AN INVESTIGATION OF THE CONCURRENT CRITERION-RELATED VALIDITY OF THE COMPREHENSIVE EXECUTIVE FUNCTION INVENTORY (CEFI) - SELF-REPORT MEASURE

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ABSTRACT

Executive function (EF) processes are crucial for meeting demands in the classroom. Because of this impact on schooling, it is important to have tools that accurately measure EF in order to facilitate the identification of student needs and the development of interventions. This project assessed the concurrent, criterion-related validity of one of these tools, the Comprehensive Executive Functioning Inventory, Self-Report (CEFI-SR; Naglieri & Goldstein, 2013). This study correlated adolescents' reports about their own behavior to scores derived from a direct measure of executive function to determine if teens were able to accurately rate their own EF abilities, indicating that the CEFI-SR had concurrent validity. Seventy-nine seventh and eighth grade students from a suburban middle school were recruited. The average age for the sample was 13 years and 10 months old, and 62% of the sample consisted of female students. Participants completed the CEFI-SR in small groups, and then, the lead examiner returned to the school to complete direct one-on-one testing with each student. Data were analyzed using Pearson product-moment correlations and t-tests. The t-tests were used to determine if significant differences between groups were present. Results from the t-tests indicated that there were no significant differences in performance across genders or grades. Additionally, no significant correlations were found between the rating scale scores and the results of the direct testing. These findings do not support the hypotheses that the CEFI-SR subscales would have moderate correlations with the direct testing scores from the NEPSY-II, indicating that the two measures may not be measuring the same constructs.

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CHAPTER 1

INTRODUCTION

Context

Early investigations into the functions of the frontal lobes of the brain began as far back as the 1840s. At that time, ‘executive function’ was not the term being used, but there was mention of a control mechanism within the brain (Goldstein, Naglieri, Princiotta, & Otero, 2014). In 1848, a 25-year-old railroad worker by the name of Phineas P. Gage sustained a severe brain injury when a tamping iron was propelled through his left cheek and left frontal lobe destroying a majority of this portion of the brain (Harlow, 1848). This incident became one of the most widely known case studies associated with executive function and frontal lobe damage. Gage experienced a drastic change in his personality; he became rude and unpredictable; and he seemed to lose an understanding of social conventions (Damasio, Grabowski, Frank, Galaburda, & Damasio, 1994). His behavior was described as immature and impulsive after the injury, which implied a lack of inhibition, a trait often found in those who sustain damage to the prefrontal cortex of the brain (Pribram, 1973).

The case of Phineas Gage, along with others, lead researchers to further investigate the role of the prefrontal cortex, which would later be recognized as the seat of executive function (Hale & Fiorello, 2004; Miller & Cohen, 2001). Alexander Luria derived many of his theories from observing individuals with frontal lobe damage. Luria has been credited with writing the first definition of executive function, but he credited the description to Bianchi (1895) and the writings of Bekhterev (1905). This definition described executive function as, “the ability to maintain an appropriate problem-solving set for attainment of a future goal" (Welsh & Pennington, 1988, pp. 201-202; many researchers credit this definition to Welsh and Pennington (1988), but Welsh and Pennington credit it to Luria (1966) (Barkley, 2012)). Barkley (2012) argued that this definition is inadequate to use as an operational definition, however, because the use of ambiguous terms such as "ability" and "appropriate" makes it difficult to determine what components, functions, and processes should actually be considered 'executive'.

Pribram (1973) was one of the first to use the term 'executive' when writing about the functions of the prefrontal cortex. His research was based on the brains of primates and what happened when there were lesions in different areas of the prefrontal cortex. He was also one of the first to stress the importance of studying the functions of the prefrontal cortex in context, noting the importance of the connections between the cortex and other parts of the brain. Pribram's research was important because it allowed for the controlled study of behavior following a lesion or direct stimulation to a specific area of the brain. This differed from observational research done with humans who had sustained brain injuries, where the localization of the brain injury was less clear.

Since the early studies on frontal lobe damage, executive function has become an umbrella term used to describe the cognitive processing that occurs in the prefrontal and frontal lobe areas of the brain. A review of the literature on executive function reveals that there is no single, agreed-upon definition of the concept (Barkley, 2012; Goldstein et al., 2014). In fact, executive function is a concept for which there are currently many definitions and models that vary, if only slightly, in the way the term is described. Some researchers chose to define executive function in terms of the skills it entails, such as planning/organization, working memory, attention, inhibition, self-monitoring, self-regulation, and initiation (P. Anderson, 2002; Banich, 2009; Baron, 2004; Burgess, 1997; Crone, 2009; Roberts & Pennington, 1996; Royall et al., 2002). One problem with defining executive function in this way is that there are at least 33 constructs that have now been attributed to this umbrella term throughout the research literature (Eslinger, 1996). An additional problem with this method is that within these definitions, there is no clear explanation for why or how these skills relate to each other (Barkley, 2012).

Others have chosen to define executive function as a unitary control center for other cognitive, emotional, and/or behavioral processes (Baddeley, 1996; Butterfield, Albertson, & Johnston, 1995; Fuster, 1997; Luria, 1966; Miller & Cohen, 2001; Naglieri & Goldstein, 2014; Posner & Snyder, 1975; Pribram, 1973; Robbins, 1996; Shallice, 1988; Shiffrin & Schneider, 1977; Welsh & Pennington, 1988). It has become more common for researchers to define executive function as consisting of fractionated, but related, skills that act together to guide goal-directed behavior. More generally, executive function has been conceptualized as a set of similar but separate cognitive processes that control and manage other cognitive processes in order to achieve desired goals (P. Anderson, 2002; Barkley, 2012; Best, Miller, & Jones, 2009; Borkowski & Burke, 1996; Corbett, Constantine, Hendren, Rocke, & Ozonoff 2009; Dawson & Guare, 2010; Denckla, 1996; Friedman et al., 2007; Gioia & Isquith, 2004; Gioia, Isquith, Guy, & Kenworthy, 2000; Oosterlaan, Scheres, & Sergeant, 2005; Shallice, 2002; Stuss & Benson, 1986; Vriezen & Pigott, 2002). This definition combines the aspects of listing the skills with the idea that these skills control other cognitive processes in order to guide goal-directed behavior. When looking at all the definitions as a whole, there is a central theme throughout the literature: executive function exerts control over automatic responses using a set of overlapping cognitive abilities associated with the prefrontal cortex and interconnected subcortical systems in order to regulate goal-directed behavior (Stuss, 1992; Zelazo, Carter, Reznick, & Frye, 1997).

Assessing Executive Function

The fact that there is no agreed upon definition of executive function makes it a difficult construct to measure. Current approaches to directly measuring executive functions have been met with a number of criticisms for various reasons. One reason is that executive function tests tend to be complicated, with multi-faceted tasks that can tap a number of processes, both executive and non-executive (P. Anderson, 2002; V. Anderson, 1998). Executive functions act by operating on other cognitive processes. Therefore, assessments used in an attempt to measure a specific executive function may be affected by the other cognitive processes on which the executive function is acting (Miyake, Emerson, & Friedman, 2000; Miyake et al., 2000). Test specificity can be low, and it can be difficult to determine the reason for why a child may have performed poorly (Kinsella, Storey, & Crawford, 2007). Attempts have been made to rectify this issue by utilizing a micro-analytic approach to assessing performance. Measures can incorporate numerous aspects of performance such as success/failure, latency, number of errors, as well as behavioral observations into the scoring. Scoring systems of this nature "enhance the diagnostic utility of EF tests" (P. Anderson, 2002, p. 74).

Another criticism of executive function measures is that there are too many from which to choose. Because executive function is said to encompass a range of skills, tests of executive function have developed to include a variety of tasks designed to assess different facets of executive function. There is a lack of consensus among researchers about the best way to assess executive function (Miyake et al., 2000). A review by Weyandt et al. (2014) found 164 different measures used to evaluate executive function.

A final criticism of direct measures of executive function is that there are often inconsistencies between behaviors exhibited during testing and those in real life (P. Anderson, 2002; Chan, Shum, Toulopoulou, & Chen, 2008). Direct measure of executive function should entail assessing an individual's ability to guide his or her behavior through novel, unstructured, and non-routine situations that require some level of judgment (Banich, 2009). This is difficult to do in clinic and laboratory settings, though, because they are designed to be highly structured and involve explicitly explaining what the task is and the rules needed to succeed. The artificial setting of a clinic, office, or laboratory may assist in hiding any executive dysfunction that may be happening in real life (Kinsella et al., 2007). Despite the drawbacks of direct assessment of executive function, studies have found that there is a significant relationship between one-to-one testing procedures and academic achievement in children of various ages, with and without learning disabilities (Best et al., 2009; Best, Miller, & Naglieri, 2011). Therefore, direct assessment measures can be helpful for identifying deficits and planning interventions, but information should be gathered from additional sources if diagnostic decisions are to be made.

Because the capacity of neuropsychological assessment data to predict daily behaviors is modest (Sbordone, 2000), it is important to include other means of assessing executive function into the evaluation process (P. Anderson, 2002; Naglieri & Goldstein, 2014). Other ways to evaluate executive function incorporate family and school interviews, behavioral observations, and rating scales such as the Behavior Rating

Inventory of Executive Function (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000) or the Comprehensive Executive Function Inventory (CEFI, Naglieri & Goldstein, 2013) (P. Anderson, 2002, Dawson & Guare, 2010). Some argue that rating scales are better than direct assessment for evaluating executive function because they look at real life situations and factor in the social aspect of executive function (Barkley, 2012).

Concurrent, Criterion Validity in Measures of Executive Function

In psychological measurement, validity is a term used to describe the extent to which empirical evidence supports an interpretation of scores representing a construct (Naglieri & Goldstein, 2014). In the *Standards for Educational and Psychological Testing,* validity is described as "the most fundamental consideration in developing and evaluating tests" (AERA, APA, & NCME, 1999, p. 9). Determining the validity of a measure of executive function can be difficult, however, because there are so many definitions and models for the construct. Thus, "the author of any measure of executive function defines the concept by the questions that are included" (Naglieri & Goldstein, 2014, p. 163). Because of the variability in the way the concept is defined and assessed across different measures, the validity is that much more difficult to establish.

The *Standards* publication indicates that construct validity is the principal component in validation work, and in order for a measure to claim to have validity, there must be multiple sources of evidence (AERA et al., 1999). Construct validity encompasses five sources of evidence crucial to determining the validity of the utility of a measure's scores and the interpretations that can be made from those scores. These sources are "(1) evidence based on test content, (2) evidence based on response process, (3) evidence based on internal structure, (4) evidence based on relations to other variables, and (5) consequences" (Chan, 2014, p. 12). This study aimed to provide "evidence based on relations to other variables," which is assessed by investigating a measure's criterion-related (concurrent and predictive) validity as well as convergent and discriminant validity.

Criterion validity of a measure can be concerned with one of two things, whether the measure can accurately predict a future behavior or whether a measure is meaningfully related to some other well-established measure of the same construct (Goodwin, 2009). For the purposes of this study, the second definition of criterion validity was used to assess the utility of the CEFI-SR. Concurrent validity is a specific type of criterion validity that is established when the scores from a new measurement procedure (CEFI-SR) are directly related to the scores from a well-established measurement tool for the same construct (NEPSY-II) when the two measures are administered at, or around, the same time (Haynes, Richard, & Kubany, 1995). "Concurrent evidence, which avoids temporal changes, is particularly useful for psychodiagnostic tests or to investigate alternate measures of some specified construct," (AERA et al., 1999, p. 14) so for this study, the CEFI-SR and the NEPSY-II were the alternate measures used to collect concurrent evidence supporting the interpretation of the test scores derived from this executive function rating scale.

Statement of Purpose

Executive functions are crucial for meeting demands in the classroom and completing daily life activities. Executive function difficulties manifest in the classroom as inefficiencies with work, difficulty expressing and showing knowledge, poor study skills, weak test performance, and academic grades that do not echo actual intellectual ability (Meltzer, 2010). In addition to academic impairments, deficits in executive function are present in a number of internalizing and externalizing forms of psychopathology. Because executive functioning can have such a great impact on schooling and other areas of life, it is important to be able to measure executive function accurately with valid assessment measures. Once a person's areas of weakness have been identified, interventions can be put in place to remediate and foster the growth of these skills.

The current research study was designed to investigate the concurrent, criterion-related validity of the CEFI self report (CEFI-SR). More specifically, this study sought to compare adolescents' reports about their own executive functioning skills (using the CEFI-SR) to scores from a direct testing measure of executive function, the NEPSY-II. Attention, inhibitory control, self-monitoring, flexibility, and working memory were the domains of executive function focused on in this study. These domains were chosen because they were the self-regulatory components of Barkley's (2012) model of executive function. This model will be discussed in greater detail in the literature review portion of this paper. The only component of Barkley's (2012) model that was not investigated was emotional control. It was omitted because it was not possible to directly assess. Outcome measures in this study were student responses to the CEFI-SR rating scale and scores earned on three subtests from the NEPSY-II (Animal Sorting, Auditory Attention/ Response Set, and Word List Interference).

It was hoped that results from this study would ultimately inform assessment decisions for those who aim to measure executive function in adolescents. Having this information allows test administrators to decide whether this measure should be used as part of an assessment battery.

Research Questions and Hypotheses

This study addressed the following research questions:

Question 1: Does the attention subscale of the CEFI-SR have concurrent, criterion-related validity when compared to direct assessment of attention using the NEPSY-II?

> Hypothesis 1: The results from the Attention subscale of the CEFI-SR will be correlated with scores earned during the Auditory Attention and Response Set subtest of the NEPSY-II. If the Attention subscale of the CEFI-SR has concurrent, criterion related validity, then a strong correlation will be found between these two measures.

Question 2: Does the Inhibitory Control subscale of the CEFI-SR have concurrent, criterion-related validity when compared to direct assessment of Inhibition using the NEPSY-II?

> Hypothesis 2: The results from the Inhibitory Control subscale of the CEFI-SR will be correlated with the total number of inhibitory errors committed during the administration of the Auditory Attention and Response Set subtest of the NEPSY-II. If the Inhibitory Control subscale of the CEFI-SR has concurrent, criterion related validity, then a strong correlation will be found between these two measures.

Question 3: Does the Self-Monitoring subscale of the CEFI-SR have concurrent, criterion-related validity when compared to direct assessment of self-monitoring using the NEPSY-II?

Hypothesis 3: The results from the Self-Monitoring subscale will be correlated with scores based on the total number of errors committed during the Animal Sorting subtest of the NEPSY-II. If the Self-Monitoring subscale of the CEFI-SR has concurrent, criterion related validity, then a strong correlation will be found between these two measures.

Question 4: Does the Flexibility subscale of the CEFI-SR have concurrent, criterion-related validity when compared to direct assessment of cognitive flexibility with problem solving using the NEPSY-II?

Hypothesis 4: The results from the Flexibility subscale will be correlated with scores based on the total number of correct sorts earned during the Animal Sorting subtest of the NEPSY-II. If the Flexibility subscale of the CEFI-SR has concurrent, criterion related validity, then a strong correlation will be found between these two measures.

Question 5: Does the Working Memory subscale of the CEFI-SR have concurrent, criterion-related validity when compared to direct assessment of working memory using the NEPSY-II?

Hypothesis 5: The results from the Working Memory subscale will be correlated with scores earned during the Recall portion of the Word List Interference subtest of the NEPSY-II. If the Working Memory subscale of the CEFI-SR has concurrent, criterion related validity, then a strong correlation will be found between these two measures.

CHAPTER 2

REVIEW OF SELECTED LITERATURE

Models of Executive Function

Models of executive function have been developed on the basis of various frameworks including information processing theory, behavior analysis, neuroimaging and brain studies, factor analytic studies, and genetics. Early models of executive function started to arise in the 1950s after Broadbent (1958) introduced his filter model. Through his experiments, he hypothesized that in the presence of competing stimuli, a filter within the brain acted to determine the relevancy of incoming information. Information that was deemed irrelevant was ignored (Broadbent, 1958). He believed that without this filter, one could become overloaded with information. He was also one of the first to make the distinction between automatic and controlled processes (Broadbent, 1958). Shiffrin and Schneider (1977) used this idea of automatic versus controlled processes as the basis for their model. They developed a dual processing theory, with the two parts being automatic processing and controlled processing. Automatic processes were described as those that did not require active attention or control. They were effortless and quick connections that were developed through training and practice. Controlled processes, on the other hand, were those that required conscious effort and attention. They postulated that with repeated practice, controlled processes could become automatic practices, therefore, requiring fewer attentional resources (Shiffrin & Schneider, 1977).

Posner and Snyder (1975) expanded on Broadbent's ideas about the filter as well as automatic versus controlled processes in the creation of their model of "cognitive control." According to the model, cognitive control was a process that guided attention and behavior and acted to inhibit automatic responses during higher-level tasks. It expanded upon Broadbent's model with the addition of the idea that the controlled processes could act to inhibit the automatic processes. Posner and Snyder (1975) argued that cognitive control allowed the individual to remain flexible in varying situations depending on one's goals. Shallice (1988) also theorized that there was a Supervisory Attentional System that regulated attention and allowed for an over-ride of automatic responses. His model was called the contention scheduling/supervisory attentional system. Both parts of this model involved inhibition. Contention scheduling referred to the control system that allowed for the inhibition of competing actions when selecting an action to perform. The supervisory attentional system functioned in non-routine situations that required inhibition in order to make a decision during a novel encounter. Overall, all of these early theorists (Posner & Snyder, 1975; Shallice, 1988; Shiffrin & Schneider, 1977) developed models based on Broadbent's original theories that the brain contains a filter that acts to help determine what is relevant and take action. They also built on his theory that the brain completes automatic and controlled processes. The later models incorporate these two ideas to state that the brain has some type of control system (filter) that assists in inhibiting automatic processes when making decisions and performing actions.

Pribram (1973) used monkeys to study the effects of direct stimulation to specific areas within the prefrontal cortex. Through his work, he discovered that the dorsolateral frontal cortex had the ability to control visual information processing by affecting the direction of attention. This was physiological support for the theories discussed above. It showed that there was a control mechanism present in the frontal lobes that could control more automatic processes. From his work with monkeys, he also discovered that those with frontal lobe lesions did not process the consequences of their behavior in the same way as the monkeys who did not have lesions (Pribram, 1973). It took them much longer to learn from mistakes, if they were able to learn at all. He concluded from this work that damage to the fontal cortex resulted in difficulty maintaining attention and registering novelty so that habituation could take place, as well as an inability to learn from the feedback of actions, making reinforcers relatively ineffective (Pribram, 1973). Pribram's work connected the filter theory, dual processing theory, and the theory of cognitive control to a specific location within the brain. He showed that there was a controlling feature of the frontal lobes that, when damaged, impacted the brain's ability to inhibit automatic responses or to turn automatic responses into controlled responses through practice and learning.

Baddeley (1996) also included in his model the idea of a central control structure he called the central executive. He created a multi-component model of working memory. Within this model, there were two components specialized for the maintenance of speech-based, phonological information (phonological loop) and visual and spatial information (the visuospatial sketchpad). These two systems worked under the control of the central executive. Baddeley also believed that Shallice's (1988) Supervisory Attentional System might be the same controlling system that he wrote about in his model.

Miyake et al. (2000) initially investigated Baddeley (1986) and Shallice's (1988) models involving the central executive or the Supervisory Attentional System, but looking at these models in conjunction with a series of studies that investigated individual differences in executive function, they determined that the functions of the frontal lobe may not be unitary and should be fractioned into different domains of executive functioning. In order to test this theory, Miyake et al. (2000) conducted an individual differences study focusing on three executive functions, shifting, working memory, and inhibition. Using confirmatory factor analysis, Miyake et al. (2000) concluded that the three skills were distinguishable but not completely independent. In other words, shifting, working memory, and inhibition were determined to be separate but moderately correlated skills, indicating that there was both unity and diversity within executive function (Miyake et al., 2000). These results supported the movement away from the idea of one central executive that controls all cognitive processes toward a fractionated model in which different executive functions with some underlying commonality work together to guide goal-directed behavior.

Similar to Miyake et al. (2000), Naglieri and Goldstein (2014) formulated their model of executive function from a factor analytic study of a large, representative sample of children and adolescents. This theory posited that executive function could be conceptualized as the "efficacy with which individuals go about acquiring knowledge as well as how well problems can be solved across nine areas (attention, emotion regulation, flexibility, inhibitory control, initiation, organization, planning, self-monitoring, and working memory)" (Goldstein et al., 2014, p. 4). Their model differed from that of Miyake et al. (2000) in that Naglieri and Goldstein (2014) concluded from their results that one, unitary factor explained the relationship between the executive function-related behaviors they were studying across the nine content areas.

Fuster (1997) developed an earlier model that also postulated that executive function was composed of differing components. This model of cross-temporal synthesis was based on three concepts, inference control, focused attention that involved resistance to distraction; planning; and working memory. This model postulated that executive function acted through these three components in order to structure goal-directed behavior. One central assumption of this model was that goal-directed action often involved periods of delay between events, responses, and goals and their associated consequences. These delays required an internal means of linking the components in this contingency. Fuster (1997) argued that these internal representations of the event, response, and goal/consequences were the means through which goal-directed behavior was achieved, and it was through the three components of executive function in this model that give rise to the mental representations. Once a goal comes to mind, the temporal integration activities of the frontal lobes construct cross-temporal chains of behaviors necessary to attain the goal. If interrupted, executive functions must also act to problem-solve the current mental manipulation to work around any interruption (Fuster, 1997).

Stuss and Benson (1986) also developed a model in which executive function was discussed as being composed of four main components: anticipation, goal selection, preplanning, and monitoring through the use of feedback. This model explained how these components fit into a hierarchical model. At the bottom of the hierarchy, are the components of ‘drive’ and ‘sequencing’. These two components are not considered executive functions in this model but they are governed by the four components of executive function listed above. Drive is composed of drive, or the basic appetitive states;

motivation, or the mental/intellectual control of the drive states; and will, which represents consciously conceived wants or desires. Sequencing is involved in organizing and maintaining information into meaningful sequences, the capacity to form sets of related information, and the capacity for the integration of a number of related and unrelated sets of information into novel knowledge. Drive and sequencing are believed to govern the nonexecutive functional systems, such as attention, alertness, visual-spatial, emotional, memory, sensory/perception, language, motor, and cognition (Stuss & Benson, 1986).

At the highest level of this model, Stuss and Benson (1986) placed the attribute of self-awareness. Therefore, this hierarchical model was ranked as follows: self-awareness at the top having control over all of the lower level functions. The next step down was the executive function level of anticipation, goal selecting, preplanning, and monitoring through the use of feedback. This level became active in novel situations to assist with problem solving and decision-making. These executive functions acted by governing over a person's drive and sequencing, and lastly, the level of drive and sequencing govern over the nonexecutive functional systems (Stuss & Benson, 1986). This model built on the prior theories and went on to define some skills involved in successful executive function.

Banich's model of executive function (2009) was also hierarchical in nature. It was based on functional neuroimaging studies conducted while implementing tasks that target specific executive function skills. The model suggested that executive function involved a temporal cascade of selection processes that are implemented in distinct locations within the prefrontal cortex. This theory stated that the process through which executive function was applied to a task began in the posterior regions of the dorsolateral prefrontal cortex (DLPFC). This region was activated to create an attentional set. The mid-DLPFC was then activated to determine what incoming information was relevant to the task. Posterior portions of the dorsal anterior cingulate cortex (ACC) were activated when a person was deciding how to respond, specifically when there were two competing responses. The last portion of the temporal cascade activated the anterior regions of the dorsal ACC when a person engaged in response evaluation (Banich, 2009). An important aspect of this model was that the degree to which the executive-control mechanisms were active depended on the efficacy of the control functions applied in the earlier portions of the cascade. Therefore, the ACC would not need to exert as much energy if the DLPFC was successfully able to control impulses.

Borkowski and Burke (1996) developed an alternate perspective of executive function based on information-processing theory. These researchers described executive function as a set of three problem solving components, task analysis, strategy selection and revision, and strategy monitoring. Other researchers have also opted for this information-processing approach to defining executive function. Butterfield et al. (1995) viewed executive function as being one of three components of brain funcitoning, the other two being cognition and metacognition. In their model, cognition was a person's store of knowledge and strategies in long-term memory that were vital for effective problem solving. Metacognition was the level at which there was an understanding of how all of a person's knowledge and strategies interconnect. Executive function worked to coordinate these two levels by monitoring and controlling the use of knowledge and strategies in concordance with the metacognitive level. Both of these models involved identifying and defining a problem, selecting a way through which to approach the problem, and assessing the outcomes of the chosen method of problem solving. What made these models different from those discussed above was that they did not include inhibition as being a contributing factor to the concept of executive function. There was a greater focus on problem solving through goal-directed action.

Hayes, Gifford, and Ruckstuhl (1996) also took a different approach to the conceptualization of executive function by describing the term through a behavior analytic framework. They theorized that executive function was a subset of rule-governed behavior. In other words, executive function was behavior that was controlled by verbalizations, either self-directed or from others. In this model, executive function was necessary when in new situations where previously learned behavior regulation came into conflict with the rules of the new task at hand. The new task rules competed with previously learned, well-practiced, automatic behaviors. The automatic behavior had to be interrupted and delayed to allow the person to learn the new rule or decide whether a different, previously learned rule might apply to the new task. Therefore, during tasks that required executive function, a person had to implement a rule in order to inhibit the automatic response, and then either select an appropriate previously learned rule or generate a new one specific to the novel task. The person must then follow the chosen rule, adhere to it, and track the effectiveness of the rule. With this model, the language changed, but the same general idea that executive function involved the inhibition of an automatic response in favor of a more appropriate behavior in novel situations remained the same.

More recently, researchers have been focusing models on the self-regulatory aspect of executive function and goal-directed behavior (Barkley, 2012; Hofmann, Schmeichel, and Baddeley, 2012). Barkley (2012) developed a model through which he hoped to clarify the operational definition of executive function. His model was based on the theory of the extended phenotype and focused on the importance of self-regulation in the social and cultural environment. He argued that there were several components of executive function because there were several different actions that one could direct at oneself to control behavior. Therefore, the different components of executive function were different types of self-regulation. These components of executive function developed as a result of two processes, the self-direction of actions and their internalization. Barkley (2012) stated, “It is the self-direction of human actions that makes an act, function, or component executive in nature” (p. 174). The model identified six self-directed actions used during self-regulation, including attention, inhibition, working memory, self-monitoring through private speech, emotional control, and flexibility of problem solving (Barkley, 2012).

Aside from identifying the components of executive function, Barkley’s (2012) model used the extended phenotype framework to examine the radiating effects of executive function outside of the self. The theory of the extended phenotype postulated, as Barkley (2012) described it, that a person’s phenotype could not be limited to protein synthesis and outward appearance. It extended to include all of the effects a gene could have on an environment. In other words, genes impacted the production of proteins and enzymes, which in turn affected a person’s bodily structures and functions, this then affected the way a person acts, a person’s behaviors could then influence other people and ultimately affect another person's behavior. Because of this theory, Barkley (2012) argued that the study of executive function had to extend past an individual's abilities to self-regulate and into how someone's executive functions impacted his social and cultural environment.

> Working within this framework, Barkley (2012) defined executive function as: the use of self-directed actions so as to choose goals and to select, enact, and sustain actions across time toward those goals usually in the context of others often relying on social and cultural means for the maximization of one's longer-term welfare as the person defines that to be. (p. 176)

Due to the explicit nature of this definition and its inclusion of the environmental context, this was the operational definition of executive function used for the purposes of this study. This definition was chosen because it incorporates the components of executive function that have been supported in other models (attention, inhibition, working memory, self-monitoring, emotional control, and flexibility of problem solving), clearly comments on the use of these self-directed actions in goal-directed behavior, and incorporates the understanding that a person's executive functions can have an impact on and be impacted by the environment.

Development of Executive Function in Adolescents

Through his work, Luria suggested a theory of how executive function develops across the life span. Goldstein et al. (2014) described Luria's developmental perspective of executive function. Luria postulated that the neuropsychological functions necessary for intelligence and executive function developed through a number of stages. Luria argued "higher cortical functions involving EF required interaction of normal neurological development and specific environmental stimuli of a cultural, historical, and social nature of development" (Goldstein et al., 2014, p. 9). This relates to Barkley's (2012) model of the extended phenotype and the argument that more efficient cortical functioning related to executive function develops out of the optimal interaction between brain development and environmental stimuli.

Luria proposed a model consisting of five stages of brain development. Stage one begins in the first year of life, and during that time, brain stem structures, such as the reticular activating system, develop. During stage two, which develops during the second year of life, the primary sensory areas for vision, hearing, and tactile perception develop in addition to the primary motor areas of gross motor movement. During the preschool years, children enter into stage three where they begin to be able to recognize and reproduce symbolic materials through secondary association areas of the brain. When children are 7 to 8 years old, the tertiary areas of the parietal lobes are activated. These areas merge with the temporal parietal and occipital lobes in order to coordinate the three major sensory channels. At this age, the child is better able to make sense of sensory input. This is vital for the development of complex mental abilities. Once a child is 8 years old, he has entered into stage five, which is full activation of the brain including the frontal lobes (Goldstein et al., 2014).

Another well-known model of executive function development was written by Barkley and outlined in Dawson and Guare (2010). This is an earlier Barkley model, and at that time, his model consisted of only five components including inhibition, working memory, internalization of speech, self-regulation of emotion/arousal/motivation, and reconstitution. During the 5 to 12 month range, behavioral inhibition becomes the first skill to develop (Barkley, 2003; Dawson & Guare, 2010). Behavioral inhibition consists of three properties: the ability to inhibit oneself in order to prevent an immediate consequence in favor of later reinforcement, the ability to stop performing a behavior if it is not eliciting the desired response, and the ability to manage distractions and interruptions (Barkley, 2003). Without inhibition using the other executive functions would be difficult. The remaining executive functions develop through a common process of privatizing behaviors that were at one time entirely publicly observable (Barkley, 2003). Barkley (2003) hypothesized that executive function was involved in the following developmental shifts: "from external events to mental representations...; from control by others to control by the self; from immediate reinforcement to delayed gratification; from the temporal now to the conjectured social future" (pp. 83-84).

Soon after the development of behavioral inhibition, children between the ages of 5 to 12 months also develop the capacity for working memory, or holding events in the mind (Dawson & Guare, 2010). This ability to make mental representations relates to the internalization that Fuster (1997) wrote about. "Nonverbal working memory becomes the foundation for the child's ability to make decisions and control behavior..." (Dawson & Guare, 2010, p. 7). Also beginning to develop at as early as five months is emotion and motivation regulation. Later in development, this skill will assist the child in social perspective taking and directing behavior toward long-term goals. The next function to develop is the internalization of speech/self monitoring. This process begins in children between the ages of 3 to 5 years old with behaviors becoming increasingly private and covert until complete internalization is reached by 9 to 12 years old (Dawson & Guare, 2010). The last element of the model to begin developing is reconstitution, or cognitive and behavioral flexibility. Development in this area does not begin until the child reaches

6 years of age. Until children develop these fundamental executive functions, adults scaffold their development using directives, limits, rules, and manipulation of the environment (Dawson & Guare, 2010). In this earlier model, Barkley did not include attention as an executive function. In his most recent model, he argues that the development of self-direction of attention, or attentional control, precedes the existence of all other executive function components. “It must be the first to arise in development and may well be the most important as it serves as a precursor to all other forms of self-regulation” (Barkley, 2012, p. 81).

The models discussed above and many years of research have established that executive function develops across the lifespan. Trietz, Heyder, and Daum (2007) determined through their work that executive function is the one cognitive ability most affected by aging. Executive functions begin to develop in infancy and do not become fully developed until adulthood (Barkley, 2012; Dawson & Guare, 2010). Barkley (2012) postulated that the brain is not fully developed until the third decade of life. This has been supported by studies that have shown that white matter development, through myelination, continues through the third decade of life (Sowell, Thompson, Tessner, & Toga, 2001). Brian growth during development occurs through the generation of neurons and neuroglia. These neurons also develop axons and dendrites in order to be able to communicate. Bundles of axons develop through the process of myelination when a fatty sheath is formed around the axon. The myelin insulates the axon and allows for a more rapid transmission of nerve signals. Myelinated axons make up the white matter of the brain. The process of myelination begins in the earliest stages of development and continues in the frontal lobes until young adulthood, paralleling the time course and development of executive function (Dawson & Guare, 2010). The increase in the white matter in the frontal and parietal cortices during adolescence has been depicted in several neuroimaging studies (Barnea-Goraly et al., 2005; Giedd et al., 1999; Giorgio et al., 2010; Giorgio et al., 2008; Reiss, Abrams, Singer, Ross, & Denckla, 1996). These studies also agree that the change in white matter is a steady, mostly linear, increase through childhood and adolescence.

The development of grey matter in the brain is more complex and follows a pattern of development with periods of increases followed by reductions. Grey matter development goes through stages of progression and regression, and in certain brain regions, development follows an inverted-U shape (Blakemore & Choudhury, 2006). For instance, the fetal brain has about the same number of neurons as an adult brain. In early childhood, following a period of increase, the number of synapses in the brain far exceeds that of an adult brain. The increase in the number of neurons and synapses peaks prior to age 5 while the child is rapidly learning and developing new skills. The brain then goes through a pruning process that allows the child to consolidate skills, and the connections that are not needed or used deteriorate (Dawson & Guare, 2010). Research indicates that changes in grey matter density coincide with the onset of puberty, with the grey matter volume reaching its peak at puberty, followed by a leveling off after puberty, and an eventual decline throughout the remainder of adolescents and into adulthood (Blakemore & Choudhury, 2006).

Research has been able to show a parallel between the development of the brain discussed above and the development of cognitive skills. Studies have shown that executive function skills develop rapidly through childhood with progression occurring in spurts rather than linearly (P. Anderson, 2002; V. Anderson, 1998). Further complicating things, different components of executive function develop at different rates and times (Isquith, Gioia, & Espy, 2004). For instance, Anderson, Anderson, Northam, Jacobs, and Catroppa (2001) showed there was improvement in selective attention, working memory, and problem solving among teens between the ages of 11 and 17, but improvement was not indicated across all of the constructs they assessed. Executive function skills, such as processing speed (Luna, Garver, Urban, Lazar, & Sweeney, 2004), the ability to plan and sequence multistep processes prior to initiating them, working memory and decision making (Hooper, Luciana, Conklin, & Yarger, 2004; Luciana, Conklin, Hooper, & Yarger, 2005) and inhibitory control (Leon-Carrion, Garcia-Orza, & Perez-Santamaria, 2004; Luna et al., 2004), increase during adolescence and on into the early 20s (Steinberg, 2007). Imaging studies have shown that executive function develops from being a less specialized and more localized system to a more distributed network that spans across the cerebral cortex and subcortical regions of the brain (Collette, Hogge, Salmon, & Van der Linden, 2006; Jurado & Rosselli, 2007). As these brain structures develop through the processes of myelination and pruning in the frontal cortex during adolescence (Blakemore & Chodhury, 2006), performance on executive function tasks improves (Giorgio et al., 2010).

Inhibition

Diamond and Taylor (1996) reported that by the age of three years, most children are reasonably able to inhibit automatic responses, but they do still make occasional perseverative errors (Best & Miller, 2010; Espy, 1997). Several studies have found that there may be a rapid period of improvement on tasks that measure inhibition during grade school, with the greatest growth occurring between 5 and 8 years (Romine & Reynolds, 2005), but this has been shown to slow down and even level off during adolescence (Brocki & Bohlin, 2004; Casey et al., 1997; Fischer, Biscaldi, & Gezeck, 1997; Huizinga, Dolan, & Van der Molen, 2006; Jonkman, Lansbergen, & Stauder, 2003; Munoz, Broughton, Goldring, & Armstrong, 1998; Williams, Ponesse, Schachar, Logan, & Tannock, 1999). Anderson, Anderson, and Lajoie (1996) reported that around the age of 11, they found an increase in impulsive behaviors that lasts for a short period of time. This may be the point at which the improvement of the skill begins to level off as more impulsive behavior can lead to poorer performance on measures that assess inhibition skills.

Working Memory

It has been reported that by the age of six years, children possess enough working memory to be able to complete complex tasks that involve various subcomponents of working memory (Gathercole, Pickering, Ambridge, & Wearing, 2004). Gathercole et al. (2004) also found linear increases in working memory skills between the ages of 4 and 14 with a leveling off between 14 and 15 years old. Many working memory studies use different tasks when increasing task complexity, which introduces the potential for confounding variables (Best et al., 2009). In an attempt to counteract this effect, Luciana and Nelson (1998) used only a self-ordered search task, which increased in difficulty across the trials by adding to the number of items to find and not by changing the task. Age differences became evident as the number of search locations increased. Six year olds reached performance maturity with three search locations; maturity was not reached until adolescence for four locations; and with six to eight search locations, maturity was not obtained until adulthood (Lucianna & Nelson, 1998). This finding of linear progression of working memory has further been supported by brain imaging studies. Kwon, Reiss, and Menon (2002) reported age-related increases in brain activity in "focal regions of the left and right dorsolateral prefrontal cortex, left ventrolateral prefrontal cortex (including Broca's area), left premotor cortex, and left and right posterior parietal cortex" during a visuospatial working memory task in a sample of people aged 7 to 22 (p. 13336).

Self-Monitoring

Somsen (2007) conducted a study in which 259 children between the ages of 6 and 18 years old completed the Wisconsin Card Sorting Test. Two aspects of the results indicated that the efficacy of self-monitoring was improving with age. The first was that there was a decrease in the number of perseverative errors that were made. The second was that the latency period following negative feedback increased through adolescence for the children who were performing well, suggesting that the children were taking this time to monitor and change their behavior in order to be successful.

Cognitive Flexibility

Cognitive flexibility is an aspect of executive function that tends to develop later than the other skills (De Luca et al., 2003). Between the ages of three and four years old children have shown the capacity to switch between two response sets when the rules are simple, but they have greater difficulty as the rules become more complex (Espy, 1997). Zelazo and Frye (1998) suggested that the greatest period of growth occurs between the ages of seven and nine and then continues to improve until adolescence. Somsen (2007) was able to show that performance on the Wisconsin Card Sorting Test improved with age, with a linear increase in the number of completed sorting rules until about 11 years of age. This indicated that the older children were better able to come up with alternate ways to solve the problem when the rule was changed, but that this skill development for this task peaks around 11 years. De Luca et al. (2003) had 194 participants ranging in age from 8 to 64 complete a number of tasks from the Cambridge Neuropsychological Test Automated Battery (CANTAB). They too found steady increases in problem-solving skills through 12 years of age.

Overall, studies investigating the development of executive function reveal a pattern of rapid growth in skills between ages 5 and 8 that becomes more moderate in late childhood. The rate at which skills are acquired diminishes but continues gradually through adolescence and into adulthood (Best et al., 2011; Romine & Reynolds, 2005).

The Impact of Genetic and Environmental Factors

A number of influences can impact the development of executive functions. It is believed that inherited genes in addition to the biological and social environment in which the child is growing can affect whether executive functions develop through a normal trajectory (Dawson & Guare, 2010). If a child's parents are disorganized or have poor attentional skills, it is likely that the child will as well. Anokhin, Golosheykin, Grant, and Heath (2010) conducted a twin study in which 747 adolescents were assessed using the Wisconsin Card Sorting Test at the age of 12 and again at 14. It was determined that familial influences did not impact performance at 12 but had a significant effect on the performance at 14. When they investigated gender, they concluded that environmental influences had the greatest impact on the boys in the study and genetic factors had the greatest impact on females (Anokhin et al., 2010). Friedman et al. (2008)

also conducted a twin study with 582 individuals to investigate the heritability of executive functions. From their results, they concluded that "individual difference in executive functions are almost entirely genetic at the level of latent variables, placing them among the most heritable psychological traits, possibly even more heritable than IQ" (Friedman et al., 2008, p. 216). Others are not as confident that it is genetics alone that are having the impact on development.

It has been reported that genetic vulnerability is expressed among those who have been exposed to stressors like strict parenting or family disarray (Asbury, Dunn, Pike, & Plomin, 2003; Asbury, Wachs, & Plomin, 2005). An increasing body of literature has indicated that the quality of parenting relates to performance on task of executive function in young children (Bernier, Carlson, &Whipple, 2010; Bibok et al., 2009; Hughes & Ensor, 2009). Hughes and Ensor (2009) found that family chaos was associated with a lack of executive function improvements between the ages of 2 and 4. Additionally, they reported that "individual differences in the extent to which mothers engaged in open-ended questions, praise, encouragement, or elaborations during a structured activity predicted individual differences in children's EF performance at age four" (Hughes & Ensor, 2009, p. 47). Some studies suggest, however, that parental impacts on executive function may be more strongly linked to socioeconomic status. Bernier, Carlson, Deschenes, and Matte-Gagne (2012) found that significant relationships between parenting and attachment and impulse control in three years olds was better explained by SES and child language.

There is a great deal of research investigating the link between cognitive ability and academic achievement and SES, but there is a much smaller pool of research about the link between SES and neurocognitive effects (Hackman & Farah, 2008). Farah et al. (2006) conducted a study with middle school children and found significant differences in working memory and cognitive control across SES groups. These skills appeared to be better developed among the teens from middle SES families when compared to low-SES families. This has also been supported by brain imaging studies. Tomarken, Dichter, Garber, and Simien (2004) found there to be a reduction in the activity of the left-frontal regions of the brains' of adolescents from lower-SES homes. Sarsour et al. (2010) reported that the effect of family SES on impulse control in school age children can be further impacted by the family structure, with the children from low-SES, single parent homes performing worse than children from low-SES, two parent homes. As a whole, this research indicates that the full impact of genetics and environment is unclear and interrelated. Some argue that genetics have the most profound effect whereas others argue that it is the environment that affects the ways the genes are expressed, so it is difficult to parse out which has the greatest effect.

Executive Function and Academics

Executive function is crucial for meeting demands in the classroom and completing daily life activities. Succeeding in an academic environment requires the coordination and integration of many sub-skills in addition to the having the flexibility necessary for shifting back and forth between focusing on the theme to looking at the details. Therefore, any deficits in these areas of executive function can have a significant impact on the accuracy and efficiency with which students are able to perform (Meltzer, 2010). Meltzer (2010) uses the analogy of the clogged funnel to illustrate the impact of weak executive function on academic performance. Students who are experiencing deficits in executive function struggle to plan, organize, and prioritize causing the incoming information to clog the top of the funnel. These students are not able to process information quickly enough and fail to shift approaches flexibly, making it difficult for them to unclog the funnel and produce a finished product. These students often experience an overload of information causing the input to exceed the output (Meltzer, 2007).

Executive function difficulties manifest in the classroom as inefficiencies with work, difficulty expressing and showing knowledge, poor study skills, weak test performance, and academic grades that do not echo actual intellectual ability (Meltzer, 2010). Specific tasks that prove to be most difficult for students struggling with executive function include summarizing information; note taking; studying; initiating, planning for, executing, and completing assignments in a timely manner; sustaining attention in the classroom or when working on assignments or tests; and remembering to turn in homework, to name a few. As curricular demands increase in higher grades, student deficits in these areas become more apparent (Meltzer, 2010).

Studies have shown that performance on inhibition and working memory tasks consistently relates to mathematics and reading performance (Blair & Razza, 2007; Brosnan, 2002; Bull & Scerif, 2001; Protopapas, Archonti, & Skaloumbakas, 2007; St. Clair-Thompson & Gathercole, 2006; van der Schoot, Licht, van der Sluis et al., 2007). A study by Sikora, Haley, Edwards, and Butler (2002) suggests that difficulties in these areas of executive function may be greater for children who struggle with math more so than children who are having problems with reading. Specifically, children who struggle to keep important information in working memory, have difficulty ignoring distractors, and fail to adapt when alternative strategies are needed have been found to also have difficulty using and evaluating strategies to solve math problems (Blair & Razza, 2007; Bull & Scerif, 2001; St. Clair-Thompson & Gathercole, 2006; Visu-Petra, Cheie, Benga, & Miclea, 2011). It appears that different math skills can be impacted by deficits in different executive functions. For instance, Best et al. (2011) determined that applied problem solving and word problems were affected by complex executive function (strategy formulation and implementation and self-monitoring) more so than basic calculation. Lamaire and Lecacheur (2011) reported that children with stronger working memory skills perform better in arithmetic. Additionally, they found that impairments in inhibition and cognitive flexibility were related to difficulties with strategy selection.

Similar to the way executive functioning affects math, different reading deficits may relate to different executive function deficits. Seventh grade children diagnosed with dyslexia have displayed poorer inhibition skills when assessed using a Stroop interference task (Protopapas et al., 2007). More specifically, van der Schoot et al. (2000) found that 9 to 12 year olds who had been diagnosed as dyslexic guessers, or children who spelled words rapidly but incorrectly, had more difficulty ignoring the distractors during a Stroop task and made more incorrect moves on a Tower task. Those who had been identified as dyslexic spellers, children who could spell accurately but very slowly, did not show signs of the same inhibition problems. This study indicates that executive function difficulties may not be present for every child diagnosed with dyslexia, but deficits in executive function in addition to dyslexia may make reading related tasks more difficult (Best et al., 2009). Brosnan et al. (2002) also found inhibition to be impaired for groups of students with dyslexia when compared to peers without dyslexia. In addition to inhibition deficits, the samples with dyslexia also had lower scores on a digit span working memory task, earning significantly lower scores on the whole test as well as the parts separately (digits forward and digits backward). Gioia, Isquith, Kenworthy, and Barton (2002) also found that children with reading disabilities were reported by their parents on the BRIEF to have impairments in inhibitory control, organization and planning, and working memory. Working memory was also found to be impaired in a sample of teens with reading disability (Rucklidge & Tannock, 2002).

Cutting, Materek, Cole, Levine, and Mahone (2009) compared typically developing children to children with general reading disability and those with specific reading comprehension deficits. Their results further supported those discussed above. Both groups of children with reading difficulties scored significantly lower than typically developing peers on measures of planning, inhibition, and self-monitoring. On the inhibition task, the children with reading comprehension problems scored significantly lower than the typically developing children and those with general reading disability. The two groups of children with reading problems performed equally poorly on the task of planning, inhibition and self-monitoring. The children with general reading disability also showed poorer performance on a task of working memory when compared to typically developing peers, but the finding was not significant ($p = 0.06$).

Executive Dysfunction and Adolescence

Executive dysfunction is a term that is used to refer to deficits in one or more areas of executive function. Because there are many different skills encompassed under the umbrella of executive function, deficits can manifest in a variety of presentations (P. Anderson, 2002). Executive function problems are common among children with psychological difficulties (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). The next section will provide a brief review of the literature related to executive function deficits that occur in relation to several childhood disorders, including externalizing and internalizing disorders, developmental disabilities, and traumatic brain injury.

Externalizing Behaviors and Disorders

As children enter into adolescence, they become two to three times more likely to experience injury or death (Pharo, Sim, Graham, Gross, & Hayne, 2011). This increased risk is believed to be the result of heightened hazardous behavior such as driving, underage drinking, drug taking, smoking, and unprotected sex. Researchers believe that the reason some teens engage in more risky behavior than others may be due to individual differences in the development of the frontal lobes and more specifically, the executive functions of impulse control, self-monitoring, and planning (Pharo et al., 2011). Pharo et al. (2011) determined that adolescents who earned lower scores on a neuropsychological battery participated in greater levels of risky behavior than individual who scored higher on the same battery. This study is support for the theory that the adolescent brain's inhibitory system is not fully developed enough to be able to counteract the demands of the excitatory or sensation-seeking systems, resulting in an increase in risk taking behaviors (Romer et al., 2011; Steinberg, 2007). Romer et al. (2009) also reported that deficits in inhibition play a large part in the emergence of both externalizing and health-risk behaviors.

Attention Deficit Hyperactivity Disorder (ADHD)

Attention Deficit Hyperactivity Disorder is the most commonly diagnosed disorder in child and adolescent psychiatric settings (Smith, Pelham, Gnagy, Molina, &

Evans, 2000). According to the American Psychiatric Association (2013), 3-7 % of school-age children have been diagnosed with this disorder, which is characterized by developmentally inappropriate levels of impulsivity and hyperactivity in addition to deficits in attention. It is important to note, however, that individuals with ADHD vary greatly in the "degree of symptoms, functional impairments from these symptoms, domains of impairment, age of diagnosis, response to treatment, and psychiatric comorbidity" (Antshel, Hier, & Barkley, 2014, p. 107). Barkley (1997, 2003) argued that problems with self-regulation, or executive function, are fundamental to ADHD and result in the outward behavioral symptoms upon which a diagnosis of the disorder is based.

Barkley first introduced his executive function theory of ADHD almost 20 years ago (1997). At that time, he argued that behavioral inhibition, self-control, and executive functioning were overlapping abilities and that self-regulation and inhibition were vital for executive function to act. In the original theory, response inhibition was essential to executive function because it provided a necessary delay in automatic responding. This delay gave executive functions the time needed to monitor, interrupt, and guide behavior toward goals (Antshel et al., 2014).

> Within Barkley's model, behavioral inhibition consists of three processes: (a) inhibiting the initial prepotent (dominant) response to an event so as to create a delay in responding, (b) interrupting an ongoing response that is proving ineffective thereby permitting a delay in and reevaluation of the decision to continue responding, and (c) protecting the self-directed (executive) responses that will occur within these delays as well as the goal-directed behavior they generate from disruption by competing events and responses (interference control or resistance to distraction). (Antshel et al., 2014, p.108)

It was Barkley's belief that ADHD arose out of deficits in behavioral inhibition and that improving inhibition would result in improvement in the other areas of executive function (2003). It was believed that deficits in behavioral inhibition were the result of genetic and neurodevelopmental origins, but social factors had an influence on expression. Lastly, Barkley (2003) wrote that the secondary deficits in the other areas of executive function resulting from the primary deficit in behavioral inhibition could make problems with behavioral inhibition worse. Behavioral inhibition is so vital to self-regulation because without inhibition causing the delay to what would be an impulsive, automatic response, one would not have the time to direct actions towards oneself. "Without this initial response delay, however, the [executive functions] are poorly accessed, arise after the fact, or even fail to be utilized at all" (Antshel et al., 2014, p. 109). Within the Barkley (1997, 2003) model of ADHD, behavioral disinhibition can impact the other self-regulating executive functions in the following ways: working memory deficiencies that lead to forgetfulness, an inability to organize, poor time management, difficulty with hindsight and forethought, and failure to plan actions toward future events.

Barkley has made some recent changes to his model, one of which is the addition of attention as an executive function. Another is a new emphasis on the importance of working memory in the model (2012). Barkley now posits that attention, behavioral inhibition, and working memory may co-develop and that primary deficits in any or all of these will lead to the behavioral symptoms displayed with ADHD (Antshel et al., 2014). Deficits in these areas can and will lead to deficits in the other areas of executive function and can radiate outward to also impact a person's social functioning. Therefore, individuals with ADHD may struggle to sustain cooperative ventures, and in turn, ADHD can negatively impact various aspects of life, including marriage, parenting, education, occupational functioning, and community participation (Antshel et al., 2014).

Research has repeatedly shown that when compared to typically developing peers, children with ADHD perform significantly worse on tasks of executive function, indicating that executive functioning is an underlying deficit in ADHD (Barkley, Edwards, Laneri, Fletcher, & Metevia, 2001; Biederman et al., 2004; Fuggetta, 2006; Goldstein & Naglieri, 2008; Nigg, Blaskey, Huang-Pollock, & Rappley, 2002; Seidman, Biederman, Faraone, Weber, & Ouellete, 1997; Willcutt et al., 2005). This research has also been supported thorough brain imaging studies, which show that deficits in the functioning of the prefrontal cortex can be linked to the presence of ADHD (Castellanos, Sonuga-Barke, Milham, & Tannock, 2006; Nigg & Casey, 2005; Sagvolden, Johansen, Aase, & Russell, 2005). The type of executive function task matters, though. A number of studies have determined that children with ADHD do not universally perform worse on all tasks of executive function (Barkley, Grodzinsky, & DuPaul, 1992; Berlin, Bohlin, Nyberg, & Janols, 2004; Geurts, Verte, Oosterlaan, Roeyers, & Sergeant, 2005; Tsal, Shalev, & Mevorach, 2005; Weyandt, 2005; Weyandt & Willis, 1994). Generally, research has shown that ADHD involves deficits in the following areas of executive function: inhibition/impulse control, working memory, planning, and attentional flexibility (Barkley, 1997; Berlin et al., 2004; Karatekin & Asaemow, 1998; Nigg, Hinshaw, Carte, & Treuting, 1998; Willcutt et al., 2005). Different profiles of functioning can be found depending on the type of ADHD with which the child is diagnosed (Klorman et al., 1999) but little agreement exists in the literature about the specifics of the profiles across types.

Klorman et al. (1999) conducted a large study which recruited 387 children all of whom fell into one of the following categories: Non-ADHD, ODD, reading disability (RD), ODD and RD, ADHD inattentive type (alone, with ODD, with RD, with ODD and RD), and ADHD combined type (alone, with ODD, with RD, with ODD and RD). This study determined that only the children with ADHD combined type had difficulty with the tower task used in this study, indicating that the children with ADHD combined type were more likely than the children with ADHD inattentive type to have deficiencies with planning, impulse control, and working memory. The children with ADHD combined type also made more nonperseverative errors on the Wisconsin Card Sorting Task than the children with ADHD inattentive type, signifying that these children may have experienced more attentional lapses and acquisition errors. Klorman et al. (2002) argued, "the absence of [executive function] deficits among ADHD/IT children suggests that these patients have a qualitatively different cognitive disorder from that of ADHD/CT patients" (p. 1154). The presence of ODD and reading disability did not impact executive function scores.

The finding that executive function deficits are not present in children with ADHD inattentive type has been refuted by other studies investigating the same issue (Gioia et al., 2002). It may have been that the measures Klorman et al. (2002) chose to use did not assess the specific areas of executive function where children with ADHD inattentive type display weaknesses. For instance, Gioia et al. (2002) reported that children with ADHD inattentive type have greater difficulties with metacognitive aspects of executive functioning, such as working memory, planning and organization, and self-monitoring. These authors also found that children with ADHD inattentive type had elevated scores on scales for inhibition and emotional control just not to the same level of severity as children with ADHD combined type. Martel, Nikolas, and Nigg (2007) used a sample of adolescents to study executive functioning in ADHD. Their findings supported the findings of those who had studied ADHD in children indicating that ADHD is more than just a delay in the development and maturation of executive function. These authors did not find performance differences between the groups of teens with ADHD inattentive type and ADHD combined type, similar to prior research of this kind (Geurts et al., 2004; Hinshaw, Carte, Sami, Treuting, & Zupan, 2002; Nigg et al., 2002; Riccio, Homack, Jarratt, & Wolfe, 2006).

Adolescents with ADHD, regardless of the presence of additional executive function deficits, perform worse than controls on achievement scores and measures of school functioning. Biederman et al. (2004) conducted a study in which they recruited a large sample of children between the ages of six and seventeen who fell into one of four categories: a control group without executive function deficits, a control group with executive function deficits, a group of children with ADHD, and a group of children with ADHD and additional executive function deficits. Executive function deficit was defined as showing weakness in at least two areas of executive function. They found that among the sample of children with ADHD, those with additional executive function deficiencies were at an increased risk to be retained in a grade, be diagnosed with a learning disability, and have overall lower academic achievement. The academic outcomes (grade retention, additional help, special class placement, any diagnosis of learning disability, WRAT math scores, and WRAT reading scores) of the control participants with executive function defects and without were not found to be meaningfully impacted, but both

ADHD groups had significantly worse academic outcomes than the control groups (Biederman et al., 2004). Miller, Nevado-Montenegro, and Hinshaw (2012) conducted a longitudinal study to investigate whether childhood performance on executive function tasks could predict academic outcomes in a sample of adolescent females diagnosed with ADHD. They used a global executive function measure that looked at planning, working memory, inhibitory control, attention, and organization and found that impaired scores on this measure predicted a higher number of suspensions/expulsions. They also determined that low working memory scores predicted poorer reading achievement.

Conduct Disorder (CD) and Oppositional Defiant Disorder (ODD).

Children diagnosed with Conduct Disorder (CD) display great difficulty following rules and tend to engage in behaviors that violate the rights of others or societal norms such as aggression toward people or animals, destruction of property, and/or deceitfulness or theft (APA, 2000). Oppositional Defiant Disorder (ODD) involves a pattern of tantrums, arguing, and angry or disruptive behavior toward authority figures. Studies of executive function in children and teens with CD or ODD argue that many of the executive function deficits seen with these children could be better accounted for by a comorbid diagnosis of ADHD. For instance, Moffitt and Henry (1989) and McBurnett et al. (1993) determined that children with comorbid CD and ADHD had deficits in executive function but groups of children with just a CD diagnosis did not display the same deficits. Similar findings have been reported for children with ODD (Speltz, DeKlyen, Calderon, Greenburg, & Fisher, 1999). Clark, Prior, and Kinsella (2000) conducted a study with 110 teens between the ages of 12 and 15 who had been diagnosed with ADHD only, ADHD and ODD/CD, ODD/CD only, and a group without diagnoses to determine if executive function deficits were specific to the presence of ADHD in this population. The results indicated that children in both groups where ADHD was present performed significantly worse on the two measures of executive function used regardless of whether the child was also diagnosed with ODD/CD. The children with ADHD or ADHD with comorbid ODD/CD showed greater impairment in their ability to generate strategies and self-monitor behavior. From these findings, Clark et al. (2000) concluded that executive function deficits present in children with externalizing disorders are specific to those with ADHD. Oosterlaan et al. (2005) came to the same conclusion after studying children with ADHD, ODD/CD and comorbid ADHD and ODD/CD. They found that ADHD was related to deficits in planning and working memory, but ODD/CD was not associated with any deficits in executive function.

Research has also indicated, however, that children with CD and ODD have been found to have impairments in inhibition/impulse control regardless of whether they also have an ADHD diagnosis (Herba, Tranah, Rubia, & Yule, 2006; Kim, Kim, & Kwon, 2001; Sergeant, Geurts, & Oosterlaan, 2002). Toupin, Dery, Pauze, Mercier, and Fortin (2000) studied 57 children in treatment for CD between the ages of 7 and 12 compared to a control group of 35 children in special education programs. Children who also met the criteria for ADHD in both groups were not excluded because the researchers had planned to control for those symptoms statistically (50.9% of the CD group and 5.7% of the control group met criteria for ADHD). From the results, Toupin et al. (2000) concluded that children with CD performed significantly worse than control children even after SES and ADHD had been controlled for, with significant differences being found on measures of self-monitoring, planning, and inhibition. They concluded from these findings that executive function deficits in a sample of children with CD could not be entirely explained by the presence of ADHD symptoms or SES. Morgan and Lilienfield (2000) conducted a meta-analytic review of 39 studies that investigated executive function in children with antisocial behavior. They found that the antisocial group performed .62 standard deviations below the comparison groups on measures of executive function, but there was significant variation within this effect size estimate (Morgan & Lilienfield, 2000). Caution must be taken when interpreting studies of executive function in CD and ODD, however. Many studies of CD/ODD have methodological problems such as variation in inclusionary criteria, diagnostic criteria, age, gender, and measurement techniques (Weyandt et al., 2014). Additionally, executive function performance scores from children with CD/ODD may not fully represent their actual ability level but rather a lack of motivation to try (Hale, & Fiorello, 2004).

Internalizing Disorders

It is often difficult to study anxiety disorders alone because of the high comorbidity that exists with internalizing disorders. For instance, Emerson, Mollet, and Harrison (2005) studied 19 boys who had been diagnosed with anxiety and depression. They found deficits in the areas of set shifting and concept formation among the children with psychiatric diagnoses when compared to a group of peers without diagnoses. These authors believed that their study was consistent with evidence to support the presence of frontal lobe executive function deficits in children with both anxiety and depression.

Anxiety-Related Disorders

Toren et al. (2000) produced one study in which anxiety was studied without the presence of comorbid depression. They studied 19 children who had been diagnosed with separation anxiety and overanxious disorder (based on DSM-III criteria) to a group of age and gender matched peers without diagnoses. For most of the measures of executive function in this study there were no significant group differences. When the Wisconsin Card Sorting task was broken down and the separate scores were compared, the anxious children made significantly more errors and provided more perseverative responses, indicating that these children may have more difficulties with cognitive flexibility and self-monitoring.

Studies have also investigated executive function skills in relation to posttraumatic stress disorder (PTSD; Beers & De Bellis, 2002; Carrion, Garrett, Menon, Weems, & Reiss, 2008) and obsessive-compulsive disorder (OCD; Friedlander & Desrocher, 2006; Shin et al., 2008) in children. Beers and De Bellis (2002) identified 14 children who had been maltreated (e.g. sexual abuse, physical abuse, witness to domestic violence) and resultantly had been diagnosed with PTSD. This sample was compared to children who had not experienced maltreatment. Executive function deficits were found in the areas of interference control, sustained attention, problem solving, set shifting, and verbal fluency. Problems with the sample (small size and the presence of comorbid major depressive disorder, dysthymic disorder, separation anxiety disorder, and ADHD-inattentive type) made it impossible for the researchers to definitively determine if the executive function deficits shown were the result of the maltreatment or the presence of the additional psychopathology. Neuroimaging studies have been able to show differences in the activity of the frontal lobes of children with and without posttraumatic symptoms (Carrion et al., 2008). Carrion et al. (2008) found that the children in both groups had similar accuracy and response times on a go/no-go task but the brain regions that were active during the task differed with the control group using the middle frontal cortex and the group of children with PTSD displaying activity in the medial frontal cortex. About their findings, Carrion et al. (2008) wrote, “because other conditions, such as ADHD, have shown similar findings, these results may represent deficits of response inhibition that cut across different clinical groups” (p. 524).

OCD is a disorder characterized by obsessive thoughts and compulsions that are engaged in in an attempt to reduce anxious feelings that are time-consuming and cause significant distress and impairment (APA, 2000). Shin et al. (2008) studied the executive function of children diagnosed with OCD, ADHD, tic disorder, depressive disorder, and a group of controls. Compared to the control group, the children with OCD performed the worst on tasks of perceptual organization. They also displayed significantly more errors and used fewer strategies when participating in the Wisconsin Card Sorting Task. These findings indicated that children with OCD might have more difficulty with set shifting and self-monitoring. Other studies, however, have found that people with OCD have the greatest difficulty with impulse control, but Shin et al. (2008) did not investigate this skill within their sample. It is hypothesized that the lack of impulse control is what leads people with this disorder to not be able to inhibit responses, leading to the perseverative behaviors (compulsions) that characterize the disorder (Friedlander & Desrocher, 2006).

When looked at as a whole, research on executive function and anxiety disorders indicates that deficits can be seen in the areas of set shifting, cognitive flexibility, concept formation, impulse control, and verbal fluency. In many of these studies, however, it is difficult to say with certainty whether the relationship exists between the executive function deficits and anxiety alone or whether the deficits may be more strongly linked to other comorbid disorders.

Depression-Related Disorders

Little research exists in the area of executive function and depression among children and adolescents. Channon (1996) conducted a study with older adolescent students who scored higher on the Beck Depression Inventory (BDI). It was a nonclinical sample, but the results from the BDI indicated that the students generally have a dysphoric mood. The students with higher BDI scores were found to make more perseverative and non-perseverative errors on the Wisconsin Card Sorting Task than peers with lower BDI scores. These results indicated that the students experiencing more depression-like symptoms showed greater difficulty with set shifting and self-monitoring.

Bipolar disorder is a disorder characterized by extreme swings in mood from depression to periods of mania. The diagnosis of bipolar in children is a controversial topic because of the diagnostic challenges related to what mania might look like in children (Weyandt et al., 2014). Among children, the manic states of bipolar are more likely to manifest as irritability and aggression rather than euphoric mood (Geller & Luby, 1997). An additional difficulty with the diagnosis of bipolar in children is that the majority of children and teens diagnosed with bipolar have also been diagnosed with comorbid ADHD (i.e., 60-90%; Costello et al., 2002). These issues make the study of executive function in children and adolescents with bipolar disorder very difficult. Doyle et al. (2005) conducted a study with 57 children diagnosed with bipolar who were between the ages of 10 and 18 years old. These children were compared to an age-matched sample of children who had not been diagnosed with bipolar or any other mood disorder. It was determined that 74% of the bipolar group also met criteria for ADHD compared to only 17% of the control group. Therefore, ADHD was statistically controlled for so that it would not impact results. The bipolar group performed significantly worse on tasks of working memory, fluency, inhibition, and sustained attention (Doyle et al., 2005). Dickstein et al. (2004) also found children with bipolar to show deficits in memory and attention when compared to a control group of children without the disorder, but they warned that their findings should be considered preliminary due to the small sample sizes, the fact that all of the children in the bipolar group were taking medication, and the presence of comorbid ADHD in over 70% of the sample.

Autism Spectrum Disorders

It has been theorized that the symptoms present in the manifestation of an autism spectrum disorder (ASD) are the result of executive function deficits (Damasio & Maurer, 1978; Maurer & Damasio, 1982). Damasio and Maurer (1978) postulated that these deficits are at the core of the disorder because children with ASD struggle with exerting effortful control when it is needed in new, complex, or ambiguous situations. In their paper, they also draw comparisons between children with ASD and those with frontal lobe damage. They formulated the theory that ASD is a frontal lobe disorder from the similarities seen in the social functioning of individuals from these two clinical groups. This early paper from Damasio and Maurer (1978) has led many others to investigate the specifics surrounding executive function deficits in individuals with ASD, including whether the deficits in executive function are global across all areas or only within specific domains and whether there is imaging evidence that supports a theory of disruption in the frontal lobes.

Neuroimaging research has showed that children with ASD display structural and functional abnormalities within the frontostriatal network of the brain (Agam, Huang, & Sekuler, 2010; Amaral, Schumann, & Nordahl, 2008; Gilbert, Bird, Brindley, Frith, & Burgess, 2008; Kana, Keller, Minshew, & Just, 2007; Schmitz et al., 2006; Shafritz, Dichter, Baranek, & Belger, 2008; Solomon et al., 2009). Courchesne and Pierce (2005) concluded from their research that the brains of individuals with autism could be characterized as having local over-connectivity and long-range under-connectivity of the frontal cortex. People with ASD often recruit more brain areas when completing tasks of executive function than typically developing peers, but studies have shown both over- and under-activation in the frontostriatal circuitry of the brains of people with ASD compared to controls (Gilbert et al., 2008; Kana et al., 2007; Schmitz et al., 2006; Shafritz et al., 2008; Solomon et al., 2009). Solomon et al. (2009) also concluded that fronto-parietal connectivity was related to ADHD symptomology. It has also been postulated that ASD results from reduced synchronization between the frontal and posterior regions of the cortex (Just, Cherkassky, Keller, & Minshew, 2004). The theory of reduced synchronization has been evidenced in a number of studies investigating the brain's activity during tasks of executive function (Agam et al., 2010; Just et al., 2004; Kana, Keller, Cherkassky, Minshew, & Just, 2006), during social processing (Kana, Keller, Cherkassky, Minshew, & Just, 2009; Welchew et al., 2005), and with the occurrence of repetitive motor behaviors (Agam et al., 2010; Langen, Durston, Kas, Van Engeland, & Staal, 2011). In general, "ASD is seen as a brain connectivity disorder, and the observed EF deficits have been related to the increased connectivity within the prefrontal cortex and the decreased connectivity of the frontal cortex with more posterior regions of the brain" (Geurts, de Vries, & van den Bergh, 2014, pp. 123-124).

Review studies and meta-analyses investigating the specific areas of executive function deficits in ASD populations show that findings across studies tend to be inconsistent (Geurts, Corbett, & Solomon, 2009; Hill, 2004; Russo et al., 2007), indicating that there may be an actual heterogeneity in the manifestation of executive function deficits among children with ASD (Pellicano, 2010). Across the research, deficits in the areas of inhibition, working memory, cognitive flexibility, and planning are most often identified as being areas of weakness of children with ASD. Many symptoms of ASD can be linked to difficulties with inhibition, including appropriate social interaction, language usage, and repetitive motor behaviors (Geurts et al., 2014). Performance on tasks of inhibition across the research has varied, however. Children and adolescents with ASD have been found to be unimpaired when assessed using a Stroop task (Eskes, Bryson, & McCormick, 1990; Ozonoff & Jensen, 1999; Russell, Jarrold, & Hood, 2002), but have shown impairment in other types of inhibition tasks that involve prepotent inhibition when compared to age, gender, and IQ matched typically developing peers (Hughes & Russell, 1993; Luna, Doll, Hegedus, Minshew, & Sweeney, 2007; Ozonoff, Strayer, McMahon, & Filloux, 1994; Russell, Hala, & Hill, 2003). Overall, researchers have concluded that children and adolescents with ASD have difficulty inhibiting a prepotent response, but this does not explain unimpaired performance on Stroop tasks. Russell et al. (2002) argued that individuals with ASD would show greater difficulty inhibiting responses during tasks with arbitrary rules. They postulated that those with autism pass executive function measures that do not lack a rationale, such as Stroop tasks.

Working memory has been shown to be an area of weakness for children and teens with ASD across a number of studies. Even children with well-developed language understanding have been reported by teachers and parents to have difficulty executing instructions, especially when more than one instruction is given at one time (Geurts et al., 2014). Willcutt, Songua-Barke, Nigg, and Sergeant (2008) reported that children with ASD show difficulty with both verbal and visual-spatial working memory, while others argue that deficits in visual-spatial working memory are more prominent (Williams, Goldstein, Carpenter, & Minshew, 2005; Williams, Goldstein, & Minshew, 2006). It appears that when verbal working memory loads are kept small, children with ASD do not have any difficulty, but as the demand for the amount and complexity of the information to be remembered increases, individuals with ASD will display more deficits (Williams et al., 2006) at an even greater rate than typically developing peers (Cui, Gao, Chen, Zou, & Wang, 2010). With regard to visual-spatial working memory, children with ASD struggle with storing, maintaining, and retrieving visual information (Corbett et al., 2009; Happe et al., 2006; Luna et al., 2007).

The study of cognitive flexibility in children with ASD has received a lot of attention, mainly due to the way it relates to the behaviors that are characteristic of the disorder, including strict adherence to routine, stereotypical and repetitive behaviors, and inflexibility with social communication (Geurts et al., 2014). Gioia et al. (2002) found that children with ASD were reported by their parents to have significant impairments in executive function when compared to a control group of their peers. Sixty-nine percent of the ASD sample were rated as clinically significant on the scale that measures shifting ability (Gioia et al., 2002). This supports the diagnostic criteria for the disorder, which indicates an inflexibility and strict adherence to routines as being a characteristic of the disorder. Studies with direct testing of cognitive flexibility have also determined that children with ASD have greater difficulty than typically developing peers (Happe et al., 2006). A number of studies have used the Wisconsin Card Sorting Task to assess cognitive flexibility in this population (Hill, 2004). Through these studies, researchers have been able to show impairment in mental flexibility in children and adolescents with ASD in relation to other clinical groups as well as compared to typically developing peers (Hughes, Russell, & Robbins, 1994; Ozonoff & McEvoy, 1994; Ozonoff, Pennington, & Rogers, 1991; Rumsey & Hamburger, 1988; Shu, Lung, Tien, & Chen, 2001). These studies have found that children with ASD make more perseverative errors, and they identify fewer categories correctly. These deficits persist over time (Ozonoff & McEvoy, 1994), and are found to be worse in children with ASD when compared to other clinical groups, such as ADHD and Tourette syndrome (Ozonoff & Jensen, 1999).

Planning is also an area of executive function where children with ASD have been found to show weakness. “Planning is a complex process of working towards a desired goal and various skills are needed, such as monitoring, reevaluating, and updating actions (Geurts et al., 2014, p. 131), and it is consistently found to be an area of impairment for children with ASD when compared to typically developing children (Gioia et al., 2002; Ozonoff & Jensen, 1999; Pellicano, 2010). In fact, Gioia et al. (2002) reported 70% of their sample was found to have a clinically significant level of problems with planning and organization. Children and adolescents with ASD have been reported to show impaired performance on tasks of planning when compared to clinical control groups (dyslexia, ADHD and Tourette syndrome: Ozonoff & Jensen, 1999; Ozonoff, & McEvoy, 1994; Ozonoff et al., 1991; Sergeant et al., 2002) and typically developing peers (Ozonoff & Jensen, 1999). Ozonoff and McEvoy (1994) tracked the development of executive function in children with ASD over a three-year period and found that deficits in planning are stable and do not improve with maturation.

Traumatic Brain Injury

Children who sustain traumatic brain injuries have been found to experience executive dysfunction (Gioia & Isquith, 2004). Ylvisaker, Szekeres, & Hartwick (1992) reported that damage to the prefrontal regions of the brain have been linked to specific deficits in the areas of planning and cognitive flexibility. Scheibel and Levin (1997) have also reported connections between damage to the frontal lobes and impaired behavioral inhibition, poor organization of learning, memory, and language formulation. Severity of the brain injury has been tied to specific deficits. Children with severe TBI have been found to have greater impairment in executive function compared to children with moderate TBI as reported by their parents on the BRIEF (Gioia et al., 2002). Children with moderate TBI were at increased risk for weaknesses in planning and organization and self-monitoring, whereas children with severe TBI were at significantly greater risk for deficits in all areas assessed on the BRIEF, including those in the behavioral regulation and metacognitive problem-solving domains. "The greatest impact of executive deficits may not be seen at the time of injury, but may emerge later with the dramatic increase in environmental, academic, behavioral, emotional, and social demands on the executive system during adolescence" (Gioia & Isquith, 2004, p. 137). Eslinger

(1998) reported that executive function deficits following injury could result in demanding, self-centered personality, lack of social tact, impulsive speech and behaviors, disinhibiton, apathy and indifference, or a lack of empathy, all of which greatly impact a person's ability to function socially.

Summary

Deficits in executive function are present in a number of internalizing and externalizing forms of psychopathology as well as academic impairments. Impairments in executive functioning have been found to accompany the following disorders, Attention Deficit/Hyperactivity Disorder (ADHD), Development Disabilities, Conduct Disorder (CD), Oppositional Defiant Disorder (ODD), anxiety disorder, depression, Bipolar Disorder, and as the result of traumatic brain injury. Gioia et al. (2002) conducted a study in which they compared the executive function profiles (measured using the BRIEF) of children with ADHD inattentive type, ADHD combined type, Autism Spectrum Disorder, moderate and severe traumatic brain injury, reading disability and a control group. They found significant differences between the executive functioning abilities of the children in these groups. Children with ADHD (inattentive or combined) and ASD were found to have greater problems with executive function than children with reading disability or severe TBI, and the children with severe TBI were more impaired than the children with moderate TBI. The children with ADHD combined type and those with ASD had elevated scores across all the scales, but the children with ADHD inattentive type and reading disability showed more specific weaknesses in the metacognitive areas of executive function, such as working memory, planning, organization, and self-monitoring. Happe et al. (2006) also found children with ADHD and ASD to show greater deficits in executive function compared to typically developing peers, but in this study, the children with ASD were reported to have deficits that were less severe and less persistent across time than children with ADHD. Older children with ASD performed better than younger children with ASD, indicating that executive functions in ASD populations may develop at a slower rate, whereas in the ADHD sample, age-related differences were not found.

Because executive functioning can have such a great impact on schooling and other areas of life, it is important to be able to measure executive function abilities accurately using valid measures. In order to do this, it is essential for the person assessing the child to have an understanding of the developmental trajectory of executive functions as well as the executive functioning profiles that accompany certain acquired and developmental disorders. Having this background knowledge will make interpreting test and rating scale scores easier and more accurate. Once a person's areas of weakness have been identified, interventions can be put in place to remediate and foster the growth of these skills.

CHAPTER 3

METHODOLOGY

Participants

The goal to recruit 85 total participants from the seventh and eighth grades (approximate age 12-14) at Wilson Area Intermediate School (WAIS) was attempted. This number was based on Cohen (1992), which reported that a minimum sample size of 85 should be used in order to detect a medium effect size from a study employing Pearson product-moment correlations. A target sample size of 85 was chosen with the goal of being able to detect a medium effect size.

Nearly 650 students attended WAIS in grades 5 through 8 at the time the study took place, with 165 to 175 students in each grade level for a total of approximately 350 students in seventh and eighth grade. The target sample size was not achieved; however, a total of 79 participants were recruited from these two grades. The students who participated in the study were those who turned in signed parental consent forms giving them permission to participate. The students were also asked to sign assent forms indicating that they themselves agreed to participate. A copy of the parental consent form and the student assent form can be found in Appendix A and Appendix B, respectively. All students with signed consent and assent forms were included in the study. There were no exclusionary criteria. The recruited students ranged in age from 12 years, 6 months to 15 years old, with an average age of 13 years, 10 months. Thirty-three of the students were in seventh grade (42% of the sample) and 46 students were in eighth grade. The students in seventh grade ranged in age from 12 years, 6 months to 13 years, 10 months, with two older students who were 14 years, 5 months and 15 years old. The eighth grade students ranged in age from 13 years, 6 months to 14 years, 9 months old. Sixty-two percent of the students in the sample self-identified as being female, and 38% of the students identified themselves as male.

Table 1.

Demographic Information

	7th Graders (*n* = 33)	8th Graders (*n* = 46)	Total Sample (*n* = 79)
Number female	20	29	49
Number male	13	17	30
Age range	12:06 – 15:00	13:06 – 14:09	12:06 – 15:00
Mean age	13:04	14:03	13:10

Instruments

Comprehensive Executive Function Inventory, Self-Report (CEFI-SR).

The CEFI-SR (Naglieri, & Goldstein, 2013) is a rating scale that asks teens between the ages of 12 and 18 to rate how often they perform specific behaviors related to executive functioning. The scale consists of 100 questions, which compose the nine scales of the measure (attention – 12 items, emotion regulation – 9 items, flexibility – 7 items, inhibitory control – 10 items, initiation – 10 items, organization – 10 items, planning – 11 items, self-monitoring – 10 items, and working memory – 11 items). The scale allows the interpreter to determine a child's areas of strength and weakness in regard to executive functioning. Ultimately, this information can be used to guide assessment, diagnose, and plan treatment.

Five of the nine scales from the CEFI-SR were used during this study, including Attention, Flexibility, Inhibitory Control, Self-Monitoring, and Working Memory. The Attention scale assessed an adolescent's ability to ignore distractions, concentrate on a task, and sustain attention. The Flexibility scale investigated a teen's ability to adjust behavior to meet the demands of the situation through finding alternative ways to solve a problem, using different approaches to problem solving, and having many ideas about how to do things. The Inhibitory Control scale looked at a child's capacity to control his impulses by asking questions related to thinking before acting, maintaining self-control, and keeping commitments. The Self-Monitoring scale measured a teen's evaluation of his own behavior in order to determine when a different approach is necessary in ways such as, finding and correcting mistakes, realizing when help is needed, and knowing when a task is finished. Lastly, the Working Memory scale assessed how well an adolescent could hold important and relevant information in mind such as remembering rules, instructions, and steps.

The original standardization sample for the CEFI-SR consisted of ratings from 700 adolescents between 12 and 18 years old, with 100 teens being used to represent each age group. The internal consistency of the CEFI-SR was assessed using Cronbach's alpha. The Full Scale coefficient for the CEFI-SR was .97 in the normative and clinical samples. The breakdown of the coefficients for each of the nine subscales is as follows among the normative and clinical samples, respectively: Attention - .86 and .86, Emotion Regulation - .78 and .83, Flexibility - .77 and .72, Inhibitory Control - .80 and .80, Initiation - .80 and .70, Organization - .85 and .84, Planning - .85 and .82, Self-Monitoring - .78 and .74, and Working Memory - .83 and .81. Test-retest reliability for the Full Scale score of the CEFI-SR was .77, and the coefficients for the individual subscales ranged from .74 to .86.

The criterion-related validity of the CEFI-SR was investigated across groups and in relation to other measures. In order to assess the criterion-related validity across groups, a small group of children and adolescents previously identified as having ADHD (33 participants), a mood disorder (5 participants), or a learning disability (25 participants) were examined. Standard scores from the CEFI-SR for each clinical sample were compared to scores from the normative standardization sample. Results indicated that the scores of the children in the clinical samples were lower than those of matched peers, meaning that the CEFI-SR was sensitive to differences in executive function-related behaviors.

Criterion-related validity studies were also done to compare the ratings on the CEFI to the BRIEF as well as tests of cognitive ability (WISC-IV and the CAS) and academic achievement (WJ-III ACH). To compare the BRIEF and CEFI self-report scales, ratings from 61 teens between 12 and 18 years old were used. The participants in this sample had previously been diagnosed with ADHD, mood disorders, and learning disability. Through comparing the BRIEF and CEFI self-report measures, moderate correlation coefficients of .68 and .63 with small effect sizes (.23 and .13) were found for the ADHD and mixed clinical groups, respectively. The fact that the BRIEF and the CEFI utilized different standardization samples may have impacted the coefficients. The studies investigating the relationship between the CEFI and the WISC-IV, the CAS, and the WJ-III Tests of Achievement were conducted using the teacher rating form only. Therefore, ratings from the CEFI-SR have not been correlated with any direct measures of cognitive or academic functioning.

The Developmental Neuropsychological Assessment, Second Edition (NEPSY-II: Animal Sorting, Auditory Attention/Response Set, and Word List Interference)

The NEPSY-II was chosen for this study because of the micro-analytic approach to assessing executive function. The scoring of a specific type of error allowed the examiner to assess executive function skills (e.g. self-monitoring) that are often difficult to measure without the presence of confounding variables. This one assessment tool allowed for the investigation of all of the skills targeted in this study, which meant that all of the students' performance scores were being compared to the same normative sample. This would not have been true if various, single-skill tests of executive function were used to assess the different skill areas. Additionally, the NEPSY-II is a tool widely used in clinic and school settings to assess executive functioning. The subtests used were quick to administer and engaging for the students. It is in its second edition and has undergone a number of reliability and validity studies, discussed below.

The NEPSY-II (Korkman et al., 2007) provides a tailored assessment for ages 3-16, across six domains. It was created to assess subtle deficiencies in neurological functioning that can interfere with learning to detect and clarify the degree to which brain damage or dysfunction affect the child's capacity to process information. This study utilized the Animal Sorting and Auditory Attention/Response Set subtests from the Attention and Executive Function domain as well as the Word List Interference task from the Memory and Learning domain. In total, it took approximately 20 to 25 minutes to complete the direct testing with each participant. The Animal Sorting subtest was designed to measure a child's ability to be mentally flexible in the formation of concepts. The task required the participant to sort eight cards, each depicting different scenes with animals, into two group of four based on some basic concept such as the number or size of the animals. Two scores from this test were used. The first was the scaled score derived from the total number of correct sorts. This score described the child's cognitive flexibility. Additionally, information was gathered about the total number of incorrect and/or repeated sorts. These errors indicated the child's level of self-monitoring.

The Auditory Attention/Response Set subtest had two parts. The first portion (Auditory Attention) was designed to measure selective and sustained attention. The Response Set portion of the task was also designed to measure selective and sustained attention with the addition of the need to inhibit previously learned responses. For these tasks, the child listened to a series of previously recorded words while responding using a page from a stimulus book that depicted four colored circles. Prior to hearing the words, the children were taught rules that they had to follow about what circle to touch and when to touch it.

The last subtest the participants took was the Word List Interference task. This test was designed to assess working memory. The child was presented with two series of words. After the first series, the child was asked to repeat the stimuli. The child was then given the second series and asked to repeat that. After each series had been presented and repeated, the child was then asked to recall the first series of words followed by the second series.

The NEPSY-II was normed using a representative sample based on information from the October 2003 census. Internal reliability was assessed through split-half, alpha methods, stability coefficients, and decision-consistency procedures. Overall, adequate to high internal consistency and stability were reported by the authors for most of the subtests. The Animal Sorting subtest's reliability coefficient for 13 to 16 year olds was .96, for Auditory Attention and Response Set the scores were .71 and .88, and for the Word List interference recall score it was .70. These scores are consistent with previous findings that executive function tasks tend to have modest reliability. Animal Sorting total correct sorts had a stability coefficient of .64, and the Word List Interference recall total score was .68. Stability coefficients were not provided for Auditory Attention and Response set for this age group. The decision consistency for Animal Sorting total errors was .96, for Auditory Attention and Response Set total correct was .88, for Auditory Attention and Response set total inhibitory errors the coefficients were .96 and .99.

Content validity of the NEPSY-II was based on previous research with the original, Finnish NEPSY in addition to a literature review, the authors' expertise, recommendations from experts, and data from the pilot and tryout studies of the first NEPSY. In order to assess construct validity, the authors looked at the internal structure of the test correlating the subtests within each domain. Within the Attention and Executive Function domain, correlations between subtests were low, but this made sense considering that different skills within executive function were being measured within this domain. Therefore, Korkman et al. (2007) argue that the strongest evidence for construct validity comes from the concurrent validity data. Concurrent validity was assessed by comparing the NEPSY-II to twelve different measures including cognitive batteries, nonverbal assessment, academic achievement tests, memory scales, another measure of executive function, language scales, and several rating scales. Correlations with these other measures were low to moderate. Concurrent validity was also assessed with special groups. For the ADHD group, the NEPSY-II was sensitive to the deficits in attention and executive function. The same was true for the reading disability group, the math disability group, the language disorder group, children with intellectual disability, children with autism spectrum disorders, children with traumatic brain injury, and children with emotional disturbance.

Procedures

The first stage of this study consisted of recruiting students to participate. Recruitment took place over two days during the last period of the day. For both seventh and eighth grade, the last period of the day was a SMART period, which was similar to study hall. There were eight seventh grade classes and eight eighth grade classes each with approximately 20 students. On the first day of recruitment, the eight eighth grade SMART classes were combined into four classrooms. Each group of about 40 students was given a five to seven minute presentation about the purpose of the study, what it entailed, and what they needed to do if they wanted to participate. At the end of the presentation, the students were given time to ask any questions they had about the study. This same procedure was repeated the next day with the seventh grade SMART classes. During the presentation, the students were given the consent forms (APPENDIX A) to bring home to their parents. The consent forms outlined the details of the study, including the procedures, any potential risk and discomfort, benefits, compensation, and confidentiality. Parents were encouraged (on the consent form) to contact the study investigator with any questions prior to deciding whether to allow their child to participate. The students' homeroom teachers then collected consent forms each day.

Once the consent forms were collected, a raffle was held. All students who returned a signed consent form, regardless of whether they were allowed to participate, were included in the first raffle. The consent form was amended to give the parents the option of whether they agreed to permit their child to participate. By doing this, it ensured that all parents reviewed the information. It was also a way to give all of the students an opportunity to be a part of the first raffle and to keep recruitment methods from being coercive. At the first raffle, the names of three students from seventh grade and three students from eighth grade were chosen at random, and each child received a $10 gift card.

Once the sample was finalized, each participant was randomly assigned a number. This number was used on all protocols to ensure anonymity. All students who had turned in signed consent forms were also asked to complete an assent form (APPENDIX B) indicating that they were willing to participate in the study. When the consent and assent forms were completed and collected, data collection began. Data from the CEFI-SR rating scale were collected before any direct testing was completed. This procedure was employed in order to prevent direct testing performance from impacting the students' perceptions of their executive function abilities. On the first day of data collection, small groups (usually less than 10) of eighth grade students were removed from class and brought to a small conference room where they were asked to independently complete the CEFI-SR. Completion of the rating scale took approximately 15 to 20 mins to complete. When the students finished and handed in the completed form, they were told to return to their classrooms. The students were also instructed to raise their hands if they had any questions about the items on the scale. Since the majority of the eighth graders completed the CEFI-SR on the first day of data collection, direct testing began with these students on the following day. Each student who had completed the CEFI-SR was pulled out of class for a 20 to 25 min individual testing session during the first seven periods of the day. During the last period of each day, small groups of seventh grade students were brought in to complete the CEFI-SR. As students completed the ratings scale, they were added to the list of students who were ready for the direct testing portion of the study. This process continued until each participant had completed the CEFI-SR followed by a one-on-one testing session.

Direct testing was completed using three subtests from the NEPSY-II (Animal Sorting, Auditory Attention/Response Set, and Word List Interference). Each adolescent was engaged in one testing session, during which he or she was asked to complete tasks involving the ability to be cognitively flexible, to self-monitor, to remember instructions, to pay attention, and to inhibit impulses. Because this testing required the students to miss class time, teachers were consulted about the best time to take each student for the individual testing. Upon completion of the data collection, a second raffle was held with the names of all the students who completed the study. At this raffle, the names of three students from seventh grade and three students from eighth grade were chosen at random, and each child received a $10 gift card.

Following the completion of the study, the school received general feedback related to the executive functioning of their seventh and eighth grade students. Classroom intervention strategies were suggested and explained for the skill areas where the students were showing need.

Data Analysis

In order to determine the concurrent, criterion-related validity of the CEFI-SR, a rating scale that purports to measure executive function skills in adolescents who are 12 to 18 years old, the construct of executive function and how it is observed must be defined. For the purpose of this study, executive function was defined as a higher-order cognitive process that involved the use of self-directed actions, such as attention, inhibition, working memory, self-monitoring, and flexibility, in order to select, enact, and sustain actions across time toward goals in the context of social and cultural environments. Student perceptions of their own ability to perform these types of tasks, as well as that individual's ability to perform on tasks of executive function from the NEPSY-II, were used to observe the construct of executive function. The scores obtained through the students' self-ratings (CEFI-SR) and the individuals' performance on the NEPSY-II subtests were the variables for all analyses. The CEFI-SR was also used to collect basic demographic information, including gender, age, and grade.

The first step in the data analysis for this study was to convert all scores to standard scores. Through the scoring process, CEFI-SR scores are converted from raw scores into standard scores. Getting standard scores for the NEPSY-II tasks required some conversion, however. The Animal Sort Correct Sorts Scaled Score was used as the direct measure of flexibility. This scaled score was converted to a standard score so it could be compared to the standard score from the Flexibility subscale of the CEFI-SR. The raw score for the number of repeated sorts completed during the Animal Sorting task was used as the measure of self-monitoring. The raw score was first converted to a z-score. It was then reverse coded by multiplying the z-score by negative one. This score was then converted to a standard score so that it could be compared to the standard score from the CEFI-SR Self-Monitoring subscale. The Auditory Attention Combined Scaled Score was used as the direct measure of attention in this study. This scaled score was then converted to a standard score, so it could be compared to the standard score from the CEFI-SR Attention subscale. The total number of inhibition errors made during the Auditory Attention and Response Set task was used as the measure of inhibition. Because this was a raw score, it was first converted to a z-score. It was then reverse coded by multiplying the z-score by negative one. This score was then converted into a standard score so that it could be compared to the standard scores from the Inhibition subscale of the CEFI-SR. The Word List Interference Recall Scaled Score was used as the measure of working memory. This scaled score was converted to a standard score, so that it could be compared to the standard score from the CEFI-SR Working Memory subscale.

Once all the scores were converted, they were analyzed using Pearson product-moment correlations. The correlation analyses were conducted to determine the strength of the association between five separate subscale scores from the CEFI-SR and the direct measure scores from the NEPSY-II. This is a common method for determining the concurrent, criterion-related validity of a measure because it allows for the comparison of individual scores on two methods of measurement (Goodwin, 2009; McBurney & White, 2004).

Before conducting the correlations, the data had to be visually examined, using scatter plots, to determine if there was any obvious patterns in the data. This was necessary because certain assumptions must be met before Pearson correlations can be conducted. For instance, the data points on the scatter plot needed to form a linear pattern. Additionally, the variables had to be approximately normally distributed, meaning that the data points should be generally clustered in the middle of the chart with just a few points at the extremes. This leads to the next assumption, which was that outliers were kept to a minimum. If a lot of data appeared at the extremes, it could artificially affect the correlation. The final assumption was that the data had homoscedasticity, meaning that the variances along the line of best fit remained similar all along the line. If the data were actually heteroscedastic, the Pearson coefficient may be an overestimate of the goodness of fit. Homoscedasticity was assessed for each set of variables using two-tailed F-tests for Variance. Results from the F-tests indicated that for each pair, the null hypotheses that the variances were equal could be accepted and that the data had homoscedasticity. Therefore, it was determined that the data for three out of the five executive functions met all of the assumptions necessary to conduct the Pearson product-moment correlations. It was not possible to conduct correlations for the Attention and Inhibitory Control data because the assumption of a normal distribution was not met. The scatter plots are provided in the following chapter.

Once it was determined that the data met the necessary assumptions, the Pearson product-moment correlations were calculated. It was necessary to compute three separate correlation coefficients for the three subscales with data meeting the necessary assumptions. The three subscales from the CEFI-SR that were used were Self-Monitoring, Flexibility, and Working Memory. A score from each of these subscales was independently correlated with one of the direct testing scores from the NEPSY-II. More specifically, the Self-Monitoring subscale scores from the CEFI-SR were correlated with the number of repeat errors performed during the Animal Sorting task on the NEPSY-II; the Flexibility subscale scores from the CEFI-SR were correlated with the total number of correct sorts during Animal Sorting; and lastly, the Working Memory subscale scores were correlated with Recall Total Scores from the Word-List interference task on the NEPSY-II.

Because it was not possible to compute a correlation for the Attention data, a t-test was used instead to determine if a significant difference was present between the mean CEFI-SR score of the students who scored the maximum score possible on the NEPSY-II subtest and those who did not. Because the data points for the Self-Monitoring assessments did not clearly form a fully normal distribution either, a t-test was additionally used for these data to compare mean CEFI-SR scores. If the CEFI-SR subscales had concurrent validity as measures of executive function, the mean of the rating scale scores for the students who earned maximum scores on the direct assessment measure should have been significantly higher than the mean of scores from the students who had some difficulty with the direct assessment measures, as a perfect performance score on a direct assessment should indicate a higher level of ability within the specified skill area. Using a t-test to analyze the Inhibitory Control data was also not possible because only three students failed to obtain the maximum score possible on the NEPSY-II assessment. This data will be discussed qualitatively in the following sections.

In addition to the correlations, t-tests were also conducted to determine if any significant differences existed within the sample. Separate samples t-tests were conducted for the response patterns on the CEFI-SR across grades and genders. Subscale scores from the CEFI-SR and the NEPSY-II were also analyzed using t-tests to investigate potential significant differences between the groups by gender and by grade. Due to the number of t-tests conducted, a Bonferroni correction was used to adjust the alpha value for determining significance to $\alpha = 0.0025$.

CHAPTER 4

RESULTS

General Findings from the CEFI-SR

All 79 participants completed the CEFI-SR. Not every student answered every question, however. Sixty-two percent of the students (n = 49) answered every question, 22% (n = 17) omitted one question, 6% (n = 5) omitted two questions, 6% (n = 5) omitted three questions, 3% (n = 2) omitted four questions, and 1% (n = 1) omitted six questions. Statistical analysis using a two-tailed t-test assuming unequal variances indicated that there was no significant difference between the number of items omitted by the seventh graders compared to the number omitted by the eighth graders. A second two-tailed t-test assuming unequal variances was conducted to determine if there was a difference by gender. This test indicated that male students omitted a significantly higher number of items ($M = 1.10$, $SD = 1.52$) than the female participants ($M = .47$, $SD = .87$), $t(41) = 2.08$, $p = .04$, but due to the number of t-tests conducted, a Bonferroni correction was used to adjust the alpha value to control the familywise error rate. With the adjusted alpha, the difference was no longer significant, indicating that there was no significant difference by gender for the number of items omitted at a rate greater than chance. Depending on which items were skipped, some subscale scores had to be prorated, and in one case, an Attention subscale score could not be calculated at all due to the number of omitted items within that specific subscale. Across the whole sample, 6% (n = 5) of the Attention subscale scores, 3% (n = 2) of the Flexibility subscale scores, 6% (n = 5) of the Inhibitory Control subscale scores, 6% (n = 5) of the Self-Monitoring subscale scores, and 6% (n = 5) of the Working Memory subscale scores were prorated due to omitted items.

The students' rating patterns were also assessed. First, the Consistency Index was investigated. This is a score that provides information about whether an inconsistent response style was indicated. In other words, this index informs the examiner as to whether the students responded differently to items designed to assess similar information. It was found that 25% of the sample (n = 20) had an inconsistent response pattern. The Consistency Index could also not be calculated for 13% (n = 10) of the sample because of omitted items. Inconsistent responding can be intentional or unintentional. It may be deliberate non-compliance, fatigue, a misunderstanding of the items or instructions, inattention, disinterest, or a lack of motivation. It is not possible to determine what may have been the cause of the high rate of inconsistent responding due to the fact that the measure was administered in the group setting, and it was not feasible to monitor each individual's behavior throughout the entire session. Two t-tests assuming equal variance indicated that significant differences did not exist between the Consistency Index scores of the seventh and eighth graders or the male and female students.

Next, the Negative Impression scores were investigated. A negative impression response style makes the individual appear unrealistically negative. Within this sample, eight students (10%) had a negative impression response style. This may indicate that the scores from these students are an underestimation of the individual's actual functioning. Lastly, the Positive Impression scores were evaluated. A positive impression response style makes the rater appear unrealistically positive. Only one student was determined to have a positive impression response style. It was possible that this student's ratings were an overestimation of his executive functioning.

According to the authors of this measure, the CEFI Full Scale Score is the most reliable indicator of a student's executive function skills. This score is based on 90 of the 100 scale items from the nine different content areas. Lower scores on this scale indicate weakness in executive function, and conversely, higher scores indicate strength. In order to get a more specific idea of how a child is functioning, however, it is important to also investigate each of the subscales individually. The CEFI-SR Full Scale scores indicated that 29% of the students reported scores in the Low Average (24%, n = 19), Below Average (4%, n = 3), and Well Below Average (1%, n = 1) ranges. The majority of the students reported overall scores in the average range (58%, n = 45). The remaining 13% of the students reported scores in the high average (5%, n = 4), superior (6%, n = 5), and very superior (1%, n = 1) ranges. Due to omitted items, one student's Full Scale score could not be calculated. Separate samples t-tests indicated that there were no significant differences in the CEFI-SR Full Scale scores across the grades or genders.

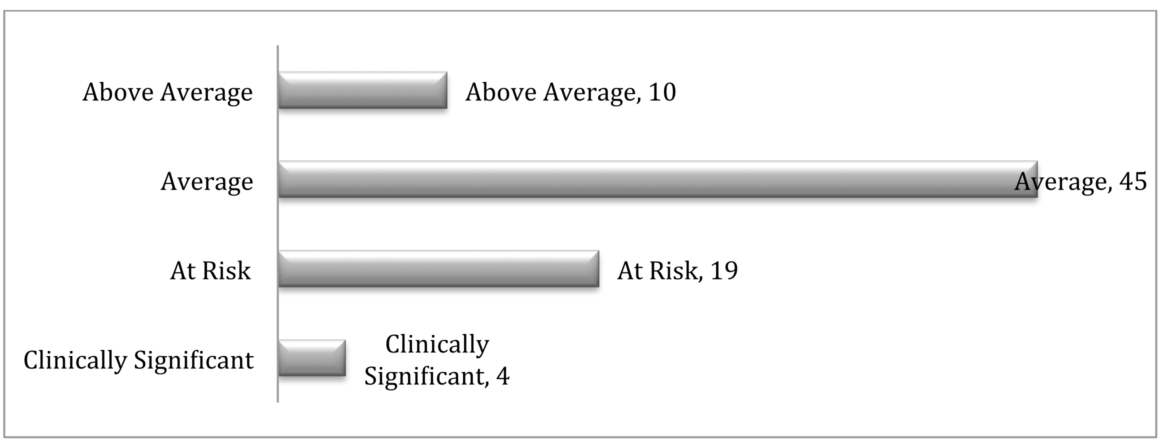

Figure 1. CEFI-SR Full Scale Score Ranges.

Students with scores in the Below Average and Well Below Average ranges are considered to have clinically significant levels of impairment in this skill area; students with scores in the Low Average range are considered at-risk; and students in the High

Average, Superior, and Very Superior ranges are all considered to be above average in their functioning.

The subscales of the CEFI-SR that were factored in the CEFI-SR Full Scale score but were not being correlated with direct testing scores from the NEPSY-II included Emotion Regulation, Initiation, Organization, and Planning. These scales were not included in the validity study for two reasons. The first being that they are not easily tested for in a one-on-one testing environment, and second, aside from emotion regulation, they are not skills that are considered executive in nature in the Barkley (2012) model chosen to operationally define executive function for this study.

Attention

The questions in the Attention subscale asked students to rate how well they were able to avoid distractions and sustain attention in order to concentrate on tasks. Analysis of scores from this area revealed that 34% (n = 27) of the students may have been having difficulty in this area as indicated by 19% (n = 15) reporting scores in the Low Average range, 11% (n = 9) with scores in the Below Average range, and 4% (n = 3) in the Well Below Average range. The highest percentage of students (47%, n = 37) earned scores in the average range, indicating that they did not believe they were having difficulty in this area, and 19% of the students reported scores in the High Average (12%, n = 9), Superior (3%, n = 2), and Very Superior (4%, n = 3) ranges. Due to omitted items, one student's Attention subscale score could not be calculated. Separate samples t-tests indicated that there were no significant differences in the CEFI-SR Attention Scale scores across the grades or genders.

The Auditory Attention and Response Set task was used to measure attention and inhibitory control in a direct testing situation. For the attention measure, the Auditory Attention Combined Score was used. This score provided the clearest picture of attention skills alone. On this task, 82% (n = 65) of the students were able to sustain their attention at the expected level. Three percent (n = 2) of the students performed in the borderline range, 6% (n = 5) performed below the expected level, and 9% (n = 7) performed well below the expected level. Separate samples t-tests indicated that there were no significant differences in the performance scores for the attention task across the grades or genders.

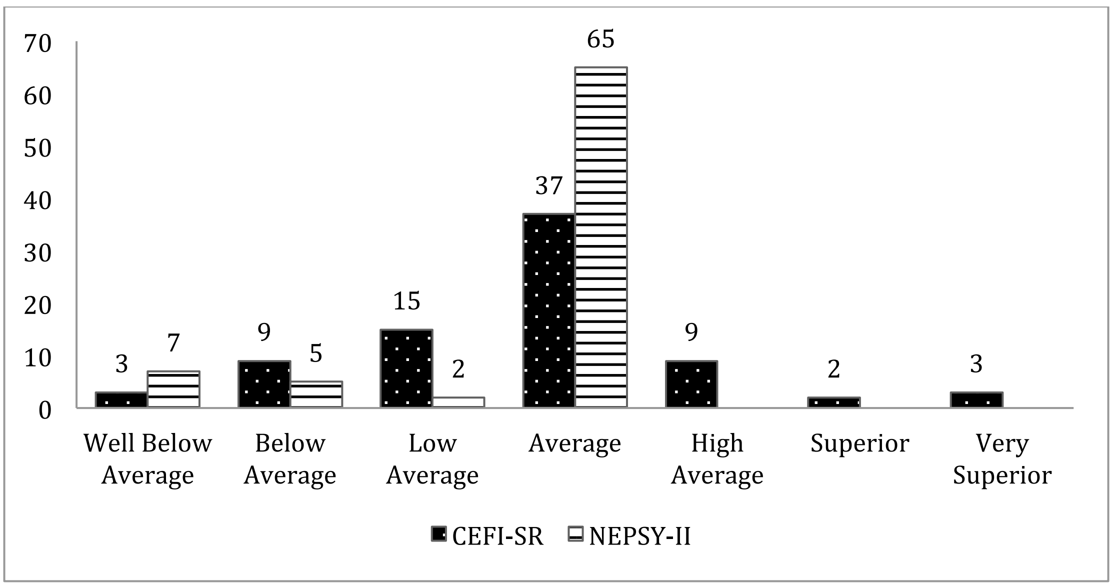

Figure 2. Ranges of Performance Scores for the Attention Measures.

It was hypothesized that the subscales from the CEFI-SR would at least be moderately correlated with the direct testing measures from the NEPSY-II if the CEFI-SR had concurrent validity as a measure of executive function. Analysis using Pearson Correlations was not possible because upon visual inspection of the scatter plot, it was evident that the data points were not normally distributed. Instead, a separate samples t-test was used to determine if a significant difference was present between the mean

CEFI-SR scores of the students who earned the maximum score on the NEPSY-II and the mean score of those who did not. A significant difference was not found between the two groups of students.

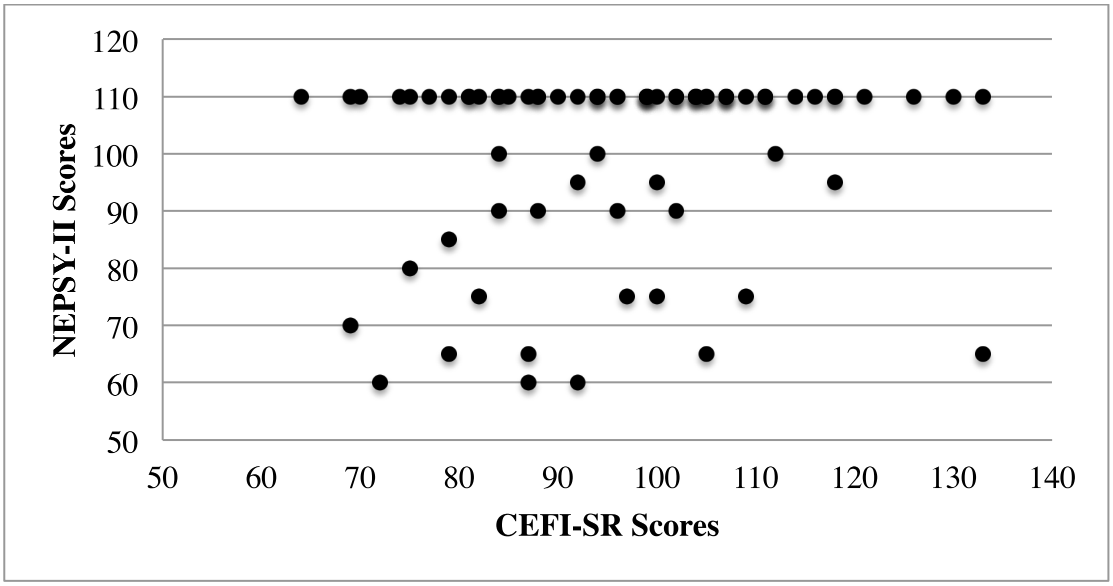

Figure 3. Scatter Plot for Attention. F Critical Value = 1.46 > F = 1.05, H_0 – accepted

Inhibitory Control

The Inhibitory Control subscale consisted of questions that asked the students to describe their ability to control behavior and/or impulses such as considering consequences before acting, maintaining self-control, and keeping commitments. Analysis of scores from this area revealed that 32% (n = 25) of the students may have been having difficulty in this area as indicated by 26% (n = 20) reporting scores in the Low Average range, 5% (n = 4) with scores in the Below Average range, and 1% (n = 1) in the Well Below Average range. The largest percentage of students (48%, n = 38) indicated scores in the average range, and 20% of the students reported scores in the High Average (13%, n = 10), Superior (6%, n = 5), and Very Superior (1%, n = 1) ranges.

Separate samples t-tests indicated that there were no significant differences between the grades or genders.

Inhibitory control was measured with the total number of inhibition errors made during the Auditory Attention and Response Set task on the NEPSY-II. Almost all of the students performed at the expected level (96%, n = 76), but three students (4%) performed in the well below expected range. Separate samples t-tests indicated that there were no significant differences in the performance scores for the inhibitory control task across the grades or genders.

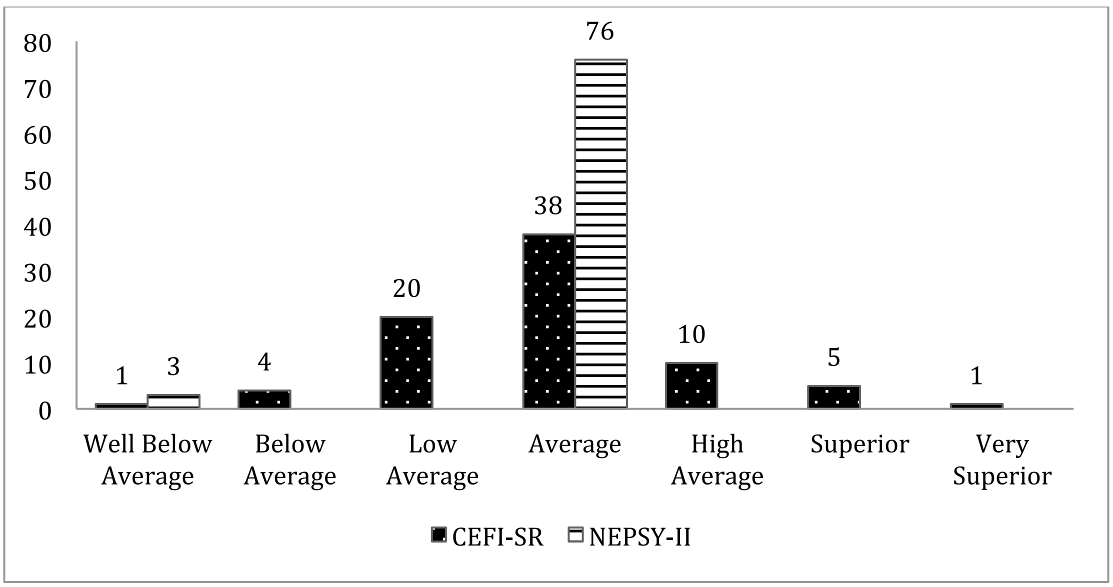

Figure 4. Ranges of Performance Scores for the Inhibition Measures

It was not possible to conduct a Pearson correlation or a t-test comparing the means of those who scored an average score on the NEPSY-II and those who did not because all but three of the students earned scores within the average range. The students were not likely to make errors on this NEPSY-II measure unless they had a significant impairment in this skill area, as evidenced by all but three of the students earning the maximum score.

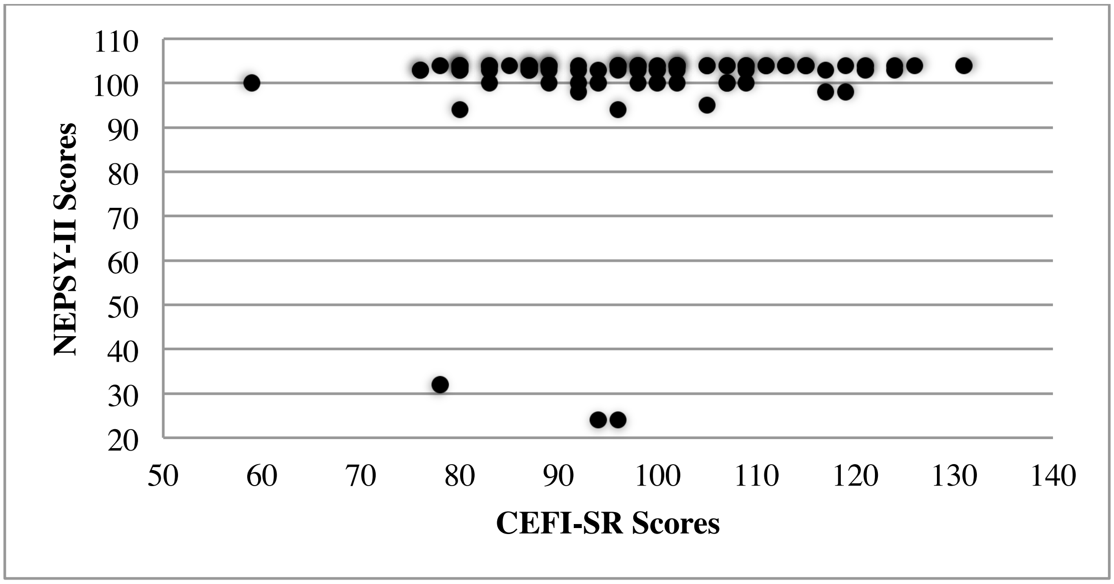

Figure 5. Scatter Plot for Inhibition. F Critical Value = 1.45 > F = 1.09, H_0 – accepted

Cognitive Flexibility

The questions in the Flexibility subscale required the raters to reflect on their ability to adjust behavior appropriately, including coming up with new ways to solve problems, having multiple ideas about how to solve a problem, and being able to use different approaches to solve problems. Scores from this area showed that more than three quarters (76%) of the student perceptions of their flexibility skills were average or higher, with 48% (n = 38) of the students in the Average range, 17% (n = 13) in the High Average range, and 11% (n = 9) in the Superior range. The remaining 24% of the students reported scores in the Low Average (15%, n = 12) and Below Average ranges (9%, n = 7). Separate t-tests indicated that there were no significant differences in the CEFI-SR Flexibility Scale scores across the grades or genders.

Cognitive flexibility was assessed using the total number of correct sorts the students were able to produce during the Animal Sorting task. On the flexibility measure, 71% of the students performed as expected or better than expected compared to same aged peers, with 53% (n = 42) performing at the expected level and 18% (n = 14) performing above the expected level. Fifteen percent (n = 12) of the students showed a Borderline performance, 11% (n = 9) performed Below Expected, and 3% (n = 2) performed Well Below Expected. A significant difference across grades or genders was not found.

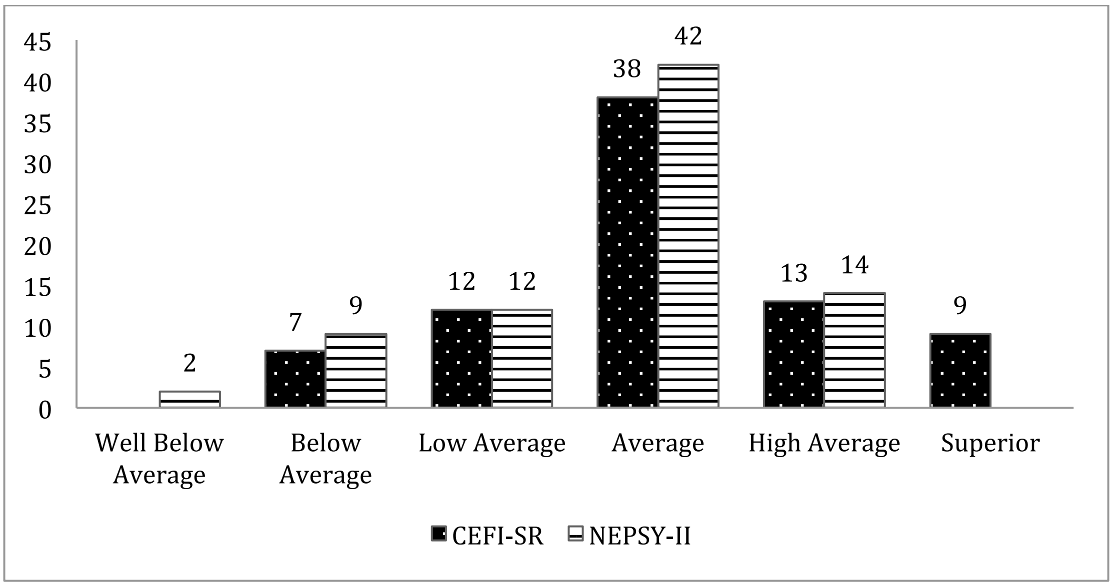

Figure 6. Ranges of Performance Scores for the Flexibility Measures.

The correlation between the Flexibility subscale from the CEFI-SR and the number of correct sorts on the Animal Sorting task from the NEPSY-II was not significant, r(77) = .18, p = .12.

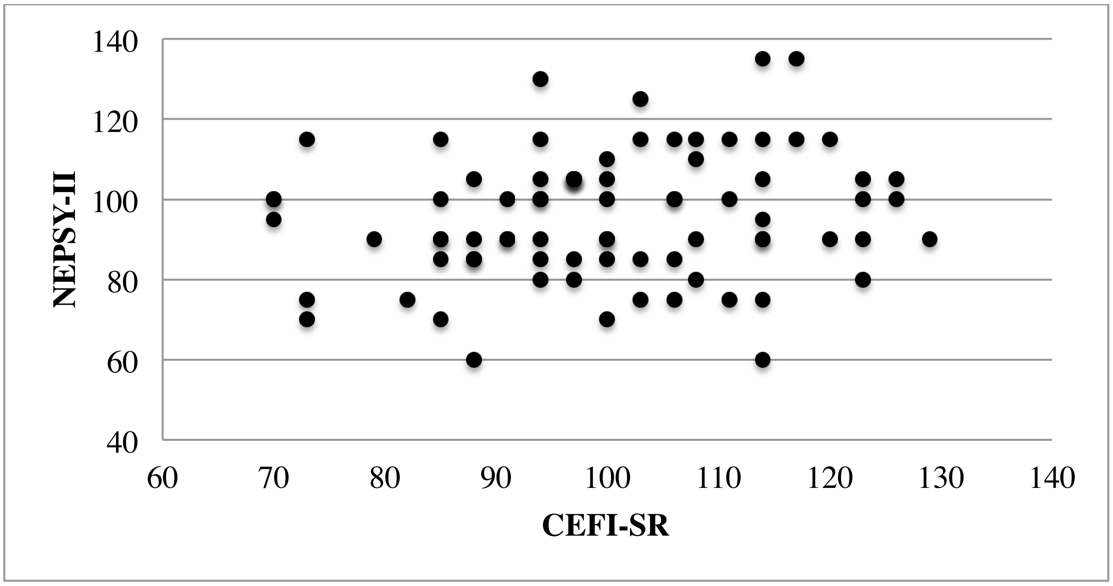

Figure 7. Scatter Plot for Flexibility. F Critical Value = 1.45 > F = 1.21, H_0 – accepted

Self-Monitoring

The Self-Monitoring subscale inquired about a student's ability to evaluate his or her own behaviors in order to assess if a new approach was needed, including fixing mistakes, knowing when help was needed, and understanding when work was finished. Within this subscale, 75% of the students rated themselves as Average or higher, with 57% (n = 45) of students in the Average range, 8% (n = 6) in the High Average range, and 10% (n = 8) in the Superior range. The remaining 25% reported scores in the Low Average (13%, n = 10), Below Average (7%, n = 6), and Well Below Average (5%, n = 4) ranges. Separate sample t-tests indicated that there were no significant differences in the CEFI-SR Self-Monitoring Scale scores across the grades or genders.

A self-monitoring score was derived from the total number of repeated sorts the students produced during the Animal Sorting task. On this measure of self-monitoring, 39% (n = 31) of the students performed above the expected level, 43% (n = 34) performed as expected, 8% (n = 6) performed in the borderline range, 4% (n = 3) performed below expected, and 6% (n = 5) performed well below the expected level. A two-tailed t-test of unequal variances indicated that there was a nearly significant difference between the scores of the students in seventh and eighth grade. The t-test revealed that the seventh grade students (*M* = 104.97, *SD* = 8.36) performed better than the eighth grade students (*M* = 95.83, *SD* = 17.30) on the task of cognitive flexibility at a level nearing significance, $t(69) = 3.11$, $p = .0027$. A significant difference between the male and female students was not found.

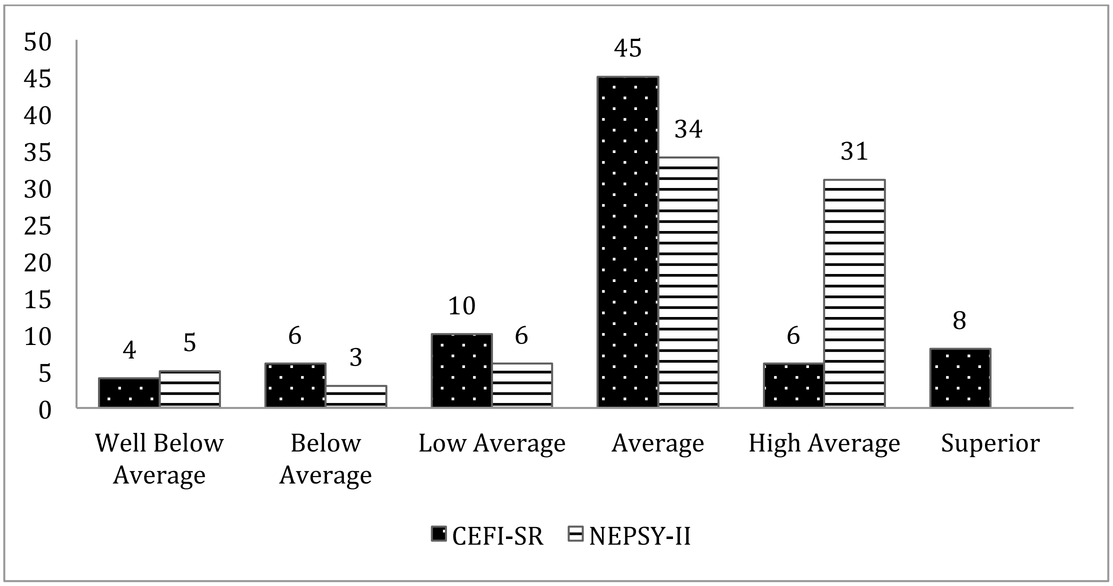

Figure 8. Ranges of Performance Scores for the Self-Monitoring Measure.

The correlation between the Self-Monitoring subscale of the CEFI-SR and the number of repeat errors on the Animal Sorting subtest of the NEPSY-II was not significant, r(77) = -.07, $p = .55$. Because it was not clearly evident that the data from the Self-Monitoring subscales was normally distributed, a second analysis using a separate samples t-test was completed to compare the mean CEFI-SR scores of the students who earned maximum scores on the NEPSY-II measure and those who did not. Results from the t-test indicated that a significant difference between these two groups of students was not present.

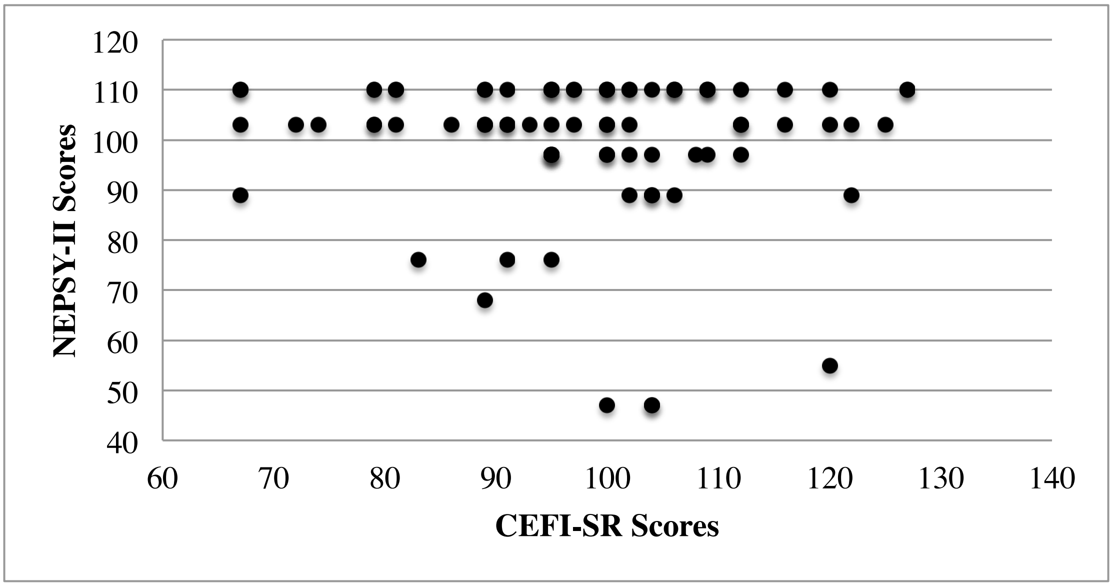

Figure 9. Scatter Plot for Self-Monitoring. F Critical Value =1.45 > F=1.08, H_0– accepted

Working Memory

The Working Memory subscale of the CEFI-SR described how well a student believed he or she could hold information in mind that was important for knowing what to do, such as remembering instructions and steps. The greatest number of students reported having difficulty in this area. Forty-two percent of the students reported scores that were lower than average. More specifically, 27% (n = 21) reported being in the Low Average range, 13% (n = 10) in the Below Average range, and 2% (n = 2) in the Well Below Average range. Forty percent (n = 38) of the students were in the Average range, 10% (n = 8) were in the High Average range, 6% (n = 5) were in the Superior range, and 1% (n = 1) was in the Very Superior range. Separate samples t-tests indicated that there were no significant differences in the CEFI-SR Working Memory Scale scores across the grades or genders.

The Word List Interference task from the NEPSY-II was given to get a measure of working memory skills. On this task, 13% (n = 10) of the students performed above the expected level, 60% (n = 47) performed as expected, 16% (n = 13) performed in the borderline range, 5% (n = 4) performed below expected, and 6% (n = 5) performed well below expected. Separate samples t-tests indicated that there were no significant differences in the performance scores for the working memory task across the grades or genders.

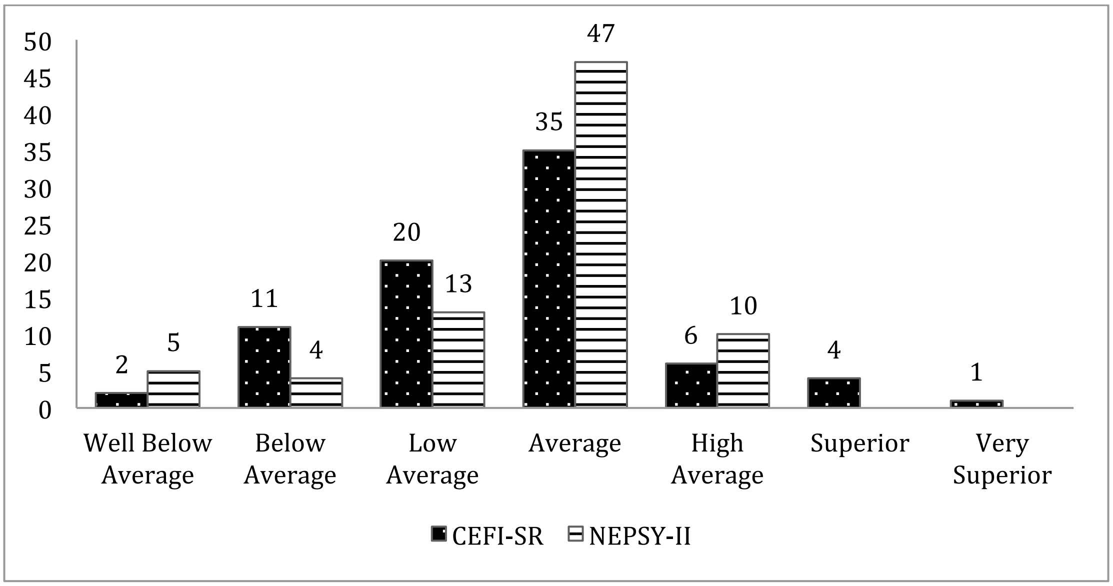

Figure 10. Ranges of Performance Scores for the Working Memory Measures.

The correlation between the Working Memory subscale of the CEFI-SR and the Recall score from the Word List Interference task of the NEPSY-II was not significant, r(77) = .16, p = .16.

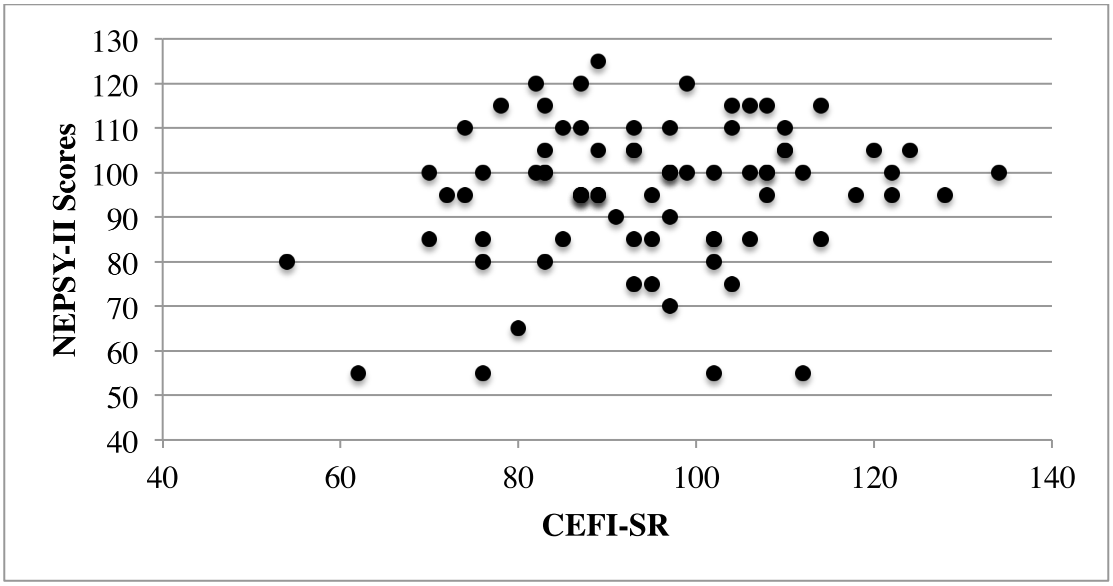

Figure 11. Scatter Plot for Working Memory. F Critical Value=1.45>F=1.00, H_0-accepted

Overall, these findings do not support the hypotheses that the CEFI-SR subscales would have moderate correlations with the direct testing scores from the NEPSY-II, indicating that the two measures may not actually be measuring the same constructs. A summary table of the Pearson Product Moment Correlations conducted is provided below. As stated previously, correlations could not be completed for the Attention and Inhibitory Control data because the patterns of data in the scatter plots did not meet the assumption of being roughly normally distributed, making Pearson correlations an invalid method of assessing this data.

Table 2.

Summary of F Tests and Correlation Coefficients

Executive Function	F Test for Homogeneity of Variance	Correlation Coefficient
Flexibility	F Critical Value = 1.45 > F = 1.21 H_0 – accepted	r(77) = .18, *p* = .12 Not Significant
Self-Monitoring	F Critical Value = 1.45 > F = 1.08 H_0– accepted	r(77) = -.07, *p* = .55 Not Significant
Working Memory	F Critical Value = 1.45 > F = 1.00 H_0-accepted	r(77) = .16, *p* = .16 Not Significant

CHAPTER 5

DISCUSSION

Summary of the Purpose

Executive function has become an umbrella term used to describe the cognitive processing that occurs in the prefrontal and frontal lobe areas of the brain. A review of the literature on executive function reveals that there is no single, agreed-upon definition of the concept (Barkley, 2012; Goldstein et al., 2014). When looking at all of the definitions as a whole, however, there is a central theme throughout the literature: executive function exerts control over automatic responses using a set of overlapping cognitive abilities associated with the prefrontal cortex and interconnected subcortical systems in order to regulate goal-directed behavior (Zelazo, Carter, Reznick, & Frye, 1997; Stuss, 1992).

> For the purposes of this project, Barkley's (2012) definition of executive function was used to operationally define the construct as: the use of self-directed actions so as to choose goals and to select, enact, and sustain actions across time toward those goals usually in the context of others often relying on social and cultural means for the maximization of one's longer-term welfare as the person defines that to be. (p. 176).

This model identified six self-directed actions used during self-regulation, including attention, inhibition, working memory, self-monitoring through private speech, emotional control, and flexibility of problem solving (Barkley, 2012).

The fact that there is no agreed upon definition or model of executive function makes it a difficult construct to measure. Current methods of assessing executive function include direct assessment and rating scales, and both approaches have been met with a number of criticisms. Some argue that rating scales are better than direct assessment for evaluating executive function, however, because they look at real life situations and factor in the social aspect of executive function (Barkley, 2012). Because executive functioning can have such a great impact on schooling and other areas of life, it is important to be able to measure executive function accurately with valid assessment measures. Executive function difficulties manifest in the classroom as inefficiencies with work, difficulty expressing and showing knowledge, poor study skills, weak test performance, and academic grades that do not echo actual intellectual ability (Meltzer, 2010). In addition to academic impairments, deficits in executive function are present in a number of internalizing and externalizing forms of psychopathology.

The Self Report measure of the Comprehensive Executive Function Inventory (CEFI-SR) is a measurement tool that purports to measure these executive function skills in adolescents. The scale asks students to rate their own perceptions of their executive functioning. The CEFI-SR has a normative sample to which the students' self-report ratings are compared. Previous research conducted by the scale's creators (Naglieri & Goldstein, 2013) indicated that the scale was moderately correlated with another widely used self-report rating scale of executive function (BRIEF) in a sample of teens who had been previously diagnosed with ADHD, mood disorders, and learning disabilities. Research to support the concurrent, criterion related validity of the Self Report version of the CEFI was limited at the time this study was designed, however, and it had not yet been compared to any direct assessments of students' cognitive, academic, or executive functioning.

The purpose of this study was to assess the concurrent, criterion related validity of the Comprehensive Executive Function Inventory Self Report version (CEFI-SR) by comparing students' ratings of their own functioning on the CEFI-SR to their performance scores on direct assessment tasks using an established tool for assessing executive function, the NEPSY-II. Attention, inhibitory control, self-monitoring, flexibility, and working memory were the domains of executive function focused on in this study. These domains were chosen because they were the self-regulatory components of Barkley's (2012) model of executive function, and they could each be measured through direct assessment using the NEPSY-II.

It was hypothesized that the subscales from the CEFI-SR would be at least moderately correlated with the direct testing measures from the NEPSY-II if the CEFI-SR had concurrent validity as a measure of executive function. These hypotheses were based on previous studies investigating the validity of this scale and others like it when compared to direct testing measures. Analyses using Pearson Correlations revealed non-significant correlations between the subscales of the CEFI-SR and the measures from the NEPSY-II. Therefore, the findings did not support the hypotheses that the CEFI-SR subscales would have moderate correlations with the direct testing scores from the NEPSY-II, indicating that the two assessment tools may not actually be measuring the same constructs.

Results

Self Report rating scales such as the CEFI-SR have advantages and disadvantages. The main advantage of a self-report scale is that you get a person's point of view regarding the issue being assessed. Rating scales take into account people's perceptions of their world and how they feel they function within it. They can also be useful in situations where observational data are not normally available. For example, with executive function, an observer in a classroom may not be able to easily see students' self-regulation skills, and it can often be difficult to know for sure whether a student is paying attention. A rating scale that addresses these issues, allows the raters to share their views on how they feel they complete these types of tasks. Additional advantages of rating scales are that they tend to be less time consuming and less costly than direct observations or psychological testing (Edelbrock, 1983), which makes them efficient tools to use in clinic and school settings where time and money may be limited.

The primary disadvantage of a self-report measure is the various inherent validity issues that can arise. For instance, people are not always truthful when responding to ratings scales about their own behavior. This can be intentional or unintentional. A person may intentionally lie on a rating scale to make him- or her-self look better or worse to the examiner. The examinees may not understand terms used in the questions, and therefore, may respond without being fully informed about what they are responding to. When it comes to rating executive function, the issue becomes particularly salient. For instance, if students are being asked to rate their abilities to self-monitor, but this is a skill they are lacking, they may unintentionally portray themselves differently on the rating scale compared to their actual level of functioning. If a student has difficulty sustaining attention, he or she may lose focus while responding to a lengthy rating scale, skewing the results. Students may not be able to acknowledge when they are not being mentally flexible because they do not have the capacity to know that there are other ways to solve a problem. Therefore, they would unintentionally rate themselves differently than how they would actually perform. Overall, self-ratings may be less sensitive to executive function deficits due to the person's impaired self-awareness. With executive function self-reports, the students are also being asked to report on skills that they often utilize without consciously thinking about. Therefore, they may not know how to appropriately answer the questions. These disadvantages do not mean that all self-report data are invalid, but these limitations should be considered when interpreting responses.

Furthermore, items on rating scales are often closed-ended questions, which tend to constrain an answer in some way. This makes the responses easier to analyze, compare, and quantify across respondents, but resultantly, there are some major disadvantages: "people understand the questions differently; respondents are forced into what may seem to them an unnatural reply; they have no opportunity to quantify their answers or to explain their opinions more precisely" (Sheatsley, 1983, p. 197). These factors can impact the response patterns of those completing the rating scales resulting in skewed results, omitted items, inconsistent response patterns, and overly positive or negative impressions.

Prior to conducing the Pearson correlations, the students' response patterns on the CEFI-SR were examined. It was determined that 38% of the students omitted at least one response when answering the scale items. This seemed to happen more so within the sample of male students, but not to a significant degree. Missing items on a rating scale can be a qualitatively informative behavior regarding executive function because it can indicate that the student was not paying close enough attention or monitoring his or her own work, but this is not the only possibility. To keep the environment from becoming coercive, students in this study were told that they did not have to answer any questions they did not feel comfortable answering. Because of the small group format in which the rating scale was administered, it was not possible to monitor how the students were responding or to follow up about omitted items. Therefore, in this situation, conclusions could not be drawn about the reasons for the high number of omitted items. In an actual clinical or school setting, it is important that students be encouraged to respond to all rating scale items to increase validity, so this issue would not be as impactful. Also, in a one to one setting, it would be easier to judge, based off of response behaviors, whether the examinees were reading and intentionally skipping items or if they were losing their place and unintentionally skipping items.

Moreover, it was found that 25% of the overall sample displayed an inconsistent response pattern. This indicated that the students responded differently to items designed to assess similar information, and an additional 13% of the sample omitted items that then made it impossible to calculate the Consistency Index. This high rate of inconsistency and omitted items may offer some explanation as to why stronger correlations were not found between the rating scale and the direct testing. For instance, responding in an inconsistent manner may be indicative of a lack of understanding regarding the wording of the questions. The students may have misinterpreted questions that were designed to measure the same skills, and therefore, they responded to the items differently. This possible confusion related to language understanding was not as big of a factor in the direct testing situation. On the other hand, an inconsistent response pattern may also indicate that the students were not responding truthfully or that they were not paying close attention to how they were responding.

These factors are very important when considering this rating scale for use in the clinical or academic environment. It is assumed that this rating scale would be used to assess students who have been referred for having difficulty with some level of executive functioning. Therefore, caution should be taken when asking a child to monitor his or her own behavior enough to rate it on a rating scale and to be able to independently focus on and accurately respond to a series of 100 questions. Again, this is not as impactful of an issue in direct testing situations because the examiner is monitoring the child. Some of the load regarding self-monitoring and adherence to the instructions is removed from the examinee and placed on the examiner through the use of prompts and redirection offered during testing.

The last aspect of the response patterns investigated was the Negative and Positive Impression scores. It was determined that 10% of the sample displayed a negative impression response style, possibly indicating that the students underestimated their executive functioning ability, and only one student responded within an overly positive impression response style, indicating that he may have overestimated his ability. Again, even though these are smaller percentages, they may have had an impact on the correlations with the direct testing. If students have poor impressions of themselves and underestimate their ability levels, they are going to look worse on paper than they do in direct testing. If the response scales alone are the only tools used to assess a child's functioning, he or she may look worse off than the reality.

According to Naglieri and Goldstein (2013), the CEFI Full Scale Score is the most reliable indicator of a student's executive function skills. This score is based on 90 of the 100 scale items from the nine different content areas. Lower scores on this scale indicate weakness in executive function, and conversely, higher scores indicate strength. In order to get a more specific idea of how a child is functioning, however, it is important to also investigate each of the subscales individually. More than half (58%) of the students in the research sample reported themselves to be functioning within the average range. Twelve percent of the sample reported themselves to be functioning better than expected for their age group, and 30% of the sample identified themselves as functioning below what would be expected compared to the norm group of age-matched peers. These ratings did not align with the students' performance scores on the NEPSY-II, as many of the students were able to perform within normal limits, indicating that the two measures may be assessing different aspects of executive function skills and resulting in non-significant correlations between the measures.

For instance, most students earned the maximum score on the direct assessment attention measure of the NEPSY-II because they were successfully able to maintain their focus for the three-minute duration of the assessment, but there was great variability in their own ratings of their abilities to attend on the CEFI-SR. Because of this pattern of performance, it was not possible to conduct a Pearson correlation with this data. The necessary assumption of normally distributed data was not met. Instead, a t-test was performed to compare the mean CEFI-SR scores of those who earned the maximum score on the NEPSY-II subtest and the mean CEFI-SR score of those who did not. Theoretically, the group of students performing at the maximum level on the direct testing assessment should have had significantly higher scores on the subscale of the rating scale than those who did not achieve maximum performance. This is not what occurred. No significant difference was found between the group means. This is likely because the two measures were assessing attention at different levels of functioning. In other words, the NEPSY-II direct assessment task determined how well students were able to initiate their attention, sustain that attention for a three minute period, and respond to a previously given instruction while listening carefully to the aurally presented stimuli. The CEFI-SR rating subscale for attention takes into consideration many different facets of attention and the environments in which they are occurring, including initiating attention to boring tasks, sustaining attention for long periods of time, concentration, attending to details, listening closely, and ignoring distractions. The non-significant difference between the means of the two groups (those earning the maximum score and those who did not) arises because most executive function tests tend to be more sensitive to brain damage or significant cognitive impairment than to a more subtle developmental delay in executive function that can more easily be detected with a rating scale.

Again, because of the nature of the NEPSY-II assessment for inhibitory control, students were not likely to make errors. Only the students with significant impairments had difficulty with this measure, resulting in only three students earning less than the maximum score. These three students were not able to stop themselves from responding to the presentation of overly learned stimuli. For example, when the recording said the name of a color, the students touched that color despite the instructions taught prior to beginning the testing. When looking at the scores of just these three students, however, it became apparent that they were also not very successful with being able to rate their executive functioning skills. Despite performing significantly below expected on this task on the NEPSY-II, two of the students still rated their inhibitory control to be within the average range on the CEFI-SR. While this is a very small portion of the sample, it illustrates that asking students with potential executive function deficits to rate their own executive function skills may not be the most reliable method. The third student to perform below the expected level was able to accurately rate his or her own functioning because the rating fell in the well below average range. When investigating the ratings of the students who performed within the expected range, it was clear that there was great variability in how the students saw their own ability levels, indicating that the CEFI-SR may be a more effective way of detecting students who are displaying more subtle deficits in this area of executive function.

The questions in the Flexibility subscale required the raters to reflect on an ability to adjust behavior appropriately, including coming up with new ways to solve problems, having multiple ideas about how to solve a problem, and being able to use different approaches to solve problems. On the surface, the questions seem to describe the NEPSY-II task, but the correlation between the two measures was not significant. The NEPSY-II task was timed. It was possible that students, who had strong cognitive flexibility with more time, gave themselves high ratings on the CEFI-SR but then ran out of time on the actual task from the NEPSY-II. It was also possible that the NEPSY-II task was too artificial to accurately represent a situation in which cognitive flexibility would be needed in real world functioning. Often, students came up with several ideas of how to solve the problem on the NEPSY-II but reached a limit and gave up, indicating that motivation can impact executive function performance (Barkley, 2012). Almost all definitions of executive function now contain the idea that they work to guide goal-directed behavior. On the NEPSY-II task, the goal is to come up with as many alternate sorts as possible, but this is not very motivating to all examinees. Depending on the students' drive to succeed, scores will and did vary. In real life, however, the importance of the goal becomes very salient. Additionally, some students may have interpreted the questions on the CEFI-SR as assessing their ability to come up with one alternate way of solving a problem, whereas as the NEPSY-II asked them to solve one problem in multiple different ways. Therefore, students may view themselves as being flexible and rate themselves as such because they can come up with one alternative way, but the NEPSY-II performance score may indicate something different if they are not able to come up with multiple means of getting to the solution.

Self-monitoring was one area of executive function assessed where the difference between the constructs being assessed on the NEPSY-II and the CEFI-SR was the most evident. The CEFI-SR asked students to rate themselves on their ability to perform tasks that they could not do during the standardized NEPSY-II testing, such as asking for help, keeping track of time, and knowing when a task was completed. The examiner was not allowed to offer assistance, the students were not told how much time they would have, and they did not know how many correct sorts were possible to be able to know when the task was complete. The nature of the NEPSY-II task only assessed a student's ability to learn from past mistakes and change a plan that was not working. These aspects of self-monitoring are on the CEFI-SR subscale but were only targeted with a few questions. It made sense that there was no correlation between these scores because they were clearly measuring different aspects of self-monitoring with the CEFI-SR having a broader application. Additionally, a significant difference was not found between the mean CEFI-SR scores of the students who earned the maximum NEPSY-II scores and those who did not, further providing evidence that these scales were assessing different skills.

Working Memory was another skill assessed through the direct assessment and the rating scale in which it was clear that different aspects of the construct were being assessed. For the NEPSY-II task, the students were asked to remember a string of unrelated words while filtering out an interference task, but the CEFI-SR asked the students to rate their ability to remember information in context, such as remembering instructions, remembering multiple things at a time, remembering what was read or heard, and remembering where things were placed. The NEPSY-II looked at the basic ability to use working memory, but the CEFI-SR took it a step farther and asked the students to assess how they performed the skill in the real world environment. Again, because of this difference, a non-significant correlation was found between the two measures.

Overall, no significant correlations were found between the subscale scores of the CEFI-SR and the performance scores of the NEPSY-II. Nor were any significant differences found between the CEFI-SR scores of the students who earned maximum NEPSY-II scores for Attention and Inhibitory Control and those who did not. This did not necessarily indicate that the CEFI-SR was invalid, but it did indicate that the direct assessment measure and the rating scale were assessing different constructs, or different aspects of similar constructs. What the measure will be used for will determine which would be more appropriate in a given situation because both rating scales and direct assessments have their strengths and weaknesses. For instance, direct assessment measures often have low to moderate test-retest reliability and limited ceilings (Goldstein et al., 2014) as evidenced in this study by so many students achieving maximum scores on several of the tasks but still showing some level of deficits on the CEFI-SR. Additionally, tests of executive function often have low ecological validity (Barkley, 2012). The artificial setting of a clinic, office, or laboratory may assist in hiding any executive dysfunction (Kinsella et al., 2007) resulting in inconsistencies between behaviors exhibited during testing and those in real life (P. Anderson, 2002; Chan et al., 2008). Lastly, measures of executive function such as the NEPSY-II tend to be more sensitive to more severe impairment in functioning, whereas rating scales tend to be more sensitive to deficits arising in everyday life.

Benefits of the Study and Implications for the Field

This study confirms previous researchers' findings that direct assessments of executive functioning are, for the most part, not sampling the same skills as executive function rating scales of executive functioning in everyday life (Alderman et al., 2003; Barkley, 2012; Shallice & Burgess, 1991). It also further indicates that tests of executive function should not be the primary or sole source for identifying executive function deficits. As Barkley wrote, "EF tests should not serve as the gold standard for evaluation EF" (2012, p. 11). The reasoning behind this statement is that direct assessment measures of executive functioning fail to consider the impact emotion and motivations have on the implementation of executive function in the real world setting through the process of goal attainment. Additionally, direct assessment does not allow the examiner to take into consideration the impact of environmental, economic, social, developmental and cultural factors on a student's ability to affectively use executive functioning skills in the real world.

While both rating scales like the CEFI-SR and direct assessments like the NEPSY-II claim to measure the same executive function skills, they seem to be measuring them at different levels. In other words, direct assessments like the NEPSY-II measure executive functions at the very basic neurological level, asking does the student have the cognitive capacity to be able to understand directions and respond appropriately, initiate and sustain attention for a three minute period, think of different ways to conceptualize an array of visual stimuli, ignore distractions, remember lists, and inhibit impulses to respond to overlearned information. Executive function rating scales allow the examiner to investigate the impact of the extended phenotype to see how brain functioning affects the students' environments and in turn how the environments impact the students' brain functioning, taking into consideration the fact that people do not utilize their executive functions in a bubble. The environment in which the person is functioning can have a major impact, and rating scales ask the examinees to consider their own functioning within the ever-changing environment.

Therefore, the best way to handle assessment of executive function is to employ a battery of tools that includes direct assessment in conjunction with rating scales. This would allow the examiner to determine if actual significant neurological impairment is present, through use of the direct measure and also to see if deficits arise when a person tries to enact their executive function in daily living. It is possible that deficits would not appear in direct assessment but would appear when the person tries to put their executive function into action but struggles because of environmental, emotional, social, cultural, economic, or motivational factors get in the way, which is more easily assessed through usage of a rating scale. In addition to using a battery of assessment tools, examiners should "seek to combine information from different informants so as to maximize the predictive power" (Edelbrock, 1983, p. 297). Because of the inherent disadvantages of using a self-report scale, especially one assessing executive function, it would be important to gather information from outside raters, such as teachers and caregivers, to compile the most accurate depiction of a student's functioning across environments.

Limitations of the Study

There were several limitations found within the design of this study. The first involved the recruitment of participants. All participants were recruited from one middle school in a suburban neighborhood. While there is diversity within the population of the student body, it is not representative of the population of the country, thereby decreasing the generalizability of the study findings. Furthermore, there was inequality within the sample. There were a greater number of female participants, and there were more eighth graders than seventh graders in the overall sample, again making it difficult to generalize the findings outside of this sample. Lastly, the sample was primarily homogenous regarding ability level. The majority of the sample consisted of typically developing students from the general education population. The majority of the students were not from clinic samples, which is the opposite of the samples used by Naglieri and Goldstein (2013) to investigate the validity of their scale. Using a sample of this nature resulted in the majority of the students reaching the ceiling on several of the direct assessment measure of executive function with the NEPSY-II. Therefore, resulting correlations between the CEFI-SR and NEPSY-II were not significant because they were measuring executive functioning skills at different levels of sensitivity.

In addition to the limitations resulting from the sample, another issue with this study was that the lead examiner completed all data collection on her own. Therefore, it is possible that the examiner could have impacted the study results due to knowing what the desired outcomes were prior to collecting data. Moreover, it is possible that the examiner may have inadvertently impacted the results due to the fatigue effects caused by directly assessing 79 students in a short period of time. The examiner made her best effort to adhere to all standardization procedures for the tools used, but because of the leeway given in the administration instructions of the NEPSY-II, it is possible that the examiner may have impacted the results in the way she administered the test items. Based on the fact that correlations were not significant and did not reach predicted levels, however, it seems unlikely that this had a major impact on results.

Lastly, there was a lack of demographic information collected that could have been used to investigate differences in scores between ethnicities, socioeconomic groups, and special education distinctions. Because of using a sample from a single middle school in a single school district, collection of identifying information was kept to a minimum, and only the information asked for through administration of the CEFI-SR was collected, which included gender, age and grade. Gender was not an open ended question, so the students were instructed to answer it how they felt comfortable or to leave it blank. While this information may have been interesting to further investigate differences between groups, it would have had no bearing on the correlations between the measures, and could not have been used to answer the research questions posed by this study. For future studies, however, it may be interesting to learn how students from different populations rate themselves on self-report rating scales of executive function to determine if patterns arise.

Implications for Future Research

The findings of the current study are unable to determine conclusively if the CEFI-SR is a valid measure of executive functioning in the adolescent population due to the limitations of the study design. Therefore, replication of the current study addressing the identified weaknesses including usage of a more diverse sample from differing geographic locations; multiple researchers to distribute the workload; and collection of additional data, may generate important information for the field of school psychology.

More research needs to be done pertaining to the efficacy of self-report executive function rating scales in general. Because being self-aware enough to be able to self-monitor is an aspect of executive function, having a person who has been referred for possible executive function deficits complete a self-report rating scale of this nature may not be the most effective method of gathering information. To further study the validity of using self-report scales, larger more expansive studies should be done comparing results collected from differing informants (i.e. parent, teacher, self). The CEFI-SR should also be compared to other self-report rating scales of this kind such as the BRIEF self-report. Efforts could also be made to correlate the CEFI-SR with other direct assessment measures of neuropsychological functioning like the Delis-Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001) or the Cognitive Assessment System, Second Edition (CAS2; Naglieri, Das, & Goldstein, 2014) to determine if stronger correlations can be found. In addition, it may be interesting to correlate ratings on the CEFI-SR to measures of classroom-based performance. For instance, a study could be done correlating subscale scores from the CEFI-SR to scores from corresponding target behaviors on a Self and Match chart or with classroom observational measures designed to assess on-task off-task behaviors. Comparing scores from the CEFI-SR to values derived in real world situations may correlate more highly because they are both investigating executive function within the academic environment and not in an artificial testing environment.

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APPENDIX A

PARENTAL CONSENT FORM

PARENT INFORMAITON AND CONSENT FORM

Title of the research study:

An investigation of the concurrent criterion-related validity of the self report measure from the Comprehensive Executive Function Inventory (CEFI)

Names and Department of investigators:

Deborah Seiple, M.Ed., Doctoral Student
Catherine Fiorello, Ph.D., Full Professor

School Psychology
College of Education
Temple University
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Philadelphia, PA 19122

Purpose of the study:
Your son/daughter is being asked to take part in a research study looking at executive functioning (attention, the ability to inhibit responses, cognitive flexibility, self-monitoring, and working memory). Your child was selected as a possible participant in this study because he/she is a student at Wilson Area Intermediate School in 7th or 8th grade. The purpose of the research is to investigate the accuracy with which children in 7th and 8th grade report their executive functioning skills.

What you should know about a research study:

- Someone will explain this research study to you.
- You volunteer to be in a research study.
- Whether you take part is up to you.
- You can choose not to take part in the research study.
- You can agree to take part now and later change your mind.
- Whatever you decide, it will not be held against you.
- Feel free to ask all the questions you want before and after you decide.
- By signing this consent form, you are not waiving any of the legal rights that you otherwise would have as a participant in a research study.

The estimated duration of your child's study participation is the remainder of the 2013-2014 academic year.

Procedures:
If you agree to allow your child to participate, I will be asking you and your child to do the following things:

First, I would ask you to complete this informed consent form. I will be visiting your child's school again in a couple of days to collect consent forms. All of the students in the 7th and 8th grades are being asked to participate, and once they are given parent permission, they will also be asked to sign an assent form indicating that they are willing to participate. The students who have been given permission to participate will be asked to complete a rating scale related to their own perceptions of their executive functioning skills. This rating scale takes about 15 minutes to complete. They will be asked to complete it during a smart period so it will not interfere with academic instruction. The rating scale asks about your child's ability to pay attention, organize, plan, control impulses and emotions, remember, and initiate tasks.

Once the rating scales have been completed, I will return to the school on several days to complete direct one-on-one testing with each child who was given permission to participate. Each child will be asked to engage in one, 20-25 minute testing session during which he/she will be asked to complete tasks involving the ability to be cognitively flexible, to remember instructions, to pay attention, and to inhibit impulses. Because this testing will require the child to miss some class time, your child's teachers will be consulted about the best time to take the child for the individual testing.

Risks and Discomforts:
A potential risk of this study is that your child might feel some discomfort from answering questions or participating in testing. If there is any indication that your child is uncomfortable or upset, all study activities will be stopped immediately, and attempts will be made to comfort and help him/her. Additionally, your child will miss about 20 to 25 minutes of class time for direct testing. There is also the possibility of some unauthorized disclosure of information about your child as a result of his/her participation in this study. Every attempt will be made to keep all information about your child, or given by your child confidential, and when keeping records of information, your child's name will not be used. He/she will be identified using a unique code number.

Benefits:
Through conducting this study, the lead investigator will be able to provide the 7th and 8th grade teachers with information about the overall executive functioning abilities of the group of students who participate. Individual students will not be identified or singled out. Instead, a general report can be provided to the teachers about areas where the children report having some difficulty, and interventions can be suggested as potential ways to support and remediate any areas of weakness. Providing this report to teacher may result in changes in the

classroom environment that will benefit the students' development of executive functioning skills.

Compensation for Participation:
As a way of thanking the 7th and 8th grade students, I will hold several raffles. The first will take place after the consent forms have been returned. Any student, who turns in a form, whether or not they have been given permission to participate, will be included in this first raffle. Another raffle will be held for the students who complete the direct testing. Two children will win at each raffle and each prize will be a $25 gift card.

Alternatives:
This is not a treatment study. The alternative to participating is not to participate.

Questions:
Please contact the research team with questions, concerns, or complaints about the research and any research-related injuries by calling or sending an email to a team member:

Deborah Seiple, M.Ed. –
Phone: (610) 416-3733 Email: deborah.seiple@temple.edu
Catherine Fiorello, Ph.D. –
Phone: (215) 204-6254 Email: catherine.fiorello@temple.edu

This research has been reviewed and approved by the Temple University Institutional Review Board. Please contact them at (215) 707-3390 or e-mail them at: irb@temple.edu for any of the following: questions, concerns, or complaints about the research; questions about your rights; to obtain information; or to offer input.

Confidentiality:
Efforts will be made to limit the disclosure of your child's personal information, including research study records, to people who have a need to review this information. However, the study team cannot promise complete secrecy. For example, although the study team has put in safeguards to protect your information, there is always a potential risk of loss of confidentiality. There are several organizations that may inspect and copy your information to make sure that the study team is following the rules and regulations regarding research and the protection of human subjects. These organizations include the IRB, Temple University, its affiliates and agents, Temple University Health System, Inc., its affiliates and agents, the study sponsor and its agents, and the Office for Human Research Protections.

Any information that is obtained in connection with this study and that can be identified with your child will remain confidential. On all records kept for this study, your child will be identified using a unique code number, not by name. All study records will be held in a locked file cabinet, and only personnel involved in the research and directly supervised by the Principal Investigator will have access to these files. Results of this study may be published. If any data is published, neither you, nor your child will be identified by name.

Signature Block for Children

Please, check the box of your choice below

❑ Yes, my child has permission to participate

❑ No, my child does NOT have permission to participate

DO NOT SIGN THIS FORM AFTER THIS DATE → June 30, 2014

____

Printed name of child

____ ____________________

Signature of parent or guardian | Date

❑ Parent

❑ Guardian (See note below)

____

Printed name of parent or guardian

Note on permission by guardians: An individual may provide permission for a child only if that individual can provide a written document indicating that he or she is legally authorized to consent to the child's general medical care. Attach the documentation to the signed document.

____ ____________________

Signature of person obtaining consent and assent | Date

____ ____________________

Printed name of person obtaining consent and assent | Date

APPENDIX B

STUDENT ASSENT FORM

ASSENT TO PARTICIPATE IN RESEARCH

Adolescents' Reporting on Executive Functions

1. I am here from Temple University to ask you to take part in a research study because I am trying to learn more about executive functioning in adolescents.

2. I have sent home a consent form that your parents have signed that said it is ok for you to join the study if you want to. If you want to join this study, I will give you a questionnaire today to fill out that asks questions about your executive functions (ability to pay attention, plan, organize, start projects, adapt, remember, and control impulses and emotions).

3. Signing this form also indicates that you are willing to have your executive functions measured during a one-on-one testing session.

4. Even though your parents have said "yes" you can still decide not to do this. If you don't want to be in this study, you don't have to participate. Remember, being in this study is up to you and no one will be upset if you do not want to participate or even if you change your mind later and want to stop.

5. You can ask any questions that you have about the study. If you have a question later that you didn't think of now, you can email me at deborah.seiple@temple.edu.

6. Signing your name at the bottom means that you agree to be in this study.

__________________________________ ____________________
Name of Participant (Print) Date

____
Signature of Participant

__________________________________ ____________________
Signature of Investigator Date

APPENDIX C

COMPREHENSIVE EXECUTIVE FUNCTION INVENTORY – SELF REPORT

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