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# Moderation of Effects of Anxiety on Verbal and Visuospatial Short-Term Memory in Young Children with Autism Spectrum Disorder

Rachael Arowolo
*Seattle Pacific University*

# Moderation of Effects of Anxiety on Verbal and Visuospatial Short-Term Memory in Young Children with Autism Spectrum Disorder

Rachael A. Arowolo

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Approved by:

Beverly J. Wilson, Ph.D.
Professor of Clinical Psychology
Seattle Pacific University
Dissertation Chair

Thane Erickson, Ph.D.
Professor of Clinical Psychology
Seattle Pacific University
Committee Member

Beau Reilly, Ph.D., ABPP, ABPdN
Adjunct Professor of Clinical Psychology
Seattle Pacific University
Eastside Psychological Associates
Committee Member

Reviewed by:

Amy Mezulis, Ph.D.
Chair, Clinical Psychology
Associate Professor of Clinical Psychology
Seattle Pacific University

Kathleen Tangenberg, Ph.D.
Dean, School of Psychology, Family & Community
Seattle Pacific University

## Dedication

I dedicate this manuscript to my husband for your unwavering support, strength, patience and love throughout my graduate training. I appreciate the invaluable impact you continue to have on my life and education. In addition, I would like to thank our families for their love, support and generosity over the years.

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**Abstract**

Children with autism spectrum disorder (ASD) exhibit developmental differences in a number of domains, including memory. Short-term memory (STM) has been studied in children with ASD but the findings have been mixed. Children with ASD are also at increased risk of developing an anxiety disorder. Anxiety has been found to impact short-term (STM) and other cognitive functions in typically developing children. Limited research suggests that trait anxiety is associated with poorer STM in school-aged children with ASD. Given that STM develops throughout early childhood, understanding the impact of anxiety in younger children with ASD may be beneficial in providing the most effective treatments. In the current study, I evaluated the impact of anxiety on the relation between developmental status and visuospatial and verbal STM in young children with ASD. In line with previous research, I hypothesized that children with ASD and high anxiety symptoms would have the lowest performance on both spatial and verbal STM. The current sample consisted of 14 children (ages 3:0-6:11), both typically developing and with ASD, and their parents. Trait anxiety was measured via parent-report on the Spence Preschool Anxiety Scale (SPAS; Spence et al., 2001), and STM was measured using the Digit Span Forward and Recognition of Pictures subtest of the Differential Ability Scales – Second Edition (DAS-II; Elliott, 2007). The main effects of both verbal and visuospatial STM regressed on status were not significant; however, developmental status predicted higher anxiety. The moderating effect of anxiety on the relation between status and both verbal and visuospatial STM was not significant. Clinical implications include the need for increased focus on the treatment of anxiety in young children with ASD. In addition, these findings suggest the need for future, larger studies to continue to explore the impact of anxiety on cognitive functions in children with anxiety.

*Keywords:* autism spectrum disorders; anxiety; short-term memory; working memory; verbal ability

# CHAPTER I

## Introduction and Literature Review

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by deficits in social communication and interaction in combination with restricted and/or repetitive interests or behaviors (American Psychiatric Association, 2013). Children with ASD can present with a wide range of symptom manifestations that fall within the autism spectrum. Moreover, the majority of children with ASD meet the criteria for another neurodevelopmental and/or psychiatric disorder, such as anxiety (Joshi et al., 2010; Levy et al., 2010). In addition, tasks that require executive function, such as working memory (WM), are often challenging for individuals with ASD.

Memory is an important component of learning and consists of long-term, short-term and working memory. The definition and conceptualization of short-term memory (STM) and WM has been debated over the years; however, one of the most widely accepted theories posits that WM consists of an attentional component and a STM storage component (Baddeley, 2000). These two components are measured using tasks that vary based on complexity, such that simpler tasks purport to measure the STM component and more complex tasks typically measure the attentional component of WM (Aben, Stapert, & Blokland, 2012). Research indicates that children with ASD may have deficits in STM and WM but findings are inconsistent (Jiang, Capistrano, & Palm, 2013; Schuh & Eigsti, 2012; Tyson et al., 2014). Deficits in STM and WM for both typically developing children and children with ASD are associated with a number of outcomes including academic achievement and adaptive skills (Duncan et al., 2007; Gilotty, Kenworthy, Sirian, Black, & Wagner, 2002).

Anxiety disorders are considered an internalizing disorder and are characterized by excessive worry or fear that impacts an individual's ability to function (American Psychiatric Association, 2013; Gullone, King, & Ollendick, 2001). Research indicates that anxiety negatively impacts cognitive functioning and is associated with poorer arithmetic and WM ability (Eysenck, Derakshan, Santos, & Calvo, 2007; Ng & Lee, 2015; Vance, Ferrin, Winther, & Gomez, 2013). Anxiety is commonly comorbid with ASD and predicts increased levels of sensory sensitivities, repetitive behaviors, insistence on sameness and circumscribed interests in children with ASD (Neil, Olsson, & Pellicano, 2016; Rodgers, Glod, Connolly, & McConachie, 2012).

A limited amount of research has evaluated the impact of anxiety on STM ability in children with ASD. However, some research findings suggest that lower WM ability is associated with higher trait anxiety in school-aged children with ASD (Ogawa, Lee, Yamaguchi, Shibata, & Goto, 2017). STM and WM skills develop throughout early childhood and understanding the impact of anxiety on the development of STM and WM in preschool-aged children with and without ASD may provide guidance for domains to target interventions.

The purpose of the current study is to evaluate the impact of anxiety on STM in children with ASD and TD. This paper will review what autism is and common comorbidities, epidemiology, and etiology of ASD. STM will be reviewed in further depth, including how it relates to other constructs of memory, the development and assessment of STM/WM, and STM/WM in individuals with autism. Finally, as a common comorbidity of autism, the development and assessment of anxiety will be reviewed, in addition to how anxiety relates to autism and how it is assessed in that population.

## Autism Spectrum Disorder

### Overview

Autism spectrum disorder is a neurodevelopmental disorder that impacts social communication and interaction domains and is accompanied by a pattern of restricted and/or repetitive interests or behaviors (American Psychiatric Association, 2013). The autism spectrum consists of a wide range unique symptom profiles. Social challenges in ASD include deficits in social and emotional reciprocity, nonverbal communication, and the development and maintenance of relationships. These deficits can manifest in a number of ways. Children with ASD often have deficits along a wide spectrum of language skills including challenges with nonverbal communication and appropriateness of communication (pragmatic language), intonation, expressive and receptive language, and repetitive use of words or phrases (echolalia) (Chan et al., 2005; Sterponi & Shankey, 2014; Volden et al., 2009). Challenges in social and emotional reciprocity can manifest in a child with ASD’s ability to initiate social interaction, share emotions, and back-and-forth conversation (Bauminger-Zviely, Golan-Itshaky, & Tubul-Lavy, 2017; Schaller & Rauh, 2017). Many children with ASD have difficulties in nonverbal communication which can be observed as limited eye contact, use of gestures, facial expression, and body language (Gordon, Pierve, Barlett, & Tanaka, 2014). Lastly, children with ASD may have difficulty with relationships due to challenges related to imaginative play, rigidity around rules, socially inappropriate behaviors, and preference to spend time in solidarity or with people significantly older or younger (Rodda & Estes, 2017).

Restricted and repetitive interests and behaviors are hallmark features of an ASD presentation. Stereotyped behaviors include motor stereotypies (e.g., hand flapping and self-stimulating behaviors), repetitive play (e.g., lining up toys), and repetitive speech (e.g., echolalia, scripting; Mooney, Gray, Tonge, 2005). Many children with ASD have difficulty with change, rigidity, and insistence on sameness (Liddon, Zarcone, Pisman, & Rooker, 2016). Restricted interests in children with ASD can manifest as preoccupations with certain objects or topics (e.g., trains, electronics; Spiker, Lin, Van Dyke, & Wood, 2012). It is common for children with ASD to have hyper- and/or hypo-sensitivities to sensory stimuli that coincide with ritualized behaviors, extreme responses to sensory stimuli, and/or excessive preoccupation with particular sensory stimuli (Deboth & Reynolds, 2017).

The diagnostic criteria of ASD underwent significant change with the publication of the Diagnostic and Statistical Manual of Mental Disorders – 5$^{th}$ Edition (DSM-5), in 2013 (American Psychiatric Association, 2013). In the DSM-5, the autism spectrum has a range of three levels that are distinguished by severity, or level of support required (American Psychiatric Association, 2013). For example, Level 1 specifies "requiring support" and is characterized by deficits in social communication causing noticeable impairments without supports in place and inflexibility of behavior that causes significant interference with functioning. Contrastingly, Level 3 specifies "requiring very substantial support" and is characterized by severe deficits in verbal and nonverbal social communication skills that cause severe impairments in functioning and minimal initiation or response in social interaction in addition to inflexibility of behavior extreme difficulty coping with change, or other restricted/repetitive behaviors that markedly interfere with functioning in all areas. This categorical severity system of the DSM-5 replaced the previous DSM – 4th Edition (DSM-IV) system that included the diagnostic categories of Asperger's disorder, autistic disorder, and pervasive developmental disorder not otherwise specified (PDD-NOS; American Psychiatric Association, 2013). The current ASD criteria also allow for a number of specifiers including with or without intellectual impairment, with or without accompanying language impairment, association with a known medical or genetic condition or environmental factor, association with another neurodevelopmental, mental, or behavioral disorder, and with catatonia (American Psychiatric Association, 2013). Diagnosis of ASD in children as young as two-years-old it possible, although the median age of diagnosis is later, at 4-years-old (Baio et al., 2018).

**Comorbid ASD Diagnoses**

ASD is commonly found to be comorbid with a number of other disorders, such that 83% of individuals with ASD qualify for another developmental or psychiatric disorder (Levy et al., 2010). Developmental disorders, such as intellectual disability, attention deficit hyperactivity disorder, oppositional defiant disorder, and language disorders, are the most common co-occurring disorders in children with ASD (Joshi et al., 2010). Additionally, psychiatric disorders such as a range of anxiety disorders and depression often co-occur in ASD (Joshi et al., 2010).

**Epidemiology/Prevalence**

Diagnoses of ASD have increased steadily over the past several decades to current estimated prevalence of approximately 1 in 59 children, or 1-2% of individuals, in the United States (Baio et al., 2018). Several theories have been posited to explain the increase in ASD prevalence, including changes in prevalence survey data collection, changes in diagnostic methods, increase in ASD awareness, changes in genetic vulnerability, or changes in environmental impact (Schieve et al., 2012). Additionally, ASD impacts males more often than females, such that males are four times more likely to be diagnosed with ASD than females (Baio et al., 2018). Finally, ASD has been identified in individuals from all ethnic, racial, and socioeconomic groups (Baio et al., 2018).

### Etiology

Despite the increase in diagnoses and understanding of ASD, the etiology of ASD remains unknown. Given that ASD is a highly heterogenous disorder, a combination of factors likely underlies the etiology of ASD. The causal explanation for ASD with the most research support is a combination of genetic, biological, and environmental factors (American Psychiatric Association, 2013). One theory posits that genetic mutations may interact and give rise to abnormal development leading to ASD (Fadda & Cury, 2016). Another theory suggests that environmental factors (e.g., exposure to toxins, prenatal stress) interact with genes and may put individuals at risk for developing ASD (Fadda & Cury, 2016). However, current research on the etiology of ASD is correlational rather than causal. Although the etiology of ASD is unknown, identifying factors to target with interventions may aid in improving daily functioning for children with ASD. Short-term memory may be one of these factors that warrants consideration and will be discussed in the next section.

## Short-Term Memory

### Overview

Memory is a construct that refers to the storage of learned information that is subject to retrieval (Sweatt, 2009). Memory is of particular importance with regards to learning, which allows people to effectively adapt to their environment (Sweatt, 2009). There are three widely accepted types of memory: long-term, short-term, and working memory (WM). Long-term memory occurs with repetition and undergoes consolidation for storage. Contrastingly, short-term memory (STM) lasts for a significantly shorter amount of time, between seconds to a few minutes, and handles information that comes through the sensory systems as well as information that has recently been retrieved from long-term memory (Sweatt). Short-term storage and working memory are both considered to be aspects of short-term memory. Working memory is considered one of the many components of executive function; other components include the higher order cognitive processes of attention and inhibitory control. The components of executive function have been debated throughout the literature due to the high correlations within the components of EF; however, these constructs are often differentially associated with other constructs outside of EF (Diamond, 2016; Miyake et al., 2000). Executive functioning abilities, including working memory, are closely tied to the prefrontal cortex of the brain, which continues to grow and develop into young adulthood (Zelazo et al., 2013). EFs are involved in top-down processes necessary for coordinating, planning, and completing goal-directed behaviors (Miyake et al., 2000). They are also associated with a number of outcomes including academic success, vocational success, socioemotional development, and both mental and physical health (Wiebe & Karbach, 2018). Working memory specifically has been linked to academic achievement, cognitive processing, and fluid intelligence (Simmering, 2016). Executive functions are an ideal target for intervention in pediatric populations due to their rapid development during childhood and sensitivity to treatment intervention (Wiebe & Karbach, 2018).

**Differentiating Short-Term and Working Memory**

The differentiation between short-term memory and working memory, has been debated throughout the psychological field due to the complexity of memory. Short-term memory (STM) refers to a memory storage that is limited in capacity and restricted in duration (Cowan, 2008). Defining working memory (WM) is more complex because it is not separate from STM (Cowan, 2008). Some researchers refer to WM as the executive attention mechanism that maintains or suppresses information and is only indirectly related to STM (Engle, 2002). However, arguably the most widely accepted model of STM and conceptualizes STM as the maintenance of information and WM as maintenance in addition to manipulation of information (Aben et al., 2012). This model was developed by Alan Baddeley and was the model utilized in the current study (Baddeley, 2000). In Baddeley's model STM is a component of the concept of WM, which was developed as an explanation for patients with STM deficits but intact long-term memory ability (Baddeley, 2000).

Baddeley's multi-component model of WM includes four separate components: the central executive, phonological loop, visuospatial sketchpad, and episodic buffer (Baddeley, 2000). The central executive refers to the attentional component of working memory that controls what information is filtered on to the phonological loop and the visuospatial sketchpad (Baddeley). The phonological loop and the visuospatial sketchpad are both short-term memory storages in addition to maintenance and manipulation functions. The phonological loop is thought to store verbal and auditory input, whereas the visuospatial sketchpad stores visual and spatial input (Baddeley). Lastly, the episodic buffer is controlled by the central executive and combines information from both the phonological loop and the visuospatial sketchpad into *episodes* that can be further processed into long-term memory.

Because WM has a limited capacity, strategies such as chunking and rehearsal, can improve the ability to maintain information in WM. The concept of *chunking* was developed by George A. Miller (1956) and refers to the grouping of information into units to expand the capacity of STM, which is typically limited to approximately four to seven units (Cowan, 2001). Chunking involves an interaction between STM, WM, and long-term memory where associations are retrieved from long-term memory to guide the way in which informational units are chunked (Lucidi et al., 2016; Portrat, Guida, Phénix, & Lemaire, 2016). Another maintenance strategy is *rehearsal,* or the repetition of the phonological information that is in STM storage to refresh that information (Repovš & Baddeley, 2006). A similar mechanism of rehearsal is utilized in spatial WM where visual and spatial information may be maintained in WM using repetitive implicit eye movements, although rehearsal in the processing of visual-spatial information is less researched (Klauer & Zhao, 2004; Postle, Idzikowski, Della Sala, Logie, & Baddeley, 2006).

**Assessment of Short-Term and Working Memory**

In addition to the variations within the literature about the conceptualization of STM and WM, there are also discrepancies in the assessment of STM and WM. Typically, STM is measured using *simple span tasks* (Aben et al., 2012). Simple span tasks primarily involve the maintenance of information such as symbols, elements or spatial positions for a specified, limited amount of time (Aben et al.). Some examples of simple span tasks that proport to measure STM include, digit span, letter span, dot memory, sentence repetition, and spatial span tasks. Contrastingly, WM is commonly assessed using *complex span tasks* which require additional cognitive resources, or a higher cognitive load, to both maintain and manipulate items such as, the introduction of competing information and/or increased reliance on processing speed and attention domains (Aben et al.). Examples of complex span tasks include *n*-back, dot matrix, letter-number sequencing, and computation span tasks. However, previous researchers have used simple span tasks to measure working memory and complex span tasks to measure short-term memory, which obscures our understanding of and generalizability of WM and STM findings (Aben et al.). The conceptual overlap between STM and WM further complicates the ability to distinguish them as separate constructs and to determine their relations with other variables. For consistency throughout the current study, simple tasks will be referred to as measuring STM and complex tasks as measuring WM.

**Development of Short-Term and Working Memory**

Children's memory develops in terms of short-term storage capacity and is influenced by other cognitive mechanisms that develop simultaneously during childhood. Understanding the way in which memory develops across the lifespan is obscured by the inability to compare memory task performance due to variations in the method of assessment at different age levels (Camos, & Barrouillet, 2018). The literature suggests that working memory comes online at approximately 5.5-months-old, when infants exhibit the ability to remember the location of an experimenter's face in one of two windows (Reznick, Morrow, Goldman, & Snyder, 2004). Between the ages of 7-months and 12-months, children develop the ability to successfully determine the location of a hidden object after increasingly longer delays as age increases (Bell & Fox, 1992). Additionally, infants between the ages of 10-months to 14-months old exhibit the ability to maintain three to four objects in STM storage (Feigenson & Carey, 2004; Kibbe & Leslie, 2013). However, the precise capacity for STM storage is shown to be variable depending on the paradigm used, although most studies indicate an increase in storage capacity throughout childhood .

Several different factors, such as attention, processing speed, strategy use, and long-term memory, may account for STM and WM development throughout childhood and into adulthood (Camos, & Barrouillet, 2018). One of these factors, attentional capacity, improves with age (Suades-Gonzalez et al., 2017) and is associated with improvements in working memory throughout childhood (Cowan, Fristoe, Elliott, Brunner, & Saults et al., 2006; Shipstead, Harrison, & Engle, 2016). This improvement in STM and WM capacity is likely attributable to the ability to attend to and thus take in more information to be committed to working memory (Camos, & Barrouillet, 2018). Similarly, age-related improvements in processing speed decrease the time it takes to complete a task, thus decreasing the likelihood of memory decay, in addition to decreasing the cognitive resources required to complete a task (Camos, & Barrouillet, 2018; Kail, 2000; Nettlebeck & Burns 2010).

Another factor that aids in the development of STM and WM is the increased use of strategies (e.g., rehearsal) during childhood (Camos, & Barrouillet, 2018). Research indicates that school-aged children do not generally utilize rehearsal strategies to remember verbal and nonverbal information, whereas college-aged young adults utilize these skills (Cowan, Saults, & Morey, 2006; Tam, Jarrold, Baddeley, & Sabatos-Devito, 2010). When children were prompted or trained to use rehearsal, their WM performance improved (Naus, Ornstein, & Aivano, 1977). Lastly, improvements in long-term memory allows for the ability to create associations between previously learned content and new content by chunking information together relationally, thus increasing the capacity for items remembered and decreasing the cognitive resources needed to remember new information (Jones, Gobet, & Pine, 2008). Together, these factors may differentially impact STM and WM development and functioning throughout childhood.

**Short-Term Memory in ASD**

Research on memory functioning in children with autism have resulted in inconsistent findings, with some studies indicating intact memory and others suggesting deficits in one or both verbal and visual-spatial memory. STM and WM ability in preschool-aged children with ASD is particularly limited. In school-aged children, several studies found that children with autism showed impairments in simple span tasks of verbal STM (Macizo, Soriano, & Paredes, 2016) and visual-spatial STM (Jiang et al., 2013; Schuh & Eigsti, 2012; Williams, Goldstein, Carpenter, & Minshew, 2005; Williams, Goldstein, & Minshew, 2006a; Zinke et al., 2010). However, other studies found that there were no impairments in STM for children with ASD (McMorris, Brown, & Bebko, 2013; Sinzig, Morsch, Bruning, Schmidt, & Lehmkuhl, 2008; Tyson et al., 2014; Williams, Goldstein, & Minshew, 2006b). The majority of studies finding STM deficits in school-aged children with ASD used digit, word, nonword, or sentence repetition tasks to measure verbal STM, and a finger window task (e.g., repetition of sequential taps on a grid) to measure visual-spatial STM (Jiang et al., 2013; Macizo et al., 2016; Schuh & Eigsti, 2012; Williams et al., 2005; Williams et al., 2006; Zinke et al., 2010). However, the majority of studies with null findings used slightly different STM tasks, including letter recall, visual search, three-word repetition, and maze learning (McMorris et al., 2013; Sinzig et al., 2008; Tyson et al., 2014; Williams et al., 2006b). These STM tasks may require different cognitive processes, such as attention, processing speed, strategy use, that may lead to divergent performance on these tasks (Alloway, Gathercole & Pickering, 2006). In addition, the majority of previous studies were conducted primarily in school-aged children whereas WM in younger, preschool-aged children with ASD has been less researched.

Assessing STM and WM in preschool-age children with autism is more difficult and only a few studies have been completed with this age group. Thus far, this limited research has yielded inconsistent findings. One study found that preschoolers aged 3-5 with ASD had deficits in visuospatial STM compared to their TD peers (Pellicano et al., 2017). Another study with a slightly older sample, 6-7 years old, using a complex WM task found no differences between children with ASD and their same-aged TD peers (Faja & Dawson, 2014). Further research on STM and WM in younger children with autism is necessary for understanding the cognitive development in these children.

STM and WM function in children with ASD is associated with a number of variables across academic, adaptive, and social domains. Research shows that lower STM ability in children with ASD is associated with lower achievement in math (St. John, Dawson, & Estes, 2018), which can be a predictor of later school achievement (Duncan et al., 2007). Additionally, parent-reported deficits in WM skills in school-aged children with autism were associated with decreased adaptive skills, particularly in communication and social domains (Gilotty et al., 2002). STM deficits have also been shown to predict higher autism symptom severity (Schuh & Eigsti, 2012), and WM deficits are associated with increased restrictive and repetitive behaviors (Lopez, Lincoln, Ozonoff, & Lai, 2005). Lastly, both verbal and visual-spatial STM ability have predicted expressive and receptive language skills, a core deficit area for individuals with autism (Stokes, Klee, Kornisch, & Furlong, 2017). Understanding the functioning of STM and WM in young children with autism is essential for being able to provide the appropriate supports for these children to be successful throughout their development and into adulthood. Given that poor STM and WM ability are associated with worse outcomes for individuals with ASD, variables that impact cognitive functioning, such as anxiety, should be explored further.

## Anxiety

### Overview

Anxiety disorders are characterized as an aversive affective state of excessive fear, nervousness, and/or anxiety (American Psychiatric Association, 2013; Gullone et al., 2001). Although the experience of anxiety is considered normal, an anxiety disorder arises when fear or anxiety becomes excessive, persists beyond developmentally appropriate periods, and/or impacts an individual’s ability to function (American Psychiatric Association). Moreover, anxiety disorders are a type of internalizing disorder, which also includes depression, social withdrawal, and somatization (Merrell, 2008). Internalizing disorders are psychological disorders that involve an ‘overcontrol’ of symptoms that are developed and maintained internally and therefore are challenging to observe and measure (Merrell). Anxiety disorders are common, with a lifetime prevalence for any anxiety disorder at 31.1% in US adults (Harvard Medical School, 2007), and many anxiety disorders onset in childhood with a prevalence of 15-20% (Beesdo, Knappe, & Pine, 2009).

**Development of Anxiety**

Anxiety disorders and risk factors for developing anxiety are identifiable in children as early as preschool age (Dougherty et al., 2012; Shepard et al., 2019). Moreover, many adults diagnosed with anxiety disorders reported onset of anxiety symptoms in childhood (Cartwright-Hatton, McNicol, & Doubleday, 2006). The most commonly diagnosed anxiety disorders in childhood include Separation Anxiety Disorder, Selective Mutism, Specific Phobia, and Social Anxiety Disorder (American Psychiatric Association, 2013; de Lijster et al., 2017). Other anxiety disorders, including Agoraphobia, Panic Disorder, Generalized Anxiety Disorder and related disorders (Obsessive Compulsive Disorder and Posttraumatic Stress Disorder), have an average onset between 21 and 35 years old (de Lijster et al.). Although anxiety disorders are common, the development of anxiety disorders is not well understood and is characterized by complex interactions between biological and environmental factors.

A number of factors influence the development of anxiety and anxiety disorders, including aspects related to vulnerability (e.g., genetic, temperament, information processing) and environmental factors (e.g., parenting, adverse life events; Esbjørn, Bender, Reinholdt-Dunne, Munck, & Ollendick, 2012; Murray, Creswell, & Cooper, 2009). One commonly studied risk factor for the development of anxiety is behavioral inhibition, or a temperamental trait of heighted negative reactivity and vigilance towards novel stimuli (White et al., 2017; Wichstrøm, Belsky, & Berg-Nielsen, 2013). Higher levels of behavioral inhibition in children as young two years old increases the risk for the development of anxiety disorders later in childhood, particularly when these heightened levels of behavioral inhibition are combined with an attentional bias towards threat (Kertz, Belden, Tillman, & Luby, 2016; Paulus, Backes, Sander, Weber, & van Gontard, 2015; White et al., 2017). Similarly, the tendency to interpret thoughts of worry and somatic symptoms as negative increases risk for the development of anxiety in children by in turn increasing their sensitivity to these anxiety symptoms (Esbjørn et al., 2015; Muris, Mayer, Freher, Duncan, & van den Hout, 2010; White & Hudson 2016). Moreover, coping style can predict anxiety symptoms such that children who used positive coping skills, such as problem- and emotion-focused strategies, had lower anxiety symptoms, whereas children who used emotional expression (i.e., crying, screaming or getting angry with self) or inhibition (i.e., keeping feelings to self or "not doing anything") coping styles had higher anxiety symptoms (Yeo, Frydenberg, Northam, & Deans, 2014).

In addition to vulnerabilities related to cognitive processing, the development of anxiety is also impacted by environmental factors, such as parenting and life stressors. A number of studies have evaluated the role of attachment in anxiety and suggest that children with insecure attachment, particularly disorganized attachment, are most at risk for developing anxiety (Kerns & Brumariu, 2014; Lecompte, Moss, Cyr, & Pascuzzo, 2014). Moreover, overprotective parenting and high levels of parental anxiety have been associated with increased anxiety in children (Dougherty et al., 2012; Rapee, 2012). Lastly, the experience of increased life stressors, including trauma, was associated with anxiety disorders in preschoolers (Dougherty et al., 2012). A combination of biological and cognitive vulnerabilities with environmental factors contribute to the development of anxiety in children.

**Assessment of Anxiety**

Anxiety is both internal and multifaceted, comprising of a number of different features including cognitive processes, behaviors, and biological responses, which makes the assessment of anxiety challenging. Moreover, anxiety can be conceptualized in two ways: State and trait anxiety (Cattell & Scheier, 1958; Han 2009; Spielberger, 1972). State anxiety refers to a transitory emotional state that results from a here-and-now reaction that activates the autonomic nervous system (Han). Contrastingly, trait anxiety has been defined as a personality characteristic that is accompanied by a predisposition for anxious or fearful reactions and a sensitivity for interpreting situations as more threatening than the situation poses (Han). Different methods of measurement have been used to address these two facets of anxiety.

In children, both state and trait anxiety have been assessed using self-report, physiology, and behavioral ratings. Due to the transitory nature of state anxiety, physiological measures are used to measure reactions to certain situations and the activation of the autonomic nervous system (Han, 2009). A variety of physiological measurements have been used to measure state anxiety in children, including heart rate monitoring, electrodermal activity, cheek blood flow and temperature (Nikolić, de Vente, Colonnesi, & Bögels, 2016), and eye blinks or startle response (Hans). Both state and trait anxiety have also been evaluated using self-report measures, such as the State-Trait Anxiety Inventory (STAI; Hans, 2009), the Screen for Child Anxiety Related Disorders (SCARED; Birmaher et al., 1999), and the Spence Anxiety Scale (Spence, Rapee, McDonald, & Ingram, 2001). However, self-report of anxiety for young children can be challenging due to children's varying level of ability to comprehend the measure and to be able to report on their experiences (Spence et al., 2001). Lastly, observational methods, such as parent, teacher and clinician report questionnaires (e.g., Child Behavioral Checklist, Spence Anxiety Scale, Behavioral Assessment Schedule for Children) are often used to measure anxiety in children (Han). Because anxiety is often internal and covert, reports of anxiety in children from multiple informants are vulnerable to disagreement between raters (Epkins & Meyers, 1994). Despite the complexity of anxiety, a variety of assessment methods of both state and trait anxiety have been validated for use in children (Han).

**Anxiety and Short-Term Memory**

Relevant to the focus of the present study, anxiety has been found to be negatively associated with performance on a number of executive functioning tasks, including working memory. The mechanism by which anxiety is hypothesized to impact cognitive functioning is through processing efficiency theory (Eysenck et al., 2007). This theory purports that cognitive resources are limited, and that anxiety utilizes a portion of these resources, leaving a reduced amount of cognitive resources to complete goal-driven tasks (Eysenck et al.). Furthermore, processing efficiency theory implies that, even if cognitive performance may not decrease due to the presence of anxiety, compensatory strategies are used which reduces overall cognitive efficiency (Eysenck et al.). Therefore, it is expected that performance on working memory tasks will decrease with the presence of anxiety.

In fact, previous research indicates that anxiety adversely impacts performance on STM and WM tasks in children. In school-aged children, trait anxiety, but not state anxiety, was associated with decreased performance on an arithmetic task (Ng & Lee, 2015). The authors suggested that the null findings with regard to state anxiety may have been due to lower levels of elicited stress than a child may have experienced in a real-life situation. Similarly, children diagnosed with an anxiety disorder performed worse on a spatial working memory task of the Cambridge Neuropsychological Test Automated Battery (CANTAB; Vance et al., 2013). This association has been shown throughout childhood, including in preschool-aged children (Visu-Petra, Stanciu, Benga, Miclea, & Cheie, 2014). Other studies have not found this association, particularly in young children, potentially due to low variability in reports of anxiety (Visu-Petra, Cheie, Câmpan, Scutelnicu, & Benga, 2016). However, most research suggests that anxiety is negatively associated with performance on working memory tasks.

An alternative theory to consider regarding the association between STM and anxiety is that deficits in STM lead to increased anxiety. Other cognitive function deficits, including inhibition, in young children has been associated with greater anxiety later in life (Kertz et al., 2016). Executive function deficits have also been shown to mediate the association between fearful temperament and anxiety in children (Affrunti & Woodruff-Borden, 2015). Currently, there is no evidence that STM or WM deficits lead to increased anxiety; however, given deficits in similar cognitive functions have been associated with increased anxiety, more research is necessary to explore this alternative theory.

**Anxiety and ASD**

Anxiety is a common feature of ASD, such that approximately 40% of children with autism have a comorbid anxiety disorder (van Steensel, Bögels, & Perrin, 2011; White, Oswald, Ollendick, & Scahill, 2009). Commonly diagnosed anxiety disorders in children with ASD include specific phobias, OCD, and social anxiety (van Steensel et al.). Anxiety is observed in children with ASD and with both low and high IQs; however, levels of anxiety are higher in children with ASD and higher IQ scores (Hallett et al., 2013). Researchers speculate that this may be due to increased awareness of their own developmental differences compared to their TD peers in combination with a lack of coping skills (Hallett et al.).

Comorbid anxiety in children with ASD has been correlated with other behavioral features of autism. For example, anxiety symptoms in children with ASD are related to increased levels of sensory sensitivities (Neil et al., 2016), repetitive behaviors, insistence on sameness and circumscribed interests (Rodgers et al., 2012). Additionally, restricted and repetitive behaviors may, in turn, predict higher levels of anxiety in children with ASD (Magiati et al., 2016). Anxiety symptoms in children with ASD have been shown to be positively associated with gastrointestinal symptoms and sleep problems (Williams, Leader, Mannion, & Chen, 2015). Moreover, anxiety in children with ASD can also impact family functioning, as parental stress is higher in children with comorbid anxiety than with ASD alone (Kerns et al., 2015). Contrastingly, anxiety in autism also appears to relate to strengths in certain domains, such as higher functional communication skills compared to children with ASD and low anxiety symptoms (Kerns et al. 2015).

**Assessment of anxiety in autism.** Due to the overlap between symptomology of ASD and anxiety disorders, differentiating between the two is challenging. Many assessments of anxiety have been neither developed nor adapted for use in children with ASD (Grondhuis & Aman, 2012). The lack of specified assessment of anxiety for children with ASD raises concerns related to the ability of a measure to discriminate between anxiety-like symptoms of ASD (e.g., restricted-repetitive behaviors, avoidance of social interaction) and clinically elevated anxiety symptoms (Wood & Gadow, 2010). Moreover, self-reports of anxiety in children with ASD may be obscured by challenges related to communication of emotions and reduced understanding of internal states (Wood & Gadow, 2010). Continued research is needed to better understand the best way to accurately measure anxiety in children with ASD. Additionally, understanding the way that anxiety impacts cognitive functions, particularly STM, in children with ASD will help guide interventions.

## Current Study

### Short-Term Memory and Anxiety in Children with ASD

Research exploring STM ability in children with autism has been largely inconsistent due to variability in the definition and assessment of STM in children (Aben, at al., 2012). However, several studies suggest that verbal and visuospatial WM are impaired in children with ASD (Jiang et al., 2013; Schuh & Eigsti, 2012; Williams et al., 2005; Williams et al., 2006; Zinke et al., 2010). Deficits in STM have been found to impact other domains of functioning. For example, STM has been found to be positively associated with autism symptom severity, restrictive/repetitive behaviors, language skills, and adaptive function (Duncan et al., 2007; Gilotty et al., 2002; Lopez et al., 2005; Schuh & Eigsti, 2012). The present study aims to expand on this research in a younger, preschool-aged sample of children with ASD.

Children with ASD are at a higher risk for qualifying for a comorbid anxiety disorder diagnosis. The impact of trait anxiety in ASD are amplified for children with higher IQ (Hallett et al., 2013). Moreover, anxiety in autism has been found to relate to higher levels of a number of other autism features (e.g., sensory symptoms, restricted and repetitive behaviors) and familial functioning (e.g., parenting stress). Anxiety plays a role in a variety of domains in children with autism, and more research is needed to understand the complexity of the impact of anxiety in ASD that are preschool-aged.

Additionally, anxiety has been shown to decrease the amount of cognitive resources available to process information. Previous studies have shown that children with ASD are more impacted by interference, or distractors, at high levels of cognitive load (Bayliss & Kritikos, 2011). Therefore, it could be expected that increased anxiety would negatively impact STM performance in children with ASD, either directly (i.e., main effect) or by amplifying effects of autism diagnosis on STM (i.e., moderation).

There has been one recent study that has evaluated both STM and anxiety in children with autism (Ogawa et al., 2017). In this study, researchers compared performance on cognitive tasks, including a spatial STM task, levels of acute stress measured via salivary cortisol, and chronic stress via parent-reported anxiety symptoms and hair cortisol in school-aged children ($M$ = 11 years) with and without ASD (Ogawa et al.). Results indicated that parent-reported anxiety was associated with increased ASD symptomology and chronic stress measured via hair cortisol in participants with ASD. Moreover, there were associations between chronic stress and spatial STM performance in children with ASD (Ogawa et al.). These variables have yet to be explored in younger, preschool-aged populations of children with ASD, the developmental period when short-term and working memory skills and anxiety begin to develop.

The current study will expand upon previous research by exploring the impact of anxiety on both spatial and verbal STM in a younger, preschool-aged sample of children with and without ASD. Significant results of the current study would increase our understanding of the impact of anxiety on STM during the early stages of development and identify areas to target for intervention in young children with ASD when interventions may be more effective.

## Hypotheses

This study examined whether parent-reported trait anxiety moderated the association between developmental status and visual-spatial working memory and between developmental status and verbal working memory.

**Hypothesis 1.** I hypothesize that children with ASD will perform worse than their TD peers on both visuospatial and verbal STM. Short-term memory span begins to increase from about one-year-old through early childhood (Feigenson & Carey, 2004; Kibbe & Leslie, 2013). Therefore, I theorize that differences in STM performance in children with ASD and TD children would begin to diverge during preschool years.

**Hypothesis 2.** I hypothesize that children with ASD will have higher parent-reported trait anxiety than of their TD peers. Children with ASD are at higher risk for developing a comorbid anxiety disorder, and there is considerable overlap between the symptomology of ASD and anxiety (Grondhuis & Aman, 2012; van Steensel et al., 2011).

**Hypothesis 3.** I hypothesize that anxiety symptoms will moderate the association between children's developmental status (ASD or TD) and both their verbal and visuospatial STM, such that children with ASD and higher anxiety will have the lowest performance in verbal and visuospatial STM. Although research assessing STM in children with ASD is inconsistent, many studies indicate children with ASD are more impaired on WM performance compared to TD children (Jiang et al., 2013; McMorris et al., 2013; Schuh & Eigsti, 2012; Sinzig et al., 2008; Tyson et al., 2014; Williams et al., 2005; Williams et al., 2006a; Williams et al., 2006b; Zinke et al., 2010). Moreover, anxiety has been shown to impact STM function in TD children and given that anxiety is highly prevalent in ASD populations, I hypothesize that anxiety will play a similar role in STM function in children with ASD (van Steensel et al., 2011; Visu-Petra et al., 2014).

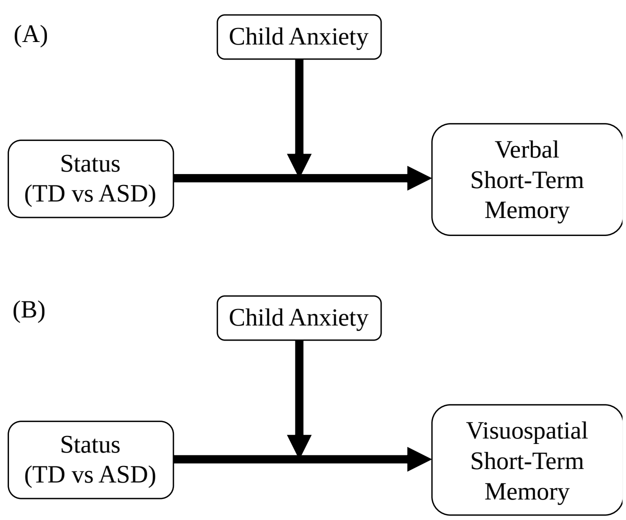


*Figure 1.* Conceptual moderation model of verbal (A) and visuospatial (B) short-term memory.

# CHAPTER II

## Method

### Participants

The current study was part of a larger study examining self-regulation in children with ASD and TD children. Participants for the current study were 14 children between the ages of 3 and 6 years old, and their parents. In this sample, 6 children had a diagnosis of autism (37.5% female; mean age = 4.5 years) and 8 were typically developing (33.3% female, mean age = 5.5). A majority, 71.4% (TD: 87.5%, ASD: 50.0%) of participants were European American, 0% Asian American, 14.3% (TD:12.5%. ASD: 16.7%) African American, and 14.3% (TD: 0%, ASD: 33.3%) Latino. The total average household income was $156,272 with a range of $9,000 to 300,000 (TD mean = $159,571, ASD mean = $150,500). Parental education level varied with 21.4% (TD = 25.0%, ASD = 16.7%) that completed some college course work, 21.4% (TD = , ASD = 33.3%) completed a bachelor's degree, 42.9% (TD = 12.5%, ASD = 33.3%) completed a master's degree, 7.1% (TD = 50.0%, ASD = 16.7%) completed some professional school post-master's, and 7.1% (TD = 12.5%, ASD = 0%) completed a professional degree beyond a master's degree.

### Procedure

**Recruitment.** Participants were recruited from local autism treatment and research centers, public and private elementary and preschools, as well as through advertisements in local listservs and community businesses. Participants were categorized into two different groups: ASD (coded as 1) and TD (coded as 0). Eligibility criteria for the ASD group included diagnosis of ASD as evaluated by a licensed clinician and verified via review of obtained diagnostic medical records. Children were excluded from the TD control group if they had a sibling with ASD or if they obtained a *t*-score greater than 14 on the Social Communication Questionnaire - Current Form (SCQ; Rutter et al., 2003), which indicates higher than average autism symptoms. All participants in this study had verbal ability within or above the normative range as measured by the Verbal Ability Score of the Differential Ability Scales - Second Edition, which is indicated by *T*-scores that are at or above 85 (DAS-II; Elliott, 2007).

**Enrollment Visit.** The enrollment visit for the study lasted approximately 60 to 90 minutes and determined if the family qualified for the study. This visit typically occurred at the family's home, or either a local library or the university laboratory if preferred. Consent from the parent and assent from the child was obtained at the beginning of the visit. A release of medical records was obtained for participants with autism to confirm a diagnosis of ASD. At the visit, an undergraduate research assistant administered several questionnaires to the parent, including a demographics questionnaire, the SCQ screener, and the Spence Preschool Anxiety Scale (SPAS; Spence et al., 2001). Meanwhile, a graduate student researcher worked with the child to administer a number of assessments, which included selected subtests of the DAS-II for the current study.

**University Visit.** The university visit occurred at a university campus in the Pacific Northwest and was video recorded for coding purposes. At this visit, the parent completed an interview with an undergraduate research assistant and any unfinished questionnaires from the enrollment visit. Additionally, a graduate student researcher worked with the child to administer several tasks that evaluate self-regulation, attention, and emotion. At the completion of the university visit, the child received a small toy and the parent received $50 to thank them for participating in our study.

**Measures**

**Verbal short-term memory.** The Recall of Digits Forward (DigF) is a diagnostic subtest of the DAS-II and proports to measure short-term memory through auditory recall (Elliott, 2007). The DigF is administered by the examiner reading aloud a series of numerical digits aloud to the child at a rate of two digits per second in a monotone voice, with a drop in tone for the last digit presented in the sequence. The child is then required to immediately repeat the digits in the order they were presented. The examiner begins by administering a two-digit sequence and increases the number of digits in the sequence, up to ten, until the ceiling (no more than one sequence correct in the block of five) and basal (no more than one sequence incorrect in the block of five) levels are reached. Correct responses (e.g. all digits in the sequence are correctly repeated) are scored as “1,” and all incorrect responses are scored “0.” All responses are summed and converted into an ability score. Items below achieved basal level that were not administered are given a score of “1.” Ability scores are then converted into standard scores for subsequent analysis.

The mean internal consistency ($\alpha$ = .92, *SEM* = 3.1) and the test-retest reliability ($r_{12}$ = .77) for the DigF subtest were strong (Elliott, 2007). The DigF subtest loaded onto the verbal factor for 2:6 to 3:5-year-olds, the verbal short-term memory factor for 4:0 to 5:11, and the verbal memory factor for 6:0 to 12:11-year-olds. Correlation coefficients between the DigF subtest and subtests measuring similar domains from Wechsler

Intelligence Scale for Children-Fourth Edition (WISC-IV; Digits Forward: .56) indicate moderate validity.

**Visuospatial short-term memory.** Recognition of Pictures (RPic) is a subtest of the DAS-II and measures short-term non-verbal memory through picture recognition of familiar objects (Elliott, 2007). The Early Years Battery (ages 2:6-6:11) of the DAS-II was used in the current study. Administration of the RPic for all age groups begins with two sample items, and then the examiner proceeds to the appropriate starting point depending on the child's age. The child is shown a page of target stimuli consisting of familiar objects for five seconds, and on the following stimulus page, the child is asked to identify those target items in an array including distractor items. Correct responses (e.g. all target items are correctly identified, and no distractor items were identified) are scored as "1," and all incorrect responses are scored "0." Responses in the specified item set are summed and converted into an ability score. Ability scores are then converted into standard scores for subsequent analysis.

The DAS-II was fielded with a national sample of participants ($N$ = 3480; 50% female), between the ages of 2:6 and 17:11 years old. The mean internal consistency for the RPic subtest was moderately strong ($\alpha$ = .79, *SEM* = 4.6), and test-retest reliability for the RPic subtest was documented ($r_{12}$ = .58). Confirmatory factor analyses resulted in support for a two-factor model for the core and diagnostic tests in 2:6 to 3:5-year-olds (*TLI* = .98), a five-factor model in 4:0 to 5:11-year-olds (*TLI* = .98), and a seven-factor model in 6:0 to 12:11-year-olds (*TLI* = .98). The RPic subtest loaded onto the non-verbal factor for 2:6 to 3:5-year-olds and onto the visual-spatial abilities factor for 4:0 to 5:11 and 6:0 to 12:11-year-olds. Correlation coefficients between the RPic subtest and subtests measuring similar domains from the WPPSI-III (symbol search: .60) suggested convergent validity.

**Child anxiety.** The Spence Preschool Anxiety Scale (SPAS; Spence et al., 2001) is a 28-question parent-report questionnaire developed to measure anxiety in preschool-aged (3 to 6-year-old) children. Items of the SPAS are rated on a scale from 0 to 4. Descriptors for each rating are as follows: 0 = not true at all, 1 = seldom true, 2 = sometimes true, 3 = quite often true, 4 = very often true. Parents are instructed to respond to the items based on which rating best describes their child. The SPAS has five subscale scores (Obsessive-Compulsive Disorders, Social Anxiety, Separation Anxiety, Physical Injury Fears, and Generalized Anxiety) and a Total Score that are summed and converted into T-scores for subsequent analyses.

The SPAS was fielded on 1,138 parents (755 mothers) and their children (50% female; 3 to 7-years-old) in Australia (Spence et al., 2001). Results of confirmatory factor analysis indicated models with four (CFI > .90, RMSEA ≈ .05) and five (CFI > .90, RMSEA ≈ .05) correlated first-order factors, as well as a model with five correlated first-order factors and one second-order factor (CFI > .90, RMSEA ≈ .05). Evaluation of construct validity indicated a moderate correlation (*r* = .68) with the Internalizing total score of the Child Behavior Checklist.

# CHAPTER III

## Results

### Power Analysis

The sample size necessary for adequate power was calculated using G*Power software prior to analysis (Faul, Erdfelder, Buchner, & Lang, 2009). The following five variables were entered as predictors into a power analysis for a multiple regression design: developmental status, anxiety, verbal ability, age and gender. Results indicated that a sample size of 92 was needed to for a moderate Cohen's $f^2$ effect size of .15, with alpha set at .05 and power of .8. The power analysis was conducted again following data collection after a small sample was obtained, using a moderate Cohen's $f^2$ effect size of .15, with alpha set at .05, power of .8 and only three predictors (developmental status, anxiety, and the interaction), resulting in a sample size of 77. The current study remained underpowered with a small sample size, despite the decrease in predictors.

### Data Entry and Preparation

Data collected for this study was entered into Statistical Package for the Social Sciences (SPSS), version 25.0, and analyzed using the PROCESS macro add-on (Hayes, 2012). Anticipated covariates included child chronological age in months (continuous), child gender (dichotomous; male = 0, female = 1), standard score of child verbal ability (continuous) from the DAS-II verbal composite (Elliott, 2007). The independent variable for the current study is developmental status (dichotomous; TD = 0, ASD = 1). The dependent variables in this study were verbal STM from the Digit Span Forward subtest (continuous; T-score) and visuospatial STM from the Recognition of Pictures subtest (continuous; *T*-score) of the DAS-II (Elliott, 2007). Finally, the moderator variable was parent-reported child anxiety (continuous; *T*-score) from the SPAS (Spence et al., 2001).

**Data Screening**

Prior to analyses, the data were screened for missingness and assessed for violations of the assumptions of multiple regression. Regarding missingness, there were no missing data across all variables. The following multiple regression assumptions were assessed to ensure they are not violated: normality, independence, linearity, homoscedasticity, multicollinearity.

**Normality.** The assumption of normality refers to the normal distribution of data and is essential in significance testing (Field, 2013). Normality and potentially present outliers were visually analyzed using probability-probably (P-P) plots. If the data does not follow the diagonal line on the plot and instead falls above or below the line (indicating kurtosis) or is ‘s’-shaped (indicating skewedness), then the assumption of normality has been violated (Field, 2013). A histogram that follows the shape of a bell would also indicate normality. Skewedness, or the symmetry of the distribution, and kurtosis, or the spread of the distribution, were also evaluated using the Shapiro-Wilk test, which assesses whether the distribution of the sample is significantly different than a normal distribution (Field, 2013). The Shapiro-Wilk test for verbal ability was significant, $D(14) = .862$, $p = .03$, indicating an abnormal distribution. Given verbal ability had a cutoff of one standard deviation below the mean, the distribution is negatively skewed. Given this assumption is violated, bootstrapping was utilized.

**Independence.** Independence is the assumption that errors are independent of one another (Field, 2013). To test this assumption, the Durbin-Watson test can be used which assesses the correlations between errors (Durbin & Watson, 1951). Addressing violations of the independence assumption largely depends on the source of the violation (Williams, Grajales, & Kurkiewicz, 2013). Results indicate that independence was not violated for the variables in this study.

**Linearity.** Linearity describes the association between variables as linear, as opposed to quadratic, cubic, etc. A scatterplot of the predictor and the outcome variable can visually indicate whether or not the data follows a linear pattern (Field, 2013). To address non-linearity, transformations can be performed. The scatterplots of the variables indicated linearity across variables.

**Equality of Variances.** The assumption of equal variance refers the consistency of variance of the outcome variable across different levels of the predictor variables. Violations of equal variance can be evaluated using the Levene's Test which assesses whether or not the variances of different groups are significantly different from one another (Levene, 1960). In this study, the equal variances between ASD and TD groups were compared. Levene's Test was significant for visuospatial memory, $F(1,12) = 4.94$, $p = .05$, and anxiety, $F(1,12) = 5.39$, $p = .04$., indicating the variances for these variables were unequal for the ASD and the TD groups. However, when using bootstrapping techniques, the assumption of homoscedasticity can be ignored (Field, 2013).

**Multicollinearity.** Multicollinearity occurs when there are strong correlations between predictor variables. When collinearity is present between predictors, it becomes more difficult to determine the unique variance of each predictor, in addition to increasing standard error in b-weights (Field, 2013). In SPSS, collinearity diagnostics were run to evaluate tolerance values and variance inflation factor (VIF) values

(Bowerman & O'Connell, 1990; Menard, 1995). If the tolerance value falls below 0.1 or if the VIF value is greater than ten, it would indicate that there are collinearity concerns. Results did not indicate the presence of multicollinearity between the predictor variables.

**Data Analytic Plan**

Correlational analyses were conducted to determine covariates that are associated with the outcome variables, visuospatial and verbal STM. T-tests were also conducted to evaluate group differences between TD and ASD on key study variables. Potential covariates (child age, verbal ability, and child gender) that were significantly correlated with the outcome variable were controlled for in subsequent analyses. As a continuous variable, anxiety was centered prior to regression analyses.

To determine the main effects of the predictor variables, status and anxiety, on the outcome variables, verbal and visuospatial STM, regression analyses were conducted without the interaction first. Correlated variables as determined by preliminary analyses were entered as covariates. Analysis of the moderating effect of parent-reported child anxiety on the association between developmental status and visuospatial and verbal STM was conducted using the PROCESS macro for SPSS (Hayes, 2012). Bootstrapping, a resampling technique, can be effective when working with small sample sizes, non-normally distributed data, and to increase the power of a study (Wright, London, & Field, 2011). For this analysis, 5000 bootstrap resamples were used. Two separate moderation analyses were run to evaluate the moderating effect of child anxiety on the association between developmental status and A) verbal STM and B) visuospatial STM, using Model 1 of PROCESS (Hayes, 2013; see Figure 2). The PROCESS macro provided statistical output including regression coefficients and standard error, as well as *p*-values, $R^2$ values, and confidence intervals.

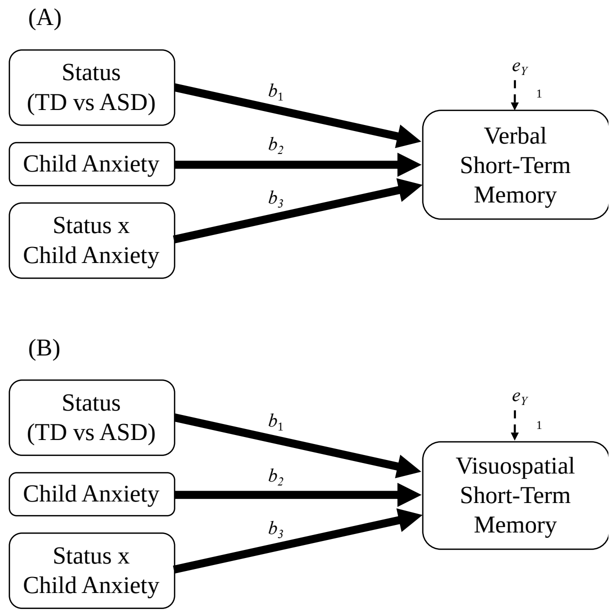


*Figure 2.* Statistical moderation model of verbal (A) and visuospatial (B) short-term memory.

In the PROCESS macro, verbal STM was entered as the outcome variable (*Y*), developmental status (ASD vs TD; *X*) was entered as the independent variable, parent-reported child anxiety was entered as the moderator variable (*M*) and was grand-mean centered, and significantly correlated demographic variables were entered as covariates. This analysis was repeated once more with visuospatial STM entered as the outcome variable in place of verbal STM. The results determined the moderating effect of child anxiety on the association between developmental status and A) verbal STM and B) visuospatial STM, in addition to the conditional effect of *X* on *Y* at different levels of *M* (Hypothesis 1).

Additionally, this analysis assessed the significance of the association between developmental status (TD = 0, ASD = 1) and A) verbal STM and B) visuospatial STM

(Hypothesis 2). A *p*-value less than .05 for either the association between developmental status and A) verbal STM and B) visuospatial STM and a negative coefficient would indicate that children with ASD have lower A) verbal STM and B) visuospatial STM performance compared to their TD peers. Similarly, the significance of the association between developmental status and child anxiety was evaluated (Hypothesis 3). A *p*-value is less than .05 for the association between developmental status and child anxiety and a positive coefficient would indicate that children with ASD had higher trait anxiety compared to their TD peers. Finally, the $R^2$ would be reported to indicate the amount of variance in A) verbal STM and B) visuospatial STM that was explained by the model.

**Descriptive Analyses**

Correlational analyses were conducted to determine potential covariates between demographic variables and key study variables (see Table 1). Age, gender, and verbal ability were potential covariates; however, only verbal ability was significantly correlated with a key study variable, visuospatial ST memory. Specifically, higher verbal ability was associated with better visuospatial ST memory. The only additional significant correlation between study variables was developmental status and anxiety, where ASD was associated with higher levels of anxiety.

**Table 1**

*Correlations of Study Variables*

| Variable | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1. Age | - | | | | | |
| 2. Gender | 0.36 | - | | | | |
| 3. Verbal Ability | 0.00 | -0.06 | - | | | |
| 4. Developmental Status | 0.45 | -0.04 | -0.47 | - | | |
| 5. Anxiety | 0.49 | 0.06 | -0.18 | 0.79** | - | |
| 6. Verbal STM | -0.22 | -0.03 | 0.38 | -0.42 | -0.22 | - |
| 7. Visuospatial STM | -0.10 | -0.27 | 0.58* | -0.16 | 0.03 | 0.13 |

*Note.* *N* = 14; age = child age in months; gender = child gender (dichotomous; male = 0, female = 1); verbal ability = DAS-II Verbal Ability Composite, t-score; developmental status =

typically developing or autism spectrum disorder (dichotomous; TD = 0, ASD = 1); anxiety = Spence Preschool Anxiety Scale total t-score; STM = short-term memory; verbal STM = DAS-II digit span forward t-score, visuospatial STM = DAS-II recognition of pictures t-score.
**p* < .05, ***p* < .01

The ASD and TD groups were compared across study variables to determine the similarities and differences between both groups (Table 2). Verbal ability was not significantly different between TD and ASD groups, but it was trending in that direction. The TD and ASD groups were significantly different on anxiety. Verbal and visuospatial STM did not differ between groups.

**Table 2**
*Means, SDs, T-Tests, and Effect Sizes for Study Variables*

| | Means (*SD*) [range] | | | | | |
|---|---|---|---|---|---|---|
| | Total (*n* =14) | TD (*n* = 8) | ASD (*n* = 6) | *t* | *p* | *d* |
| Verbal Ability | 109.00 (14.72) [93-149] | 114.75 (16.17) [95-149] | 101.33 (8.60) [93-112] | -1.84 | 0.09 | -0.99 |
| Anxiety | 50.71 (10.56) [38-70] | 43.75 (4.33) [38-53] | 60.00 (9.08) [47-70] | 4.05 | 0.01** | -2.42 |
| Verbal STM | 55.14 (9.27) [35-73] | 58.38 (8.91) [43-73] | 50.83 (8.57) [35-59] | -1.59 | 0.14 | -0.86 |
| Visuospatial STM | 48.79 (7.96) [37-63] | 49.88 (10.01) [37-63] | 47.33 (4.50) [40-53] | -0.64 | 0.54 | -0.31 |

*Note. SD* = standard deviation; verbal ability = DAS-II Verbal Ability Composite, t-score; developmental status = typically developing or autism spectrum disorder (dichotomous); anxiety = Spence Preschool Anxiety Scale total t-score; STM = short-term memory; verbal STM = DAS-II digit span forward t-score, visuospatial STM = DAS-II recognition of pictures t-score.
**p* < .05, ***p* < .01

**Test of Hypotheses**

**Hypothesis 1. Developmental status predicting short-term memory performance.** To evaluate the relation between developmental status and short-term memory performance, two separate regression analyses were conducted for each verbal and visuospatial short-term memory. Although verbal ability was found to be correlated with visuospatial STM, it was not controlled for during this analysis to increase power given a small sample size. First, developmental status was entered on its own as a predictor with verbal short-term memory. Developmental status was not a significant predictor of verbal STM, $t(1,12) = -1.59$, $p = .14$ (see Table 3). Next, developmental status was entered separately as a predictor of visuospatial short-term memory. Similarly, developmental status did not significantly predict visuospatial STM, $t(1,12) = -.58$, $p = .58$. Therefore, children with autism and their typically developing peers did not vary on their verbal and visuospatial memory.

**Table 3**

*Hierarchical Regression: Short-term Memory on Developmental Status*

| Variable | *B* | *SE B* | *β* | *t* | $R^2$ | *F* | *p* |
|---|---|---|---|---|---|---|---|
| *Dependent Variable: Verbal STM* | | | | | | | |
| Constant | 58.38 | 3.10 | | 18.83 | | | .00 |
| Developmental Status | -7.54 | 4.74 | -.42 | -1.59 | .174 | 2.54 | .14 |
| *Dependent Variable: Visuospatial STM* | | | | | | | |
| Constant | 49.88 | 2.89 | | 17.25 | | | .00 |
| Developmental Status | -2.54 | 4.42 | -.16 | -.58 | .03 | .33 | .58 |

*Note*. *N* = 14; developmental status = typically developing or autism spectrum disorder (dichotomous; TD = 0, ASD = 1); STM = short-term memory; verbal STM = DAS-II digit span forward t-score, visuospatial STM = DAS-II recognition of pictures t-score; *LL* = lower limit, *UL* = upper limit.

**Hypothesis 2. Developmental status predicting anxiety symptoms.** The relation between developmental status and anxiety symptoms was assessed using regression analysis. Developmental status was entered as the sole predictor of anxiety. Results indicated that status significantly predicted anxiety and accounted for 62% of the variance, $F(1,12) = 19.99$, $p = .001$, indicating that children with autism had higher overall anxiety compared to their typically developing peers (see Table 4).

**Table 4**

*Hierarchical Regression: Anxiety on Developmental Status*

| Variable | *B* | *SE B* | *β* | *t* | $R^2$ | *F* | *p* |
|---|---|---|---|---|---|---|---|
| *Dependent Variable: Anxiety* | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Constant | -6.96 | 2.38 | | -2.93 | | | .01 |
| Developmental Status | 16.25 | 3.64 | .79 | 4.47 | .62 | 19.99 | .001 |

*Note*. *N* = 14; developmental status = typically developing or autism spectrum disorder (dichotomous; TD = 0, ASD = 1); anxiety = Spence Preschool Anxiety Scale total t-score; *LL* = lower limit, *UL* = upper limit.

**Hypothesis 3. Anxiety moderating the relation between developmental status and short-term memory performance.** Two, separate moderated regressions were conducted to determine the moderating effect of anxiety on the relation between developmental status and both verbal and visuospatial short-term memory performance. First, developmental status was entered as the independent predictor variable, anxiety was entered as the moderating predictor, and verbal short-term memory as the outcome variable. Anxiety was centered prior to conducting the analysis. Verbal ability was not included as a covariable in either analyses, even though it was correlated with study variables, in an effort to increase the power of the analysis. The interaction between developmental status and anxiety was not significant, $F(1,12) = 1.13$, $p = .45$ and contributed to 5% of the variance in the model (see Table 5). A second moderated regression analysis was run with visuospatial short-term memory as the outcome variable in place of verbal short-term memory. Similarly, the interaction of developmental status and anxiety did not predict visuospatial memory, $F(1,12) = 0.84$, $p = .28$, and the interaction contributed to 11% of the variance in the model.

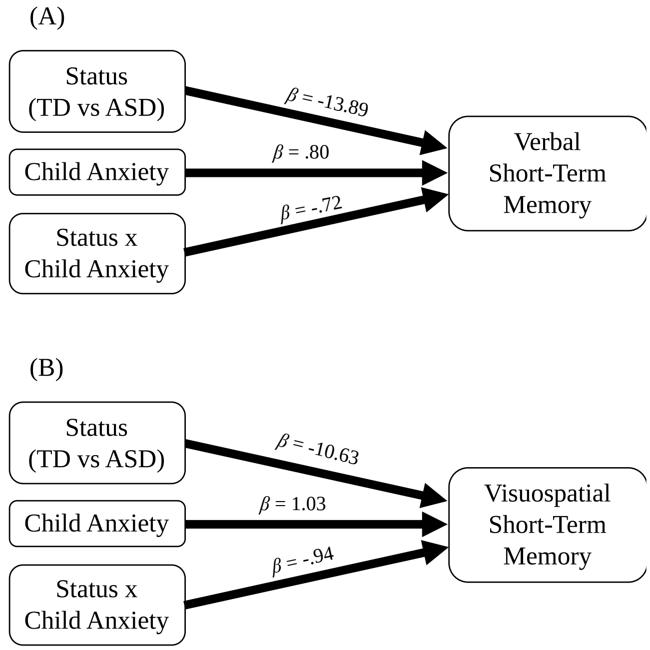


*Figure 3.* Moderated Regression for verbal (A) and visuospatial (B) short-term memory.

**Table 5**

*PROCESS Analysis for the Moderating Effects of Anxiety on the Relation Between Developmental Status and Short-term Memory*

| Variable | *β* | *SE β* | $R^2$ | $\Delta R^2$ | *t* | *F* | *p* | *LLCI* | *ULCI* |
|---|---|---|---|---|---|---|---|---|---|
| *Dependent Variable: Verbal STM* | | | | | | | | | |
| Model Summary | | | .25 | | | 1.13 | .38 | | |
| Developmental Status | -13.89 | 8.52 | | | .13 | | .13 | -32.88 | 5.11 |
| Anxiety | .80 | .80 | | | .34 | | .34 | -.97 | 2.58 |
| Developmental | | | | | .45 | | | | |
| Status*Anxiety | -.72 | .92 | | .05 | | .63 | .45 | -2.76 | 1.32 |
| *Dependent Variable: Visuospatial STM* | | | | | | | | | |
| Model Summary | | | .20 | | | .84 | .50 | | |
| Developmental Status | -10.63 | 7.57 | | | -1.41 | | .19 | -27.50 | 6.23 |
| Anxiety | 1.03 | .71 | | | 1.46 | | .18 | -.54 | 2.61 |
| Developmental | | | | | | | | | |
| Status*Anxiety | -.94 | .81 | | .11 | -1.15 | 1.32 | .28 | -2.75 | .88 |

*Note. N* = 14; developmental status = typically developing or autism spectrum disorder (dichotomous; TD = 0, ASD = 1); anxiety = Spence Preschool Anxiety Scale total t-score; STM = short-term memory; verbal STM = DAS-II digit span forward t-score, visuospatial STM = DAS-II recognition of pictures t-score; *LL* = lower limit, *UL* = upper limit.

**Post-hoc Analyses**

Given the limited findings, small sample size, and low power, exploratory analyses were conducted to determine other relations between key study variables. Following Eysenck's theory on cognitive processing, anxiety is purported to decrease processing efficiency by consuming a portion of the limited cognitive resources available for goal-directed tasks (Eysenck et al., 2007). Gaining expressive and receptive language skills, particularly at the preschool age, is an active process that utilizes cognitive resources. Therefore, anxiety was analyzed as a moderating factor in the relation between developmental status and verbal ability (see Figure 4). Results indicated a significant direct effect of developmental status, $\beta = -33.33$, $p = .01$, and anxiety, $\beta = 2.79$, $p = .01$, on verbal ability (see Table 6). ASD status predicted lower verbal ability scores, and higher levels of anxiety predicted higher verbal ability scores. The moderating effect of anxiety on the relation between developmental status and verbal ability was significant, $F(1,12) = 6.41$, $p = .03$, and contributed to an additional 27% of the variance in the model beyond the main effects. These results indicate that verbal ability remained similar across levels of anxiety for children with ASD (see Figure 5). However, in TD children, higher levels of anxiety predicted higher verbal ability scores.

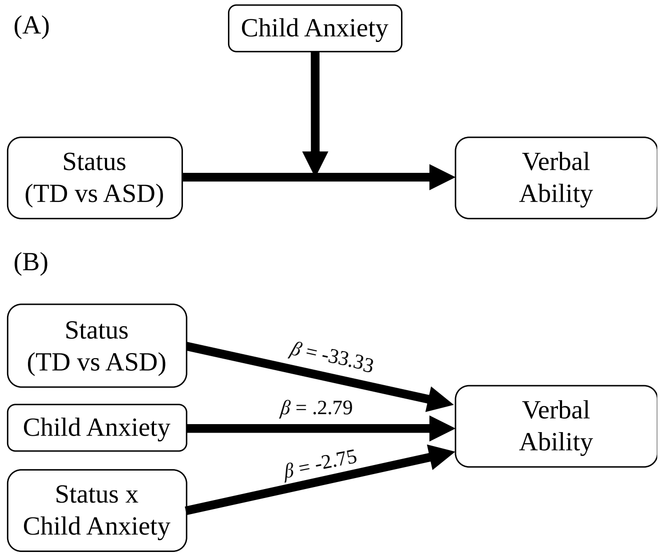


*Figure 4.* (A) Conceptual moderation model of verbal ability. (B) Moderated Regression for verbal ability

**Table 6**

*PROCESS Analysis for the Moderating Effects of Anxiety on the Relation Between Developmental Status and Verbal Ability*

| Variable | *β* | *SE β* | $R^2$ | $\Delta R^2$ | *F* | *p* | *LLCI* | *ULCI* |
|---|---|---|---|---|---|---|---|---|
| *Dependent Variable: Verbal Ability* | | | | | | | | |
| Model Summary | | | .58 | | 1.13 | .03 | | |
| Constant | 134.21 | 7.60 | | | | .00 | 117.27 | 151.16 |
| Developmental Status | -33.33 | 10.09 | | | | .01 | -55.82 | -10.84 |
| Anxiety | 2.79 | .94 | | | | .01 | .69 | 4.50 |
| Developmental Status*Anxiety | -2.75 | 1.08 | | .27 | 6.41 | .03 | -5.16 | -.33 |

*Note. N* = 14; developmental status = typically developing or autism spectrum disorder (dichotomous; TD = 0, ASD = 1); anxiety = Spence Preschool Anxiety Scale total *t*-score; *LL* = lower limit, *UL* = upper limit.

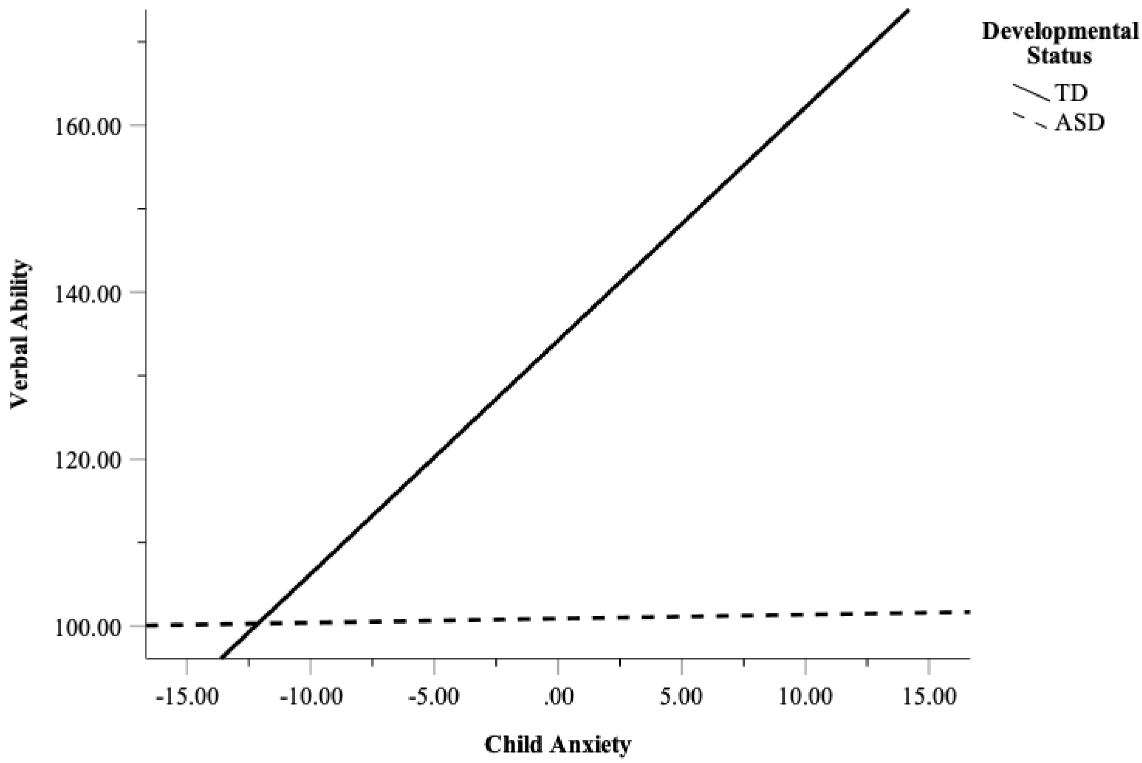


*Figure 5.* Line graph depicting the moderation effect of anxiety on developmental status on verbal ability.

Additionally, the total anxiety subscale of the Spence Preschool Anxiety Scale (SPAS) has been used throughout this study. However, there are five other subscales that were calculated from the SPAS: obsessive compulsive disorder (OCD), social anxiety, separation anxiety, physical/injury anxiety, and generalized anxiety. Independent t-test analyses were conducted on these subtests to provide additional exploratory information to characterize the similarities and differences in anxiety between the ASD and TD groups (see Table 7). There were significant differences between TD and ASD groups on OCD, separation anxiety, physical injury anxiety and generalized anxiety. For each of these subscales, the ASD group had higher levels of anxiety than their TD peers. Social anxiety was the only subscale of the SPAS that was not significantly different between groups.

**Table 7**

*Means, SDs, T-Tests, and Effect Sizes for SPAS Subscales*

| | Means (SD) [range] | | | | | |
|---|---|---|---|---|---|---|
| | Total (*n* =14) | TD (*n* = 8) | ASD (*n* = 6) | *t* | *p* | *d* |
| OCD | 44.64 (7.10) [40-62] | 41.00 (2.83) [40-48] | 49.50 (8.39) [40-62] | 2.70 | .02* | 1.46 |
| Social Anxiety | 49.21 (10.56) [40-76] | 45.63 (6.80) [40-61] | 54.00 (13.31) [42-76] | 1.54 | .15 | .83 |
| Separation Anxiety | 52.93 (13.55) [40-87] | 46.75 (4.06) [42-52] | 61.17 (17.66) [40-87] | 2.26 | .04* | 1.22 |
| Physical/Injury Anxiety | 52.43 (10.61) [40-72] | 44.63 (4.93) [40-55] | 62.83 (5.60) [55-72] | 6.46 | .00** | 3.49 |
| Generalized Anxiety | 50.57 (9.76) [40-66] | 45.75 (5.45) [40-56] | 57.00 (10.92) [40-66] | 2.55 | .03* | 1.38 |

*Note.* SPAS = Spence Preschool Anxiety Scale; OCD = obsessive compulsive disorder.
**p* < .05, ***p* < .01

# CHAPTER IV

## Discussion

The current study sought to evaluate the role of parent-reported trait anxiety in the verbal and visuospatial STM of young children with and without ASD. This study involved 14 participants with ASD and TD between the ages of 3-6 years old. It was hypothesized that children with ASD would perform worse than their TD peers on verbal and visuospatial STM, in addition to children with ASD having higher anxiety. The final hypothesis of this study was that anxiety symptoms would moderate the relation between developmental status and both verbal and visuospatial STM, such that STM in children with ASD would be impacted more significantly by anxiety than their TD peers. Exploratory questions related to effects of ASD status and anxiety on verbal ability were also examined. The following section includes interpretations of the study findings, clinical implications, strengths and limitations of the study and suggestions for future research.

### Interpretation of Results

**Developmental status predicting short-term memory performance.** The hypothesis that children with ASD would perform worse on both verbal and visuospatial STM tasks compared to their TD peers was not supported by this study. However, there was a trend towards ASD status predicting lower verbal STM, $t(1,12) = -1.59$, $p = .14$, and the effect size for the differences between children with ASD and TD on verbal STM was large, Cohen's $d = 0.86$, suggesting that an adequately powered sample may find a significant difference. Limited research indicates that children with ASD may have difficulty rehearsing verbal information to maintain that information in verbal STM, suggesting difficulties in the functioning of the phonological loop (Joseph, Steele, Meyer, & Tager-Flusberg, 2005). Moreover, results of this particular study found no differences in visuospatial STM between TD and ASD participants (Joseph et al., 2005). The current study found a stronger relation between and effect size for developmental status and verbal STM compared to visuospatial STM, which is consistent with some previous studies (Joseph et al., 2005). However, overall the previous literature on STM in preschool-aged children is limited, and the existing research in this area is generally inconsistent, with some studies finding that children with ASD have worse STM than their TD peers and others finding no differences (Faja & Dawson, 2014; Pellicano et al., 2017). The results of this study may support previous null findings with no differences between children with ASD or TD with regard to short-term memory performance. In addition, STM and WM skills are continuously developing from infancy through adulthood (Camos, & Barrouillet, 2018). Thus, these null findings may also be attributable to STM being in its early stages of development at the preschool-age, with the hypothesis that children with ASD start to diverge from their TD peers in later stages of development.

**Developmental status predicting anxiety symptoms.** The current study supported the hypothesis that developmental status predicts parent-rated trait anxiety. When anxiety was regressed on developmental status, status accounted for 62% of the variance in anxiety. In addition, a t-test comparing mean anxiety between children with ASD and TD was significant with a large effect size (Cohen's $d$ = -2.19), indicating that children with ASD had significantly higher parent-rated anxiety than TD children. These results support previous literature which indicates that up to 40% of children with ASD have co-occurring anxiety disorders (van Steensel, Bögels, & Perrin, 2011; White, Oswald, Ollendick, & Scahill, 2009). In this study, 50% of the participants with ASD had elevated anxiety symptoms. This appears to be slightly higher than in previous studies, but it is important to note that the sample size for ASD participants in this study was very small (*n* = 6). The high percentage of ASD participants with significant anxiety may also be reflective of the lack of anxiety measures that have been validated for children with ASD, which can lead to overidentifying the anxiety-like symptoms of ASD as anxiety (Grondhuis & Aman, 2012; Wood & Gadow, 2010). In addition, this study contributes to the limited research on anxiety in preschool-aged children with ASD (Salazar et al., 2015; Sukhodolsky et al., 2020).

**Anxiety moderating the relation between developmental status and short-term memory performance.** The moderating effect of anxiety on the relation between developmental status and both verbal and visuospatial STM performance was not supported by the results of this study. Given the low sample size, the only significant covariate, verbal ability, was not included in analyses to increase statistical power. The necessary power for this study was reassessed using G*Power software given the decrease in the number of predictors compared to the a priori analysis (Faul, Erdfelder, Buchner, & Lang, 2009). Therefore, the number of predictors entered into the software was three (developmental status and anxiety), with a Cohen's $f^2$ effect size of .15, alpha set at .05, and power of .08. The suggested number of participants dropped to 77; however, the sample size for this study was still much lower, which indicates a significantly underpowered analysis.

One way to interpret the lack of significant moderation effects of anxiety on the relation between developmental status and STM performance, beyond power concerns, relates to the type of memory task utilized in this study. Additionally, tasks that measure STM, as opposed to WM, are typically simpler in that they require less cognitive resources than complex tasks that tap into the manipulation of information in STM store or WM. According to Eysenck's theory of processing efficiency, anxiety uses a portion of cognitive resources leaving the brain with less resources to complete a given task (Eysenck et al., 2007). Simple short-term memory tasks that do not include the manipulation of information generally require less cognitive resources to complete (Aben et al., 2012). Therefore, even if anxiety utilizes a portion of the limited cognitive resources available, there may be enough remaining cognitive resources to adequately complete a simple STM task.

Another consideration for the null findings is that the current sample is reflective of the larger population, and the moderating effect of anxiety on the relation between developmental status and STM is not significant for preschool-aged children. Only one prior study looked at the effects of anxiety on spatial STM and found significant associations in school-aged children with ASD (Ogawa et al., 2017). However, at the preschool-age, STM is early in development, and it may be too early to detect differences in STM skills between ASD and TD children. The minimal previous research on STM differences in preschool-aged children is inconsistent, with some studies with significant findings, and others finding no differences (Faja & Dawson, 2014; Pellicano et al., 2017). Additionally, due to a number of factors, including unclear definitions of STM versus

WM and a wide variety of STM assessments, the cumulative findings of previous literature are mixed with regard to significant versus null findings.

**Exploratory analyses.** Given the underpowered analyses of this study, other relations between key study variables were considered to better understand the similarities and differences between the ASD and TD groups. Although anxiety did not predict lower levels of STM, verbal ability development is another cognitive skill that takes a significant amount of cognitive effort, particularly in the early years of life. Thus, following the principles of Eysenck's theory of cognitive processing efficiency, anxiety may take up the cognitive resources necessary for appropriate development of verbal ability (Eysenck et al., 2007). The previous literature on the association between anxiety and verbal ability is limited, and the existing literature evaluates the impact of verbal ability deficits on the development of anxiety (Brownlie, Bao, & Beitchman, 2016). Although it has not been researched, the reverse, anxiety impacting the development of verbal ability or language, should also be considered. The results of this exploratory analysis in this study indicated that anxiety was a significant moderating factor of the relation between developmental status and verbal ability, accounting for 27% of the variance. Interestingly, verbal ability remained consistent across levels of anxiety for ASD; however, for TD children, higher verbal ability was associated with higher anxiety. Therefore, it appears that verbal ability was not impacted by anxiety for children with autism, whereas the verbal ability of TD children seemed to benefit from higher levels of anxiety. Given that verbal ability is a large component of IQ, it follows previous research that better verbal ability was associated with higher anxiety in TD children (Kermarrec, Attinger, Guignard, & Tordjman, 2020). Similar associations between anxiety and verbal ability have been found for children with ASD in previous research, although this was not supported by the current study's results (Hallett et al., 2013). It is important to note that for children with ASD, verbal ability scores appeared to fall in the average range, whereas for TD children, their scores varied from average to above average. Due to the study's cutoff of a minimum of average level verbal ability, critical information to understand this moderation is missing from this dataset. The lack of variability in verbal ability scores in children with ASD may have limited anxiety's impact on these scores. The impact of anxiety on the association between developmental status and lower than average verbal ability is important in understanding the differential effects of anxiety in ASD vs TD children.

A second analysis was completed to explore how the anxiety subscales on the SPAS compare across children with ASD and TD. Four of the five subscales of the SPAS were significantly higher for children with ASD than TD, including OCD, separation anxiety, physical injury anxiety, and generalized anxiety. Previous research suggests that Separation Anxiety Disorder, Selective Mutism, Specific Phobias, and Social Phobia are most commonly diagnosed in childhood (American Psychiatric Association, 2013; de Lijster et al., 2017). The SPAS was specifically created for preschool-aged children and does not map evenly onto the DSM-5 criteria for differential anxiety disorders. However, it is interesting to note that children with ASD seem to exhibit more generalized anxiety and OCD than their TD peers. Exploring the prevalence of GAD and OCD in ASD populations may reveal an earlier onset of these disorders in children with ASD than in TD populations, which may have implications for treatment development and implementation.

**Clinical Implications**

The results of this study have several clinical implications for children with and without ASD and their families. The most significant finding of this study supports a large breadth of previous research on anxiety in ASD. In previous research, up to 40% of children with ASD have co-occurring anxiety, which is associated with other difficulties including increased sensory sensitivities (Neil et al., 2016), gastrointestinal problems, sleep problems (Williams, Leader, Mannion, & Chen, 2015), and higher parental stress (Kerns et al., 2015). The current study found similarly high rates in young, preschool-aged children with anxiety, suggesting an early onset of anxiety and is in support of the limited, previous literature in this age group (Salazar et al., 2015; Sukhodolsky et al., 2020). An early onset of anxiety may be associated with an increased risk of anxiety-related difficulties as a child develops; however, it also allows for the opportunity for early intervention. There are a few empirically supported interventions for anxiety in children and adolescents with ASD, including modified cognitive behavioral therapy (CBT) and group therapy (Reaven et al., 2009; van Steensel, Zegers, & Bogels, 2017; White et al., 2013). However, there are no empirically supported interventions for anxiety in preschoolers. Modifications often need to be made for interventions with children with ASD due to their unique sensory differences, social challenges, verbal ability, etc. Specifically, tailoring interventions for individuals with autism will likely be most effective in supporting their individual needs. Given the developing cognitive ability of preschool-aged children with ASD compared to their school-aged peers, behaviorally based and parenting interventions can be more effective for this age group (Kasari, Gulsrud, Paparella, Hellemann, & Berry, 2015; Lang, Regester, Launderdale, Ashebaugh,

& Haring, 2010; Virués-Ortega, 2010). Anxiety interventions that are specifically designed to address the unique needs of preschool-aged children with autism may be important for treatment effectiveness and prevention of subsequent difficulties later in childhood.

Although this study detected no significant impact of anxiety on the relation between status and either verbal or visuospatial STM, short-term memory, WM and related executive functions are known to be associated with a number of critical variables including adaptive skills, academic achievement, autism symptom severity, and language skills (Gilotty et al., 2002; St. John et al, 2018; Schuh & Eigsti, 2012; Stokes et al, 2017). Given that STM was not significantly different between TD and ASD groups in the current study, which was underpowered, more research is needed in this area. In addition, it is possible that STM may play a more prominent role in other critical areas of functioning in older children with ASD but not in younger children.

Lastly, anxiety appeared to play a different role in verbal ability depending on whether the participant was TD or had ASD. Anxiety was associated with higher verbal ability in TD children, which suggests the importance of assessing anxiety in children who are functioning well verbally. Given that anxiety tends to increase with age, addressing anxiety management early may protect a child from difficulties later in life. Verbal ability for children with ASD did not seem to vary at different levels of anxiety. Although treating anxiety in children with ASD will likely improve a number of other presenting symptoms, it may not have the same impact on improving verbal ability. Interventions that target other factors, such as joint attention and play skills, that are associated with verbal ability may be more effective in improving language in children with ASD (Kasari, Gulsrud, Freeman, Paparella, & Hellemann, 2012).

**Strengths and Limitations**

The current study had a number of strengths to note. First, this study used a quasi-experimental design, which allowed for comparison of groups drawn from meaningfully distinct populations. These groups were relatively similar in size and demographic characteristics. Benefits of this type of experimental design include the ability to manipulate the independent variable and control many confounding variables (Thompson & Panacek, 2006). In addition, this study was completed with young, preschool-aged children, allowing for the extension of previous studies that have utilized school-aged child, adolescent, or adult samples. There are significant developmental changes in STM and WM that occur during the window of 3-6 years old that have not often been captured in other research samples.

A number of significant limitations of this study were identified. Importantly, this study was severely underpowered, reaching only about a quarter of the proposed sample size. This limitation makes the results of this study particularly susceptible to type-II error, or the failure to reject the null hypotheses of the study. Additionally, the cross-sectional design of the study does not allow for the ability to determine a causal effect between the study variables over time, whereas a longitudinal study would provide stronger support for causal inferences. Due to the quasi-experimental design of the current study, there are increased threats to internal validity, such as confounding variables, due to the lack of random assignment to groups (Thompson & Panacek, 2006). Another limitation of the study relates to generalizability. The participants of this study were predominantly European American, from middle to high income families, and with average to above average verbal ability, making it difficult to apply these findings to other racial groups, socioeconomic statuses, and verbal skills that is more representative of the larger population.

**Conclusions and Future Directions**

This study sought to better understand the associations between developmental status, anxiety, and verbal and visuospatial STM. The study findings with regard to anxiety were significant, consistent with previous research, and extended this research to younger children. This study supported the limited prior research on anxiety in young children with ASD and concluded that significant symptoms of anxiety are present as early as preschool. The current study, however, did not provide conclusive data on STM in young children with and without ASD. Although this study was underpowered, trending associations and effect sizes suggested that the area of STM and WM warrant continued exploration in children with ASD.

Future research should continue to explore the development of STM and WM in young children. There is a wide variation of definitions and assessments of STM and WM; therefore, repeated use of the same measures across studies may help clarify the impact of STM and WM throughout cognitive development. In addition, given the overlap between STM/WM and other executive functions, exploration of these related constructs may be beneficial in understanding how cognitive functions compare across TD and ASD children. Furthermore, increased understanding of the role of anxiety in cognitive processing in children with and without ASD may better inform treatment targets and mechanisms, especially given the high levels of anxiety in children with ASD.

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