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Assessing Executive Functioning in Young Children with Autism Spectrum Disorder

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Walden University
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Abstract

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MS, Rochester Institute of Technology, 2007

BS, Colorado State University, 2002

Dissertation Submitted in Partial Fulfillment

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Abstract

This study examined the inconsistency within research surrounding the relationship between executive functioning skills and autism symptomology in those being assessed for autism in early childhood (e.g., 34 to 60 months of age). Inconsistencies in current research connecting autism symptomology and executive dysfunction affect the best practice of practitioners that assess for disabilities. This study aimed to identify correlations between autism symptomology and executive functioning skills and whether combining autism symptomology and executive functioning skills assessments provide a more reliable classification as autism or non-autism. The framework foundation drew upon research that determined connections between those suffering from traumatic brain injury to the frontal lobe and those with autism. Autism and executive functioning testing outcomes ($N = 42$) were provided by an early childhood assessment center and entered in to multiple linear and logistic regression models. The results of the multiple linear regression indicated that there is a significant relationship between executive function skills and autism symptoms, and the results of the multiple logistic regression showed that together executive functioning skills and autism symptomology are strong predictors of classification. There is a positive social impact in the results of this study as it provides further knowledge of the best practice for practitioners who assess for disabilities due to the established connections between executive function deficits and autism in early childhood and determined some predictors when assessing for autism. The results may affect how autism and recommendations are identified in early childhood.

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Chapter 1: Introduction to the Study

Over this past decade, the diagnosis of autism and its related disorders have increased (Center for Disease Control and Prevention [CDC], 2015). The autism diagnosis rate in 2010 was one in 150 children and changed to one in 68 children in about 5 years (CDC, 2015). Broadly defined, autism is a disorder that affects the social communication and behavior of an individual (American Psychiatric Association [APA], 2015). Because characteristics of autism emerge in early childhood (Ronald, Edelson, Asherson, & Saudino, 2010), early identification can allow for earlier intervention (Espy, Kaufman, Glisky, & McDiarmid, 2001). Current research into the relationship between autism and executive functioning is rooted in the groundbreaking research of Damasio and Maurer's (1978) who initially proposed that executive dysfunction (i.e. issues with working memory, flexibility, planning, and inhibition) precipitated autism symptomology. The attractiveness of this prospect is amplified by the fact that executive dysfunction is measurable in those with autism throughout development (Geurts & Vissers, 2012; Geurts, Corbett, & Solomon, 2009; Hill, 2004). Research that has focused on the development of executive function skills has illustrated that these abilities begin to develop within months of birth, become enhanced in the preschool years, and continues to develop into adolescence (Pellicano, 2012).

Previous research is inconsistent and inconclusive in establishing a connection between executive function deficiency and autism in early childhood. This study contributes to a better understanding of the link between executive functions and autism, which results in a positive social change as it contributes to understanding and determination of the best predictors when assessing for autism. Connections between executive functioning and autism, the research problem, purpose of this study, and research questions will be further presented in this chapter.

Background

While relationships between executive functioning and autism symptomology are immature, researchers have begun exploring the topic. Research concerning those in early childhood, children between 1 and 5 years of age, is divided in conclusions toward the connection between autism symptomology and executive dysfunction. For example, Etemad Smithson et al. (2013) and Russell-Smith, Comerford, Mayberry, and Whitehouse (2014) included preschool aged children in their samples, and they examined relationships between executive function skills and autism symptomology by focusing on individuals who have already received a diagnosis of autism or non-autism. Both research teams' conclusions indicated that there were no statistically significant connections between executive dysfunction and autism symptomology in early childhood; whereas, Garon, Bryson, and Smith (2008), Panerai, Tasca, Genitori, Arrigo, and Elia (2014), and Yerys, Hepburn, Pennington, and Rogers (2007) all established a connection between autism symptomology and executive dysfunction in early childhood.

Research has also demonstrated connections between executive dysfunction and specific, potential symptoms of autism, such as theory of mind, joint attention, and imitation in early childhood. For example, Benson, Sabbagh, Carlson, and Zelazo (2013) examined theory of mind deficits in those with executive dysfunction and autism (mean age of their sample was3.5 years) and found connections between the two. Cruz, Gillespie-Lynch, Le, Hutman, and Johnson (2012), using a sample of 3- to 7-year olds, and Miller and Marcovitch (2015), using a sample of 12- to 24-month olds, focused their studies on the lack of joint attention in those with autism and established connections between joint attention and executive functioning skills. McDonald et al. (2014) provided information on communication skills connected to executive dysfunction and deficits in those with autism. Thus, a question arises regarding why some studies show connections between executive dysfunction and autism symptomology in early childhood, while, others do not.

A potential reconciliation might be realized by examining research where differences in executive dysfunction in those identified with varying degrees of autism. It has been found that varying degrees of autism (e.g., high/moderate/low; autism and Asperger's; autism and Attention Deficit Hyperactivity Disorder [ADHD]) demonstrated differing patterns in executive dysfunction. For example, Taddei and Contena (2013) examined children between 7 and 17 years of age and found that those within the autism spectrum (high/moderate/low functioning autism and Asperger's) display different executive function profiles and were statistically different from typically developing children.

Another potential reconciliation of the difference in research regarding the executive dysfunction and autism symptoms is the potential that intervention plays a role. Luna, Doll, Hegedus, Minshew, and Sweeney (2007) indicated that developmental improvements of executive functioning in those with autism may be dependent on whether the child was gaining intervention support. As those that have already been identified have likely received supports, the presence of intervention may explain the inconsistent findings of executive functioning in those already diagnosed with autism.

The gap is evident through inconsistencies in previous research in establishing a connection between executive function and autism and the findings have clear implications for autism assessment in children between 34 to 60 months of age. The inconsistencies in previous research (Etemad Smithson et al., 2013; Yerys et al., 2007; and Garon et al., 2008) regarding whether executive dysfunction is present in those with autism between the ages of 34 to 60 months, may be due to the examination of global autism features (i.e. social functioning and repetitive or stereotyped behaviors) or the population used as the sample. Participants used in previous samples were those identified to be on the spectrum prior to the study or those who demonstrated characteristics to warrant a pervasive developmental disorder – not otherwise specified diagnosis. This condition lead to a non-normed sampling of the degree of autism. Furthermore, this condition affected how autism and executive dysfunction were examined, and the type of sample used in the study. These may have contributed to the conclusion of the research. This study addresses these components.

Problem Statement

There are a few inconsistencies present in current research connecting autism symptomology and executive dysfunction. One inconsistency is in the identified age to show correlation between autism and executive functions in early childhood, while another is due to the types of tools used. Garon et al. (2008) detected executive dysfunction in working memory, inhibition, and shifting in children between 3 to 5 years of age. Yerys et al. (2007) argued that executive dysfunction must be a secondary deficit in autism as children older than 5 years of age with autism demonstrate executive function deficits; however, Yerys et al. (2007) utilized modified clinical laboratory assessment measures of executive functioning for the younger (2 to 4 years of age) sample. Etemad Smithson et al. (2013) did not substantiate a correlation between autism symptoms and executive functioning skills (e.g., shifting, inhibition, working memory, planning/organization, and emotional control) in early childhood; however, the link may have been masked between executive dysfunction and autism as the sample included those who do not fully meet the criteria for autism. Moreover, Etemad Smithson et al. (2013) used scores in the analysis of executive function that are not as sensitive to age differences or dysfunction. Yerys et al. (2007) and Etemad Smithson et al. (2013) used the Autism Diagnostic Observation Schedule to examine broad deficits on post-diagnosed individuals, where a deficit in one individual may not be a deficit in another (Reese et al., 2013).

Purpose of Study

The purpose of the current quantitative study is to address the inconsistencies identified in previous research by looking at assessment outcomes from the initial, early childhood evaluation for autism and excludes the more generic form of pervasive developmental disorder that was included in some previous research samples. My goal for this study was to extend the tools used to look at specific features of autism by exploring the relationship between specific autism symptomology (e.g., relating to people, self-regulation, emotional responding, social-emotional reciprocity, imitation, etc.) and executive function skills (e.g., working memory, shifting, initiating, planning/organization, inhibiting, flexibility, and pre-metacognition). This study examines the correlation between specific autism symptomology as it pertains to executive function skills in early childhood (e.g., 34 to 60 months of age) and determines if both autism symptomology and executive functioning skills predict autism or non-autism classification.

Nature of Study

In this quantitative study, the relationship among the measurable variables of executive function and autism symptomology have been examined. Rating scales have been used to define the measure of executive function and various symptoms (e.g., self-regulation, etc.) related to autism. This study also used an observational measure that looks specifically at a child's imitation skills and emotional connection when assessing for autism. Assessment measures to be included in this study are the following: a) Childhood Autism Rating Scale, Second Edition (CARS-2); b) Autism Spectrum Rating Scale (ASRS); and c) Behavior Rating Inventory of Executive Function, Preschool Edition (BREIF-P).

Data have been derived from a secondary source. A database has been created by a practitioner who performs evaluations for school-based autism classification at an early childhood center. Data from the source includes the age of child, aim of evaluation, outcome of initial evaluation (e.g., evaluation outcome as autism or non-autism classification), CARS-2, ASRS, and BRIEF-P results.

Research Questions

In this study, rating scales have been used for executive function and measures of various symptoms (e.g., self-regulation, etc.) related to autism, as well as an observation measure that includes a child's imitation skills, ability to relate to others, non-verbal communication use (includes joint attention), and emotional connection when assessing for autism. Assessment measures to be included in this study are the following: a) Childhood Autism Rating Scale, Second Edition; b) Autism Spectrum Rating Scale; and c) Behavior Rating Inventory of Executive Function.

Research Question 1 (RQ1): Quantitative: What is the relationship between executive dysfunction and autism symptoms?

Null Hypothesis 1 ($H_0$1): Executive dysfunction, as measured by the Behavior Rating Inventory of Executive Function, and autism symptoms, as measured by the Childhood Autism Rating Scale, Second Edition, have no statistically significantly correlation.

Alternate Hypothesis 1 (H_a1): Executive dysfunction, as measured by the Behavior Rating Inventory of Executive Function, and autism symptoms, as measured by the Childhood Autism Rating Scale, Second Edition, have statistically significantly correlation.

Null Hypothesis 2 ($H_0$2): Executive dysfunction, as measured by the Behavior Rating Inventory of Executive Function, and autism symptoms, as measured by the Autism Spectrum Rating Scale, have no statistically significantly correlation.

Alternate Hypothesis 2 (H_a2): Executive dysfunction, as measured by the Behavior Rating Inventory of Executive Function, and autism symptoms, as measured by the Autism Spectrum Rating Scale, have statistically significantly correlation.

Research Question 2 (RQ2): Quantitative: Do executive functioning deficits and autism symptoms predict autism classification (e.g., evaluation outcome as autism or non-autism classification)?

Null Hypothesis 3 (H_03): Executive function scores, as measured by the Behavior Rating Inventory of Executive Functioning, and autism symptomology, as measured by Childhood Autism Rating Scale, Second Edition and Autism Spectrum Rating Scale do not predict autism classification.

Alternative Hypothesis 3 (H_a3): Executive function scores, as measured by the Behavior Rating Inventory of Executive Functioning, and autism symptomology, as measured by Childhood Autism Rating Scale, Second Edition and Autism Spectrum Rating Scale predict autism classification.

The method used to analyze the first research question is linear regression analysis. In the first research question, the independent variables are autism symptoms as measured by the total score on the CARS-2 and ASRS. The dependent variable is the measure of executive functioning, as measured by the global measure of executive functioning on the BRIEF-P. A linear multiple regression analysis allowed an investigation into whether an individual's overall measure of autism, as determined by the ASRS or CARS-2, contributed significantly to executive functioning, as measured through the BRIEF-P. To avoid Type I and Type II errors and an over or underestimate of significance, the analyses have been checked for the assumptions of multiple variable regression (Osborne & Waters, 2002, para. 1).

The second research question used multiple logistic regression. Multiple logistic regression utilizes categorical data to create a prediction probability (McDonald, 2014). This approach determines which contributing variables affected the outcome (McDonald, 2014), where the dependent variable was the outcome from the evaluation (autism or non-autism classification). Culminating these measures in a multiple logistic regression allowed for control over covariates to test the influences of the predicting variables (e.g., autism measures and executive functioning measure). Also, by using this type of analysis, the unique contribution of each predicting variable on the dependent variable is determinable (Lewis, 2007).

Framework

Executive functioning takes place in the frontal region of the brain (Diamond, 2013). As such, the theoretical basis for this study comes from Kennedy and Coelho (2005) and Damasio and Maurer (1978) as they examined aspects of brain functioning. Damasio and Maurer (1978) identified similarities between those with autism and those experiencing a traumatic brain injury within the frontal region of the brain. Damasio and Maurer's (1978) research created the foundation of connecting autism and brain development, as their research examined components of autism to real world executive functioning skill. Damasio and Maurer (1978) connected brain dysfunction in the frontal cortex (where executive dysfunction takes place) and deficits in autism. Kennedy and Coelho (2005) used traumatic brain injury research to determine that damage to the frontal region of the brain affects metacognition or an individuals' ability to be aware of themselves. This is one example of an executive function. When performing new actions, executive functioning skills became more needed than when performing routinized actions (Kennedy & Coelho, 2005). While observing a given situation, self-awareness activates and creates the underlying ability to perform an action or behavior (Kennedy & Coelho, 2005). This performance relies on one's ability to initiate, inhibit responses, persist in a task, organize one's actions and thoughts, think flexibly, and gain awareness to implement a plan (Kennedy & Coelho, 2005). However, some of these executive functioning skills are delayed or impaired in those with autism. Young children with autism demonstrate challenges in imitation (Diamond & Taylor, 1996; Plauche Johnson & Myer, 2007), self-regulation, and emotional connections. These areas can be affected in those with autism (Packham, 2011) and may influence the ability to be self-aware in a situation.

Limitations

There are limitations to the design of this study. One limitation is that parents who refer their children for evaluation have concerns for an aspect of development. Another limitation is that the parent may complete a rating scale with bias, either positive (not wanting classification) or negative (wanting a classification). There are also threats to the validity of the analysis when using multiple logistic regression. When using multiple independent variables, it is possible that the variables might be multi-collinear, which may create a challenge when interpreting the coefficient estimates while attempting to understand the effects of each predictor (Kamer-Ainur & Marioara, 2003).

Significance

Engaging in this study advances the knowledge of the field because I addressed the inconsistencies in previous research by attempting to establish a connection between executive function deficiency and autism in early childhood. This study contributed to a better understanding of the link between executive functions and autism and determines some of the best predictors when assessing for autism. Originality in this work lies in the examination of age appropriate executive function skills in comparison to a narrower representation of autism related symptoms (e.g., relating to people, self-regulation, emotional responding, social-emotional reciprocity, imitation, etc.). Results from this study increase knowledge of the current practice of evaluation for autism and connections to executive dysfunction.

Summary

As discussed in this chapter, previous research of autism and executive functioning skills demonstrate inconsistencies in young children. Research that examined executive dysfunction in those with autism in childhood, adolescence, and adulthood have illustrated connections. Associations between autism and executive dysfunction is found through Benson et al. (2013), Cruz et al. (2012), Miller and Marcovitch (2015), Panerai et al. (2014), and Taddei and Contena (2013), which is contrary to the findings of Etemad Smithson et al. (2013), Russell-Smith et al. (2014). The function of measurement of the variables and the broad scope of some of the symptoms of autism has been examined (e.g., social communication and unusual behaviors) and has contributed to the findings of the researchers as specific components of autism (e.g., joint attention, imitation, theory of mind, etc.) are shown to have direct connections to the evaluation of autism and executive dysfunction separately.

Chapter 2: Literature Review

Introduction

Early childhood holds a wide range of normal development that narrows around 8 years of age (Shonkoff& Phillips, 2000). Even within the wide range of normal growth, developmental disorders, such as autism and ADHD, can be identified in early childhood (Espy et al., 2001; Packham, 2011; Ronald et al., 2010). These disorders root themselves in infancy, when many neural systems are beginning to develop, including executive function.

Executive functions are skills derived from brain processes that allow for planning, goal creating, rule following, attending, holding and manipulating information, inhibiting response, and shifting strategies (Diamond, 2013). Executive function and social functioning merge together through the ability to observe, make inferences, understand perspectives of others, inhibit responses, initiate actions, and understand language (Garcia Winner, 2002).

Social awareness, typically a deficit in those with autism, requires social cognition (Garcia Winner, 2008) and thinking (Garcia Winner, 2000), in addition to executive functions, such as shifting attention and inhibition. Those with autism need to learn social cognitive flexibility and flexible behavior (Kenworthy, Yerys, Anthony, & Wallace, 2008); therefore, there exists a plausible link between autism and general executive functioning skills that may be identifiable prior to a formal autism diagnosis. Deficits in autism include limited ability to understand and use language and engage in social relationships, while engaging in stereotyped, purposeless, and/or repetitive behavior. Researchers have shown that executive dysfunction is connected to deficits in autism, such as communication skills (McDonald et al., 2014), social skills (Corbetta, Constantine, Hendrena, Rocke, & Ozonoff, 2009; Geurts, Verte, Oosterlaan, Roeyers, & Sergeant, 2004; Gilotty, Kenworthy, Sirian, Black, & Wagner, 2002; Hill, 2004), imitation (Van Leeuwen, Van Baaren, Martin, & Bekkering, 2009), self-regulation (McDonald et al., 2014), theory of mind (Benson et al., 2013; McDonald et al., 2014), and joint attention (Cruz et al., 2012; Miller &Marcovitch, 2015). Thus, the purpose of the present quantitative study is to examine every day executive functioning skills as they relate to the initial evaluation for autism in early child development. Before being able to examine the current links and relationship between autism and executive functioning skills, one needs to understand each dynamic autism and executive functioning skills. What is autism? What are executive function skills? What are the similarities between autism and executive dysfunction? Understanding the connections and relationship between executive dysfunction and autism allows for further development of assessment for autism and planning for intervention needs of the individual child.

Literature Search Strategy

I used Walden University's library database and the Google Scholar search engine to search for pertinent articles. The key search terms that I used included: *autism, executive functioning skills, executive dysfunction, early childhood, joint attention, Theory of Mind, imitation, self-regulation, pre-metacognition, working memory, imitation, abnormal development, normal development,* and *brain development*. I searched from year 2010 through 2016 for recent literature and from 1900 to 2016 for historical references to inform the study.

Autism

Autism is a disorder that is broken down into symptomology of limited social communication and repetitive or stereotyped behavior (APA, 2015). In these two primary areas, a practitioner attempts to identify a pattern of social language and behavior that is associated with autism. For example, a practitioner examines social communication skills through pragmatic language, receptive and expressive language skills, back and forth exchanges, and joint attention ability (APA, 2015). For repetitive and stereotyped behaviors, a practitioner examines behaviors that are repeated and usually associated with autism, such as hand flapping, jumping, repeated vocalizations, behavioral rigidity or inflexibility with changes in routine and/or situations, and repeating the same solution with the same result more than once (APA, 2015).

Social Skills

In the scope of autism spectrum disorder, social skills are an overarching area of concern that has relation to executive function. Those with autism and/or Asperger's are characterized by social impairments and stereotyped or repetitive behaviors (APA, 2015). In effort to socially interact, a practitioner looks to the facial expression of a given individual to ascertain various nonverbal components, such as emotion, connection, judge engagement, and so forth. One example has been Critchley et al. (2000) examined a theory pertaining to the differences in direct (explicit) and associative (implicit) ability to process faces using a sample of seven individuals with Asperger's, two with autism, and nine control subjects. The researchers hypothesized that individuals with autism/Asperger's would demonstrate limited use of four brain structures (fusiform gyrus, inferior temporal gyrus, middle temporal gyrus, and amygdala) used to recognize faces. These structures stemmed across the frontal, prefrontal, occipital and temporal cortices. Critchley et al. (2000) matched controls with identified autism/Asperger's individuals in intelligence, age, education, and occupation. Overall, Critchley et al. (2000) indicated that those with Autism Spectrum Disorder made significantly more errors in explicit processing of facial expressions, as determined through brain scans.

The brain scans also revealed significant differences in the activation in the four studied brain regions when reading social stimuli. For example, in those with autism/Asperger's, the location of brain activation varied from the prefrontal cortex, frontal cortex, and occipital cortex; whereas, in the control group, the fusiform gyrus activated, which was in the inferior lateral and medial occipitotemporal gyri. Critchley et al. (2000) concluded that there were biological differences between those with and without autism/Asperger's as identified by the brain structures activated when processing facial expressions. Critchley et al.'s (2000) conclusions have relevance as the brain structures examined also lie in the same areas where executive functions occur.

Behavior

Another area affected by executive dysfunction that also overlaps in autism is behavior. Stereotypical autistic behavior includes repetitive movements, such as hand flapping, toe walking, and jumping; repetitive vocalizations such as repeating phrases; and challenges shifting and stopping behavior. In those with autism, there are challenges shifting or stopping a behavior, which may appear to be behavioral rigidity or inflexibility to changes (Von Hahn & Bentley, 2013). Restrictive and repetitive behavior/actions and rigidity of behavior(s) occur as executive functioning skill levels decrease (Pellicano, 2012).

Executive Function

Robinson, Goddard, Dritschel, Wisely, and Howlin (2009) research results implied that autism was characterized by social skill deficits and behavioral deficits that were linked to executive dysfunction. Mounting evidence suggested that executive dysfunction may be an early indicator of autism; however, executive function skills extend beyond those observed in social skills and behaviors. Executive function skills are used in everyday life and evolve from birth through adulthood. These types of skills include simple eye movements (Johnson, 1995), imitation of actions of others (Diamond & Taylor, 1996), and searching for hidden objects (Diamond, 1990). These skills are early precipitators of early executive function skills in toddler years and may relate to autism. As executive function skills continue to develop and undergo spurts of growth, they can be affected by biological and environmental experiences. These factors contribute to typical and atypical development of executive function skills.

Executive Function in Everyday Life

Why are executive function skills important Mueller and Dollaghan (2013) defined executive function as a set of cognitive processes that use general brain regions (e.g., pre-frontal cortex and frontal lobe). Executive functioning skills include the capacity to organize thoughts and actions, remember and recall information, plan, maintain attention, and inhibit responses (Autism Speaks, 2010; Beirman, Diamond, &Zelazo, 2011; President and Fellows of Harvard College, 2014; Washington State Department of Early Learning, 2012). The brain's complex neural circuitry, routed through the frontal and prefrontal region, allows for these processes to function (McCloskey, 2011). Executive function is the management of multiple pieces of information from the environment and the body while also managing distractions (President and Fellows of Harvard College, 2014). Just as a conductor leads an orchestra of instruments to create a musical composition, executive functioning is the conductor that directs which systems enter the process at various times (McCloskey, 2010). The harmonious engagement different systems affect everyday functions, such as how children interact and engage in the classroom and productivity and regulates how to engage with other people (President and Fellows of Harvard College, 2014).

Development of Executive Function

Executive functioning skills change and develop over time and not all executive function skills are equally developed at any given age (Willoughby, Kupersmidt, & Voegler-Lee, 2012). In comparison to other executive functioning skills, some are of greater complexity and require abstract thinking around 37 to 68 months of age (Willoughby, Kupersmidt, &Voegler-Lee, 2012). Within the first few years of life, executive functioning differentiates from one unitary process to multiple processes working together (Wieba et al., 2011). Through maturation, executive functioning skills transition from a unitary entity into distinctly defined entities working together. After 1 to 2 years of age, main features progress from one rudimentary function into three separate prime functions: working memory, inhibitory control, and mental flexibility (President and Fellows of Harvard College, 2014; Diamond & Lee, 2011). The brain neural areas fully connect to each other (President and Fellows of Harvard College, 2014) and become distinct entities that operate separately, yet in harmony with each other (Wieba et al., 2011) in adulthood.

Wieba et al. (2011) examined the pathway of executive function from toddler age through adulthood. The authors characterized adulthood executive function as components that act in unity though diverse in number and they proposed that a toddlers' executive function originated as a unitary process that, overtime, matured into multiple processes working together. This development coincides with the prefrontal regions fully mature in early adulthood. The authors identified that working memory, inhibition, and shifting are the first three executive functions to begin to mature and differentiate from the others. These three components separate at 7 years of age and are examined through how effectively children perform various tasks associated with different executive function skills.

Aging and maturity are not the only mechanisms that affect the development of executive functioning skills. Executive functions can progress with training and rehearsal (President and Fellows of Harvard College, 2014; Diamond & Lee, 2011). Interventions and supports were put in place in the school environment in efforts to increase a young child's executive function skills due to the relationship between executive function and academic and social outcomes (Blair & Razza, 2007; Brock, Rimm-Kaufman, Nathanson,

& Grimm, 2009; Espy et al., 2001; Ferrier, Bassett, & Denham, 2014; Willoughby et al., 2012).

Finally, Mullette-Gillman and Huettel (2009) determined that humans have a natural ability to shift and change behavior using executive function. Outcomes from the study indicate that the prefrontal and parietal areas of the brain became activated when learning is paired with rewards and executive function processes provide information for the task. Executive function does not, however, provide the ability to control the performance of task. When considering that executive functions may improve with practice, one also needs to consider what might interfere in this process by exploring biological and environmental experiences as well as typical and atypical development of executive functions.

Biological and Environmental Experiences

Extensive changes in executive function skills occur early in childhood (Cuevas et al., 2014). Environmental factors and genes that create brain-based components affect the development of executive functions. Deprivation, institutionalization, parent deployment for the military, parent mental health, and the stress infants experience in daycare demonstrate adverse influences on the advancement of executive functioning skills in children (Berry, Blair, Ursache, Willoughby, & Granger, 2014; Bos, Fox, Zeanah, & Nelson, 2009; Hewage, Bohlin, Wijewardena & Lindmark, 2011).

Furthermore, it has been shown that psychosocial executive functioning components are affected using institutionalizations versus use of foster care (Bos et al., 2009) and that the quality and amount of stress in daycare from ages 7 to 36 months predicts the development of working memory, inhibition, and attention in children at age 48 months (Berry et al., 2014). As such, working memory, attention, inhibition, and self-regulation are influenced through biological and/or environmental experiences.

Working memory. Taylor and Lamoreaux (2008) illustrated that the brain's neurological structures change as it learns new information. For example, in memory skills, a neural signal transmits through a pathway when exposed to a new pattern. As the synaptic strength increases, learning takes place. As more firing occurs through the synapse, the neuron becomes bushier, more established, and the information is encoded. A constructed memory becomes modified when it is remembered due to the filters and frame of references used when brought into conscious awareness. New data can be added to encoding as the brain looks for connections to earlier or other information (e.g., info through all senses – sight, smell, sound, tactile). The brain analyzes new and old information while accounting for variations in accounts. An example is how a listener needs to recognize a speaker's intentions, perspective, and examine assumptions when constructing the account. When considering autism deficits, such as understanding perspectives and an individual's intentions, working memory as an executive function skill may be affected and it may be affected due to neurological structure that aides in new learning.

Taking this further, working memory skills as related to executive function are examined in learning in the classroom. Gathercole et al. (2008) studied those with poor working memory skills in the classroom, with the objective to determine if inattentive behavior occurs succinctly with poor working memory skills. Using a sample of four and five year olds in a group and eight and nine year olds in another group, the researchers determined that problem behaviors occur due to executive dysfunction, identified as limited working memory skills. Executive functions were examined in early development for the children aged four and five years.

Inhibitory control. Thorell, Lindqvist, Bergman, Bohlin, and Klingberg (2008) examined the elementary versions of working memory and inhibitory control that is present in early life. Thorell et al. (2008) noted that working memory and inhibitory control rapidly develop between the preschool and early school age and are related to theory of mind and academic achievement. Using a sample with a mean age of 56 months, Thorell et al. (2008) determine if inhibitory control and working memory can improve due to training. Results indicated that all children improved significantly in all trained tasks. Though working memory significantly improved and inhibition improved, the inhibition improvement was not as significant. It is important to note that inhibitory control can improve with support, though this is a continued deficit in those with ADHD and autism.

Self-regulation. There are biological-social mechanisms that contribute to the development of attention control and self-regulation skills (Rueda, Posner, & Rothbart, 2004). Genetic and co-occurring socialization experience (environment) support the development of attention and self-regulation (Rueda et al., 2004). Williford, Vick Whittaker, Vitiello, and Downer (2013) examined the development of self-regulation through Hispanic student’s engagement with peers, teachers, and tasks or activities. The research was conducted with two hypotheses that self-regulation develops contingent on positive interactions with peers or teachers and tasks or activities, and positive engagement with peers or teachers mitigates for less engagement in activities/tasks in the development of self-regulation.

Results confirmed the hypotheses and identify clinically significant correlations of self-regulation with the following: 1) positive teacher or peer and activity or task engagement; 2) positive teacher engagement; 3) task engagement; 4) positive peer engagement plus task engagement; 5) positive peer engagement plus negative activity engagement; and 6) positive teacher engagement plus negative activity engagement. This evidence suggested a biological and environmental connection in the development of these executive function skills. However, even environmental growth in this executive function skill requires awareness of the actions of others, which may not occur in those with autism.

Typical and Atypical Development of Executive Functioning Skills

Child development follows patterns, which can be considered typical or atypical. Variation, dedication (Mandell & Ward, 2011), interaction, and practice (President and Fellows of Harvard College, 2014; Beirman et al., 2011) promote the advancement of executive functioning skills in the brain. This creates a typical pattern for development of executive function skills versus an atypical pattern of development. Normally developing children have executive functioning skill development that occurs as the brain matures and endures alterations in the prefrontal cortex (Zelazo, 2010; Zelazo & Müller, 2010). Alterations occur in the prefrontal cortex due to experiences, neuron presence, amount of grey matter, and weight changes (Knapp & Morgan, 2013). Moreover, Hill

(2004) indicates that executive functioning deficits arise from a biological basis, such as differences between brain structures; however, practicing executive function skills grow that portion of the brain, creating steady and stalwart neuron networks (Knapp & Morgan, 2013; Zelazo, 2010; Zelazo & Müller, 2010). The grey and white matter of the brain impact the intricacy and effectiveness of executive functioning skills (Knapp & Morgan, 2013).

Past research effectively identified deficits in those aged 2 through 6 years of age. For example, Best and Miller (2010) examine executive function development in those from age 2 years of age through adulthood. Between ages 2 and 5, Best and Miller identified three distinctive features of executive function as attentional flexibility, inhibitory control, and working memory. Comparing the executive function trajectories of this age group to 5 to 7yearolds and 9 to 11 year olds, the older children demonstrated the ability to inhibit actions more efficiently than younger groups. Additionally, by following children diagnosed with autism throughout their childhood and adolescent development, Anderson, Liang, and Lord (2014) sought to determine if cognitive deficits present at 2 years of age persisted at 19 years of age. Anderson et al. (2014) found that the deficits at age 2 or 3 persisted at age 19. At the same time, Anderson et al. (2014) found that 9% of those diagnosed with autism at age 2 did not maintain the classification at age 19. Considering that classifications were typically maintained, it is reasonable that deficits were not overcome with age. Executive function skills may be a faulty in early development, creating a deficit that continues to through later development.

Lucenet and Blaye (2014) examined the increase in ability to use executive control as a child ages and whether working memory load affects the ability to use executive control. The sample, comprised of twenty-nine 5-year-olds and twenty-eight 6-year-olds from primary Caucasian and middleclass environments. The authors utilized AX-CPT on a computer, which allows participants to learn the task in the first four responses. Participants completed the tasks in two, 20- to 30- minute sessions. A break between sessions allows participants to return to the classroom. Analysis of the data indicated that there is a shift in executive control ability between ages 5 and 6 years. Results also indicated that increasing the working memory load over a prolonged period does not increase a child's activation of executive control. Future research is indicated in this area as different areas of executive control indicate different patterns in increasing skills and demand. Additional research in the developmental shift in executive control is another suggestion by the authors.

Problems in early childhood with executive functioning skills are associated with long term consequences (Zelazo, 2010; Zelazo & Müller, 2010). For example, executive functioning deficiencies in early childhood affect judgement ability (e.g., moral reasoning, decision making, etc.), and understanding the viewpoint of others (Zelazo, 2010; Zelazo & Müller, 2010). Atypical development of executive functioning skills occurs for various reasons including early deprivation of psycho-emotional support (Bos et al. 2009), which frequently occurs in institutional care. By comparing those with and without deprivation of psycho-emotional support, the authors isolated a pattern in the development of visual memory and executive functioning skills. Placement in institutions at a young age yielded changes within the neural structures (i.e. medial temporal lobe and pre-frontal cortex) of the brain. These structures affect the ability to perform executive function skills.

Disorders Associated with Atypical Development

Children with Attention Deficit and Hyperactivity Disorder (ADHD) and autism have been found to have differing executive dysfunction profiles (Geurts et al., 2004; Pennington &Ozonoff, 1996; Ozonoff& Jensen, 1999; Sergeant, Geurts, &Oosterlaan, 2002). Those with autism have more pronounced deficits than those with ADHD (Corbetta et al., 2009; Geurts et al., 2004). Russell (1997) labeled autism as an executive functioning disorder due to the significant deficits present in cognitive flexibility, planning, and working memory. Geurts et al. (2004) compared ADHD children and found similarities between children with high functioning autism. Additionally, executive functioning deficits in planning, flexibility ability (Zelazo, 2010; Zelazo & Müller, 2010), inhibition (Corbetta et al., 2009; Geurts et al., 2004), working memory, and attending skills (Corbetta et al., 2009) have been observed. Differences among executive dysfunction maybe due to severity of autism, potential comorbidity of disorders, or supplementary elements. Hill concluded that evidence of shortfalls of executive function skills exist throughout the population of those with autism and executive function might assist in the assessment for autism (Hill, 2004).

Connecting Executive Function to Autism

Theoretical Framework

As previously discussed, the prefrontal and frontal cortices are known location of executive functions (McCloskey, 2010; McCloskey, 2011; Mueller &Dollaghan, 2013), and there is a connection between this region of the brain and disorders, such as autism. Furthermore, it has also been shown that those with Asperger's syndrome also have a neurological basis for these disorders that stems from the prefrontal cortex (Damasio & Maurer, 1978). This part of the brain is known to affect goal-oriented behavior and reasoning, planning and deciding behaviors of personal and social emotions, and understanding body language (Damasio & Maurer, 1978). There are further connections between identified areas of brain damage in the frontal region and autism, such as challenges regulating, reading, emotional connections, and translating emotions into the appropriate feelings (Damasio & Maurer, 1978). Declines in frontal lobe performance are associated with social cognitive and executive function impairments.

Looking specifically at executive dysfunction, Kennedy and Coelho (2005) determined that frontal region brain damage affects metacognition, which is the ability to be self-aware. When performing new actions, these skills became more needed than when performing routinized actions (Kennedy & Coelho, 2005). Eslinger, Moore, Anderson, and Grossman (2011) examined whether social impairments are linked with frontal lobe impairment following a neural system model of social cognition. Using 26 participants divided between control and targeted population, Eslinger et al. (2011) investigated empathy as the control for deficits in social cognition (e.g., theory of mind) and executive function in those with dementia. Patients completed cognitive and emotion measures while their caregivers completed emotion measures including empathy, depression, prediction of social consequences (theory of mind), flexibility, shifting, and inhibition. Measures completed by caregivers were positively correlated with prediction of social consequences; however, executive function measures were not. Correlations were present among social-cognition, empathy, and executive functioning. Eslinger et al. (2011) observed declines in theory of mind, flexibility, shifting, and inhibition which were correlated with declines in empathy; thus, leading to the understanding that social cognition and executive functions decrease with frontal lobe declines.

Executive dysfunction occurs due to deficits in the pre-frontal and frontal lobes (Elliott, 2003), and children identified with autism have deficits in the prefrontal cortex (Autism Speaks, 2010; Geurts et al., 2004; Hill, 2004; Hill 2006). As such, these deficits overlap. For example, consider that those with autism have challenges in perseveration, which can be associated with challenges in the executive function of shifting and inhibiting (Possin, Filoteo, Roesch, Zizak, Rilling, & Davis, 2005). In another example, imitating and demonstrating social awareness, can be associated with challenges in executive functions of meta cognition, self-regulation, working memory, and emotional control (Diamond & Taylor, 1996; Packham, 2011; Plauche Johnson & Myer, 2007). The ability to perform in a situation, based on the observations of others' given situation, activates self-awareness, which creates the basis to initiate, inhibit responses, persist in a task, organize one's actions and thoughts, think flexibly, and gain awareness to implement a plan (Kennedy & Coelho, 2005).

Symptoms and Skills: Broad Perspective

In efforts to examine the relationship between autism and executive functioning skills, one needs to understand current links between autism symptomology and executive function. Those with high functioning autism and Asperger's are also identified with deficits in executive function, theory of mind, and emotional recognition (Sticher et al., 2010). Various research groups examined varying degrees of autism (Asperger's, high functioning autism, autism, and pervasive developmental disorder – not otherwise specified) to discern changes in executive functioning skill.

Verte, Geurts, Roeyers, Oosterlaan, and Sergeant (2006) examined children, aged 6 through 13 years of age, by comparing high functioning autism, Asperger's, Pervasive Developmental Disorder - Not Otherwise Specified, and normal functioning children to discern if executive functions differentiated the level of autism. Analyzed results indicated that there are limited differences between children identified with ADHD when compared to those identified with autism. Both demonstrate differences to those in the control group, with no identified disorder. Inhibition deficits were present in both those with ADHD and autism. Overall, executive function deficits were not as pronounced in those with ADHD than those with autism; however, those with autism show more significant deficits.

Continuing the examination of executive function in those with varying degrees of autism, Robinson et al. (2009) examined age related differences of executive function skill in children, between 8 and 17 years of age, who are identified with an autism spectrum disorder; as well as whether intellectual competence in those with autism influences executive function ability. Specific executive function impairments that are examined include planning/self-monitoring, inhibition, and mental flexibility. Executive function measures in Robinson et al.'s (2009) study include mental flexibility measures such as the Tower of London (mental flexibility), Wisconsin Card Sorting (response inhibition), and Stroop test (planning/self-monitoring). Results compared those with an autism spectrum disorder to typical performing peers. Children with an autism spectrum disorder produced significantly more perseverative responses and demonstrated challenges in inhibition and self-monitoring skills. Further examination of executive functions (specifically inhibition and self-monitoring) in individuals from age 8 to 17 years indicate that impairments were consistent and stable across development in those with an autism spectrum disorder.

Rosenthal et al. (2013) added to the work of Robinson et al. (2009) by further differentiating those identified with an autism spectrum disorder (e.g., PDD-NOS, Asperger's, autism) and expanded the examined age range. To be specific, Rosenthal et al. (2013) examined 185 children identified with an autism spectrum disorder from age 5 through 18. Rosenthal et al. (2013) hypothesized a variation in executive dysfunction as a child with an autism spectrum disorder. Thus, the researchers broke the study into 4 age groups. Using the BRIEF to measure executive functioning skills, specific scales demonstrated changes with age in those with an autism spectrum disorder. The specific scales where scores worsened as a child aged were initiation, working memory, and organization of materials. Additionally, the scores on the shift scale on the BRIEF were worse with the youngest and oldest aged groups.

Not unlike Rosenthal et al. (2013) and Robinson et al. (2009), Etemad Smithson et al. (2013) examined real world executive function skills in those identified with autism in 4 and 5yearolds. Etemad Smithson et al. (2013) indicated that children diagnosed with autism spectrum disorders have elevated scores in every assessed area of executive function; however, not all areas demonstrated clinical significance. Participants in the study ranged in diagnoses - autism, Asperger's, and Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS) and participants with autism spectrum disorders were compared to those without autism spectrum disorders. All subjects participated in the Autism Diagnostic Observation Schedule and parents completed the Behavior Rating Inventory of Executive Function. Those with autism spectrum disorders demonstrated clinically significant deficits in working memory, global functioning, and emergent metacognition. However, results on the flexibility measure do not indicate clinical significance or more significant problems than typically developing children. The lack of significance in flexibility is a surprising result when considering children with autism often demonstrate behavioral rigidity or inflexibility. This is a consistent result with preschool aged children in other studies; yet, inconsistent with older individuals diagnosed with autism or autism related disorders. In this case, researchers utilized raw scores to determine correlations, which are not as sensitive to age differences, and a combined sample of those with autism, Asperger's, and Pervasive Developmental Disorder – Not Otherwise Specified.

Taddei and Contena (2013) illustrated that those with autism show statistically different executive function profiles compared to Asperger's; both of which are statistically different than typically developing children. The Behavior Rating Inventory of Executive Function is normed to provide specific T-scores for various age groups. The same raw score for a three-year old or four-year old equates with different T-scores. The authors utilized the Autism Diagnostic Observation Schedule, which aide in the diagnosis of autism based on three broad categories. Examination of connections between autism and executive function on specific symptomology of autism localizes potential relationships. Correlations between specific symptomology and executive function allows for development of focused interventions and tracking and measurement of skill development. Further examination of autism and executive function should focus on real world impairments, which is supported by Isquith, Gioia, and Espy (2004) as these affect every day behavior and social functioning. Etemad Smithson et al. (2013) contributes to the current questioning of early executive functioning skill prior to evaluation for autism symptomology. The current study would address the questions that arose from Etemad Smithson et al. (2013), such as T-scores instead of raw scores and separation of the sample after determination of disability.

Continuing to delve into real world constructs to examine executive function skills and post-diagnosis of autism, Panerai et al. (2014) examine executive function within various levels of autism high functioning, mild to moderate, and intellectually disabled. These researchers find that executive function is not a unitary function. Using a tool that examines everyday executive function skills – the Behavior Rating Inventory of Executive Function– as one of the measures of executive function, they compare those with autism diagnoses to those without the diagnoses. Results indicate that significance is present in those with autism in planning and flexibility. Those with intelligence quotients in the intellectually disabled range demonstrate executive dysfunction in flexibility, planning, and generativity. Those with borderline intelligence demonstrate significant differences in flexibility and response inhibition. High-functioning autistics in the study demonstrated challenges in flexibility. On the Behavior Rating Inventory of Executive Function, those with autism spectrum disorders differentiate from those with no autism spectrum disorders. Commonly affected in all levels of autism is the shifting subtest; however, high-functioning autism differentiates with affects in inhibition and emotional control, which is contrary to results on other measures of executive function in the same study. This may be due to the sample size, as the authors indicate they found large sample size effects due to a small sample. This study primarily focused on individual's little limitation in communication; however, limited communication is one diagnostic feature of autism. Thus, one future direction of Panerai et al.'s (2014) study is an examination of communication skills as they pertain to executive functions. Another direction is to examine additional executive function constructs, such as working memory and metacognition, in comparison to autism symptomology, which is an aim of the current study. The Panerai et al. (2014) study maintains a notion that future research should separate the population examined as all older individuals within the autism spectrum demonstrate varying degrees of executive dysfunction.

Symptoms and Skills: Specific Perspective

There are overlaps between executive function deficits and specific deficits experienced by those with autism. According to Autism Speaks (2010), examples of the executive function deficits and specific components of autism include difficulty in the following: 1) maintaining attention, 2) multi-tasking between more than one complex thought, and 3) sequencing, planning, and self-regulation. Additionally, social skills (Diamond, 2013), joint attention (Cruz et al., 2012; Miller &Marcovitch, 2015), theory of mind (Benson et al., 2013; Hutchins, Prelock, & Bouyea, 2010; Lerner, Hutchins, &Prelock, 2011), and imitation (Van Leeuwen et al., 2009) are specific symptoms of autism that are connected to executive dysfunction. Research shows that deficits in self-regulation in early childhood contributes to classification of autism (Silva & Schalock, 2012); while research also demonstrates that self-regulation is a process developing early in childhood, around the age of 3 years (Raver, Jones, Li-Grining, Zhai, Bub, &Pressler, 2011; Silva &Schalock, 2012).

Social skills and stereotyped behaviors are the primary areas of autism associated with executive dysfunction (Diamond, 2013). Executive functioning takes place in the frontal region of the brain (Diamond, 2013). Using Damasio and Maurer's (1978) research to understand the foundation of connecting autism and brain development, Diamond (2013) examines components of autism to real world executive functioning skills, which include planning, flexing ones' thinking, switching tasks, and remembering and manipulating social rules. Though intervention supports for those with autism focuses in the development of executive function, questions remain about whether it is a diagnostic marker for autism and if there are maturational effects of executive function in autism that is different than in typical development. A few contributing factors to the ability to socialize with others, is joint attention, theory of mind, imitation, and self-regulation.

Joint attention. An area that helps identify the presence of autism is joint attention, which has links to various executive functions (Cruz et al., 2012). Joint attention is sharing attention between people to a source (Bruner, 1995; Carpenter & Liebal, 2011). Gaze alternates between the partner and locus (Carpenter & Liebal, 2011). One learns to share or coordinate a common point of reference first as a responder (i.e. following the gaze or gesture of another) and later in development, as an initiator (Charman, 2003; Mundy & Newall, 2007). Cruz et al. (2012) aim to correlate the relationship of executive function (inhibit, initiate, shift, flexibility, metacognition, working memory, and planning) and responding joint attention in a post-diagnosed autism population. Results indicate that inhibit, shifting, and planning correlate to joint attention; thus, the section of the brain responsible for social-emotional learning establishes connections between response joint attention and executive functioning. These results concur with prior research in that the development of joint attention aides in the processing and organizing of social-learning (Mundy & Newall, 2007); however, Cruz et al. utilized an older sample of participants. A younger sample undergoing the first assessment for autism may illustrate different results.

Using younger participants, Miller and Marcovitch (2015) examined responding and initiating joint attention, language, imitation, and two executive functions, inhibition and planning. Measuring the frequency of initiating and responding to joint attention in 47 participants, 14 to 18 months of age, the analyses indicate joint attention and executive function are not particular to gender, executive function is not significant at this age, and initiating joint attention decreases with age. These results suggest that early executive function skills are distinctly different at this age versus preschool age. Additionally, 14-month performance predicted 18-month performance and that executive functions are emerging skills at this age. This study is limited in the type of measures used to examine executive function, which are laboratory-based measures of inhibition versus real-world based measures. Inhibition and planning skills were the only executive functions measured. Nonsignificant results found by Miller and Marcovitch (2015) in later age stages sharply contrast to Cruz et al. (2012), who demonstrated a link between inhibit, shifting, and planning to joint attention in those aged 14-18 months. As joint attention skill is a social-cognitive hallmark succinctly mastered by 2 years of age (Zelazo, 2004); thus, the lack of correlation may be due to inconsistent executive function skill or the maturing nature of joint attention skill at 14 and 18 months of age.

Theory of mind. Another component connected to post-diagnosed autism that associates to executive function is theory of mind (Benson et al., 2013), which is the perception to conceptualize how others think and feel, and how that relates to oneself (Autism Speaks, 2010; Hutchins et al., 2010; Lerner et al., 2011). Thinking about others and oneself impact behavior. While examining development of attention and memory (two executive functions) in relation to theory of mind, Benson et al., (2013) demonstrate that students experience individual progressions in skill development. Results suggest that executive functioning skills influence the advancement of theory of mind proficiency. Researchers suggest that future research examine executive function as it affects theory of mind development and define connections between results and real world executive function. Benson et al. (2013) focused their work on adults; however, theory of mind continually develops from infancy throughout adulthood (Moriguchi, Ohnishi, Mori, Matsuda, & Komaki, 2007), which is similar in executive function skill.

Looking further into communication skills as it pertains to executive function, specifically flexibility and inhibition, and theory of mind development, McDonald et al. (2014) use 25 adult participants with traumatic brain injury to illustrate the differences between low and high conditions of executive functions. Results indicate that theory of mind and neuropsychological measures are significantly lower for the group with brain injury, indicating that those with brain injury demonstrate impairments in inhibiting, thinking flexibility, understanding the viewpoint of others, and regulating verbal output.

Lastly, deficits in theory of mind and executive functioning skills are associated with mesolimbic and prefrontal cortex dysfunction (Critchley et al., 2000). This connection demonstrates that a component of autism is primarily associated with executive dysfunction (Geurts et al., 2004). Being able to recognize the feelings of others to identify how to relate the experience to oneself, relies on the ability to not only see the details but also the big picture (Autism Speaks, 2010). These are deficits in those with autism. For example, in attempting to recognize the faces of people, those with high functioning autism or Asperger's disorder demonstrate challenges as evidenced by the errors made in processing direct and apparent (explicit) cues (Critchley et al., 2000).

Imitation. Connected to joint attention, another area that identifies those with autism and is connected to executive dysfunction is imitation. Imitation is a primary area that helps to identify autism (Diamond & Taylor, 1996). In developing motor and vocal imitation, child's language and joint attention skills increase (Stone & Yoder, 2001). In normal development, imitation skills enable learning and socialization (Ingersoll, 2008). These skills occur naturally and through direct teaching while increasing the ability to learn behaviors (Stone & Yoder, 2001). Imitation serves as a method to learn behaviors and socialization to and from others (Ingersoll, 2008). Examining executive function as a moderator of imitation skills, Van Leeuwen et al. (2009) task 48 participants working memory with various loads while performing specific responses. They determined that inhibition is needed to control imitation; however, the research did not explore social imitation in real world situations nor those being assessed for autism, indicating future research should incorporate real world social imitation, impact of working memory and inhibition, and use of imitation skill in those being evaluated for autism.

Self-regulation. Beginning in infancy, self-regulation intertwines with executive function (Raver et al., 2011; Silva &Schalock, 2012). Self-regulation is the ability to inhibit one's impulses, control responses, handle emotions, and concentrate (Grove-Gillespie & Seibel, 2006). Examining these skills in 602 children entering preschool, Raver et al. (2011) indicate that development of these skills begins in infancy and may be shaped by experiences. Creating control ($N = 8$) and experimental ($N = 9$) classrooms, the researchers provided interventions focusing on the development of self-regulation skills for teachers to use with children between the ages of 3 and 4. Outcomes from this experiment indicate that self-regulation skills connect to executive function and increase with support in early childhood. Examination of continuing developmental skills determines if the gains maintain over time, and it is important to determine the effectiveness of this intervention with children who have more needs due to developmental disorders.

Looking specifically at autism as a developmental disorder, self-regulation is an area shown to be affected in those diagnosed with autism (Silva &Schalock, 2012). Using a sample of 37 children diagnosed with autism, self-regulation skills require language to mediate execution of non-routine actions (Joseph, McGrath, & Tager-Flushberg, 2005). Using a sample of 37 children with autism as compared to 31 non-autistic children, Joseph et al., (2005) aim to examine self-directed speech while performing non-routine activities. They determined that children with autism did not use language skills internally to regulate their actions on tasks that required planning, working memory, and inhibition; however, this was a preliminary examination of these skills. Recommendations include examination of self-regulation as it pertains to executive functions in those with autism.

Assessment of Autism and Executive Functioning Skills

In efforts to examine the relationship between autism and executive functioning skills, psychometrically validated tools were chosen for the present study. When examining for executive function skills and symptoms of autism, there are different tools utilized with a younger population. There are limited tools that can be utilized to evaluate children under the age of 6 (Best & Miller, 2010; Espy et al., 2001); however, preschool children's executive functioning skills can be measured (Anderson & Reidy, 2012). Clinical laboratory assessment measures of executive functioning are modified for children (Anderson & Reidy, 2012). There are three chosen assessments for this study: 1) Childhood Autism Rating Scale, Second Edition (CARS-2; Schopler, Van Bourgondien, Wellman, & Love, 2010); 2) Autism Spectrum Rating Scale (ASRS; Goldstein & Naglieri, 2009); and 3) Behavior Rating Inventory of Executive Functioning, Preschool Edition (BRIEF-P; Gioia, Isquith, Guy, & Kentworthy, 2013). These assessments do not focus on child performance on one day of assessment, where a child may or may not have the maturity to complete a direct task (Best & Miller, 2010) or the ability to maintain attention to a task, gain attention to task, and compliance to complete the given task (Anderson & Reidy, 2012). The person completing these rating scales considers the observed behavior of the child over a longer period.

The CARS-2 is used by taking into consideration parent interview, parent completion of a CARS-2 questionnaire, multiple clinician observations of the child, and direct assessment of the child. Utilizing observations of a child for specific processes and skills are also a function of direct assessment (Follmer & Stefanou, 2014). The CARS-2 was designed specifically for use with an autism population and has norms for children ages 2 through 12 to compare the assessed child symptoms to those who do have autism. Schopler et al. (2010), the creators of the CARS-2, report internal consistency reliability of .93 and test-retest reliability as .88, which indicate that it is an acceptable measure.

Correlated with the CARS ($r = .43$), the ASRS is another good measure of autism symptomology. Additionally, it is a rating scale that is completed by the parents about behaviors a child may or may not engaged. Furthermore, the rating scale allows parents to inform the practitioner about the frequency of the observed behavior. Goldstein and

Naglieri (2014) report excellent reliability that ranges from α = .77 to .97, depending on the subtest. Goldstein and Naglieri (2014) report the lowest α = .77 on the Adult Socialization measure with overall scale reliability of α = .97. The ASRS is used as guide when making diagnostic decisions pertaining to the presence of autism.

Lastly, the measure of executive function is a rating scale of everyday executive functioning skills. Gioia et al. (2013) report internal consistency for the BRIEF-P within the high range (α = .80 to .98) for all scales, with good test-retest reliability (rs = .82) on the parent rating form, which will be utilized for this study. Examination of everyday executive functioning skills allows the practitioner to understand what a child can do on an everyday basis versus the one instance of standardized assessment, where he or she may not be willing to perform the given task.

Summary

The relationship between autism and executive functioning skills has been examined through understanding autism symptomology, exploring the nature of executive functioning skills, identifying current links between autism symptomology and executive function, and understanding how assessment takes place to identify autism and examine executive function. Wieba et al. (2011) illustrates that 3-year-olds have differentiating executive function skills that continue to differentiate into childhood, adolescence, and adulthood. However, there are skills that precipitate development of executive function skill earlier than three years of age, such as eye movement (Johnson, 1995), imitation of others (Diamond & Taylor, 1996) and searching for hidden objects (Diamond, 1990).

When considering the various executive functioning skills required in daily actions/behaviors, it is necessary to consider how these areas are affected in those with autism. The ability to shift in performing a task requires working memory to hold onto directions within the mind. It also requires the ability to shift within the plan of action from the current action to a new action. Also, consider the executive functioning skills needed for social interaction to occur. Social engagement requires theory of mind, self-regulation, working memory, and joint attention; all of which connect to executive functioning skills and are missing in those with autism (Pellicano, 2012; Von Hahn & Bentley, 2013).

The reviewed research thus far indicates inclusionary constructs for future research. First, no study examines executive function prior to an evaluation for autism symptomology as past research focus on post-diagnosed individuals. Additionally, future studies need to include a larger sample in studying the relationship between planning, response inhibition, mental flexibility, and generativity to autism symptomology. Third, studies need to extend constructs of executive function to include working memory and self-monitoring. Lastly, future studies need to compare executive functioning to specific constructs of autism related symptomology. These future directions continue to be a need in ascertaining the relationship of executive dysfunction to autism symptoms. Understanding the connections between autism symptoms and executive function advance understanding of assessment practices and potential links of causality. Furthering Panerai et al.'s (2014) and Etemad Smithson et al.'s (2013) research, the current study will examine components related to the initial early childhood assessment of autism and specific autism symptomology (i.e. relating to people, imitation, self-regulation, etc.) as it pertains to executive function skills (i.e. planning, shifting, flexibility, inhibition, working memory, emotional control, and emergent metacognition).

The research presented thus far, examines the relationship between executive function skills and autism symptomology by focusing on individuals who have already received a diagnosis of autism or non-autism. Thus, the purpose of the present quantitative study is to examine and describe real world executive functioning skills (independent variable) as they relate to the initial evaluation for autism in early child development (dependent variable). The overall aim is to further the understanding of executive function assessment in autism in early child development. Additionally, this quantitative study further explores the relationship between executive function and autism symptomology as it pertains to the outcome of the initial evaluation for autism.

Chapter 3: Research Method

Aims and Hypotheses

The researcher's goal for this study was to examine specific autism symptomology as it pertained to executive function skills in early childhood (e.g., 34 to 60 months of age). The purpose of this study was to address the inconsistencies identified in previous research by looking at assessment outcomes from the initial, early childhood evaluation for autism and its relation to executive dysfunction in those evaluated for autism. The researcher used individuals evaluated for autism, as opposed to prior studies that focused on a more general evaluation for PDD, in studying the relationship between executive dysfunction and autism symptomatology.

In this study, the researcher aimed to extend the tools used to look at specific features of autism by examining the relationship between specific autism symptomology (e.g., relating to people, self-regulation, emotional responding, social-emotional reciprocity, imitation, etc.) and executive function skills (e.g., working memory, shifting, initiating, planning/organization, inhibiting, flexibility, and pre-metacognition).

There are two research questions. In one research question, the researcher examined the relationship between executive dysfunction and autism symptoms. The research hypothesis is that working memory, emergent metacognition, planning/organization, inhibition, and emotional control on the Behavior Rating Inventory of Executive Function – Preschool will demonstrate statistically significant prediction of autism, as identified on the Childhood Autism Rating Scale, Second Edition and Autism Spectrum Rating Scale in children from ages 2 to 5. In another component to this study, the second research question examines if executive dysfunction combined with autism symptoms provide a significant statistical prediction of the outcome (e.g., autism or non-autism classification) of an autism evaluation in young children between the ages of 2 and 5 years.

Design and Approach

This is a quantitative study that contributes to the knowledge of the assessment for school-identified autism in early childhood. Parents who sought an evaluation from a school district's early childhood center to discern if the child had a disability according to the Individuals with Disabilities Education Act (IDEA) of 2004, which qualified a child for school-based support (National School Board Association, 2014). The targeted population for this study were the children who were brought to the center for an evaluation for autism. Parents sought an evaluation if he or she believes there to be an issue and/or if the family's pediatrician refers the child for an evaluation.

Located in a predominantly Hispanic area, with lower to mid-socioeconomic status (Proximity One, 2014), the evaluation center receives calls each day to schedule screenings for children with concerns of a disability. A screening determined the type of evaluation required, such as an evaluation for speech, intellectual disability, emotional disability, or autism. Evaluation tools used for school-based assessments are psychometrically validated on diverse population (Gioia et al., 2013; Goldstein &Naglieri, 2009; Schopler et al., 2010). As such, the sample is a nonprobability sample of those who self-identify a potential need for an evaluation. A database has been created from the evaluations conducted at the intake center to assist in this study. Some data have been excluded from the analysis. Excluded data included evaluations initiated for concerns outside of autism and evaluations that do not include measures from specific tests (e.g., if no Autism Spectrum Rating Scale is obtained, the data has been excluded, etc.). The inquiry of the study addresses inferential questions between autism and executive dysfunction.

Setting and Sample

Sample Size Analysis

A G-power analysis (Miles & Shevlin, 2001) has been conducted to determine the appropriate sample size. This type of analysis allows for an estimate of the appropriate sample size required to reject the null hypothesis (Miles & Shevlin, 2001). In general, to determine an estimate for sample size, an alpha level of significance and level of power is selected in addition to reviewing past research for effect sizes. As noted by Faul, Erdfelder, Buchner, and Lang (2009), the alpha level of .05 allows for 5% chance of deriving the wrong conclusion. Faul et al. (2009) also noted that statistical power standard is 80%, which means that if the study was conducted 100 times, one would be more likely to derive the appropriate outcome in 80% of the studies. For this study, based on past research, one may anticipate a medium effect size (Boonstra, Oosterlaan, Sergeant, & Buitelaar, 2005; Etemad Smithson et al., 2012; Robinson et al., 2009; Schoemaker, Mulder, Dekovic, & Matthys, 2013) when examining executive functioning skills in young, preschool aged children in comparison to symptomology. Boonstra et al. (2005) found a medium effect size of .64 for executive functioning measures.

For the multiple linear regression, a G-Power calculator had been utilized effect size, alpha level significance, and statistical power to derive a sample size (Faul, Erdfelder, Lang, & Buchner, 2007). Medium effect size ranges from .06 to .14 in performing analyses of variance (Cohen, 1988). However, the number of predictor variables was also considered for this study. In this instance, only the BRIEF-P variables (nine variables) are being used to determine if they predict the total autism scores as measured by the ASRS and CARS-2. As such, there have been two separate multiple linear regression analyses conducted to examine the nine executive functioning measures of the BRIEF against the ASRS (e.g., the DSM-IV rating) and CARS-2 (e.g., the Total Score). The following factors had been entered into Faul et al.'s (2007) G-power calculator: a) medium effect size, b) a .05 alpha level significance, c) 80% statistical power, and d) nine predictor variables. The results from the calculator indicated that the total sample size ranged from 46 (medium effect size of .14) to 126 (medium effect size of .05).

For multiple logistic regression, there are a few ways to determine sample size. McDonald (2014) indicates that this type of analysis should occur with a sample of 10 to 20 times the number of independent variables. Though there are two independent variables, executive dysfunction and autism symptoms each contain multiple dimensions. Each rating scale includes several identified components. The BRIEF-P has five individual variables, three composite scales (combination of two of the individual variables), and one overall measure (combination of all individual scales) of executive functioning. These variables have been analyzed in the context of the autism symptomatology measures, which contain a DSM-IV score on the ASRS (comprises both Social Communication and Unusual Behaviors) and a total score on the CARS-2, to identify which components may be uniquely linked to the categorical diagnosis outcome of autism or non-autism. There is one measure of executive functioning, in conjunction with the two autism measures, are used to examine the relationship with the categorical outcome of autism or non-autism. Thus, based on this method, the multiple logistic regression analysis with 3 predictors requires a sample size of approximately 30 to 60 participants.

Participants

A database has been created from children who came to an early childhood intake center in a southwestern city in the United States. The power analysis indicated that the sample size should include approximately 46 to 126 participants for the first research question and 30 to 60 for the second research question. Participants were coded for an initial evaluation based on a screening result to evaluate for autism. The outcome of the evaluation has been placed as a coded result as one of the following: autism or not autism.

Procedures

Parents of children who enter the child center seek a screening and potentially an evaluation due to concerns for his/her child. After a screening, it had been determined what the evaluation will entail and what potential classification to be examined. Children who are evaluated for autism undergo evaluation with certain instruments, such as the BRIEF-P, ADOS-2, ASRS, CARS-2, and so forth. After the evaluation, the practitioner entered the data into a database, created by the practitioner, without identifying information.

The practitioner who examines the children is trained to perform psycho-educational evaluations for autism and other childhood disorders. The database was a collection of data from evaluations that have been conducted to provide school-based services to a child. Evaluations are thorough.

Parents bring their children to the early childhood center for an evaluation due to parent or pediatrician concern for development. For most children, this is the first evaluation to determine if a disability is present. Permission to access the database had been granted from the practitioner and school district. Data taken for this study had been limited to the age of the child, initial reason for evaluation, conclusion of the evaluation, and specific assessment tools (e.g., CARS-2, ASRS, and BRIEF-P).

Instruments

Various instruments are used to evaluate for autism while others examine components of executive function. In this study, the tools used that had been used to examine specific symptoms of autism include the Childhood Autism Rating Scale, Second Edition (Schopler et al., 2010; CARS-2) and the Autism Spectrum Rating Scale (Goldstein &Naglieri, 2009; ASRS). Executive functioning skills are examined through a scale-based measure called Behavior Rating Inventory of Executive Functioning (Gioia et al., 2013; BRIEF). Past research on the tools used in this study already have established psychometric properties of reliability and validity.

Autism Measures

CARS-2. The Childhood Autism Rating Scale, Second Edition is a measure completed through observations and parent interviews. A child is given a rating from 1 to 4, where a 1 is considered "normal" or "typical" functioning while a 4 is considered more clinically significant or "abnormal." There are 15 areas to achieve a rating on the assessment tool that has been validated on a diverse population (Schopler et al., 2010). The CARS-2 authors, Schopler et al. (2010), indicate that assessment tool has internal consistency reliability of .93 on the Standard version. These are in an acceptable range.

When a person uses an observation-based assessment tool, the observation needs to be an adequate length to gain a sample of the behavior and non-behavior (Hintze, 2005). This affects internal consistency reliability of a measure (Hintze, 2005). As such, an analysis of the secondary data has been conducted to determine its own internal consistency. The analysis indicates that the Cronbach's alpha for the 15 rating items was .87, which is consistent with Schopler et al. (2010). Test-retest was not conducted on the current data set as it comes from a secondary data source; however, Schopler et al. (2010) reported good test-retest reliability of .88 on the standard version of the CARS-2.

ASRS. The ASRS is an established rating scale with good psychometric properties. Goldstein and Naglieri (2014) determined that the tool has excellent reliability that ranges from $\alpha = .77$ to .97, depending on the subtest. Goldstein and Naglieri report that the lowest $\alpha = .77$ is on the Adult Socialization measure. The overall scale, though, holds its reliability at $\alpha = .97$. Goldstein and Naglieri noted that the ASRS is correlated with the first version of the CARS and determined its validity ($r = .43$).

Internal consistency has been explored in the secondary data sample. The analysis on the secondary data indicates that the Cronbach alpha was .90. This was comparable to the results reported by Goldstein and Naglieri (2014) for the ASRS measure. The ASRS was designed to measure behaviors of youth aged 2 to 18 years that were associated with the Autism Spectrum Disorder. It is validated on a diverse population (Goldstein &Naglieri, 2014). This scale is a rating where a parent estimates the frequency of various behaviors from 0 (Never) to 5 (Almost Always). It can be used to guide diagnostic decision-making pertaining to autism or other pervasive developmental disorders and can be completed by parents and teachers. This scale is broken into two overall composites – Social Communication and Unusual Behaviors. Additionally, two composites combine ratings typically present in those with autism – Total Score and Diagnostic Statistical Manual (DSM) Rating. Though the measure has the DSM-IV associated with the tool, the breakdown of Social Communication and Unusual Behavior is consistent in verbiage with the DSM-V. The scale uses a T-Score metric, which has a normative mean of 50 and standard deviation of 10. Thus, a T-score is a continuous variable as a child's score may take a value between 30 to 99. For evaluation purposes, the T-score result may denote the level of significance when comparing scores to determine the presence of autism symptomology.

Subscales included under Social Communication composite include the following: Peer Interaction, Adult Interaction, and Social-Emotional Reciprocity. Social Communication is the ability to use verbal and non-verbal communication appropriately to initiate, engage in, and maintain social contact. Peer Interaction is the willingness and capacity to successfully engage in activities that develop and maintain relationships with other children while adult interaction is the willingness and capacity to successfully engage in activities that develop and maintain relationships with adults. Social-Emotional Reciprocity is the ability to provide an appropriate emotional response to another person in a social situation.

Subtests included under Unusual Behaviors composite include the following: Atypical Language, Stereotyped Behaviors, Behavioral Rigidity, Sensory Sensitivity, and Attention and Self-Regulation. Unusual Behaviors are those that demonstrate an individual's inability to tolerate changes in routine, reaction to certain sensory experiences, and if the individual engages in apparently purposeless, stereotypical behaviors. Atypical language is spoken communication that may be repetitive, unstructured, or unconventional. Stereotypy is the engagement in apparently purposeless and repetitive behaviors. Behavioral Rigidity scale measures one's ability to tolerate changes in routine, activities, or behavior; aspects of the environment must remain unchanged. Sensory Sensitivity measures if the individual has over or under reaction to certain experiences sensed through touch, sound, vision, smell, or taste. Lastly, Attention and Self-Regulation scale is the ability to appropriately focus attention on one thing while ignoring distractions.

Executive Function Measures

BRIEF-P. The BREIF-P is a rating system validated on diverse populations to examine the executive functioning skills in children (Gioia et al., 2013). Cronbach alpha have been explored on the secondary data sample on the BRIEF-P scales. It is found to be .97, which falls within the high range. This is comparable to the internal consistency reported by Gioia et al. (2013), which falls within the high range (α = .80 to .98) for all scales. Though test-retest could not be assessed on the sample data due to the secondary nature of the data, Gioia et al. (2013) indicate that the measure has good test-retest reliability (rs = .82) for the parent rating form. Executive functions are a collection of processes that are responsible for guiding, directing, and managing cognitive, emotional, and behavioral functions and it manifests during novel problem solving. There are eight clinical scales (Inhibit, Shift, Emotional Control, Working Memory, Plan/Organize) and two validity scales (Inconsistency and Negativity). The five non-overlapping scales form the Global Executive Composite (GEC) and overlapping between various scales formulate three summary indexes. The Inhibitory Self-Control Index is composed of the Inhibit and Emotional Control scales. The Flexibility Index is composed of the Shift and Emotional Control scales. The Emergent Metacognition Index is composed of the Working Memory and Plan/Organize scales. It provides a well-rounded picture of the behavior of the child being rated.

This measure is a rating scale completed by the parent. Rating scales allow an individual's everyday observed behaviors equate with a perceived frequency – never, sometimes, or often. Akin to other rating scales, it is dependent on the observation of the parent and ability to estimate the frequency. A child rated by his or her parents regarding five singular areas of executive functioning (inhibit, shifting, emotional control, working memory, and planning/organizing), two melded areas of functioning (emergent metacognition and flexibility), and global executive functioning (a combination of all five singular scales). T-Scores are reported on the BRIEF-P, where scores below 65 are in the average range; between 65 and 70 are in the at-risk range; scores 71 and higher are termed clinically significant. A child's score could take on a value between 30 and 99.

Inhibit is the ability to stop oneself from doing something; to hinder oneself from engaging in an activity. The Inhibit scale measures inhibitory control (i.e., ability to inhibit, resist, or not act on an impulse) and the ability to stop ones' own behavior at the appropriate time. An elevated score on this scale would indicate disinhibition including high levels of physical activity, inappropriate physical responses to others, a tendency to interrupt and disrupt group activities, and a general failure to "look before leaping".

The Emotional Control scale measures the impact of executive function difficulties on emotional expression and assesses a child's ability to modulate/control emotional responses. An elevated score on this scale would indicate difficulty with emotional control include overblown emotional reactions to seemingly minor events, crying easily or laughing hysterically with little provocation or have temper tantrums with increased frequency and severity that is not age appropriate. The Shift scale measures the ability to move freely from one situation, activity, or aspect of a problem to another, as the circumstances demand. Key aspects of shifting include the ability to make transitions, problem-solving, flexibility, switch/alternate attention, and change focus from one mindset or topic to another.

The Working Memory scale measures the capacity to hold information in mind to complete a task or make a response. Working memory is essential for sustaining problem-solving activities, carrying out multi-step activities, completing basic mental manipulations, and following complex instruction. Integral to working memory is the ability to sustain attention and performance. An elevated score on this scale indicates difficulty remembering things (e.g., directions) even for a few seconds, losing track of what the child is doing while working, or forgetting what the child is supposed to retrieve when instructed. One may forget the rules governing a specific task even as one works on that task, lose track of situational demands, and struggle with implementing required activity sequences. One may have difficulty "sticking to" an activity for an age appropriate amount of time and frequently switch tasks or fail to complete tasks.

The Plan/Organize scale measures the ability to manage current and future-oriented task demands with situational context. The "plan" component of this scale relates to the ability to anticipate future events, implement instructions or goals, and develop appropriate steps ahead of time to carry out a task or activity. In preschool children, developmentally appropriate planning often involves implementing a goal or end state (provided by an adult) by strategically selecting the most effective method or steps to attain that goal. Planning often requires sequencing or stringing together a series of actions/responses. Organization on this scale relates to the ability to bring order to information, action, or material. Another goal may include achieving a goal or following an established organized plan. The ability to organize information is important in how information is learned, remembered, and implemented across contexts.

Type of Analysis

The SPSS software has been used for the data analysis. One method to analyze the hypothesis related to the first research question is multiple linear regression analysis.

The second research question is analyzed using multiple logistic regression. Age and gender are controlled for in these analyses as age and gender correlate with both executive function skill and autism symptomology. Additionally, data from the secondary source may include those with missing data pieces. This can occur when a child is examined for a disability and the examiner decided not enough evidence was present to continue to assess for a disability. Another instance when data from a tool may not be present is if a child or child's parent did not complete the assessment tool or only completed a portion of the assessment tool appropriately. Identification of these instances takes place when the data is cleaned. After the data is cleaned, it decreased the number of participants in the study; however, the sample size is provided as a range and allows for variance of the sample size.

For the first hypothesis, a multiple linear regression analysis examines the proportions of variance in the dependent variable. This type of analysis allows for management of covariates to test the effects of the predictor variables. Using this analysis type, the unique contribution of each independent variable on the dependent variable can be determined (Lewis, 2007). In the first hypothesis, the independent variables are the scales on the BRIEF while the dependent variables are the scales on the CARS-2 and ASRS. In effect, the analysis for the first hypothesis examines each subtest of executive functioning skill and the overall global measure of executive functioning skill, as measured by the BRIEF-P, in comparison to each selected component of autism symptomology, as measured by the CARS-2 and ASRS. This type of analysis determines if there is a correlation between components of autism and executive functions.

Assumptions of correlation tests include linearity and homoscedasticity (Laerd Statistics, 2013). This is also true of logistic regression. Additionally, assumptions of logistic regression need to be checked to avoid Type I and Type II errors (Osborne & Waters, 2002, para. 1). This allows one to know if there is an over or under estimate of significance (Osborne & Waters, 2002, para. 1). A multiple linear regression analysis could demonstrate if there is a significant predictive relationship between measures of executive functioning (i.e. BRIEF-P) and measures of autism symptoms (i.e. CARS-2 and ASRS). A logistic regression analysis allows a comparison to examine if each component of executive functioning as measured through the BRIEF-P (e.g., working memory, flexibility, organization, shifting, emotional control, etc.) and additional autism symptom features as measured by the CARS-2 and ASRS contribute significantly to whether an individual receives a diagnosis of autism.

Logistic regression utilizes categorical data to create a prediction probability (McDonald, 2014) and is utilized for the second hypothesis of this study. One may also determine which contributing variables affect the outcome (McDonald, 2014). For this portion of the study, the dependent variable is the outcome from the evaluation (autism classification or no autism classification) is identified for each participant. Additionally, each participant has a measure of autism symptomology through the Childhood Autism Rating Scale, Second Edition and Autism Spectrum Rating Scale and executive function skill through the Behavior Rating Inventory of Executive Functioning – Preschool (BRIEF-P). Though the BRIEF-P includes multiple scales – 9 scales for executive function, only the Global measure of the BRIEF-P will be used for the logistic regression, along with the total score on the CARS-2 and the DSM-IV score on ASRS. Scores from the BRIEF-P, CARS-2, and ASRS enter the analysis as predictors. By placing the autism and executive functioning measures into multiple logistic regression, it determines if the BRIEF-P, CARS-2 and ASRS affect the dependent variable, which is the reported outcome (autism or no autism) of the autism evaluation. This analysis allows one to determine the unique contribution of each measure of autism symptomology and executive function measures on the final autism classification. It may also determine the odds of these assessment tools predicting the outcome of classification.

Threats to Validity

When an assessment is taking place, a parent is informed of what the evaluator is evaluating. As such, it is possible that a parent may complete an assessment tool by rating a child either higher (showing greater impairment) or lower (showing lower impairment) than what a child is really demonstrating. Additionally, observers of the child through assessment (a team) complete the CARS-2 rating. The results from the CARS-2 may be contrary to the results from the other tools and the outcome of the evaluation. These instances may affect the analysis of the current study.

Ethical Considerations and Procedures

The Institutional Review Board reviewed the application to determine if the secondary source study meets current standards (approval number 07-14-17-0240788). In preparing for this review, one needed to consider multiple components. The aims of the research are to identify the relationship between variables. As such, one needs to avoid errors and uphold accountability. One area of accountability includes avoidance of conflict of interest and protection of human subjects. Data for this study comes from a database. The evaluations are conducted on children, ages 34 to 60 months. The evaluations are not conducted as a function of the study. Upon entering data into the database, personal identifiable information is removed. The database is not created to specifically conduct research. The database does not contain subject names or information that would lead to the identity of a subject. Though information is in a database, there is consideration for informed consent. According to American Psychological Association Code of Ethics (2010) for research, there are instances when informed consent does not need to be obtained. Specifically, informed consent does not need to be obtained when the research is conducted of normal educational practices in educational settings and when it is archival research that does not disclose participant's identities. The database is accessed by the practitioner to disseminate to the researcher. The researcher has access to information relevant to the purpose of the study.

Summary

The quantitative study will examine the following two connections: 1) executive functioning skills and autism symptomology; 2) measures of executive functioning skills and measures of autism symptomology predicting autism classification. The first examination aims to determine if executive functioning measures can predict severity of measured autism symptomology. The second examination breaks into two groups to examine the odds of receiving an autism classification based on the measures of executive functioning skills and autism symptomology together. Given the statistical power needed while minimizing effect size when examining two groups, a G-power calculator (Faul et al., 2007) determined that the sample size needs to encapsulate 30 to 126 subjects from the secondary data source.

Using SPSS, the data has been analyzed using multiple linear regression and multiple logistic regression. Examination of executive functioning skills and autism symptomology is done using linear regression. This allows one to determine the contribution and correlation of each component of executive function on each component of autism symptomology. Logistic regression analysis is performed on whether the measures of executive functioning skills and measures of autism symptomology predict autism classification. This allows the researcher to determine the unique contribution of each aspect of measured autism symptomology and each measure of executive functioning and the combination of the measures have on autism classification.

Chapter 4: Results

Introduction

Research questions in this study focus on the initial, early childhood evaluation for autism to better understand the link between executive functions and autism. With information taken from a database created by a practitioner in an early childhood center, the relationship between executive functioning and autism had been examined. The first analysis was completed using multiple linear regression analyses to examine the relationship between executive dysfunction and autism symptoms. A second analysis was completed to examine if the evaluation results from executive functioning and autism scales predict the outcome of an autism classification (e.g., autism or non-autism). Using multiple logistic regression, the odds of an autism or non-autism classification had been examined for the second hypothesis.

Information had been taken from the early childhood practitioners database of past evaluations to conduct the multiple linear and logistic regressions to answer the research questions of this study. The sample represents parents, pediatricians, and practitioners that question the presence of autism in early childhood. Focusing on the rationale for evaluation and the type of tests used in the evaluation, 71cases had been transferred for this study. However, of the 71 cases, not all three test measures had been used for each evaluation. Thus, the number of cases used in the analyses decreased to 42. This is slightly below the range of cases that Faul et al.'s (2007) G-power calculator indicates. Descriptive information pertaining to averages and standard deviation of the sample for each variable are provided in Table 1(Appendix A).

Multiple Linear Regression

Multiple regression analyses have been conducted to identify the relationship that exists between executive functioning skills (e.g., BRIEF-P Global score) and autism symptomology (e.g., ASRS DSM-IV; CARS-2 Total score). A multiple linear regression has been calculated to predict executive dysfunction scores (e.g., BRIEF-P) based on autism symptomology scores (e.g. ASRS DSM-IV and CARS-2). There were nine measures on the BRIEF that each have a respective null and alternate hypothesis presented in their respective sections to examine the relationship between a specific measure of executive functioning to the autism symptomology predictors (e.g., ASRS DSM-IV and CARS-2 total score).

Assumptions

In general, there were assumptions to consider in multiple linear regression. Examining assumptions in this study, there is little to no multicollinearity between variables. Another assumption is that the residuals are normally distributed. The third assumption is that normality is multivariate. Lastly, there are assumptions that samples are homogeneous and independent and there are linear relationships between variables.

Pearson's Correlation coefficients and level of significance between each pair of variables can be found in Table 1. There are no substantial correlations ($r < .9$; Hinkle, Wiersma, & Jurs, 2003) between the measures of autism symptomology (e.g., ASRS DSM-IV score, CARS-2 Total score), which indicates that there is no concern over multicollinearity in the data. Sole examination of autism symptomology variables, ASRS DSM-IV score and CARS-2 total score, indicate no correlation ($r = .05$, $p > .01$) or overlap in what they measure. Additionally, there is no overlap between the CARS-2 total score and global BRIEF-P executive functioning measure ($r = .05$, $p > .01$); however, when examining all the variables, there is overlap between the ASRS DSM-IV and global measure of executive functioning ($r = .78$, $p < .000$). This correlation, though, is not large enough to warrant concerns over multicollinearity.

Finally, P-P plots (Appendix B) completed for this study is used to examine the deviations from normality of the residuals for the global measure of executive functioning (Figure 1), ASRS DSM-IV score (Figure 2), and CARS-2 total score (Figure 3), inhibitory self- control (Figure 4), flexibility (Figure 5), emergent metacognition (Figure 6), inhibit (Figure 7), shift (Figure 8), emotional control (Figure 9), working memory (Figure 10), and planning/organization (Figure 11). As the plots illustrate for the variables, the data wraps around the diagonal to indicate that the data may be normally distributed for measure.

BRIEF-P Global Measure

For the global measure of the BRIEF-P: The null hypothesis is that the ASRS DSM-IV score does not significantly contribute to the global measure of the BRIEF-P (H_o: $\beta_{\text{ASRS DSM-IV}} = 0$). The alternative is the ASRS DSM-IV significantly contributes global measure of the BRIEF-P (H_A: $\beta_{\text{ASRS DSM-IV}} \neq 0$). Another null hypothesis is that the CARS-2 total score does not significantly contribute to the global measure of the BRIEF-P (H_o: $\beta_{\text{CARS-2 Total Score}} = 0$), while the alternative hypothesis is that it does (H_A: $\beta_{\text{CARS-2 Total Score}} \neq 0$).

In conducting a multiple regression analysis to examine the regression of the global measure of the BRIEF-P on the predictors of the CARS-2 and ASRS DSM-IV, results of the ANOVA analysis (Table 2) illustrates that the model with two predictor variables is a good method to predict the outcome variable. The overall model accounts for a significant amount of variance in the Global measure of the BRIEF-P (R^2= .64, F (2, 39) = 34.710, p<.000). Though the model shows overall statistical significance, only the ASRS (b = 1.51, p<.01) is significantly related to the BRIEF-P Global measure of executive functioning. The predicted rating of executive functioning skill on the BRIEF-P increases as the ASRS DSM-IV measure increases. The CARS-2 (b = -.36, p>.01) is not a significant predictor.

Thus, when considering the predictor factors, one null hypothesis is retained. The null hypothesis that the CARS-2 total score does not significantly contribute to the Global measure of the BRIEF-P (H_o: $\beta_{\text{CARS-2 Total Score}} = 0$) is retained. This indicates that the CARS-2 Total score does not significantly contribute to the global measure of executive functioning skill. Additionally, the null hypothesis of the ASRS DSM-IV not significantly contributing to the Global measure of the BRIEF-P, is not retained. This means that the ASRS DSM-IV measure contributes to the global measure of executive dysfunction.

Inhibitory Self-Control

For the inhibitory self-control measure of the BRIEF-P: A null hypothesis is that the ASRS DSM-IV score does not significantly contribute to the inhibitory self-control BRIEF-P (H_o: $\beta_{\text{ASRS DSM-IV}} = 0$). The alternative is the ASRS DSM-IV significantly contributes inhibitory self-control of the BRIEF-P (H_A: $\beta_{\text{ASRS DSM-IV}} \neq 0$). Another null hypothesis is that the CARS-2 total score does not significantly contribute to the inhibitory self-control of the BRIEF-P (H_o: $\beta_{\text{CARS-2 Total Score}} = 0$), while the alternative hypothesis is that it does (H_A: $\beta_{\text{CARS-2 Total Score}} \neq 0$).

A multiple regression analysis had been performed to determine how the inhibitory self-control measure of the BRIEF-P is affected by the autism symptomology predictors, CARS-2 total score and ASRS DSM-IV score. ANOVA results are reported in Table 3, which indicate a good method to determine the outcome variable. This model accounted for a significant amount of variance in the inhibitory self-control measure of executive functioning ($R^2 = .58$, F (2, 39) = 27.332, $p<.000$). In this model, the ASRS DSM-IV score (b = 1.344, $p< .001$) is significantly related to inhibitory self-control on the BRIEF measure; the higher the rating on the inhibitory self-control measure, the higher the rating on the ASRS DSM-IV. Additionally, the CARS-2 t-score (b = -.386, $p< .05$) is significantly related to inhibitory self-control in that higher the rating on the inhibitory self-control measure, the lower the measure on the CARS-2 measure.

When considering the predictor factors in this model, no null hypotheses are retained. The null hypothesis that the ASRS DSM-IV does not significantly contribute to the inhibitory self-control measure of the BRIEF-P, is not retained. Additionally, the null hypothesis that the CARS-2 total score does not significantly contribute to the inhibitory self-control measure of the BRIEF-P is not retained. Both null hypotheses are rejected, which means that the ASRS DSM-IV and the CARS-2 contribute to the inhibitory self-control measure of executive function.

Flexibility

Null and alternate hypotheses for the flexibility measure of the BRIEF-P: the null hypothesis is that the ASRS DSM-IV score does not significantly contribute to the flexibility BRIEF-P (H_o: $\beta_{\text{ASRS DSM-IV}} = 0$). The alternative is the ASRS DSM-IV significantly contributes flexibility of the BRIEF-P (H_A: $\beta_{\text{ASRS DSM-IV}} \neq 0$). Another null hypothesis is that the CARS-2 total score does not significantly contribute to the flexibility of the BRIEF-P (H_o: $\beta_{\text{CARS-2 Total Score}} = 0$), while the alternative hypothesis is that it does (H_A: $\beta_{\text{CARS-2 Total Score}} \neq 0$).

This multiple linear regression is executed by regressing flexibility on the predictors of autism symptomology (CARS-2 total score and ASRS DSM-IV score). The overall model ANOVA analysis (Table 4) illustrates a good method to predict the outcome variable when entering two predictor variables. This model also accounts for a significant amount of variance in the flexibility measure of the BRIEF-P ($R^2 = .63$, F (2, 39) = 32.489, $p<.001$). Both predictors, the ASRS DSM-IV (b = 1.371, $p < .001$) and CARS-2 t-score (b = -.522, $p < .01$) are shown to be significantly related to the flexibility measure of the BRIEF-P. The relationship between the measure of flexibility and ASRS indicates that the higher the rating of flexibility, the higher the rating on the ASRS. Additionally, it also indicates that the higher the rating in flexibility, the lower the rating on the CARS-2.

The predictor factors in this model affect the measure of the BRIEF-P, flexibility measure. As such, no null hypotheses are retained. The null hypotheses that the ASRS DSM-IV and the CARS-2 total score do not significantly contribute to the flexibility measure of the BRIEF-P, is not retained. Rejection of both null hypotheses indicates that the ASRS DSM-IV and the CARS-2 contribute to the flexibility measure of executive function.

Emergent Metacognition

Null and alternate hypotheses for the emergent metacognition measure of the BRIEF-P: A null hypothesis is that the ASRS DSM-IV score does not significantly contribute to the emergent metacognition of the BRIEF-P (H_o: $\beta_{\text{ASRS DSM-IV}} = 0$), while the alternative hypothesis is that it does (H_A: $\beta_{\text{ASRS DSM-IV}} \neq 0$). The other null hypothesis is that the CARS-2 total score does not significantly contribute to the emergent metacognition BRIEF-P (H_o: $\beta_{\text{CARS-2 Total Score}} = 0$), while the alternative is that the CARS-2 total score significantly contributes emergent metacognition of the BRIEF-P (H_A: $\beta_{\text{CARS-2 Total Score}} \neq 0$).

Another multiple regression analysis is conducted to regress the emergent metacognition measure of the BRIEF-P on the predictors, CARS-2 and ASRS DSM-IV. With the two entered predictor variables, results of the ANOVA indicate that this method predicts the outcome variable (Table 5). In this model, a significant amount of variance in the emergent metacognition measure on the BRIEF-P P (R^2= .45, F (2, 39) = 15.723, p<.001) is accounted; however, only the ASRS (b = 1.229, p < .001) shows a significant relationship to the BRIEF-P measure. This indicates that the predicted rating of executive functioning skill increases as the rating of the ASRS increases. The CARS-2 (b = -.283, p>.01) is not a significant predictor.

In this model, not all predictor factors affect the emergent metacognition measured on the BRIEF-P. The null hypothesis that the CARS-2 total score does not significantly contribute to the emergent metacognition measure of the BRIEF-P, is retained. However, the null hypothesis that the ASRS DSM-IV does not significantly contribute to the emergent metacognition measure of the BRIEF-P is not retained. Rejection of the null hypotheses indicates that the ASRS DSM-IV contributes to the prediction of the emergent metacognition measure of executive function.

Inhibit

Null and alternate hypotheses for the inhibit measure of the BRIEF-P: A null hypothesis is that the ASRS DSM-IV score does not significantly contribute to the inhibit measure of the BRIEF-P (H_o: $\beta_{\text{ASRS DSM-IV}} = 0$), while the alternative hypothesis is that it does (H_A: $\beta_{\text{ASRS DSM-IV}} \neq 0$). The other null hypothesis is that the CARS-2 total score does not significantly contribute to the inhibit measure of the BRIEF-P (H_o: $\beta_{\text{CARS-2 Total Score}} = 0$), while the alternative is that it does significantly contribute (H_A: $\beta_{\text{CARS-2 Total Score}} \neq 0$).

A multiple regression analysis had been conducted to examine the regression of the inhibit measure of the BRIEF-P on autism predictive measures, ASRS DSM-IV and CARS-2. For this study, two predictor factors had been entered into the model to determine if this is a good method to predict the outcome variable. The ANOVA results can be found in Table 6. It accounts for a significant amount of variance in the inhibit measure of the BRIEF ($R^2 = .53$, F (2, 39) = 21.873, $p<.001$). Despite the model showing overall statistical significance, only the ASRS (b = 1.195, $p < .001$) significantly contributes to the BRIEF-P inhibit measure. This indicates that as a student's predicted rating on the inhibit measure increases as the rating on the ASRS DSM-IV increases. The CARS-2 (b = -.351, p >.05) is not a significant predictor.

Predictor factors in this model do not universally affect the measure of the BRIEF-P, inhibit measure. The null hypothesis that the CARS-2 total score does not significantly contribute to the inhibit measure of the BRIEF-P is retained, while the null hypothesis that the ASRS DSM-IV score does not significantly contribute to the inhibit measure of the BRIEF-P is not retained. This indicates that the ASRS DSM-IV does contribute to the predicted inhibit measure of executive function while the CARS-2 does not.

Shift

Null and alternate hypotheses for the shift measure of the BRIEF-P: A null hypothesis is that the ASRS DSM-IV score does not significantly contribute to the shift measure of the BRIEF-P (H_o: $\beta_{\text{ASRS DSM-IV}} = 0$), while the alternative hypothesis is that it does (H_A: $\beta_{\text{ASRS DSM-IV}} \neq 0$). The other null hypothesis is that the CARS-2 total score does not significantly contribute to the shift measure of the BRIEF-P (H_o: $\beta_{\text{CARS-2 Total Score}} = 0$), while the alternative is that it does significantly contribute (H_A: $\beta_{\text{CARS-2 Total Score}} \neq 0$).

Examination of the regression of the shift measure of the BRIEF-P in terms of the autism predictors (e.g., CARS-2 and ASRS DSM-IV) occurs through a multiple regression. An ANOVA (Table 7) illustrates that the method is a good way to predict the outcome variable with two entered predictive variables. In general, the model accounts for a significant amount of variance in the shift measure of the BRIEF-P (R^2= .47, F (2, 39) = 17.56, p<.001). Both the ASRS DSM-IV (b = 1.13, p < .001) and CARS-2 (b = -

.43, $p < .05$) are significantly related to a student's predicted shift scale measure. As the ASRS increases, so does the predicted value of the shift scale measure. As the CARS-2 increases, though, a student's predicted shift value decreases.

Considering that both predictor factors in this model affect the measure of the BRIEF-P, shift measure, no null hypotheses are retained. The null hypotheses that the ASRS DSM-IV and the CARS-2 total score do not significantly contribute to the inhibit measure of the BRIEF-P, is not retained as factors contribute to the predicted shift measure of executive function.

Emotional Control

Null and alternate hypotheses for the emotional control measure of the BRIEF-P: A null hypothesis is that the ASRS DSM-IV score does not significantly contribute to the emotional control measure of the BRIEF-P (H_o: $\beta_{\text{ASRS DSM-IV}} = 0$), while the alternative hypothesis is that it does (H_A: $\beta_{\text{ASRS DSM-IV}} \neq 0$). The other null hypothesis is that the CARS-2 total score does not significantly contribute to the emotional control measure of the BRIEF-P (H_o: $\beta_{\text{CARS-2 Total Score}} = 0$), while the alternative is that it does significantly contribute (H_A: $\beta_{\text{CARS-2 Total Score}} \neq 0$).

A regression of the emotional control measure on the BRIEF-P on autism predictive factors of ASRS DSM-IV and CARS-2 total score occurs through a multiple regression analysis. The ANOVA analysis (Table 8) finds that the two predictive factors are a good method to predict the outcome variable. Overall, the model accounts for a significant amount of variance in the emotional control measure of the BRIEF-P ($R^2 = .45$, F (2, 39) = 16.10, $p<.001$). Despite the model showing overall significance, the

ASRS DSM-IV (b = 1.12, $p < .001$) and not the CARS-2 (b = -.40, $p > .05$), is significantly related to the BRIEF-P emotional control scale. This indicates that the student's executive functioning predicted rating will increase as the ASRS DSM-IV rating increases.

For this model, the predictor factor of ASRS DSM-IV influences the emotional control measure of the BRIEF-P. This means that the null hypotheses that the ASRS DSM-IV does not significantly contribute to the emotional control measure of the BRIEF-P, is not retained. However, the null hypothesis that the CARS-2 total score does not significantly contribute to the emotional control measure of the BRIEF-P is retained. In general, the ASRS DSM-IV contributes to the emotional control measure of executive function.

Working Memory

Null and alternate hypotheses for the working memory measure of the BRIEF-P: A null hypothesis is that the ASRS DSM-IV score does not significantly contribute to the working memory measure of the BRIEF-P (H_o: $\beta_{\text{ASRS DSM-IV}} = 0$), while the alternative hypothesis is that it does (H_A: $\beta_{\text{ASRS DSM-IV}} \neq 0$). The other null hypothesis is that the CARS-2 total score does not significantly contribute to the working memory measure of the BRIEF-P (H_o: $\beta_{\text{CARS-2 Total Score}} = 0$), while the alternative is that it does significantly contribute (H_A: $\beta_{\text{CARS-2 Total Score}} \neq 0$).

Another multiple regression analysis has been performed to examine the regression of the working memory component of executive function on the BRIEF-P in terms of the predictors ASRS DSM-IV and CARS-2 total. An ANOVA analysis (Table

9) illustrates that this model is a good method to predict the outcome variable with the two predictive variables. Though the overall model accounts for significant amount of variance in the working memory measure of the BRIEF-P ($R^2 = .58$, $F(2, 39) = 26.95$, $p < .001$), only one variable is significantly related. The ASRS ($b = 1.30$, $p < .001$) is significantly related the working memory measure of executive functioning. This indicates that the predicted rating of working memory increases as the ASRS increases. The CARS-2 ($b = -.25$, $p > .05$) is not a significant predictor.

For this model, the predictor factor of CARS-2 does not affect the working memory measure of the BRIEF-P. The null hypotheses that the CARS-2 total score does not significantly contribute to the working memory measure of the BRIEF-P is retained. However, the null hypothesis that the ASRS DSM-IV does not significantly contribute to the working memory measure of the BRIEF-P is not retained. Rejection of the later null hypothesis indicates that the ASRS DSM-IV, not the CARS-2, significantly contributes to the predicted rating of working scale of executive function.

Planning/Organization

The null hypothesis for the planning/organization measure of the BRIEF-P is that the ASRS DSM-IV score does not significantly contribute (H_o: $\beta_{\text{ASRS DSM-IV}} = 0$), while the alternative hypothesis does (H_A: $\beta_{\text{ASRS DSM-IV}} \neq 0$). The other null hypothesis is that the CARS-2 total score does not significantly contribute to the planning/organization measure of the BRIEF-P (H_o: $\beta_{\text{CARS-2 Total Score}} = 0$), while the alternative is that it does significantly contribute (H_A: $\beta_{\text{CARS-2 Total Score}} \neq 0$).

Regression of the planning/organization measure of the BRIEF-P on the predictors of CARS-2 and ASRS DSM-IV has been implemented through a multiple regression analysis. The ANOVA (Table 10) analysis with two entered predictor variables to predict the outcome variable indicates that this model is a good method. The model accounts for significant amount of variance in the planning/organization measure of the BRIEF-P (R^2= .55, F (2, 39) = 24.16p<.001) though only one predictor is significantly related. The ASRS (b = 1.32, p<.001) is significantly related to the BRIEF-P planning/organization measure of executive functioning while the CARS-2 (b = -.28, p>.05) is not a significant predictor. This indicates that the student's executive functioning predicted rating of planning/organization skill on the BRIEF-P increases as the ASRS DSM-IV measure increases.

The ASRS predictor factor in this model significantly influences the planning/organization measure of the BRIEF-P. As such, the null hypothesis that the ASRS DSM-IV does not significantly contribute to the planning/organization measure of the BRIEF-P is not retained. This indicates that the ASRS DSM-IV significantly contributes to the planning/organization measure of executive function. However, the null hypothesis that the CARS-2 total score does not significantly contribute to the planning/organization measure of the BRIEF-P is retained.

Multiple Logistic Regression

This analysis examines potential factors that influence final school-based classification for autism and the odds of predicting autism classification. Comparisons of final school-based classification of autism or non-autism (dependent variable) to the results from the CARS-2 total score, ASRS DSM-IV score, and BRIEF-P global score (independent variables). This research analysis aims to determine if results from the CARS-2, ASRS and BRIEF-P predict autism classification.

Predicting Outcomes

Logistic regression has been used to predict category data with binary outcomes (e.g., yes or no, etc.) paired with two or more measured variables (McDonald, 2014). This allows one to examine the relationship between variables in determining the probability of the dependent binary variables change (McDonald, 2014). The null hypothesis of this logistic regression analysis is that there are no relationships between the independent and dependent variables. Another null hypothesis is that the addition of an independent variable will not improve the fit of the model.

Similar to linear regression, there are assumptions to consider in logistic regression. Two similar assumptions are that normality is multivariate and there is little to no multicollinearity between variables. In logistic regression, other assumptions are that variables are not overly dispersed and the continuous variables are linearly related to the outcome variable. Additionally, this type of analysis assumes autonomous observations.

A multiple logistic regression analysis was conducted in a sample that was 76% male to evaluate how well results from three assessments predict autism classification. The Childhood Autism Rating Scale, Second Edition (M = 41.16, SD = 7.65), Autism Spectrum Rating Scale was the Diagnostic Statistician Manual, Fourth Edition (M = 67.08, SD = 8.52), and Behavior Rating Inventory of Executive Functioning, Preschool

Version Global (M = 65.32, SD = 15.28) measure of executive functioning were entered into the analysis as predictors of the likelihood to receive a classification of autism. These variables are compared to the dependent variable of autism classification, which occurred positively in 53.5% of the sample. The likelihood of an autism classification (coded as 0 for yes and 1 for no) in an evaluation along with the three variables (e.g. global executive functioning, ASRS DSM-IV, and CARS-2) enter in a binary logistic regression. The three forecasting variables that influence the fit of the model (examined in the chi-square) produce a significant change, χ^2 (3, N = 42) = 23.49, $p < .01$. In addition to the chi-square, the Hosmer and Lemeshow Test assesses the overall fit of the model by dividing the sample data into predicted probabilities (Bartlett, 2014). The significance of the p-value indicates whether the model is a good fit. When performing this test, a significant result means that the model is a poor fit, whereas a non-significant result yields a model of good fit (Bartlett, 2014). The non-significance of the Homer and Lemeshow Test, χ^2 (8, N = 42) = 4.979, p = .76, indicates that there is no evidence of a poor fit. This means that the observed rates match the expected rates of this given sample and that there is no evidence of making poor predictions within this model.

Despite a good fit of the data (χ^2 (1) = 10.00, p = .002), the DSM-IV T-score (b = -.15, p = .11; Odds Ratio = .86) and BRIEF Global T-score (B =-.01, p = .89; Odds Ratio = .99) are not significant predictors. The only significant predictor for an autism classification or not is the CARS-2 t-score (b = -.26, $p < .05$; Odds Ratio = .77). This suggests that the lower the CARS-2 T-score, the less likely one would be classified in the autism group 33.3% of the time. Results are presented in Table 11.

In general, the research question has aimed to determine if the ASRS DSM-IV, BRIEF-P global measure, and CARS-2 total score predict the likelihood of autism classification. Results indicate that the ASRS DSM-IV and BRIEF-P global scores are not significant predictors. However, the CARS-2 total score is identified as a significant predictor through this analysis. The three factors, CARS-2, ASRS DSM-IV, and BRIEF-P global measure, together affect whether one receives an autism classification.

Summary

Overall, the results of the analyses indicate that there are significant relationships between autism symptomology and executive functioning skills. The linear regression analysis indicates that executive functioning skills share a significant relationship with autism symptomology as measured by the ASRS DSM-IV. Not all the executive functioning skills, though, share a statistically significant relationship with the CARS-2.

The ASRS DSM-IV and CARS-2 hypotheses significantly contribute to each measure of the BRIEF-P (e.g., global measure, emergent metacognition, flexibility, inhibit, emotional control, working memory, and planning/organization). The relationships between the ASRS and BRIEF-P are positive relationships. Results of the analyses show overall statistical significance for the models though differences for each autism symptomology measure (e.g., ASRS DSM-IV and CARS-2); however, only the ASRS is significantly related to the executive functioning measure. The student's predicted rating of executive functioning skill on the global score, emergent metacognition, inhibit, emotional control, working memory, and planning/organization scales increase as the ASRS DSM-IV measure increases.

The ASRS DSM-IV and CARS-2 hypotheses significantly contribute to each measure of the BRIEF-P (i.e., inhibitory self-control, flexibility, and shifting). In the ASRS DSM-IV and CARS-2 model are significantly related to inhibitory self-control on the BRIEF measure. The higher the rating on the inhibitory self-control, flexibility, and shift measures, the higher the rating on the ASRS DSM-IV. The higher the rating on the inhibitory self-control, flexibility, and shift measures measure, the lower the measure on the CARS-2 measure. The relationships between these significant measures of the CARS-2 and the BRIEF-P are negative relationships. This may mean that the lower the ratings on the BRIEF-P, the higher the total score on the CARS-2.

The research question examined the final school-based classification of autism or non-autism to the results from the CARS-2 total score, ASRS DSM-IV score, and BRIEF-P global score. The null hypothesis is that all the variables in the regression equation take the value zero and have no relationship. Another null hypothesis is that the addition of an independent variable does not improve the fit of the model. The alternate hypothesis is that the model with predictor variables (e.g., CARS-2, BRIEF-P Global, and ASRS DSM-IV) is accurate and differs significantly from the null of zero. In the multiple logistic regression indicates that the three variables, BRIEF-P, ASRS DSM-IV, and CARS-2, predicts the classification of autism. However, ASRS DSM-IV, and BRIEF-P are not significant predictors, while CARS-2 is a significant predictor of autism classification.

Chapter 5: Conclusions, Discussion, and Recommendations

Findings and Importance

The theoretical basis for this study came from Kennedy and Coelho (2005) and Damasio and Maurer (1978), who identified similarities between those with autism and traumatic brain injury within the frontal region of the brain. Those findings laid the foundation to connect autism to development of the frontal brain, which houses executive functioning skills (i.e. planning, flexing one's thinking, switching tasks, and remembering and manipulating social rules). The current study continues the connection, as it demonstrated that in early childhood, there are connections between autism and executive functioning skills.

There had been two aims in engaging in this study. One aim had been to discern a relationship between executive functioning skills and autism symptomology. The other aim had been to determine if autism symptomology and executive dysfunction predict a classification of autism or non-autism diagnosis. Overall, the results of the analyses indicated that there have been significant relationships between autism symptomology and executive functioning skills. At the same time, results indicated that some measures of autism symptomology were not significantly related to executive functioning skills. These results have been explored overall and per type of analysis (i.e., multiple linear regression, multiple logistic regression) and component of executive functioning skill.

Overall study. In general, the results indicate that there was a relationship between autism symptomology and executive dysfunction in that there was a significant linear relationship between some of the variables. Reminiscent of Kennedy and Coelho

(2005), who found that damage in the frontal region of the brain affects metacognition, results indicated that there was a significant relationship between autism symptomology and emergent metacognition. Additionally, this study finds that working memory, inhibition, shifting, and flexibility were four executive functions that were shown in early childhood to be related to autism symptomology.

Multiple linear regression. Multiple linear regressions were used in this study to examine various measures of autism symptomology as it compares to many components of executive functioning. Generally, there is a relationship between autism symptomology (e.g., ASRS DSM-IV, etc.) and executive functioning (e.g., BRIEF Global, etc.); however, not all areas of executive functioning and autism symptomology demonstrate a significant relationship. The relationship between autism symptoms and executive functioning skill varies. There are some relationships between autism symptomology and executive functioning that are positive relationships and some relationships between autism symptomology and executive functioning that are negative relationships; however, the variant relationships between autism symptomology and executive functioning skills may occur due to how the variables have been derived. For example, two of the rating scales included in the analyses were completed by the parent, while the other is completed by a team of practitioners. This factor may affect the outcome of the analysis and will be discussed further in the limitation section of this chapter.

In this study, there are significant positive relationships between one measure of autism symptomology (i.e., ASRS DSM-IV) and many components of executive functioning (i.e., BRIEF global, emergent metacognition, inhibition, emotional control, working memory, shifting, flexibility, inhibitory self-control, and planning/organization); however, this was not true for all measures of autism symptomology. A significant negative relationship was found between a measure of executive functioning (i.e., shift and inhibitory self-control) to a measure of autism symptomology (i.e., CARS-2). Additionally, there was no significant relationship found between the executive function of flexibility and the CARS-2 measure of autism symptomology. This is consistent with past research of the relationship between autism and executive functioning in older individuals (Hill, 2004; Taddei & Contena, 2013).

Not unlike the findings of Robinson et al. (2009), where impairments in metacognition were considered consistent and stable through the development of one diagnosed with autism spectrum disorder, emergent metacognition in this study has a positive relationship to a measure of autism symptomology in early childhood. In the past, Robinson et al. (2009) and Etemad Smithson et al. (2013) found that those with autism spectrum disorders demonstrated clinically significant deficits in emergent metacognition/self-monitoring skills. This is akin to the current research study in terms of one measure of autism symptomology.

Etemad Smithson et al. (2013) did not verify a correlation between autism symptomology and the executive functioning skills of emotional control in early childhood; however, research studies conducted by Diamond and Taylor (1996), Plauche Johnson and Myer (2007), and Packham (2011) indicated that the ability to imitate and demonstrate social awareness was parallel skills in metacognition, working memory, and emotional control. Panerai et al. (2014) had found that those within the high functioning autism range had a clinically significant relationship with emotional control. Emotional control in this study was found to be associated with one measure of autism symptomology. This also contributed to why emotional control had not been not found to be clinically significant to the CARS-2 measure of autism symptomology as the CARS-2 was not a measure for those with high functioning autism. Researchers may guide future research on a relationship between those being assessed for high functioning autism and those with challenges in emotional control.

Though Etemad Smithson et al. (2013) did not establish a correlation between autism symptomology and working memory in early childhood, Yerys et al. (2007) stated that working memory dysfunction is a secondary deficit in autism that emerges after the age of 5 years. However, Gathercole et al. (2008) indicated that working memory develops earlier than 5 years of age. Furthermore, working memory was determined to be a measurable construct in those with autism throughout their development (Geurts & Vissers, 2012; Geurts, Corbett, & Solomon, 2009; Hill, 2004). Working memory was also believed to be one of the primary units of executive functioning skills developing from the time of birth (Garon et al., 2008; Pelicano, 2012; President and Fellows of Harvard College, 2014; Diamond & Lee, 2011). Though there is a split in the outcomes between autism symptomology measures, the results from this study indicate that there are components of autism symptomology that predict working memory skill in early childhood. The variant results are a function of the measures used in the study.

Planning/organizational skills have been measured and found to be related to one measure of autism symptomology. In the past, planning and organizational skills were examined in those diagnosed with autism and found to be needed for development of language skills (Joseph et al., 2005). Additionally, Cruz et al.'s (2012) results indicated that planning skills were needed to develop joint attention skill, which lacks in those with autism in early childhood (APA, 2015; Cruz et al., 2012; Miller &Marcovitch, 2015). This measure of executive functioning has not been not found to be related to the CARS-2 measure of autism symptomology. This may be a function of the limited areas that directly measure the quality of joint attention on the CARS-2. Researchers may focus future research on a specific measure of joint attention in relationship to planning and organization skills.

For the inhibitory control and shift measures of executive functioning, the results varied within the measures of autism symptomology. As the ASRS measure of autism symptomology increased, the predicted value of the inhibitory control and shift measures increased. On the other hand, as the CARS-2 measure of autism symptomology increased, the student's predicted inhibitory control and shift values decreased. This variation was considered in terms of the current study and past research. The variation among measures in determining a relationship between shifting and autism symptomology in early childhood is a component to consider when reviewing Yerys et al. (2007) and Etemad Smithson et al. (2013). Yerys et al. (2007) believed shifting to be a secondary deficit in autism while Etemad Smithson et al. (2013) believed that shifting was not substantially correlated to autism symptomology. In this study, the variation among the measures of autism symptomology indicated that type of measure used can demonstrate a relationship between shifting and autism symptomology in children younger than 5 years of age. This is also supported by Wieba et al. (2011), who found that the ability to shift and inhibitory control are two of the first three executive functioning skills to mature and differentiate from the others. Additionally, the rapid development of working memory and inhibitory control occurs between preschool and early school age and are related to a student's academic achievement (Thorell et al., 2008).

It is possible that the CARS-2 measure may not be as sensitive of a measure to these types of skills. The executive functioning skill of shifting incorporates other executive functioning skills, such as working memory, emotional control, flexibility, and planning. It is the ability to redirect a mindset from one line of thinking to another. The ability to shift or stop a behavior is associated with autism symptomology related to restrictive and repetitive behaviors (Pellicano, 2012; Possin et al., 2005; Von Hahn & Bentley, 2013) and the ability to incorporate social thinking and awareness (Garcia Winner, 2000; Garcia Winner, 2008). Of the 60 points available on the CARS-2 measure, approximately eight points are directly associated with these components.

The surprising component in this study is the lack of a statistically significant relationship between the executive functioning skill of flexibility and autism symptomology. Given the relationship between perseverative behaviors and behavioral rigidity, which is related to the ability to be flexible (Von Hahn & Bentley, 2013; Pellicano, 2012) and the demonstration of those deficits in those with autism (Possin et al., 2005), one may believe that these components would be related. Past research has shown a split in the clinical significance of flexibility to autism symptomology with some studies (e.g. Etemad Smithson et al., 2013, etc.) demonstrating no clinical significance and others (e.g., Panerai et al., 2014, etc.) demonstrating clinical significance in those diagnosed with autism. This study indicates that neither measure of autism symptomology is clinically significantly linked to flexibility.

Multiple logistic regression. Results of the multiple logistic regression indicate that when taking the three factors (e.g., DSM-IV T-Score, BRIEF Global T-Score, and CARS-2 Total Score) together, they significantly contribute to make a prediction of whether the child received an autism classification. Finding these connections are important as it addressed an inconsistency noted by the examination of previous studies (e.g., Benson et al., 2013; Cruz et al., 2012; Miller &Marcovitch, 2015; Panerai et al., 2014; Taddei & Contena, 2013, etc.) by establishing a connection between autism symptomology and executive dysfunction in early childhood. In the evaluation of autism, the results indicate that relationship between executive dysfunction and autism symptomology in assessment tools affect a meaningful classification of the student. This may indicate that the three variables together sufficiently predict classification while one single assessment does not indicate classification.

In the vein of the current study, Benson et al. (2013), Cruz et al. (2012), Miller and Marcovitch (2015), Panerai et al. (2014), and Taddei and Contena (2013) found associations between autism and executive dysfunction. This is contrary to the findings of Etemad Smithson et al. (2013) and Russell-Smith et al. (2014) who did not find an association between executive dysfunction and autism symptoms. Etemad Smithson et al. (2013), however, questioned whether results would be similar in a study that examined these skills prior to an autism diagnosis. The current study made comparisons in those being evaluated for the presence of autism. The measures used to determine the classification of autism or no autism, indicated that all three measures contribute to an effective determination. Additionally, results from this study indicate that there was a relationship between the ASRS DSM IV and executive functioning measures.

The individual contribution of each factor has been examined to determine if one factor is a predictor of whether a person receives an autism classification. Results indicate that the CARS-2 is a significant predictor while the ASRS DSM-IV T-score and BRIEF Global T-score are not significant predictors in whether a child received an autism classification. Moreover, the negative relationship of the CARS-2 indicates that as the CARS-2 score decreases, the higher the likelihood of an autism classification. In considering this type of relationship, one examines how the contributing data results may be different. The other linear variables (e.g., ASRS and BRIEF-P) are higher than the CARS-2 scores (e.g., clinical significance on the CARS-2 starts at a much lower T-score than that on the ASRS and BRIEF-P) and may affect the analyses in the study.

Results from the study are practical implications for those diagnosed with autism. One implication is that one or two overall measures of autism may not be sufficient in determining the presence of autism. Additional measures, such as the BRIEF-P, that measures executive dysfunction are also needed to make an accurate prediction of the presence of autism. Addressing all concerns allows a practitioner to address specific needs for individuals diagnosed with autism and determine intervention(s). Identification of executive dysfunction in early childhood in those with autism can also be remedied through direction intervention and support (Blair &Razza, 2007; Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; Espy et al., 2001; Ferrier, Bassett, & Denham, 2014; Willoughby et al., 2012).

Limitations

This study has been limited in a few ways. One way was in the number of cases available in the database to conduct an analysis. For the first analysis, 46 participants were required. The study had 42 complete cases contributing to the analysis. The variation amongst the required amount of cases may contribute to the ending results and may influence the power of the analysis. Another limitation is that this study limited its exploration to the ASRS DSM-IV scale and the CARS-2 Total T-score rating though there are several other components within each rating scale.

There are a few additional procedural limitations present in the study. One is that parents referred their child for evaluation due to developmental concerns for the child. This may influence the results as those that have been evaluated may have demonstrated a higher preponderance of symptomology. Another procedural limitation is that the parent may have a bias when completing the given rating scale about the child. The rating scales did not have a check system to determine if there was an overly negative or positive perspective while completing the scales. This may have influenced the results of the analyses. For example, in the multiple logistic regression when using the BRIEF, ASRS, and CARS-2 in determining the likely outcome of the evaluation, there is a negative relationship with the CARS-2 and the outcome of the evaluation. In the multiple linear regressions, there frequently are negative relationships between the BRIEF scales and the CARS-2. Considering the CARS-2 is a measure that two or more practitioners complete to determine the severity in multiple areas, the ratings may be more severely noted by practitioners when compared to the given parent who completed the rating scale. However, practitioners rarely use one measure to determine a disability; thus, a preponderance of data may have led to contrary results from the CARS-2 results.

Despite these limitations, this study established a connection between specific components of autism symptomology and executive functioning skills. All measures of the BRIEF-P are significantly related to the ASRS DSM-IV measure. Only three measures from the BRIEF-P (i.e., inhibitory self-control, flexibility, and shift) are related to the CARS-2 total score. Additionally, the ASRS DSM-IV, CARS-2, and Global measure on the BRIEF-P contribute to the prediction of autism or non-autism.

Further Research

There are recommendations for future research. One recommendation is to replicate the analysis with a larger sample size. Further research could analyze other measures on the scale to identify a relationship of smaller components that contribute to the larger measures used in this study. When assessing for autism, an evaluator examines symptomology in multiple environments. This study focused on the ratings on the ASRS and BRIEF-P completed by parents. Future research could include measures from classroom teachers or other raters that have contact with the child.

In considering the gap in literature that lead to this study, future research may explore additional components of autism symptomology as measured on the ASRS and CARS-2 as it relates to executive functioning skills. For example, future research could examine peer relationships, adult relationships, and social emotional reciprocity on the ASRS in conjunction with emotional regulation on the CARS-2 as these components relate to executive functioning skills. The research that examines specific components of autism symptomology may also focus to specific components of executive functioning, such as the ability to shift and emotional control.

Conclusions and Summary

The essence of the study was to examine how executive functioning is affected in early childhood in those evaluated for autism. Past research indicated inconsistencies in the relationship of executive functioning skills to those with autism; however, executive dysfunction is typically present in those with autism that are older than 6 years of age (Benson et al., 2013; Hill, 2004; Robinson et al., 2009; Rosenthal et al., 2013; Taddei & Contena, 2013; Verte et al., 2006). Research that examined one component of executive function and one component of autism indicated a connection in early childhood as young as 18 months of age (Benson et al., 2013; Cruz et al., 2012; Charman, 2003; Diamond & Taylor, 1996; Hutchins, Prelock, &Bouyea, 2010; Lerner, Hutchins, &Prelock, 201; Mundy & Newall, 2007; Miller &Marcovitch, 2015; Silva &Schalock, 2012; Van Leeuwen et al., 2009).

The hypotheses that the ASRS DSM-IV and/or CARS-2 significantly contribute to each measure of the BRIEF-P (e.g., global measure, emergent metacognition, flexibility, inhibit, emotional control, working memory, and planning/organization) have been examined in this study. The relationships that exist between autism symptomology and measures of executive functioning skills are positive relationships; however, not all areas of executive functioning and autism symptomology demonstrate a significant relationship nor a positive one. Flexibility is the only measure of executive functioning skills to illustrate no statistically significant relationship to the measures of autism symptomology.

This study determined that there are connections between specific components of executive functioning (e.g., global measure of executive functioning, shift, emergent metacognition, inhibition, emotional control, working memory, planning/organization, and inhibitory control) to the ASRS DSM-IV measure of autism symptomology. There are significant positive relationships between measures of autism symptomology and executive functioning skills. The measures of executive functioning that demonstrate a significant positive relationship. Positive relationships are found between emergent metacognition, emotional control, working memory, shifting, inhibitory control, and planning/organization and autism symptomology as measured by the ASRS DSM-IV scale. The findings of the positive relationship between emergent metacognition and autism symptomology is akin to the work of Robinson et al. Even though Panerai et al. determined that those with high functioning autism had significantly related autism symptomology to emotional control, this study indicated that autism symptomology is related to a measure of emotional control; however, this may be interrelated to the mixed results with measures of autism symptomology to the emotional control measure. The same is also true for the results on the relationship between working memory and planning/organizational skills and measures of autism symptomology; though, working memory was determined to be a measurable construct throughout one's development (Gathercole et al., 2008; Geurts & Vissers, 2012; Geurts, Corbett, & Solomon, 2009; Hill, 2004) while planning/organizational skills were found to be needed for the development of other milestones, such as language (Joseph et al., 2005).

There are measures of executive functioning that demonstrate a significant negative relationship to measures of autism symptomology. The ASRS DSM-IV and CARS-2 autism symptomology measures are significantly unrelated to inhibitory self-control and shift scales on the measure of executive functioning skills. The variant results indicate that this could be a contributing factor to the present split amongst results of past research. The type of measure used within a study lead to whether a substantial relationship is found between autism symptomology and executive functioning skills. It is also possible that the CARS-2 measurements may not be as sensitive to the types of skills that can be affected in those with autism as it generalizes many areas of potential concern into 15 general areas for a total of8 out of 60 points.

The other research question aimed to examine the predicting factors (e.g., CARS-2, BRIEF-P Global, and ASRS DSM-IV) of an autism classification. This analysis showed that in the evaluation of autism, the tools contribute meaningfully to the outcome of an autism assessment. Results indicate that relationship between executive dysfunction and autism symptomology in assessment tools affect a meaningful classification of the student. A practical implication of this result is that a body of tools can efficiently and accurately predict the presence of autism in early childhood. These tools not only work together cohesively, they can be used to ascertain what areas need to be addressed in intervention for students classified with autism. Past research indicated that early identification of autism can allow for earlier intervention (Espy, Kaufman, Glisky, & McDiarmid, 2001) and that interventions and supports increase executive functioning skills (Blair &Razza, 2007; Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; Espy et al., 2001; Ferrier, Bassett, & Denham, 2014; Willoughby et al., 2012).

Limitations to this study include the number of cases available in the database to conduct an analysis, limited exploration to the ASRS DSM-IV scale and the CARS-2 Total T-score rating, and parental referral due to developmental concerns for the child may influence ratings provided by the parent. Notwithstanding the limitations, this study connects autism symptomology and executive dysfunction and directs future research. Future research may utilize a larger sample size, break down the ratings used to specific or smaller components of autism symptomology, and include measures additional raters (other than the parents) that have contact with the child.

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Appendix A: Tables

Table 1

Means, Standard Deviations, and Pearson Correlation Coefficients

	Mean	Standard Deviation	Correlation with ASRS DSM-IV	Correlation with CARS-2
ASRS DSM-IV	68.19	8.16		
CARS-2 Total Score	41.88	8.19		
BRIEF-P Global	65.50	15.59	.77*	-.15
Inhibitory Self Control	61.50	14.72	.73**	-.18
Flexibility	59.21	14.88	.74**	-.25
Emergent Metacognition	65.48	15.22	.65**	-.12
Inhibition	63.02	13.77	.70**	-.17
Shift	67.57	14.04	.64**	-.22
Emotional Control	57.64	14.19	.63**	-.20
Working Memory	67.64	14.04	.75**	-.11
Planning/Organization	53.76	14.63	.73**	-.12

* $p < .01$
**$p < .001$

Table 2

ANOVA of ASRS-DSM-IV, CARS-2, and Global BRIEF-P

	Sum of Squares	df	Mean Square	F
Regression	6384.58	2	3192.29	34.72*
Residuals	3585.92	39	91.95	
Total	9970.50	41		

* $p < .001$

Table 3

ANOVA of ASRS-DSM-IV, CARS-2, and Inhibitory Self-Control BRIEF-P

	Sum of Squares	df	Mean Square	F
Regression	5185.17	2	2592.59	27.33*
Residuals	3699.33	39	94.86	
Total	8884.50	41		

* p <.001

Table 4

ANOVA of ASRS-DSM-IV, CARS-2, and Flexibility BRIEF-P

	Sum of Squares	df	Mean Square	F
Regression	5669.96	2	2834.98	32.49*
Residuals	3403.11	39	87.26	
Total	9073.07	41		

* p <.001

Table 5

ANOVA of ASRS-DSM-IV, CARS-2, and Emergent Metacognition BRIEF-P

	Sum of Squares	df	Mean Square	F
Regression	4240.90	2	2120.45	15.72*
Residuals	5259.58	39	134.86	
Total	9500.48	41		

* p <.001

Table 6

ANOVA of ASRS-DSM-IV, CARS-2, and Inhibit BRIEF-P

	Sum of Squares	df	Mean Square	F
Regression	4111.53	2	2055.77	21.87*
Residuals	3665.44	39	93.99	
Total	7776.98	41		

* p <.001

Table 7

ANOVA of ASRS-DSM-IV, CARS-2, and Shift BRIEF-P

	Sum of Squares	df	Mean Square	F
Regression	3827.17	2	1913.59	17.56*
Residuals	4251.11	39	109.00	
Total	8078.29	41		

* p <.001

Table 8

ANOVA of ASRS-DSM-IV, CARS-2, and Emotional Control BRIEF-P

	Sum of Squares	df	Mean Square	F
Regression	3733.74	2	1866.87	16.10*
Residuals	4521.90	39	115.95	
Total	8255.64	41		

* p <.001

Table 9

ANOVA of ASRS-DSM-IV, CARS-2, and Working Memory BRIEF-P

	Sum of Squares	df	Mean Square	F
Regression	4690.06	2	2345.03	26.95*
Residuals	3393.59	39	87.02	
Total	8083.64	41		

* p <.001

Table 10

ANOVA of ASRS-DSM-IV, CARS-2, and Planning/Organization BRIEF-P

	Sum of Squares	df	Mean Square	F
Regression	4856.89	2	2428.44	24.16*
Residuals	3920.73	39	100.53	
Total	8777.62	41		

* p <.001

Table 11

*Logistic Regression Predicting Autism Classification (*N = 42)

	Regression Coefficient	Chi Squared	P-value	Odds Ratio (95% Confidence Interval)
Constant	20.28	10.00	.00	-
ASRS DSM-IV	-.15	2.59	.11	.86 (.71, 1.03)
BRIEF-P Global	-.01	.02	.89	.99 (.90, 1.10)
CARS-2 Total	-.26	7.37	.01	.77 (.66, .93)

Appendix B: Figures

Normal P-P Plot for Global Executive Functioning

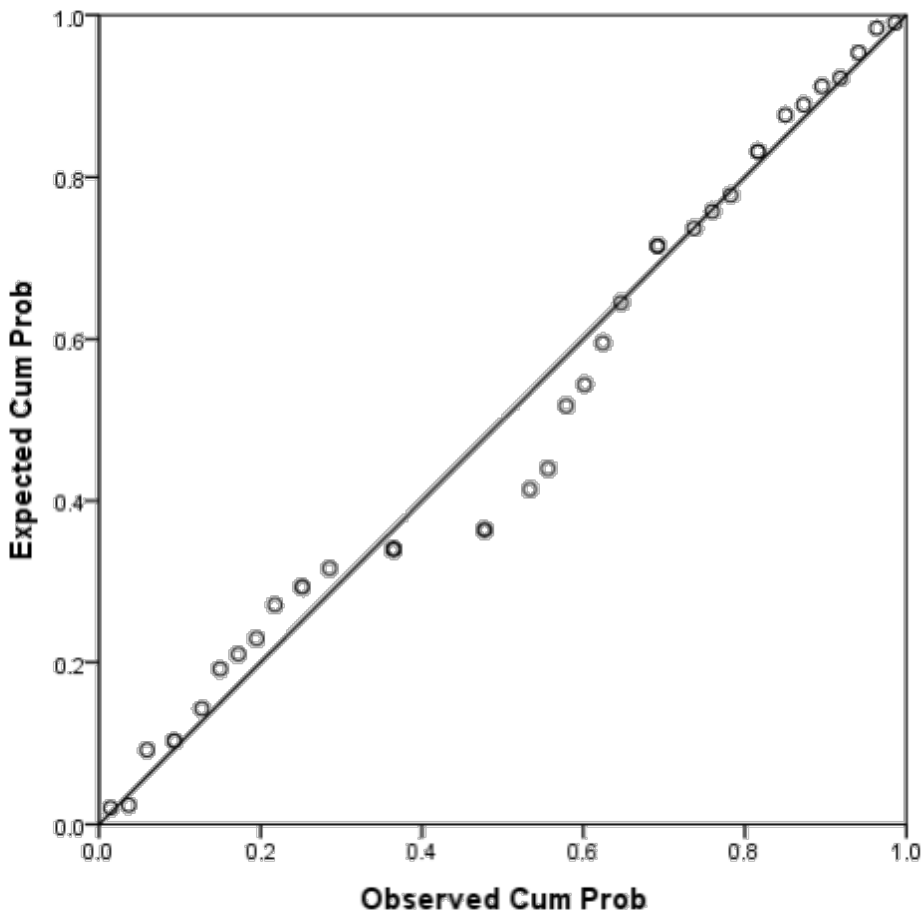

Figure 1. The P-P plot illustrates normal distribution of residuals (left side) versus the non-normally distributed residuals (right side) of the global measure of executive functioning skill. Overall results are wrapped around the diagonal. Wrapping around the diagonal would indicate that the residuals are normally distributed.

Normal P-P Plot of the ASRS DSM-IV

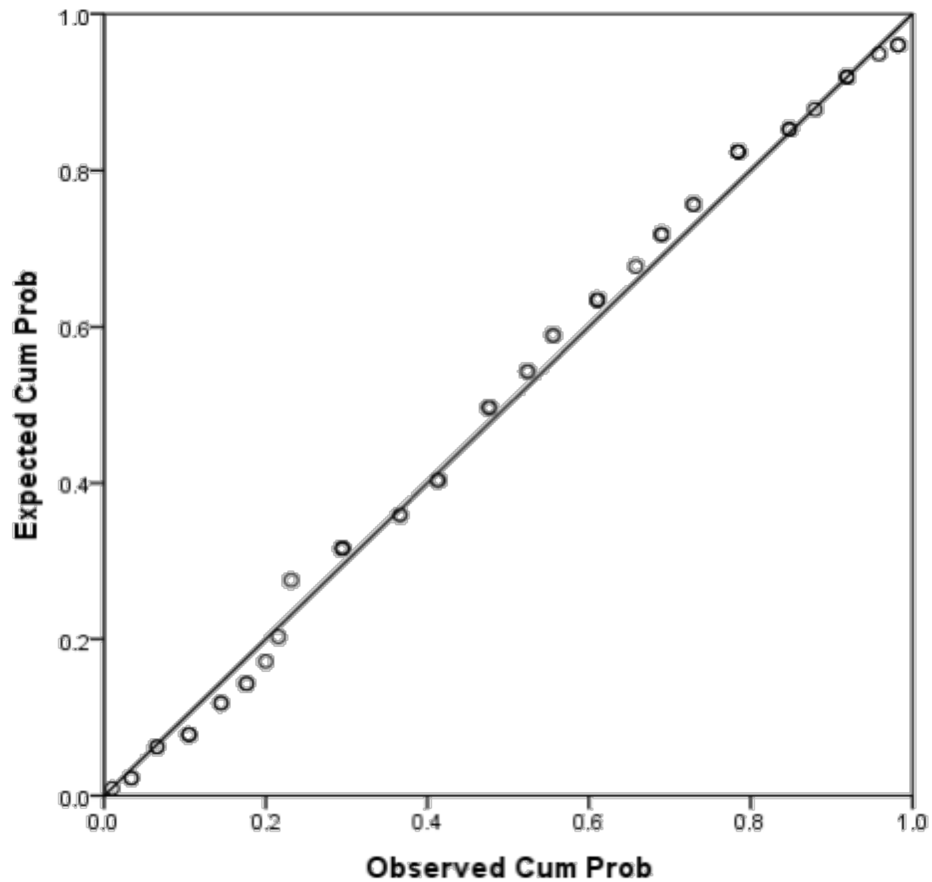

Figure 2. The P-P plot illustrates normal distribution of residuals (left side) versus the non-normally distributed residuals (right side) of the DSM-IV measure of autism symptomology on the ASRS. Overall results are wrapped around the diagonal. Wrapping around the diagonal would indicate that the residuals are normally distributed.

Normal P-P Plot of the CARS-2 Total Score

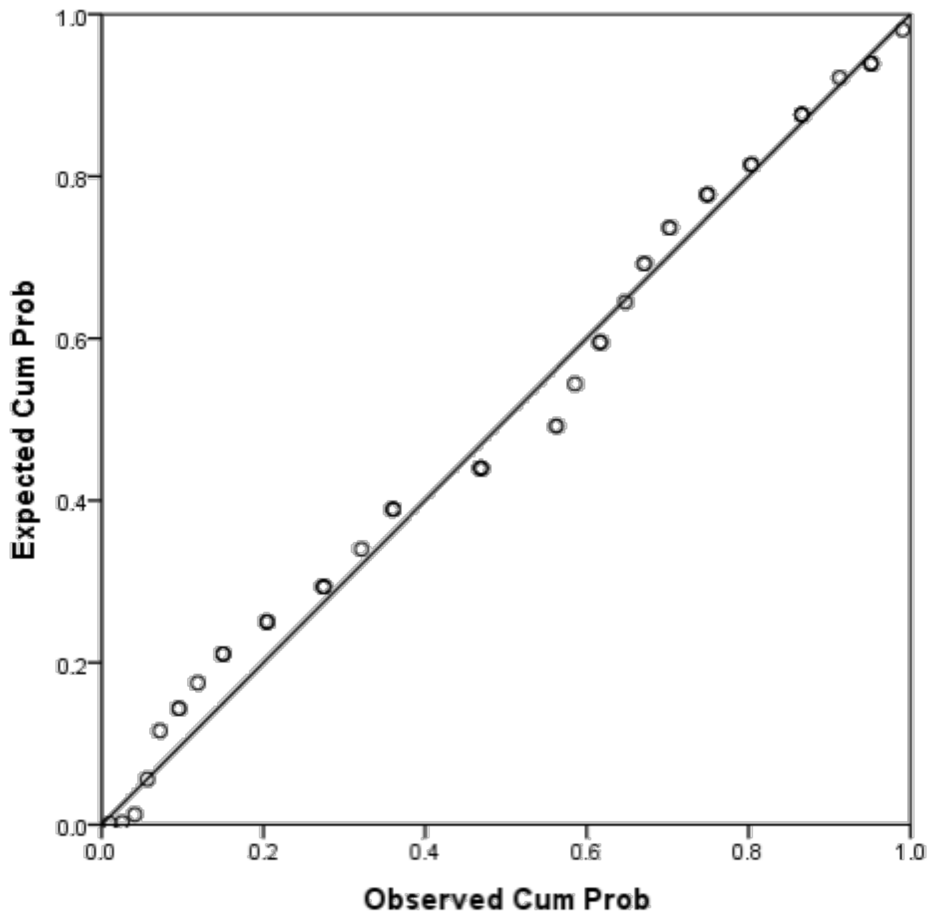

Figure 3. The P-P plot illustrates normal distribution of residuals (left side) versus the non-normally distributed residuals (right side) of the CARS-2 total score, which is measure of autism symptomology. Overall results are wrapped around the diagonal. Wrapping around the diagonal would indicate that the residuals are normally distributed.

Normal P-P Plot of Inhibitory/Self-Control

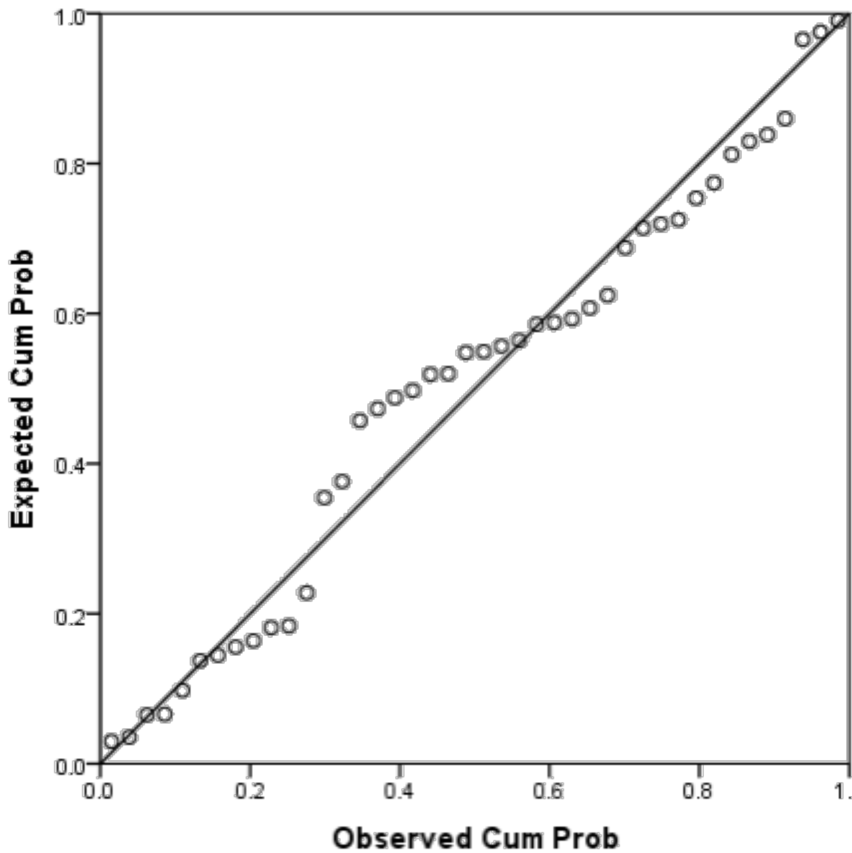

Figure 4. The P-P plot illustrates normal distribution of residuals (left side) versus the non-normally distributed residuals (right side) of the BRIEF-P inhibitory control composite measure. Overall results are wrapped around the diagonal. Wrapping around the diagonal would indicate that the residuals are normally distributed.

Normal P-P Plot of Flexibility

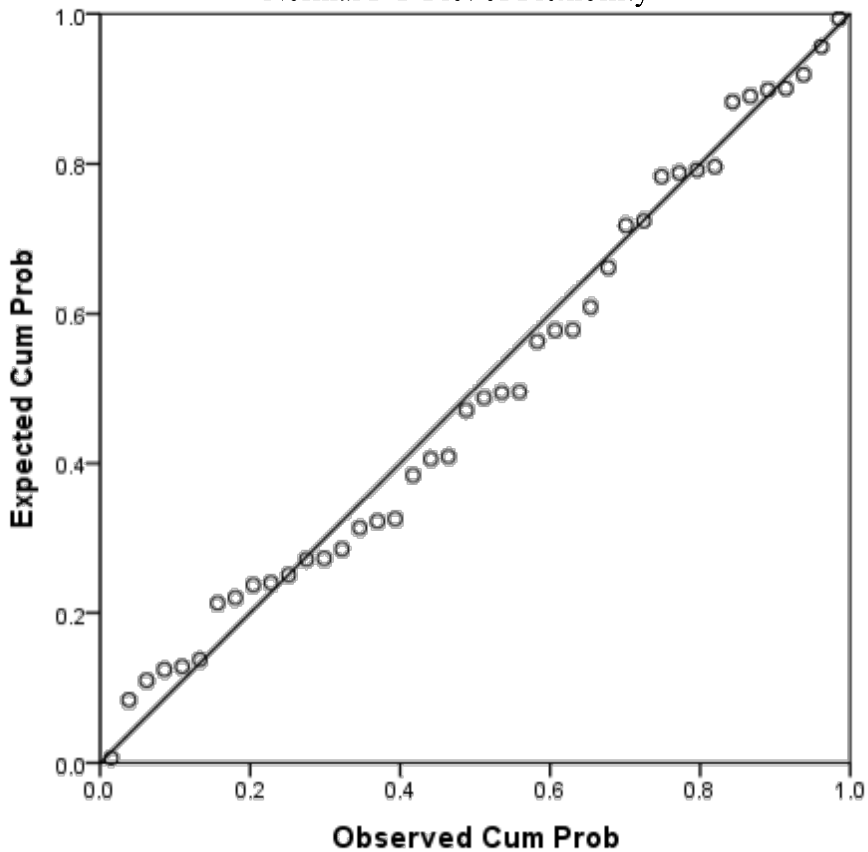

Figure 5. The P-P plot illustrates normal distribution of residuals (left side) versus the non-normally distributed residuals (right side) of the BRIEF-P flexibility composite measure. Overall results are wrapped around the diagonal. Wrapping around the diagonal would indicate that the residuals are normally distributed.

Normal P-P Plot of Emergent Metacognition

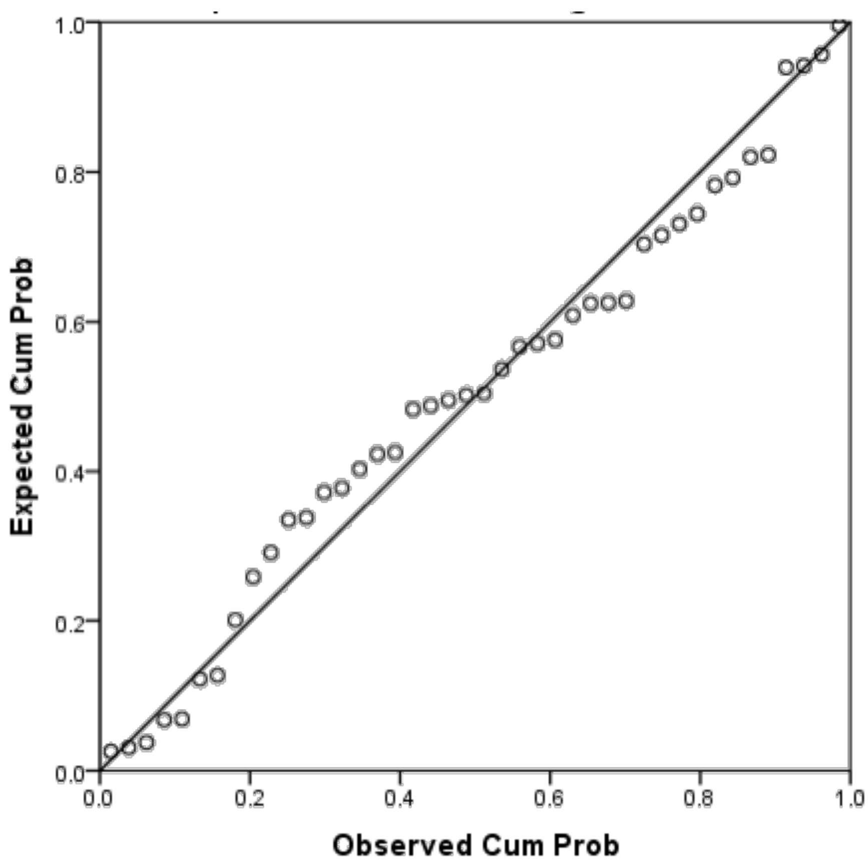

Figure 6. The P-P plot illustrates normal distribution of residuals (left side) versus the non-normally distributed residuals (right side) of the BRIEF-P emergent metacognition composite measure. Overall results are wrapped around the diagonal. Wrapping around the diagonal would indicate that the residuals are normally distributed.

Normal P-P Plot of Inhibition

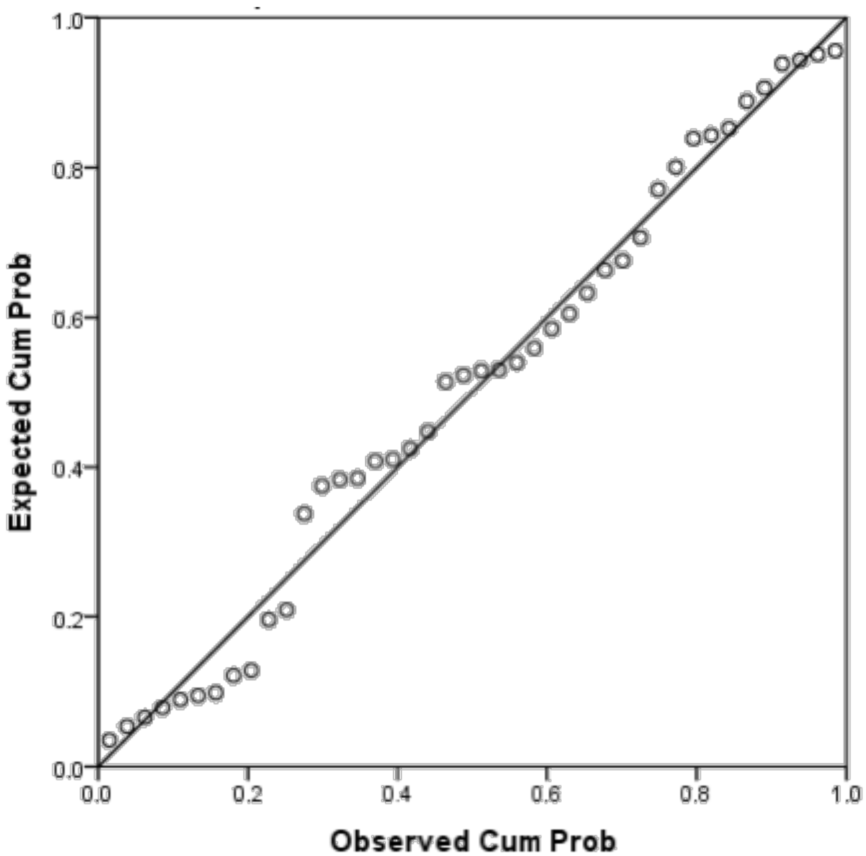

Figure 7. The P-P plot illustrates normal distribution of residuals (left side) versus the non-normally distributed residuals (right side) of the BRIEF-P inhibition scale. Overall results are wrapped around the diagonal. Wrapping around the diagonal would indicate that the residuals are normally distributed.

Normal P-P Plot of Shift

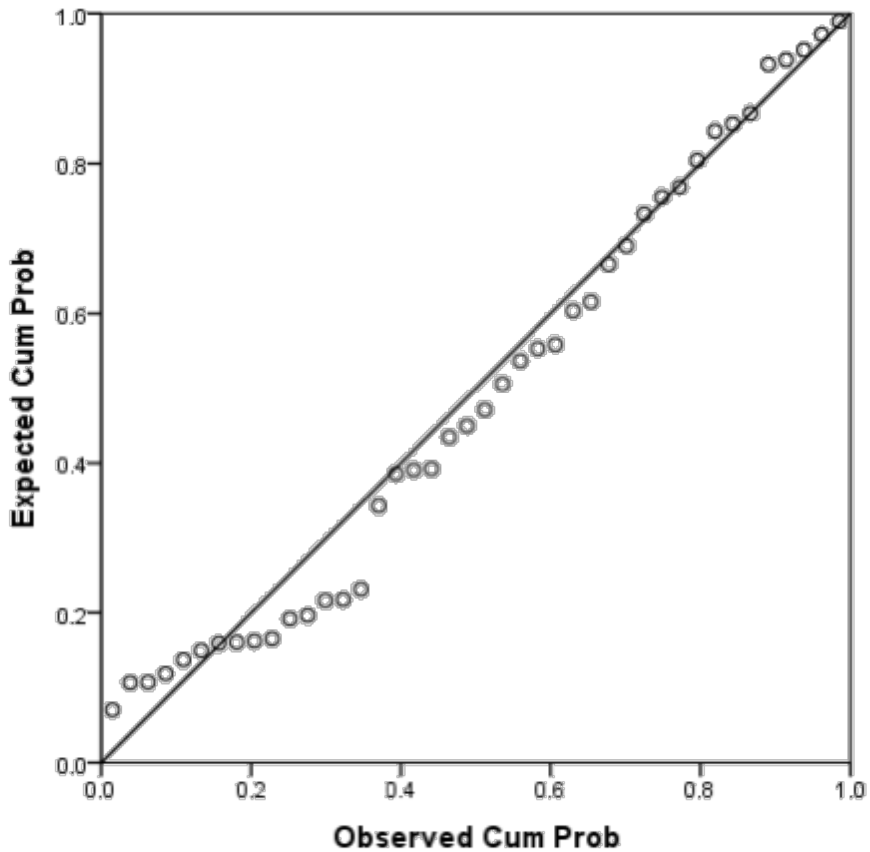

Figure 8. The P-P plot illustrates normal distribution of residuals (left side) versus the non-normally distributed residuals (right side) of the BRIEF-P shift measure. Overall results are wrapped around the diagonal. Wrapping around the diagonal would indicate that the residuals are normally distributed.

Normal P-P Plot of Emotional Control

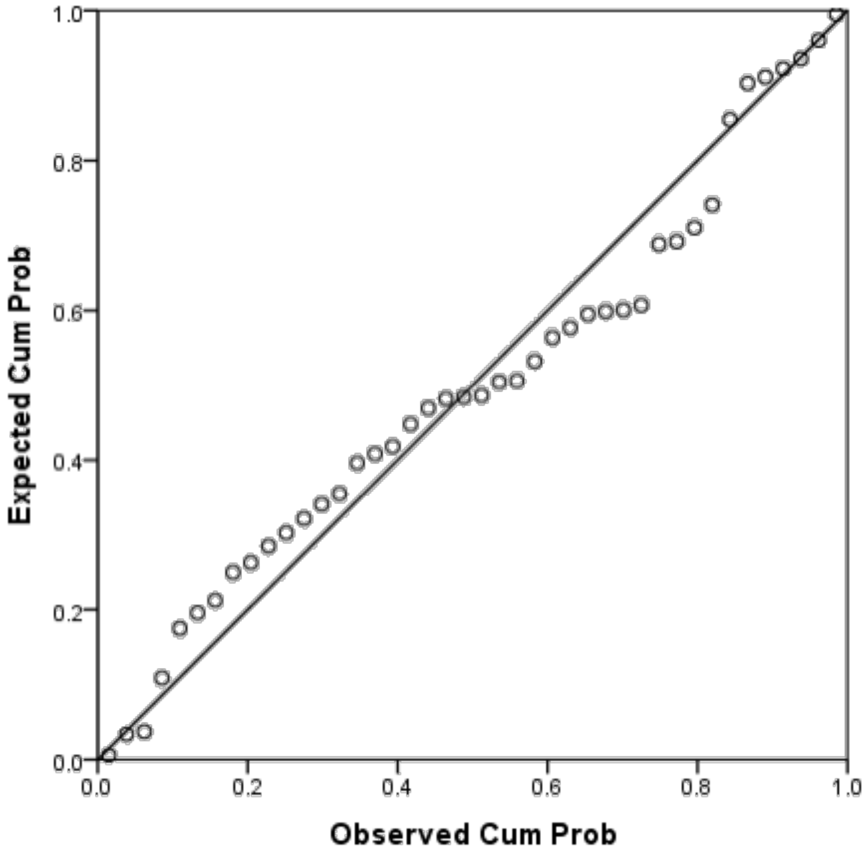

Figure 9. The P-P plot illustrates normal distribution of residuals (left side) versus the non-normally distributed residuals (right side) of the BRIEF-P emotional control scale. Overall results are wrapped around the diagonal. Wrapping around the diagonal would indicate that the residuals are normally distributed.

Normal P-P Plot of Working Memory

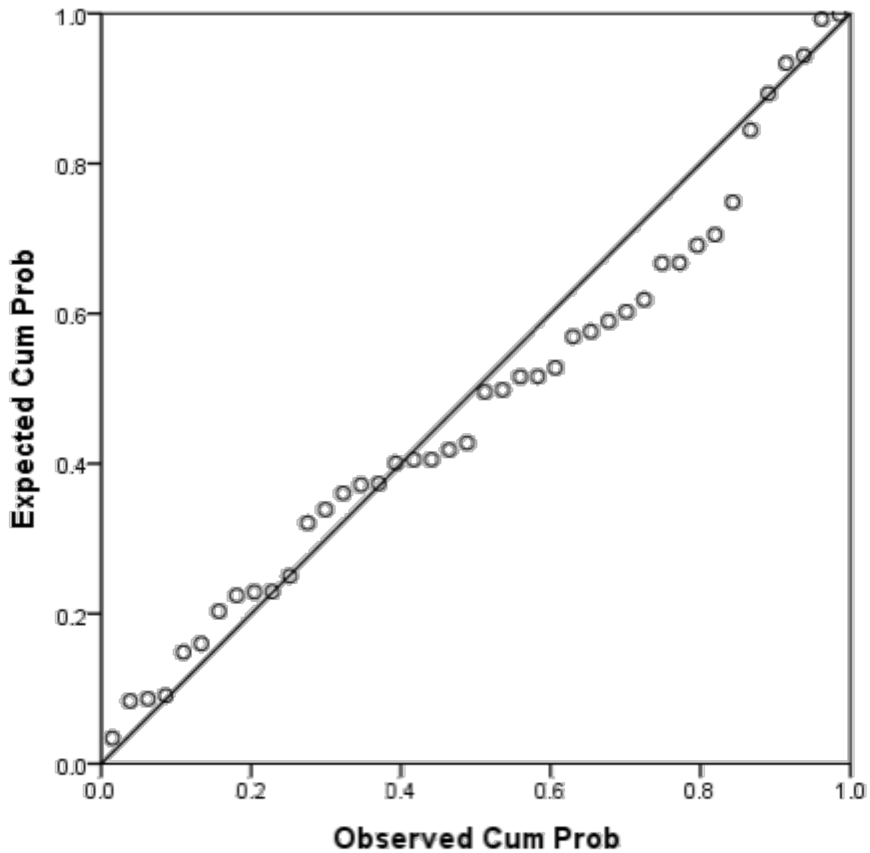

Figure 10. The P-P plot illustrates normal distribution of residuals (left side) versus the non-normally distributed residuals (right side) of the BRIEF-P working memory scale. Overall results are wrapped around the diagonal. Wrapping around the diagonal would indicate that the residuals are normally distributed.

Normal P-P Plot of Planning/Organization

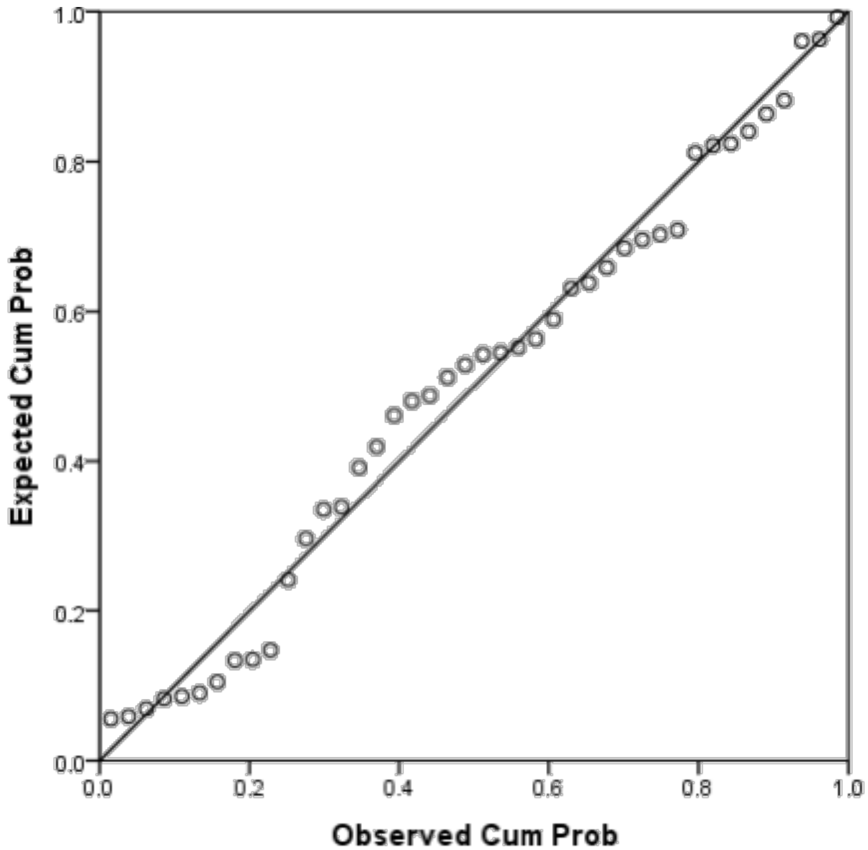

Figure 11. The P-P plot illustrates normal distribution of residuals (left side) versus the non-normally distributed residuals (right side) of the BRIEF-P planning/organization measure. Overall results are wrapped around the diagonal. Wrapping around the diagonal would indicate that the residuals are normally distributed.