of Variance (MANOVA) were conducted to examine the proposed research questions. In order to test whether there were significant differences among the means of the three groups, the Wilk's lambda coefficients were examined. In cases where the multivariate test was significant (Wilk's lambda), univariate *F*-tests were conducted. Those cases that reported a significant *F* value were further analyzed using the Scheffé test ($p < .05$). Means were compared using this test, as it is the most conservative test. As part of the secondary analyses, a paired sample *t*-test and Pearson *r* coefficients were computed.

CHAPTER IV

RESULTS

Introduction

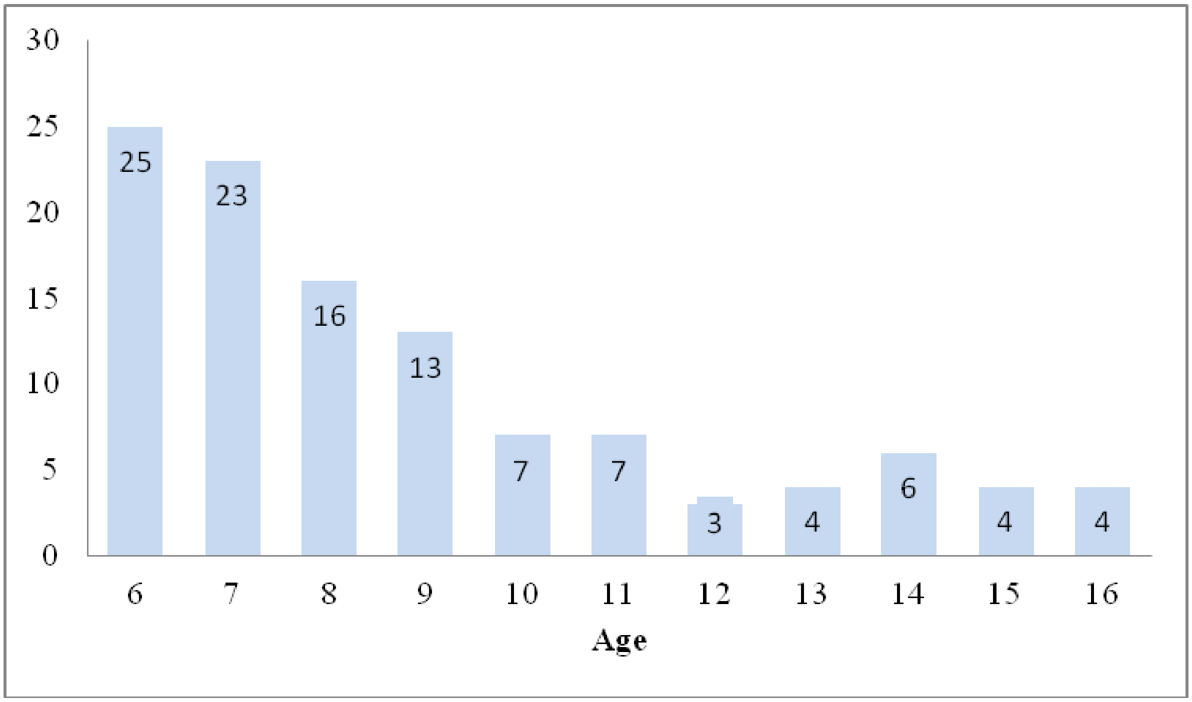
The primary purpose of the study was to compare the patterns of EF deficits in children with RD-only, ADHD-only, and ADHD/RD-combined. More specifically, this study assessed which of the indexes and clinical scales of the BRIEF, as reported by parents, best discriminated children with RD-only from children with ADHD-only, and those with both conditions (ADHD/RD-combined). A secondary analysis also compared parent and teacher ratings of EF deficits as measured by the BRIEF. A final analysis was conducted to explore the relationship between the BRIEF scores and other performance-based measures of EF, such as the Digit Span subtest from the WISC-IV and the Conners' Continuous Performance Test. The data used in this study were recorded on the Archival Data Forms, and then coded and entered into the SPSS-19 computer program for statistical analysis.

This chapter describes the data that were collected and analyzed in order to examine the research questions, and presents the results of the analyses that pertain to the study. The results presented below are based on the research questions posed in the study. Each research question is restated and is followed by the results and analyses pertaining to each question.

Description of the Sample

As mentioned in Chapter III, the data used in the study consisted of children who received a comprehensive psycho-educational assessment battery in a private clinical setting between July 2007 and December 2010. The sample in the study included 112 children ages 6.0-16.0, from middle and upper socio-economic backgrounds. The mean age of the sample was 8.9 (*SD* = 2.92) (see Figure 3). More than 81 percent of the subjects were under 11 years of age.

Figure 3. Age Distribution of the Sample



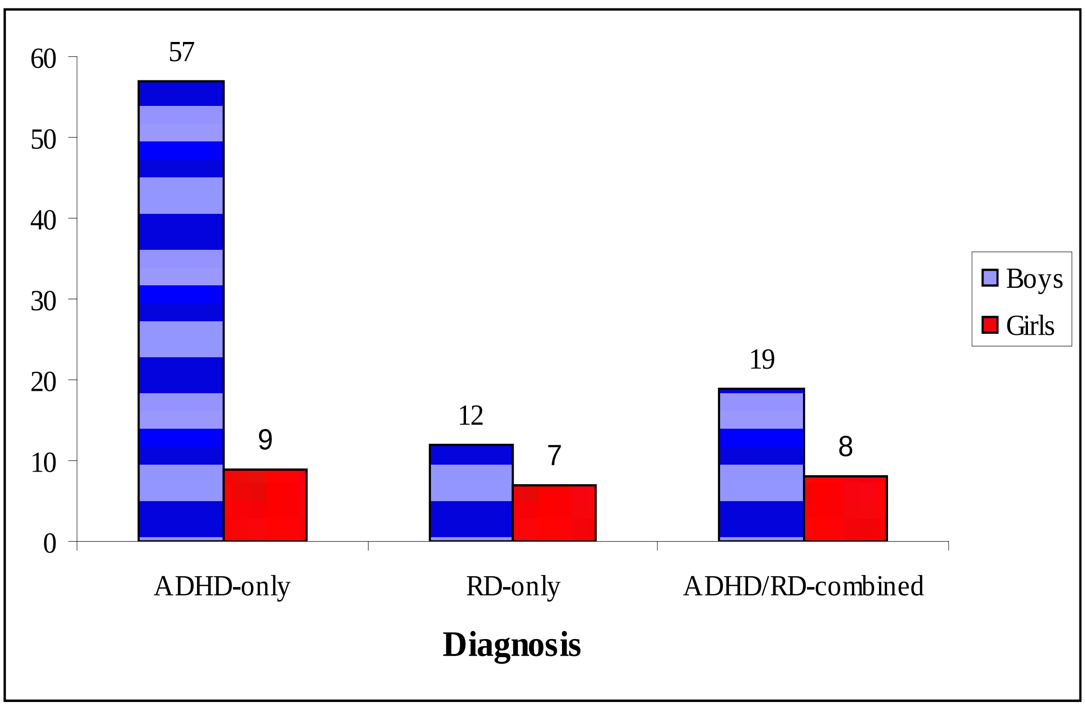
Twenty-one per cent of the sample were girls (*n* = 24), while 79% included male participants (*n* = 88). In terms of the diagnostic groups, 17% were diagnosed with RD-only (*n* = 19), 59% were diagnosed with ADHD-only (*n* = 66), and 24% were diagnosed with ADHD/RD-combined (*n* = 27) (see Figure 4). Among the ADHD group, 33% received an ADHD-I diagnosis (*n* = 22), 12% an ADHD-HI diagnosis (*n* = 8), and 55% an ADHD-C diagnosis (*n* = 36) (see Table 2).

Table 2

Demographic Information of the Present Sample (N = 112)

	ADHD-only	RD-only	ADHD/RD	Total
Sample Size				
Overall *N*	66	19	27	112
n of females	9	7	8	24
n of males	57	12	19	88
Age				
Mean (years)	8.7	9.5	9.1	8.9
Standard Deviation	2.8	3.3	3.1	2.9

Figure 4. Distribution of the Sample Based on Diagnosis and Gender



Research Question #1

1. Are there significant differences among the BRIEF scale and index scores of the RD-only group, ADHD-only group, and ADHD/RD-combined group as described by parents?

A one-way multivariate analysis of variance (MANOVA) was conducted to determine the effect of the disability diagnosis (RD-only, ADHD-only, and ADHD/RD-combined) on the BRIEF scores. The one-way MANOVA revealed a significant multivariate effect for the disability diagnosis, Wilks' $\lambda = .71$, $F(20, 188)$, $p = .03$. Univariate ANOVAs indicated significant differences for the Inhibit scale $F(2, 103) = 3.50$, $p = .034$; the Monitor scale $F(2, 103) = 4.24$, $p = .017$; and the Working Memory scale $F(2, 103) = 3.34$, $p = .039$. However, non-significant differences were found among the three groups in the other five scales (Shift, Emotional Control, Initiate, Plan/Organize, and Organization of Materials) or indexes (Behavioral Regulation and Metacognition). Means and standard deviations are reported in Table 3.

In order to further explore the differences among the means found with the MANOVA, a series of Scheffe's tests were conducted. As research has shown, the Scheffe's test is one of the most conservative post-hoc procedures. With respect to the Inhibit scale, the RD-only ($M = 53.1$; $SD = 9.2$) scored significantly lower than the ADHD-only ($M = 61.9$; $SD = 12.6$) and ADHD/RD-combined groups ($M = 62.6$; $SD = 13.0$). In other words, the RD-only group showed less deficits on the inhibit domain when compared to the ADHD groups (ADHD-only and ADHD/RD-combined). No significant differences were observed between the RD-only group and the ADHD/RD-combined group.

Table 3

Descriptive Statistics for Research Question #1: BRIEF Scale and Index Scores for the Three Diagnostic Groups: ADHD-only, RD-only and ADHD/RD-combined as Described by Parents

	ADHD-only		RD-only		ADHD/RD-combined	
Scale Score	Mean	SD	Mean	SD	Mean	SD
Inhibit [a]	61.9	12.6	53.1	9.2	62.6	13.0
Shift	55.7	10.7	55.0	14.6	59.9	15.0
Emotional Control	56.1	13.2	54.6	7.7	55.3	13.0
Initiate	61.9	9.8	55.5	10.6	62.3	13.5
Working Memory [b]	68.2	9.9	61.3	12.6	65.0	9.7
Plan/Organize	62.5	11.8	60.8	11.4	64.7	12.0
Organiz. of Material	59.7	11.4	56.5	11.0	57.8	8.9
Monitor [c]	64.9	10.8	56.4	10.6	59.5	14.3
Index Score						
Behav. Regulation	59.1	11.3	54.7	7.7	60.3	13.2
Metacognition	65.1	9.7	59.8	12.6	65.9	10.0

Note. Means ≥ 65 are considered clinically elevated.
[a]The RD-only group scored significantly lower than the ADHD-only and ADHD/RD-combined groups.
[b]The RD-only group scored significantly lower than the ADHD-only group.
[c]The RD-only group scored significantly lower than the ADHD-only group.

With respect to the Working Memory scale, post-hoc Sheffe's tests showed that the RD-only (M = 61.3; SD = 12.6) scored significantly lower than the ADHD-only group (*M* = 68.2; *SD* = 9.9). In other words, the RD-only group showed fewer deficits on the working memory domain when compared to the ADHD group, but not the ADHD/RD-combined.

In terms of the Monitor scale, the RD-only group (*M* = 56.4; *SD* = 10.6) scored significantly lower than the ADHD-only group (*M* = 64.9; *SD* = 10.8). In other words, the RD-only group showed fewer deficits on the monitor domain when compared to the ADHD-only group. No significant differences were observed between the RD-only and the ADHD/RD-combined groups.

As noted in Chapter III, any *T*-score of or equal to 65 ($M \geq 65$) indicates a clinically elevated score. Results from the present study indicated that children diagnosed with ADHD-only and ADHD/RD-combined obtained a clinically elevated *T*-score for the Working Memory scale, as well as Metacognition Index. In terms of the RD-only groups, no clinical elevations were observed.

Research Question #2

2. Are there significant differences among the BRIEF scale and index scores of the three ADHD sub-types (ADHD-I, ADHD-HI, and ADHD-C) as described by parents?

A one-way multivariate analysis of variance (MANOVA) was conducted to determine the effect of the ADHD sub-type diagnosis (ADHD-I, ADHD-HI, and ADHD-C) on the BRIEF scores. Means and standard deviations are reported in Table 4. The MANOVA test of differences among groups using the Wilks Lambda criteria was not statistically significant, Wilks' $\lambda = .583$, $F(20, 102)$. The BRIEF scale and index scores did not vary significantly based on the ADHD-sub-type.

Although the MANOVA results reported above were not significant, the ADHD-I group obtained a relatively much lower score on the Inhibit scale (*M* = 53.6; *SD* = 11.9) than the ADHD-HI (*M* = 61.6; *SD* = 6.6) and ADHD-C groups (*M* = 66.8; *SD* = 11.7). Additionally, the same pattern was observed on the Behavioral Regulation Index. The ADHD-I group obtained a relatively much lower score on the Behavioral Regulation Index (*M* = 53.0; *SD* = 9.7) than the ADHD-HI (*M* = 60.5; *SD* = 7.3) and ADHD-C groups (*M* = 62.2; *SD* = 11.7). In other words, although not statistically significant, children diagnosed with ADHD-I tend to report less behavioral problems than children with ADHD-HI and ADHD-C.

In terms of the clinical elevations, results indicated that all three ADHD groups (ADHD-I, ADHD-HI, and ADHD-C) demonstrated clinically elevated scores for the Working Memory scale. With respect to the ADHD-I, the current study also suggested clinically elevated scores for the Plan/Organize scale and Metacognition Index. Likewise, the ADHD-HI demonstrated a clinically elevated score on the Monitor scale. Finally, the ADHD-C group obtained clinically elevated scores on the Inhibit and Monitor scales.

Table 4

Descriptive Statistics for Research Question #2: BRIEF Scale and Index Scores for the Three ADHD Groups: ADHD-I, ADHD-HI, and ADHD-C as Described by Parents.

	Inattentive		Hyperact/Impul		Combined	
Scale Score	Mean	SD	Mean	SD	Mean	SD
Inhibit	53.6	11.9	61.6	6.6	66.8	11.7
Shift	54.1	10.8	59.4	10.7	55.7	10.7
Emotional Control	53.7	12.7	56.1	11.2	57.4	14.0
Initiate	60.0	9.5	58.5	10.6	60.4	11.9
Working Memory	69.8	9.8	68.0	13.9	67.3	9.0
Plan/Organize	66.3	9.3	63.4	12.7	60.2	12.6
Organiz. of Material	61.7	10.2	58.5	10.6	60.4	11.9
Monitor	61.7	10.2	66.8	8.7	66.3	11.4
Index Score						
Behav. Regulation	53.0	9.7	60.5	7.3	62.2	11.7
Metacognition	65.7	9.0	64.6	12.5	64.8	9.7

Note. Means ≥ 65 are considered clinically elevated.

Research Question #3

3. Are there significant differences among the BRIEF scale and index scores as described by parents and teachers?

In order to answer this research question, a paired sample *t*-test was conducted to compare parent’s and teacher’s ratings of EF. Results indicated significant differences in three scales (Initiate, Organization of Materials, and Working Memory) and one index score (Metacognition). For all three scales and index score, teacher ratings were higher than parent ratings. In other words, teachers reported higher EF deficits for three scales and one index scale when compared to parent ratings. Means and standard deviations are reported in Table 5.

With respect to the Initiate scale, statistical analysis using a paired-sample *t*-test found a significant difference in parents' and teachers' ratings on the Initiate scale, $t(15) = 3.8$, $p < .05$. Specifically, teachers' ratings ($M = 63.3$; $SD = 10.3$) were significantly higher than parent ratings ($M = 53.4$; $SD = 9.7$). In terms of the Organization of Materials scale, paired sample *t*-test results also showed a significant difference in teachers' ratings ($M = 65.8$; $SD = 18.2$) and parents' ratings ($M = 54.6$; $SD = 8.6$), $t\ (15) = 2.8$, $p < .05$. In the working memory domain, paired sample *t*-test results also showed a significant difference in teachers' ratings ($M = 70.0$; $SD = 11.7$) and parents' ratings ($M = 63.1$; $SD = 12.1$), $t\ (15) = 2.9$, $p < .05$.

Finally, in terms of the index scales, the paired-sample *t*-test found a significant difference in the parents' and teachers' ratings on the Metacognition Index, $t\ (14) = 3.3$, $p < .05$. Teachers indicated greater deficits on this index ($M = 67.6$; $SD = 9.5$) when compared to parents ($M = 59.2$; $SD = 10.2$).

Table 5

Descriptive Statistics for Research Question #3: BRIEF Scale and Index Scores as Predicted by Parents and Teachers.

	Parents		Teachers	
Scale Score	Mean	SD	Mean	SD
Inhibit	58.9	9.6	62.3	12.6
Shift	50.6	13.2	57.1	11.8
Emotional Control	51.8	16.0	54.7	15.6
Initiate*	53.4	9.7	63.3	10.3
Working Memory*	63.1	12.1	<u>70.0</u>	11.7
Plan/Organize	58.5	12.3	<u>65.7</u>	9.5
Organization of Materials*	54.6	8.6	<u>65.8</u>	18.2
Monitor	62.3	9.2	<u>66.1</u>	9.9
Index Score				
Behavioral Regulation	52.9	11.9	58.9	11.2
Metacognition*	59.2	10.2	<u>67.6</u>	9.5

Note. Means ≥ 65 are considered <u>clinically elevated</u>.
*significant at the .05 level.

In terms of the clinical elevations, teachers' results indicated clinically elevated scores for the Working Memory, the Plan/Organize, the Organization of Materials, and Monitor scales, as well as Metacognition Index. Interestingly, parents did not indicate any clinically elevated scores.

Research Question #4

4. Are there significant differences among the BRIEF scale and index scores of the RD-only group as described by parents and teachers?

Within the RD-only group, only one child had both parent and teacher BRIEF ratings. Therefore, a paired-sample t-test could not be conducted.

Research Question #5

5. Are there significant differences among the BRIEF scale and index scores of the ADHD-only group as described by parents and teachers?

To address the question whether parents and teachers differed in their BRIEF ratings for children diagnosed with ADHD-only, a paired sample *t*-test was conducted. Means and standard deviations are reported in Table 6. Statistical analyses using a paired-sample *t*-test found a significant difference in parents' and teachers' ratings on the Plan/Organize scale, $t(8) = 3.5$, $p < .001$. Specifically, teachers' ratings (M = 66.2; SD = 11.4) were significantly higher than parent ratings (M = 53.1; SD = 10.4). Results also indicated a significant difference in parents' and teachers' ratings on the Working Memory scale, $t(8) = 3.4$, $p < .001$. With respect to the Working Memory scale, the paired sample *t*-test results also showed a significant difference in teachers' ratings (M = 69.8; SD = 11.6) and parents' ratings (M = 59.1; SD = 9.3). However, non-significant differences were found among the other scales (Inhibit, Shift, Emotional Control, Initiate, Organization of Materials, and Monitor) or index scales (Behavioral Regulation and Metacognition).

Table 6

Descriptive Statistics for Research Question #5: BRIEF Scale and Index Scores for the ADHD-only Group as Described by Parents and Teachers.

	Parents		Teachers	
Scale Score	Mean	SD	Mean	SD
Inhibit	56.7	7.6	61.2	9.9
Shift	46.3	6.1	59.8	14.3
Emotional Control	51.9	16.0	53.9	11.5
Initiate	51.6	8.2	61.2	9.9
Working Memory*	59.1	9.3	69.8	11.6
Plan/Organize*	53.1	10.4	66.2	11.4
Organization of Materials	53.6	7.4	70.1	20.3
Monitor	60.8	8.9	66.2	9.9
Index Score				
Behavioral Regulation	49.2	4.8	59.4	11.4
Metacognition	56.7	9.1	68.8	10.8

Note. Means ≥ 65 are considered clinically elevated.
*significant at the .05 level.
Statistics based on nine pairs of teacher-parent ratings

In terms of the clinical elevations, teachers' results indicated clinically elevated scores for the Working Memory, the Plan/Organize, the Organization of Materials, and Monitor scales, as well as Metacognition Index. As observed in Research Question #3, parents did not indicate any clinically elevated scores.

Research Question #6

6. Are there significant differences among the BRIEF scale and index scores of the ADHD/RD-combined group as described by parents and teachers?

To examine the relationship between parent and teacher reports of EF a series of paired sample *t*-test were conducted. At the $p < .001$, no significant differences were found between parent and teacher ratings. However, at the $p < .05$, a significant difference was observed on the Initiate scale, $t(5) = 2.9$, $p < .05$. Teachers reported higher deficits on the Initiate scale ($M = 67.7$; $SD = 10.9$) than parents ($M = 57.5$; $SD = 11.6$). Non-significant differences were found among the other scales (Working Memory, Inhibit, Shift, Emotional Control, Initiate, Organization of Materials, and Monitor) or index scales (Behavioral Regulation and Metacognition). Means and standard deviations are reported in Table 7.

In terms of the clinical elevations, teachers' results indicated clinically elevated scores for the Working Memory, the Plan/Organize, and Monitor scales, as well as Metacognition Index. The same elevations were observed for parents' ratings of EF.

Table 7

Descriptive Statistics for Research Question #6: BRIEF Scale and Index Scores for the ADHD/RD-combined Group as Described by Parents and Teachers.

	Parents		Teachers	
Scale Score	Mean	SD	Mean	SD
Inhibit	63.7	11.5	62.7	15.3
Shift	57.5	19.2	53.0	7.7
Emotional Control	53.2	18.4	54.8	22.5
Initiate*	57.5	11.6	67.7	10.9
Working Memory	70.3	14.0	73.2	11.4
Plan/Organize	70.2	7.2	66.2	6.4
Organization of Materials	57.7	9.9	61.2	15.8
Monitor	66.9	7.6	68.3	9.4
Index Score				
Behavioral Regulation	59.6	17.4	57.8	12.8
Metacognition	66.0	9.5	68.2	5.8

Note. Means ≥ 65 are considered clinically elevated.
*significant at the .05 level.
Statistics based on five pairs of teacher-parent ratings

Research Question #7

7. Is there a significant relationship between the BRIEF scale and index scores and other performance-based measures of executive functioning as rated by parents and teachers?

Pearson Product-Moment correlations (Pearson *r*) were conducted between the BRIEF Parent ratings and the three performance-based measures of EF of interest in this study (Conners' Continuous Performance Test: Commission and Omission errors, and the Digit Span subtest from the WISC-IV). A significant positive correlation was found between the Metacognition Index score and the Digit Span score. Specifically, students who demonstrate higher deficits on the Metacognition Index, as reported by their parents, were more likely to have higher scores on the Digit Span subtest of the WISC-IV ($r = .21$, $p < .05$). No significant correlations were observed between the Conners' Continuous Performance Test and the BRIEF scales and index scores.

Pearson Product-Moment correlations (Pearson *r*) were also conducted among the BRIEF-Teacher ratings and the three performance-based measures of EF (Conners' Continuous Performance Test: Commission and Omission errors, and the Digit Span subtest from the WISC-IV). However, no significant correlations were observed.

CHAPTER V

DISCUSSION

Introduction

This chapter will first provide a summary of the importance of the study, including its theoretical framework, purpose, and relevance. This section will then be followed by a discussion and interpretation of the research findings, based on the literature review and the data obtained. Limitations of the study, as well as recommendations for future research will also be provided. Finally, implications for policy and practice will be presented.

Restatement of the Research Problem

Research on brain functioning and EF can be traced back to the theoretical and empirical work of the Soviet psychologist Alexander Luria (1902–1977). Luria's theory of processing changed the way clinicians comprehend and assess the way humans understand and break down information. His theory, previously explained in the literature review, describes three functional systems, which were associated with particular areas of the brain and specific functions. According to Luria, the first unit is located mainly in the brain stem and is responsible for regulating and maintaining arousal of the cortex. The second unit is responsible for encoding, processing, and storing of information and encompasses the temporal, parietal, and occipital lobes. The third unit, which is located in the frontal lobe, is responsible for programming, regulating, and verifying human behavior (Luria, 1973).

Stemming from Luria's work, the term EF was described as part of cognitive theory and has become the focus of widespread research interest ever since (Denckla, 1996; Welsh & Pennington, 1988; Willcutt et al., 2001). Anderson (2002) described EF as including "anticipation, goal selection, planning, initiation of activity, self regulation, mental flexibility, deployment of attention, and utilization of feedback" (p. 71). EF deficits are prevalent in a plethora of differing psychological and learning disorders (Denckla, 1996). Therefore, the study of EF deficits is beneficial in remediating and strengthening varied learning and behavioral difficulties. In schools, attention problems and reading disorders are the leading areas of deficit in children (Kibby et al., 2004). Several tests designed to measure EF, such as the BRIEF, have been based on Luria's theory of brain functioning. The results from the present study provided clear support for Luria's theory, and the way he conceptualized brain functioning. The results from the present study demonstrated that EF is an umbrella term that encompasses several functions such as monitoring, planning, organizing, inhibiting and working memory.

The primary purpose of this study was to compare the patterns of EF deficits in children with RD-only, ADHD-only, and ADHD/RD-combined. More specifically, this study assessed which of the scales and indexes of the BRIEF, as reported by parents, best discriminated children with RD-only from children with ADHD-only, and from those with both conditions (ADHD/RD-combined). A secondary analysis also compared parent and teacher ratings of executive functioning deficits as measured by the BRIEF. A final analysis was conducted to explore the relationship among the BRIEF scores and other performance-based measures of EF, such as the Conners' Continuous Performance Test (Omission and Commission errors) and the Digit Span subtest of the WISC-IV.

Summary and Interpretation of Findings

Research Question #1. This question explored whether BRIEF scores, as reported by parents, were significantly different among the three diagnostic groups included in the study (ADHD-only, RD-only, and ADHD/RD-combined). Results indicated significant differences for the Inhibit, Monitor, and Working Memory scales. More specifically, children in the ADHD groups (both ADHD-only and ADHD/RD-combined) demonstrated greater EF deficits in the areas of inhibition, monitoring and working memory than children in the RD-only group.

Previous literature and research suggests that children with ADHD demonstrate significant impairments on measures of response inhibition, vigilance, working memory, and planning (Alloway et al., 2009; Willcutt et al., 2005). As expected, the results provide clear support for theories that highlight behavioral dis-inhibition as a primary deficit in children with ADHD (Pennington & Ozonoff, 1996). Results from the current study indicate that children with ADHD-only and ADHD/RD-combined demonstrated greater EF deficits in the Inhibit and Monitor scales than children with RD-only. According to parents, children with ADHD-only and ADHD/RD-combined have marked difficulty resisting impulses and difficulty considering consequences before acting. They are often perceived as less in control of themselves than their peers (Inhibit scale). Additionally, they are often unaware of their own behavior and the impact this behavior has on their social interactions with others (Monitor scale).

In addition to the behavioral regulation deficit in children with ADHD, it is also important to highlight the working memory deficit observed in this group. Results from the current study found a significant difference between the Working Memory scale score of children in the ADHD-only group and RD-only group. Children in the ADHD-only group were described by their parents as having substantial difficulty holding an appropriate amount of information in mind or in "active memory" for further processing, encoding, and/or mental manipulation. These findings are in line with previous research that has demonstrated that children with ADHD have fluctuating attention on tasks requiring vigilance (Marzocchi et al., 2008; Pennington et al., 1993; Willcutt et al., 2001).

In terms of the RD-only group, results from the present study did not indicate the presence of inhibition or behavioral deficits, which is consistent with previous research (Kibby et al., 2004). That is, the RD-only group did not show symptomatology indicative of ADHD and obtained typical scores on measures of behavioral regulation.

However, when exploring the BRIEF scores of the RD-only group it can be observed that the two highest scores were seen on the Working Memory and Plan/Organize scales. Although these scores were lower than the two ADHD groups (ADHD-only and ADHD/RD-combined), and were not clinically elevated, children with RD-only showed mild deficits in these two scales (Working Memory and Plan/Organize). This finding partially supports the idea of underlying working memory and planning deficits in children with reading disorders (Welsh & Pennington, 1988).

With respect to working memory, Sesma et al. (2009) explained that many children struggle with reading comprehension due to phonological processing deficits and word reading accuracy. However, other children have reading comprehension difficulties as a result of deficits in EF, specifically working memory and planning. If the reader is not able to hold this information actively in mind, the entire reading process will be less efficient or halted completely. The ability to sustain is, in part, supported by working memory. To maintain continuity in a task, the child must hold information in the mind. If a child is losing track of what has been read, it will be more difficult to sustain attention to the task (Sesma et al., 2009).

Additionally, the Plan/Organize scale was the second highest score obtained by children in the RD-only group. Research has shown that planning is also associated with the active strategic (metacognitive) aspects of the reading process (Sesma et al., 2009). Deficits in strategy development may make it more difficult for children with reading disabilities to compensate for their disability. In the current study, children with RD-only demonstrated mild deficits when asked to anticipate future events, set goals, and develop appropriate sequential steps ahead of time in order to carry out a task or activity. Additionally, children with deficits in planning have difficulties bringing order to information and appreciating main ideas or concepts when learning or communicating information (Plan/Organize scale). Although not clinically elevated, this result again partially supports Sesma et al. (2009) findings. As stated before, Sesma et al. proposes that children with reading comprehension difficulties demonstrate EF deficits in the areas of working memory and planning.

Research Question #2. This question explored whether BRIEF scores were significantly different among the three ADHD sub-types (ADHD-I, ADHD-HI, and ADHD-C). Results indicated no significant difference among the three ADHD sub-types as reported by parents. However, sample sizes in the current study might not have provided sufficient power to find significant differences among the sub-types. In other words, the reduced number of participants likely contributed to the lack of statistically significant differences. Additionally, there was significant disparity in the number of participants for each ADHD sub-type group. The ADHD-I group included 22 participants; the ADHD-HI consisted of eight participants, while the ADHD-C included 36 participants.

Although MANOVA results were not significant, it was observed that the ADHD-I group demonstrated fewer deficits on the Inhibit scale, as well as on the Behavioral Regulation Index when compared to the ADHD-HI and ADHD-C groups. More specifically, the ADHD-C group was the only ADHD sub-type that obtained a clinically elevated mean score on the Inhibit scale.

Although not statistically significant, these findings are consistent with prior research, which indicates a behavioral inhibition/regulation deficit in children with ADHD-HI and ADHD-C (Gioia et al., 2000; McCandless & O'Laughlin, 2007; Nigg, Blaskey, Huang-Pollock, & Rappley, 2002; Solanto et al., 2007). Gioia et al. (2000) reported in their study that the Behavioral Regulating Index and underlying scales on the BRIEF (Inhibit, Shift, and Emotional Control scales) best differentiated ADHD-I and ADHD-C. Additionally, both Solanto et al. (2007) and Nigg et al. (2002) found that children with ADHD-C demonstrated greater difficulty with inhibitory control than children with ADHD- I. As Barkley (1997) stated "it is this dimension [behavioral inhibition] that, virtually by definition, distinguishes those with ADHD from others without it" (p. 75).

Current findings partially support this statement. Non-significant differences were found among the three ADHD sub-types. However, exploratory analyses, as mentioned above, indicated higher scores on the Behavioral Regulation Index and the Inhibit scale for the ADHD- HI and ADHD-C. It is anticipated that with a larger sample size and more children included in each ADHD sub-type (ADHD-I, ADHD-HI, and ADHD-C), significant differences among the three groups might have been found. Future research should further explore the patterns of strengths and weaknesses that these children might have, which would lead to more effective intervention strategies.

Further exploratory analysis also indicated that all three ADHD sub-types obtained clinically elevated scores on the Working Memory scale. These results were consistent with previous research conducted by Gioia et al. (2000). The authors found that all three ADHD sub-types (ADHD-I, ADHD-HI, and ADHD-C) received clinically elevated scores on the Working Memory scale, as rated by parents and teachers. However, Gioia et al. also highlighted that this scale did not differentiate between the ADHD-I and ADHD-C.

Overall, results from the current study are somewhat consistent with McCandless and O'Laughlin (2007) findings, which demonstrated that the Working Memory scale was effective in distinguishing the ADHD group from the non-ADHD group, while the Inhibit scale proved effective to distinguish among ADHD sub-types. Although this study did not include a control group, based on the results from McCandless and O'Laughlin (2007) and current findings, it can be inferred that the Working Memory scale may be most useful in "*ruling in*" a diagnosis of ADHD, while the Inhibit scale may be most useful in determining the ADHD sub-type.

Research Question #3. This research question investigated the agreement between parents and teacher ratings of EF deficits. The major findings were that teacher ratings of EF deficits, when compared to parent ratings, were higher for every scale, as well as for one index score. Statistically significant differences were noted between parent and teacher ratings in three scales (Initiate, Organization of Materials, and Working Memory) and one index scale (Metacognition).

Based on teachers' ratings, it was concluded that children have greater difficulties beginning, starting, or "getting going" on tasks (Initiate scale); organizing, keeping track of, and/or cleaning up their belongings (Organization of Materials scale); as well as staying on task and paying attention (Working Memory scale). The findings in this study were in line with previous research, whereby teachers tend to report higher EF deficits than parents (Mares et al., 2007).

The observed difference between parent and teacher ratings may be attributed to different perceptions of the problem, as well as the situation specificity of children's behavior. These results are also consistent with Barkley's paper (2003). According to Barkley, the symptoms associated with EF deficits are significantly impacted by a variety of situational and task-related factors. In the same line of ideas, Mares et al. (2007) indicated that tasks and expectations for performance often fluctuate across home and school environments, potentially placing different demands on a child's EF. Additionally, Mares et al. (2007) reported that "the more complicated the task, the greater the need for effective planning, organizing, monitoring, and regulating of behavior" (p.528).

Research Questions #4-5-6. These research questions investigated EF deficits in children diagnosed with RD-only, ADHD-only and ADHD/RD-combined as described by parents and teachers.

In terms of the RD-only group, statistical analysis could not be performed due to the extremely low number of participants. The low number of children who received both the parent and teacher version of the BRIEF may be related to a common misconception that children with a reading disorder do not demonstrate EF deficits. The BRIEF Parent Form was completed as part of the standard battery that children receive in the clinical setting where the data were collected. However, the BRIEF Teacher Form is typically only completed when the clinician performing the assessment considers it necessary to further assess EF deficits. Although parents did not report significant EF deficits in children with RD-only, future research should include teacher reports of EF in order to better assess this group of children and the possible impact EF deficit may have in their learning process.

With respect to the ADHD-only group, results indicated significant differences between teacher and parent ratings on two scales: Plan/Organize and Working Memory. In terms of the ADHD/RD-combined group, a significant difference was only observed on the Initiate scale. When analyzing these results, it is important to take into consideration the sample size for both of these groups (ADHD-only and ADHD/RD-combined). The ADHD-only and the ADHD/RD-combined groups had less than ten children each. Specifically, the ADHD-only group included nine pairs of parent-teacher ratings, while the ADHD/RD-combined group was composed of only five pairs of parent-teacher ratings. Therefore, sample sizes may not have provided sufficient power to find significant differences between parent and teacher ratings in other scales.

As mentioned before, significant differences were observed in the Plan/Organize and Working Memory scales (ADHD-only group), as well as in the Initiate scale (ADHD/RD-combined group). These findings are somewhat inconsistent with Mares et al. (2007) who found significant differences among every scale and index scale of the

BRIEF on a sample of children diagnosed with ADHD. The disparity in findings may be due to sample differences. First, the sample used by Mares et al. (2007) included children with comorbid disorders such as Oppositional Defiant Disorder, Conduct Disorder, Anxiety Disorders, among others, while the present study only included children with ADHD-only, RD-only and ADHD/RD-combined. Additionally, Mares et al. included 240 children, while the current sample that had both parent and teacher ratings included less than ten children in each sub-group.

Although statistically significant differences were only observed in three scales for both ADHD groups (ADHD-only and ADHD/RD-combined), teachers' scores were consistently higher across scales and indexes when compared to parent ratings. This pattern of teachers' ratings being higher than parents' ratings was consistent with previous research, which has demonstrated low to moderate correlations between parent and teacher reports (Gioia et al., 2000; Mares et al., 2007; McCandless & O'Laughlin, 2007).

This discrepancy between parent and teacher reports does not necessarily mean that one type of informant is providing invalid or unreliable information. On the contrary, it should be interpreted as indicating that parents and teachers observe the child in different settings and provide different, but useful information for the assessment process. Low correlations between parent and teacher ratings reflect the degree to which each provides unique information, with the parent providing information regarding behavior at home and teachers providing information about school behavior. Additionally, parents and teachers may differ in their perception of the behavior problem. Given that teachers, compared with parents, are more familiar with age-appropriate behaviors of children, they may generally be more inclined to report EF deficits. The use of teacher reports, rather than parental reporting alone, may increase identification and diagnostic accuracy, and in consequence, definition of the target behavior for the treatment plan. Furthermore, it may be of relevance to further explore if training parents and teachers in the recognition and identification of ADHD symptoms might produce higher concordance in their ratings of the child's behavior.

Research Question #7. This research question explored the relationship between BRIEF scores and other performance-based measures of EF, such as the Digit Span subtest from the WISC-IV and the Omission and Commission errors from the Conners' Continuous Performance Test (CCPT). No significant correlations were observed among teacher ratings of EF, as measured by the BRIEF, and other performance-based measures of EF. However, with respect to parent ratings of EF, a significant positive correlation was observed between the Metacognition Index of the BRIEF and the Digit Span subtest of the WISC-IV. Children who reported greater deficits on the Metacognition Index obtained a higher score on the Digit Span subtest. In other words, children who exhibit greater EF deficits, as measured by the Metacognition Index, obtained a higher score on the Digit Span subtest, which translate to better working memory skills. A higher score on the Digit Span subtest is interpreted as having better ability to remember sequences of numbers and to hold on to information for later processing.

When interpreting these results, however, it is important to take into consideration several aspects. First, the relationship between these two variables (Metacognition Index and Digit Span subtest) is not linear. In other words, the results of the present study indicated that a high score on the Metacognition Index (more EF deficits) indicates a higher score on the Digit Span subtest (better working memory skills). However, a low score on the Metacognition Index (no EF deficits) does not necessarily mean a lower score on the Digit Span subtest (poor working memory skills). Future research is needed to explore in greater detail the relationship between these two variables. More specifically, future studies should attempt to group children with high and low scores on the Metacognition Index and other BRIEF scales, and see how these two groups perform on different performance-based measures of EF.

Second, the correlation between the Metacognition Index of the BRIEF and the Digit Span subtest of the WISC-IV was .21, which means that it only explained four percent of the total variance. The other 96 percent of the variance is explained by other variables not considered in the study, such as intellectual functioning, medication, family's educational level, among others. Finally, future research should try to separate the three diagnostic groups (RD, ADHD, and ADHD/RD) before exploring the relationship between these variables (BRIEF scores and other performance-based measures of EF).

This finding, in response to research question #7, was consistent with previous research, which has demonstrated inconsistencies between performance on traditional measures of EF and real life behavior (Anderson, 2002). In a clinical setting, the examiner acts as the child's frontal lobe helping him/her organize his/her behavior and helping him/her stay on task and paying attention. This explains why children, who demonstrate greater metacognitive deficits, as rated by parents, were still able to get a high score on a working memory task in a clinical setting.

In the same order of ideas, Dawson and Guare (2010) indicated that clinicians that attempt to assess EF in the context of a formal evaluation in the typical clinical setting face a challenging task. Many of the factors that demand the use of EF on the part of the child are removed from the equation due to the nature of the situation. For example, two critical EF skills are initiation and sustained attention. In standardized testing situations, the clinician cues the child to start and presents tasks that are necessarily brief in nature, therefore reducing the demand for sustained attention. A child's strong performance on a clinical measure of EF does not necessarily means that the same child applied good EF skills in the context of daily performance at home or at school (Dawson & Guare, 2010). With respect to the present study, results are consistent with the findings of Dawson and Guare, and this could explain why children with higher metacognitive deficits, as rated by parents, obtained a higher score on a measure of working memory, as measured by the Digit Span subtest of the WISC-IV in a clinical setting.

Additionally, as mentioned above, the current study only involved single subtest scores from other performance-based measures of EF (Digit Span subtest from the WISC-IV and the Omission and Commission errors from the CCPT). The present study did not incorporate a broad and comprehensive performance-based measure of EF, such as the Developmental Neuropsychological Assessment (NEPSY). The use of additional varied assessment tools would have provided a more comprehensive assessment of the constructs investigated in the study, making it possible to more thoroughly test thus particular question (research question #7), and possibly yielding more significant findings.

Limitations and Future Research

Although the findings of this study were theoretically meaningful, several limitations should be recognized. One major limitation of this study was the small samples sizes for the three groups. More specifically, the RD-only (n = 19) and ADHD/RD-combined (n = 27) when compared to the ADHD-only group (n = 66). With larger cell sizes, the study would have had more statistical power. Replication including more children with RD and both disorders (ADHD/RD) is recommended. This notwithstanding, it is important to highlight that the present study started with an initial population of approximately 1000 students (see Figure 1). From the initial pool (N = 1000), 15 per cent of the students (n = 150) did not have consent to release information for research purposes, which left 850 students of the initial sample. After applying the inclusion and exclusion criteria, the final sample only included 112 children, which represents 11.2 percent from the initial population. Future research involving archival data and exceptional student education should take this information into consideration, and begin their studies with a larger population.

Additionally, the nature of the reading disability of the children that participated in the study (word reading difficulties versus reading comprehension weaknesses) is unknown. Future research should attempt to specify the nature of their reading difficulty in order to better understand the role of EF deficits in children with a reading disability.

Second, the children that participated in the study were recruited from a convenience sample. The majority of the families attending the clinical setting from which the data were obtained were middle- to upper-class Caucasian families. Additionally, the majority of the children attended private schools. There was little representation of individuals from racial and ethnic minority backgrounds, thus limiting generalization to a larger population. Future research should include children with varied racial representation and socio-economic levels. A more varied population would lend credence to the generalizability of the findings.

Third, as is typical of childhood psychopathologies, the children included in the present study likely did not present pure deficits in either reading or attention. Diagnoses of ADHD and RD were the primary diagnoses; however, children may have demonstrated concurrent deficits that were not diagnosed. For example, they may have had mild deficits in social skills, expressive and/or receptive language, among others. Children who met the exclusionary criteria were removed from the study, but mild symptoms may still have co-existed with the primary diagnoses.

Fourth, the quantification of EF components was limited to one measure per construct. Although this is a common practice in the EF research, different measures are often used across studies. This notwithstanding, due to the complexity of assessing EF in children, as addressed in the introduction and literature review, findings might have been limited by the tool used in the present study (the BRIEF).

Implications

Research has shown that EF deficits have detrimental effects on children’s academic functioning, specifically increasing the risk for grade retention and lower academic achievement (Biederman et al., 2004). Therefore, professionals in the mental health field, as well as educators, can potentially use the information obtained in the present study in the understanding, conceptualization, and treatment of EF deficits in children with ADHD and RD.

The present study made important contributions in three specific areas. First, this research is an important step toward understanding EF as it manifests itself in different childhood psychopathologies such as ADHD and RD. Second, the current study also has important contributions to clinicians and educators, and how the conceptualization and understanding of EF can affect the assessment process, as well as the intervention/educational outcome. Finally, this study provided a new conceptualization of the BRIEF as an instrument to be used with different childhood psychopathologies.

First, the results of the present study confirmed the findings of other studies that EF deficits are not exclusively observed in children with ADHD. Children with RD also demonstrate EF deficits. It is important for teachers to understand these concepts. Generally, interventions used to help children who are struggling with reading are focused exclusively on the linguistic nature of the task. However, it may be even more beneficial to incorporate specific EF strategies, particularly in the areas of working memory and planning/organizing. If interventions are not properly designed to address EF deficits, this may contribute to the underachievement and dropout rates of these students. Children with EF deficits may require additional academic interventions to prevent academic failure.

Additionally, professionals should acknowledge the controversy in the ADHD literature as to whether sub-types are similar or distinct disorders. Current findings suggest that the ADHD subtypes share similar cognitive executive deficits, but that they are differentiated on the basis of behavioral regulation skills as indicated by the BRIEF.

Second, the current research also made important contributions for school and clinical psychologists conducting assessment with children. As was previously discussed, teachers reported greater levels of EF deficits compared to parents. In response to the research questions formulated in the present study, teachers reported more variety and severity of EF impairments, and identified more children as having clinically significant levels of EF deficits. On several scale and index scores, parents reported scores within the typical range, while teachers indicated clinically elevated scores. The results of the present study emphasize the importance of including the teacher's report of the child's school functioning in the assessment process, as well as the importance of including the school in the treatment plan.

In terms of the current sample, it was observed that less than 20 children had both parent and teacher BRIEF reports. More alarmingly, the RD-only group included only one child with both BRIEF parent and teacher report. Therefore, an optimal evaluation should consist of direct input from multiple informants. This issue is of particular importance when trying to design intervention plans. School, behavioral, and pharmacological treatment interventions depend on accurate identification and monitoring of target symptoms. It is predicted that once EF deficits have been accurately identified and included in the treatment plan, EF interventions would ultimately result in better academic functioning, better use of appropriate strategies and skills for problem solving, better organization, increased feelings of school satisfaction and self-esteem, less behavioral and emotional concerns, and overall reduced underachievement.

Findings from the present study also emphasize the important role that teachers play in the early identification of EF problems not recognized by parents. Research has shown that early identification may allow teachers and parents to implement behavioral and academic programming prior to the onset of any learning, social, or behavioral problems commonly associated with EF deficits. Teacher reports can also be used to inform parents who are unaware of some of the difficulties that their child might be experiencing at school and perhaps even at home.

Additionally, school and clinical psychologists should also include children's self-assessment as part of the comprehensive assessment. The BRIEF has a self-report questionnaire for children ages 11-18 that was designed to complement the BRIEF Parent and Teacher Forms. As explained in the literature review, during adolescence (ages 11-18 years), important executive functions emerge and develop: increased reasoning, self-awareness, flexibility, organization, and self-monitoring; greater memory capacity; better behavioral regulation; and the ability to multi-task. Understanding an adolescent's level of awareness of his/her own difficulties with self-regulation is a critical element in focused treatment and educational planning.

Finally, although the BRIEF was not intended as a primary assessment tool for reading disabilities, it can be helpful in the assessment process of children with RD. The role of the BRIEF in this case would be to document the secondary deficits of EF that may be important in designing and implementing educational interventions. That is, if a child with RD has deficits in sustaining attention, planning behavior, and working memory, these areas should be addressed within a special education program.

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APPENDIX A

PROCEDURAL STEPS

For each individual folder, please check the following items in order:

1. Permission to Treat and Custody Form: Check the statement “I do not agree to the release psychometric information for research purposes” to assure consent to release information.
2. On section “Diagnostic Impressions”: check the child’s diagnosis, if diagnoses include any of the following (Reading Disorder, ADHD or Reading Disorder and ADHD), please continue to complete the form. Otherwise, close folder and continue to next child.
3. There must be no history of developmental delays or psychiatric conditions.
4. Assign each participant with a code.
5. Check the child’s age in years and months.
6. Check the child’s gender.
7. On the social developmental history, check if the child was taking medication at the time of testing. If yes, specify which medication.
8. On the Intellectual Assessment section, please check the child’s Verbal Comprehension, Perceptual Reasoning and Full Scale IQ scores.
9. On the Executive Functioning section, please check the child’s BRIEF scores.
10. On the Attention Control section, please check the child’s CCPT score.
11. On the Intellectual Assessment section, please check the child’s DS score.

APPENDIX B
PERMISSION TO TREAT AND CUSTODY FORM

CHILD PROVIDER SPECIALISTS
Assisting With One Small Miracle Each Day

Main Office: Miami Children's Dan Marino Center
2900 South Commerce Parkway
Weston, FL 33331
Phone: 954 577-3396 Fax: 954 915-0394

PERMISSION TO TREAT AND CUSTODY/GUARDIANSHIP STATEMENT

I certify that I am the parent/guardian of ____________________________, minor child, and that I am fully entrusted to make medical decisions for my child. I authorize ____________________ to initiate treatment/testing to the minor named above. If any split or shared custody, or shared guardianship agreement exists, I certify that I have notified all other guardians/parents of my intention to seek psychological services for the aforementioned child with the staff of Child Provider Specialists and/or their designee to receive neurocognitive/mental health assessment and/or treatment services.

Psychometric Data obtained in the process of evaluating your child may be used for research purposes. In the event that the information is utilized for such purposes no names will be required and the anonymity of the patient will be insured. If you do not agree to the release of information for research purposes, please initial in the space provided below.

____ I do not agree to the release psychometric information for research purposes.

____________________________ ____________________________
Printed Name of Parent/Guardian Signature of Parent/Guardian

APPENDIX C

ARCHIVAL DATA FORM

Participant # ______

Child's age: ______ years ______ months.

Gender: ______ Male ______ Female

Grade: _______

IQ: ______ Verbal Comprehension Index

______ Perceptual Reasoning Index

______ Full Scale IQ

Diagnosis: ______ Reading Disorder

______ ADHD: Combined Type

______ ADHD: Predominantly Inattentive Type

______ ADHD: Predominantly Hyperactive/Impulsive Type

______ Reading Disorder/ADHD

<u>BRIEF Scores:</u> ______ Initiate

Parent Form ______ Inhibit

______ Shift

______ Plan/Organize

_______ Organization of Materials

_______ Monitor

_______ Emotional Control

_______ Working Memory

_______ Metacognition Index

_______ Behavioral Regulation Index

<u>BRIEF Scores:</u> _______ Initiate

Teacher Form _______ Inhibit

_______ Shift

_______ Plan/Organize

_______ Organization of Materials

_______ Monitor

_______ Emotional Control

_______ Working Memory

_______ Metacognition Index

_______ Behavioral Regulation Index

<u>CCPT:</u> _______ Omission _______ Comission

<u>Digit Span:</u> _______

APPENDIX D

IRB APPROVAL LETTER