THE INFLUENCE OF WORKING MEMORY AND ANXIETY IN ADOLESCENTS

by

Donna Ward

Liberty University

A Dissertation Proposal Presented in Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

Liberty University

April 30, 2024

THE INFLUENCE OF WORKING MEMORY AND ANXIETY IN ADOLESCENTS

by

Donna Ward

Liberty University

A Dissertation Presented in Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

Liberty University

April 30, 2024

APPROVED BY:

[redacted]

Danisha Keating, Ph.D., Committee Chair

[redacted]

Margaret Gopaul, Ph.D., MSCP, Committee Member

ABSTRACT

Literature supports a reliable link between lower working memory (WM) performance and higher anxiety, and both anxiety and WM are reported as comorbid with neurodevelopmental disorders (NDDs). This study sought to understand to what extent WM deficits and anxiety exists in adolescent NDD and non-NDD groups. Participants (*N* = 11,400; ages 9-10) were obtained from the Adolescent Brain Cognitive Development (ABCD) study archived dataset, with the approval of the NIMH approval. Participants in the dataset were recruited from 21 sites across the U.S. A Mann-Whitney U test, comparing the NDD (*N*=2756) and non-NDD (*N*=8644) groups was statistically significant, noting a more pronounced of WM deficits in the NDD group. A Chi-Square test of independence comparing generalized anxiety disorder (GAD) and NDDs was statistically significant, indicating higher incidence of a GAD diagnosis in the NDD group. Kendall's Tau-b correlation test of GAD and NDDs was statistically significant, indicating a GAD diagnosis is likely to coincide an NDD diagnosis. Kendall's Tau-b correlation test of WM and GAD was statistically significant, revealing lower WM scores coincided with an increased GAD diagnosis and vice versa (monotonic relationship). The study results are relevant to mental health professionals as a recommendation for comprehensive assessment when evaluating and treating adolescents. Church, community organizations and employers may also utilize study findings to create awareness and a culture of inclusion and support.

Dedication

This manuscript is dedicated to my incredible husband, Emmett. Your encouragement and faith in me helped me make forward progress when sometimes I did not feel I could go the distance. Thank you for your patience and the sacrifices you have made over the past few years. My dear son Eythan, you are a special gift and a great source of inspiration. Thank you for allowing me to miss a few tennis matches. Your support and hugs helped me to stay the course. Mom, life has not been easy for you. I witnessed you work to receive your high school diploma, get a college degree, and carve out a career, all while caring for six children. You are my model of perseverance and what it looks like to overcome regardless of circumstances. To our Lord God Almighty, thank you for your strength in my weakness and being an ever-present help.

Acknowledgments

I wish to acknowledge Dr. Danish Keating, my dissertation chair, and Dr. Margaret Gopaul, my committee member. I am thankful for the amazing patience with me and my aim to use an archived dataset, even when it looked like approvals would not come. The words of encouragement, challenge to think more critically, and become a better writer truly made the difference.

I would like to thank my family and friends who understood that I would not make events as frequently as before, but still they provided continued support and encouragement.

TABLE OF CONTENTS

List of Tables

List of Figures

CHAPTER 1: INTRODUCTION TO THE STUDY

Introduction

The relationship between working memory (WM) and anxiety has been firmly established in the literature (Angelopoulou & Drigas, 2021; Donolato et al., 2019; Stout et al., 2020; Waechter et al., 2018). In addition, current literature supports an association with neurodevelopmental disorders (NDDs), WM, and anxiety (Doering et al., 2022; Tajik-Parvinchi et al., 2021; van der Meer et al., 2018). Chapter One describes the challenges associated with deficits in WM and clinical anxiety.

The chapter begins with a background review of WM, anxiety, and NDDs. Current literature is offered in support of the problem statement and the study's purpose is clarified. The research questions and the study's hypothesis were provided along with early assumptions and limitations of the study. Theoretical frameworks that provide a foundation for the study were explored. The chapter also include definitions of key terms and how the anticipated findings might add to the body of literature and practical implications for the future.

Background

Within this quantitative study, recent literature related to WM, anxiety, and NDDs was explored. Literature has established a reliable association between lower WM performance and higher anxiety (Lukasik et al., 2019; Mikels & Reuter-Lorenz, 2019; Moran, 2016; Shi et al., 2019). Eysenck et al. (2007) proposed the attentional control theory (ACT) and suggested that anxiety impairs cognitive abilities by enabling a greater influence of the stimulus-driven attentional system; the higher the anxiety, the greater the disruption. In a subsequent study related to the attentional control theory, Eysenck and

Derakshan (2011) postulated that anxiety affects the executive component of WM. In a study on affective WM, researchers Mikels and Reuter-Lorenz (2019) agreed with Eysenck et al. (2007) and Eysenck and Derakshan (2011) regarding ACT, reporting that anxiety disrupts the executive component of WM, which helps to prevent distractions from irrelevant information and controls attention shifting between tasks.

WM and anxiety have been identified as comorbid with neurodevelopmental disorders (Doering et al., 2022; Golshan et al., 2019; Kofler et al., 2018; Tajik-Parvinchi et al., 2021). According to Licari et al. (2019), NDDs occur due to disturbances in processes of brain development in the embryonic stage and/or during early childhood, resulting in disorders such as ADHD, ASD, intellectual disability (ID), and other conditions. Tajik-Parvinchi et al. (2021) suggested that 20% to 70% of children with NDDs have clinically significant levels of anxiety. Further, children with NDDs have impairments in executive functions (EF), which involve cognitive processes such as WM, inhibitory control, and shifting, which when impaired predicted an increase in emotion dysregulation and internalizing symptoms of anxiety and depression (Tajik-Parvinchi et al., 2021).

Deficits in WM affect a broad range of cognitive abilities and is one aspect that explains the individual differences in global fluid intelligence, with at least a 40% variance (Avery et al., 2020). Common neurological disorders associated with WM deficits include attention deficit hyperactivity disorder (ADHD), autism spectrum disorder (ASD), specific learning disorders (SLDs) (Kofler et al., 2019; Operto et al., 2021; Rabiee et al., 2020) and a spectrum of anxiety disorders (Abushalbaq et al., 2021). Related to ADHD, a study by D'Agati et al. (2019) suggested a 25% comorbidity rate

with anxiety disorders, which when present in childhood could reduce inhibitory dysfunction, and in adolescence could increase WM deficits. Ezell et al. (2019) study of 20 ASD male adolescents found that 50% met the criterion for an anxiety disorder. Uljarević et al. (2020) reported comparable results in their study of 255 adolescent and adult ASD participants (151 male, Mage = 33.52) where more than 38 % reported clinical anxiety symptoms, with a trend of a moderate increase in severity from adolescence to middle adulthood (Uljarević et al., 2020).

Gontard et al. (2022) reported that NDDs have a wide range of impairing and debilitating developmental deficits and comorbid conditions such as ADHD, ASD, anxiety disorders, depressive disorders, conduct and oppositional defiant disorders, and intellectual and special developmental disorders. Hur et al. (2019), Finell et al. (2021), and Gontard et al. (2022), have found that NDDs and comorbid conditions can have debilitating and incapacitating effects on children and adolescents. In some cases, ASD and ADHD are co-occurring conditions and taken separately and together, internalizing behaviors are frequently present (Dellapiazza et al., 2021). The Bible offers comfort for those experiencing mental health challenges. Isaiah 43:2 reminds of God's word, "When you pass through the waters, I will be with you; And through the rivers, they shall not overflow you. When you walk through the fire, you shall not be burned, Nor shall the flame scorch you."

Problem Statement

It is not known to what extent WM deficits and anxiety exist in adolescents with a NDD diagnosis versus typically developing adolescents in the United States (U.S.). WM is a core executive function component that involves retaining information in the mind

and mentally processing that information (Angelopoulou & Drigas, 2021; Baddeley & Hitch, 1974; Ling & Diamond, 2019; Zelazo, 2020). WM supports the ability to action plan, update an individual's thinking, calculate a route, re-order a to-do list, evaluate alternatives, and relate two pieces of information (Ling & Diamond, 2019).

Anxiety disorders (i.e., generalized anxiety disorder, social anxiety disorder, specific phobias, separation anxiety disorder, etc.) are among the more frequent clusters of pathologies among the youth population (Murphy et al., 2018; Waechter et al., 2018). Research has found that anxiety has implications of impairment across several domains; social, familial, and academic functioning (Caviola et al., 2022; Murphy et al., 2018). For example, Caviola et al. (2022) found that math anxiety and performance were correlational. In another study, anxiety was identified as correlational to poorer academic self-concept (i.e., an individual's perceptions and judgments about their performance), and school dropout, which in turn could contribute to poorer life outcomes (Brumariu et al., 2022).

Current literature has reported an association between anxiety and WM (Donolato et al., 2019; Stout et al., 2020; Waechter et al., 2018). According to Moran's (2016) prominent meta-analysis of both experimental and self-reported studies, anxiety is associated with poorer WM performance. Some studies suggest that anxiety influences WM performance and other studies report the transdiagnostic nature of WM and anxiety. For example, Alba et al.'s (2019) correlation study reported that WM interacts with adversity-related anxiety such as absence of parenting or institutional caregiving leading to emotion dysregulation. Waechter et al.'s (2018) study results indicated that poorer WM was related to greater anxiety levels, and Yoon et al.'s (2018) correlation and

regression analysis found poorer WM capacity when presented with negative distractors, was associated with greater rumination in the GAD participants. Grol et al. (2018) evaluated excessive worry (a feature of anxiety) and WM in a college sample that received WM training and posited a causal relationship: WM influences anxiety.

Impairments in WM and anxiety, if untreated, have negative implications for academic achievement, workplace functioning, occupational attainment, other psychiatric problems, and real-life adversities (Barkus, 2020; East-Richard et al., 2020; Hasslinger et al., 2022; Plana-Ripoll et al., 2023; Yoon et al., 2018). For example, early adolescence anxiety is a risk factor for developing depression at a later age (Beloe & Derakshan, 2020). Scholars support that anxiety and depression are both associated with rumination and impairments in inhibiting negative distractors and that worry, and rumination serves as a maladapted coping strategy (Stout et al., 2020; Yoon et al., 2018). Høj Jørgensen et al. (2023) posited autism and ADHD as underlying childhood disorders that are sometimes diagnosed for the first-time during adulthood in substance use disorders.

Although the literature supports the link between anxiety and WM, few studies have given attention to adolescents, and fewer in a longitudinal study design (Barker et al., 2019; Lisica et al., 2022; Lukasik et al., 2019; Murphy et al., 2018; Stout et al., 2020). Barker et al. (2019) reported that most anxiety-related research has focused on adult populations. Regarding the need for adolescent studies, Doering et al. (2022) noted the increase in the frequency of anxiety symptoms during the transition from childhood to adolescence. Beloe and Derakshan (2020) reported that clinically significant anxiety levels typically do not manifest until adolescence. Regarding suggestions that anxiety influences WM deficits, Lisica et al. (2022), Lukasik et al. (2019), Murphy et al. (2018),

and Stout et al. (2020) all suggested future studies of adolescents' executive function factors, such as WM, in relation to anxiety. Another gap in the literature is related to large sample sizes. Donolato et al. (2019) and Murphy et al. (2018) proposed larger sample sizes to examine the effect as well as longitudinal studies for examining factors across ages.

With the practical implications of WM and its relation to anxiety and in consideration of the limitations of earlier research, the current study investigated the relationship between WM and anxiety in an adolescent cohort. Creswell et al. (2020) and Hudson et al. (2019) noted the low recognition and treatment of anxiety in adolescents. Joining East-Richard et al. (2020), Hasslinger et al. (2022) and other researchers reference above discussed the implications of anxiety and WM. Creswell et al. (2020) highlighted the negative implications of anxiety on adolescents' social, educational, and health functioning and the potential for developing other mental health challenges.

Purpose Of The Study

The purpose of this quantitative correlational study was to analyze archival data from the Adolescent Brain Cognitive Development (ABCD) study for a correlation between WM and anxiety, and also to determine if there was a correlation between NDDs and WM and anxiety. The hypothesis was there will be a higher incidence of WM deficits and anxiety in the NDD diagnosed versus typically developing adolescents in the United States (U.S.).

Research Questions And Hypotheses

Research Questions

RQ1: What is the difference in WM deficits between adolescents with NDDs and typically developing adolescents?

Hypothesis 1: Adolescents with WM deficits will not have a higher incidence of NDDs than typically developing adolescents.

RQ2: What is the difference in anxiety between adolescents with NDDs and typically developing adolescents?

Hypothesis 2: Adolescents with high anxiety measures will not have a higher incidence of NDDs than typically developing adolescents.

RQ3: What is the relationship between WM deficits, anxiety, and NDDs in adolescents?

Hypothesis 3: There is not a significant correlation between WM deficits and anxiety, but there is a significant correlation between anxiety and neurodevelopmental disorders.

Assumptions And Limitations Of The Study

Assumptions

A longitudinal design was employed with the ABCD study, which performed data collection at baseline and subsequent years. This study performed analysis of the selected variables from the ABCD study. The study assumed there would be sufficient data for the participants for an appropriate sample size.

Limitations

There were several potential limitations and challenges considered. Limitations include causal relationships between variables and limitations of the List Sort Working Memory Test (LSWMT). First, correlational studies do not establish causal relations between variables but instead seek to determine whether there is a relationship between variables (Curtis et al., 2016; Martin, 2012). Another limitation is related to the List Sorting Working Memory Test used in the ABCD study. This test was designed to assess WM as part of the NIH Toolbox Cognition Battery (NIHTB-CB) (Tulsky et al., 2014). According to Tulsky et al. (2013), the test is different from a single modality measure used frequently to evaluate the cognition of the visual-spatial sketchpad (i.e., visual) or phonological loop (i.e., auditory) subsystems. Rather, the LSWMT assesses cognitive function over the human lifespan (Tulsky et al., 2013). However, Tulsky et al. (2014) offered support that the List Sort Working Memory Test is valid and reliable for measuring WM in children and adults.

Theoretical Foundations Of The Study

Working Memory

Working Memory refers to a brain system responsible for temporarily retaining and manipulating information for use in a subsequent action (Angelopoulou & Drigas, 2021; Baddeley & Hitch, 1974; Zelazo, 2020). The concept of WM emerged during the cognitive revolution in the 1950s as a computer system term that Newell and Simon (1956) used to describe temporarily accessible information needed for the computer to solve calculations. The term was later applied similarly to human processing and problem-solving (Cowan, 2022; Miller et al., 1960).

Baddeley and Hitch's (1974) multicomponent model proposed that WM is a limited capacity storage with limited processing capabilities. Baddeley (2010) further refined the model by adding a central executive component that functions as an attentional control system. Finell et al. (2021) offered that the central executive is responsible for monitoring, planning, manipulating information, and selecting strategies to execute tasks at hand. Baddeley (2010) noted two short-term storage systems (Figure 1a), the phonological loop, and the visuospatial sketchpad which supports the central executive. The phonological loop holds audio and verbal information, while the visuospatial sketchpad is responsible for holding visual and spatial information in temporary storage (Angelopoulou & Drigas, 2021; Baddeley, 2000).

The episodic buffer component of WM was introduced as responsible for combining information from various subsystems, including long-term memory, to bring information into temporary storage (Figure 1b) (Baddeley, 2000). Baddeley and Hitch's (1974) WM model is long-standing and referenced in a broad range of research (Avery et al., 2020; Cowan, 2022; Finell et al., 2021; Sepp et al., 2019).

Figure 1.

Working Memory Model with Episodic Buffer

Removed to comply with copyright

Baddeley, A. (2000). *The episodic buffer: a new component of working memory?*. Elsevier Ltd. https://doi.org/10.1016/S1364-6613(00)01538-2

Attention Control Theory

There is broad consensus that attention and WM are intimately linked (Angelopoulou & Drigas, 2021; Baddeley, 2010; Cowan, 2017; Oberauer, 2019; Shi et al., 2019). Attention control WM holds information regarding goals for use in ongoing processing and distraction inhibition (Cowan, 2017; Oberauer, 2019). The Attentional Control Theory (ACT) posited by Eysenck et al. (2007) draws on the Baddeley and Hitch (1974) WM model and the Eysenck and Calvo (1992) Processing Efficiency Theory (PET) of anxiety and performance. According to Eysenck and Calvo (1992) and Eysenck and Derakshan (2011), the central executive, an attention-like, limited capacity component of the Baddeley and Hitch (1974) WM model, is impaired by anxiety.

The ACT postulates that deficits in attention control are key to developing anxiety symptoms (Eysenck et al., 2007; Shi et al., 2019). Aligned with ACT, Eysenck et al. (2007) and Oberauer (2019) agreed that the influence of goals on attention is frequently characterized as “top-down” attention or cognitive attention. “Bottom-up” or automatic attention is influenced by the prominence of stimuli, independent of current goals or

learned information (Eysenck et al., 2007; Oberauer, 2019). Threats or threatening stimuli capture an individual's attention. The more frequently an individual experiences state or trait anxiety, the chance of ambiguous information is interpreted as threatening and thus captures attention. Attentional control is needed to disengage the perceived threat (Shi et al., 2019).

Multiple Deficit Model

The multiple deficit model (MDM) was proposed by Pennington (2006) in response to the prevailing single deficit model (SDM) of that time failing to address the multiple factors of symptom, genetic and cognitive overlaps between neurodevelopmental disorders (NDDs) such as autism and ADHD or dyslexia and speech disorders (Pennington, 2006). The SDM failed empirically to explain the atypical neuropsychological development and could not account for inter-individual variations and pervasive comorbidity (McGrath et al., 2020; Pennington, 2006). SDM also failed empirically due to common findings in children with NDDs that lacked key underlying cognitive deficits as well as children without NDDs that possessed the key underlying deficit (McGrath et al., 2020).

The MDM has progressed to a multi-level framework for understanding NDDs, spanning etiology (e.g., genes, environments, and gene-environment interplay), neuropsychology, brain mechanisms, and behavioral symptoms. Several methods and studies (e.g., structural equation modeling, regression outlier approaches, behavioral genetic studies, and longitudinal family risk studies) have been applied to evaluate the MDM across levels of analysis (McGrath et al., 2020). There is consistent support for fundamental tenets of the MDM framework that multiple probable risk factors

corresponded with NDDs and that shared risk factors contribute to comorbidity (McGrath et al., 2020; Pennington, 2006).

A recent study by Peisch and Arnett (2022) evaluated the additive models of MDM in children with and without an ADHD diagnosis, and they found high heterogeneous disorder (inter-individual variations) with multiple pathways resulting in the same clinical diagnosis with multiple points across the cognitive-behavioral and neurological factors. Peisch and Arnett's (2022) findings were similar to the McGrath et al. (2020) study results, reporting the MDM constructs explained the greater variance in ADHD and comorbid disorders than the SDM. The MDM acknowledges the heterogeneity of NDDs, recognizing that a meaningful proportion of individuals with an NDD may have a specific deficit but not all will (Kibby et al., 2021). Together, McGrath et al. (2020), Kibby et al. (2021) and Peisch and Arnett (2022) studies suggests the MDM was a suitable framework for evaluating NDDs and comorbid condition of WM and for this study.

Definition Of Terms

The following is a list of definitions of terms that are used in this study.

Adolescents. Youth between the ages of nine (9) – 19 years (Minh et al., 2023).

Anxiety. Excessive fear, worry, and panic that occur absent of a real threat (American Psychiatric Association, 2022).

Attention Control Working Memory (WM). Utilizing attention to maintain information regarding goals and subgoals for use in ongoing processing and inhibition of distractions from the goals (Cowan, 2017).

Attention Control Theory. Two attentional systems responsible for selective attention, top-down goal-directed and bottom-up stimulus-driven systems equivalent to the central executive of the WM model. Threats or threatening stimuli will capture attention. Attentional control is needed to disengage the threat (Eysenck et al., 2007; Shi et al., 2019).

Attention Deficit Hyperactivity Disorder (ADHD). A neurodevelopmental disorder with a persistent pattern of inattention and/or hyperactivity-impulsivity for at least six months that interferes with daily functioning or development (APA, 2022).

Autism Spectrum Disorder (ASD). A complex developmental disorder with persistent deficits in social communication and interactions, repetitive behaviors, and restricted interests (APA, 2022).

Executive Function. Neurocognitive skills support the intentional top-down control of thoughts, actions, and emotions necessary for conscious reasoning, deliberate actions, emotion regulation, self-regulated learning, complex social functions, and adjusting the changing situations (Diamond, 2013; Zelazo, 2020).

Generalized Anxiety Disorder. Persistent and excessive worry that interferes with daily activities characterized by one or more symptoms such as physical symptoms, feeling on the edge, difficulty concentrating, easily fatigued, problems sleeping or muscle tension (APA, 2022).

Neurodevelopmental Disorder (NDD). A group of disorders with onset during the developmental period which involves deficits leading to impairments in personal, academic, social, and occupational functions. Examples of neurodevelopmental disorders

include ADHD, ASD, developmental coordination disorders, learning disorder, and tick disorder (APA, 2022).

Working Memory (WM). Involves keeping the information in the mind and manipulating (i.e., cognitively processing) the information, such as solving a math problem with multiple steps (Baddeley & Hitch, 1974; Zelazo, 2020).

Significance Of The Study

Adolescence is characterized as a sensitive period, a time of dramatic developmental changes in an adolescent's body, hormones, and brain structure and functioning (Pfeifer & Allen, 2021; Volkow et al., 2018). This study contributes to the longitudinal research using a large sample size from archival data from the ABCD study that enhances our understanding of the relationship between WM and anxiety from pre- to early adolescence. The intent of this study's design was that it might be replicated with the same or other large cohorts like the ABCD study or expand with the ABCD cohort into late adolescence and emerging adulthood. Such longitudinal, large-sample designs analyzing anxiety and WM, were identified as an opportunity for future research (Donolato et al., 2019; Murphy et al., 2018). This study may also contribute by adding more research on anxiety among adolescents. Barker et al. (2019) identified anxiety as a gap in adolescent literature.

Considering anxiety and WM are comorbid in some individuals and comorbid with several other disorders (depression, attention deficit hyperactivity disorder (ADHD), autism spectrum disorder (ASD), and specific learning disorders (SLD) (Crisci et al., 2021; D'Agati et al., 2019; Fosco et al., 2020; Kofler et al., 2018; Spinhoven et al., 2018), this study might inform the need for a broader battery of clinical assessments and

interventions that consider overlapping brain structure and mechanisms. This study could inform tailored treatment plans for adolescents with the aim of improving symptoms and function, aligning with the transdiagnostic interventions framework proposed by Astle et al. (2022). The Astle et al. (2022) transdiagnostic framework calls for a child-centric approach of prioritizing the most impactful concern rather than a diagnostic feature.

Summary

Chapter One introduced the study, offering evidence of the relationship between WM, anxiety, and NDDs. The background literature on WM and anxiety reported the bi-directional influence of one on the other and a shared theoretical framework, the Attentional Control Theory (ACT). The background literature also explored the impact of NDDs on children and adolescents, specifically highlighting the debilitating effect of NDDS and the comorbidity with anxiety and other conditions. The problem statement illuminated the gaps found in the current literature.

The purpose of the study was elucidated as an evaluation of correlations between WM, anxiety, and NDDs. Also covered in the chapter were the research questions and hypotheses that guided this study as well as assumptions and limitations and definitions of the terms used in the study. A biblical perspective on mental health suffering is offered in Isaiah 43:2: provides comfort and assurance of God’s care and presence with those that experience the challenges of mental health challenges.

CHAPTER 2: LITERATURE REVIEW

Overview

This study was guided by a literature review of relevant constructs of the study. The research strategy was outlined including the databases and biblical resources searched, search terms, and delimitations. A detailed literature review was performed on the research topic and constructs. A biblical perspective was offered as a biblical foundation for the study.

Description Of Search Strategy

A review of the current literature was conducted with various databases including EBSCOhost Academic Search Ultimate, ELSEVIER Clinical Key, APA PsycNET, ProQuest, Springer Link, and Google Scholar. Reference lists were also scanned for relevant articles. The search criteria were restricted to peer-reviewed journal articles published within the past five years. The search was limited to adolescents ages nine (9) to 19 years (Minh et al., 2023). The key terms searched included working memory, executive function, anxiety, worry, internalizing symptoms, and neurodevelopmental disorders. Biblical research sources included the Bible, Strong's Concordance word studies, The Encyclopedia of Christianity, commentaries, and research studies.

Review Of Literature

WM, anxiety, and NDDs contribute negatively to academic achievement, occupational attainment, workplace functioning, other psychiatric problems, and real-life adversities (Barkus, 2020; East-Richard et al., 2020; Hasslinger et al., 2022; Yoon et al., 2018). This review of literature explored the core features and challenges related to the

constructs of WM, clinical anxiety, and NDD diagnosis. The review also examined the influence of comorbidity and the interplay between deficits and symptoms.

Working Memory

Working memory (WM) involves the retaining of information in the mind and cognitively processing the information (Baddeley & Hitch, 1974). According to Rosenberg et al. (2020), WM varies across individuals and changes across the lifespan, emerging in infancy, quickly developing during the first year, plateauing in late adolescence, and starts to decline after age 40. WM is a core feature of executive functions, a group of top-down cognitive processes responsible for facilitating goal-directed behavior and approaches to novel situations (Diamond, 2013; Tajik-Parvinchi et al., 2021). There are two subsidiary systems of WM, phonological (verbal) WM and visuospatial WM. WM is limited in capacity to update and manage verbal and visual-spatial content (Cowan, 2022; Diamond, 2013; Warren et al., 2021). Baddeley (2000) and Baddeley et al. (2021) posited phonological WM as temporary storage of verbal and acoustic information leveraging an articulatory rehearsal system associated with the Brodmann areas of the cerebral cortex. Like phonological WM, visuospatial WM holds visual information in temporary storage (Baddeley, 2000; Baddeley et al., 2021).

In addition to actively holding and manipulating information, Warren et al. (2021) noted an attentional control aspect of WM exists. WM is vital for an individual to retain verbal, visual, or spatial information, as well as the ability to relate information to what comes later, such as doing math in one's head. WM involves making sense of language (i.e., spoken and written), reordering items on a to-do list, incorporating novel information into thoughts or plans (i.e. ,updating), vetting alternatives, identifying

connections between concepts or items, deriving general principles from information, and pulling apart (i.e., deconstructing) and reconstructing elements in new ways (Diamond, 2013).

The construct of WM memory can be viewed as a result of the 1950s emerging cognitive revolution, beginning with the term to describe temporarily accessible groups of critical information required for computers to solve geometric verification (Cowan, 2022). Early literature suggests that the term working memory in humans was initially introduced around 1960s and was characterized as quick-access memory used to execute plans (van Ede & Nobre, 2022). Baddeley and Hitch (1974) put forth the multi-component WM model which is one of the most dominant WM models cited in literature. Baddeley et al. (2021) posited that WM is a multi-component system responsible for manipulating information storage for great and complex cognitive utility with subcomponents: phonological loop (verbal WM), visual-spatial sketchpad (visual-spatial WM), and the central executive (attentional control system).

A year earlier, Baddeley (2000) posited that the episodic buffer was included in the model to integrate sensory information. According to Baddeley (2000) and Melrose et al. (2020), the episodic buffer is believed to function as a limited-capacity, temporary storage capable of binding information from various dimensions (episodes, verbal and visual) and can access elements of long-term memory to facilitate maintenance. Baddeley (2000) posited the episodic buffer is governed by the central executive component of memory, which Chai et al. (2018) suggested serves as the "control center" overseeing the manipulation, recall, and processing of verbal and non-verbal information for problem-solving, decision-making, and writing manuscripts. The embedded-processes model

proposed by Cowan (2022) argued that Baddeley and Hitch (1974) model failed to consider the focus of attention to stimuli presented in their simplified model of the perceptual process and highlighted the critical role of the WM 'capacity' element of WM. In an attempt to diminish the confusion due to discrepancies in definitions for WM, Cowan (2017) offered this definition: "The ensemble of components of the mind that hold information temporarily in a heightened state of availability for use in ongoing information processing" (p. 1159). This definition was considered more acceptable by Cowan (2017) because it excluded statements about the mechanism and other functions of WM).

Recent cognitive neuroscience studies, such as Chai et al. (2018) have examined verbal and nonverbal (visual-spatial) WM elements. Findings indicate associations or dissociations help to identify the phonological loops (verbal) and visual-spatial sketchpad, suggesting that the Wernicke's and Broca's are activated by acoustic and verbal information while the right hemisphere is activated with visuospatial information (Chai et al., 2018). A functional connectivity meta-analysis by Chen et al. (2018) found connectivity across the fronto-parietal control, dorsal attention, and ventral attention networks. According to Chai et al. (2018), Chen et al. (2018), and Hur et al. (2019), the frontoparietal network has been implicated in engaging the dorsal prefrontal cortex (DLPFC), the parietal cortex (PAR), and the anterior cingulate cortex (ACC) as the neural network underlying WM. Specifically, the DLPFC has been primarily implicated in tasks demanding central executive control. The ACC has been acting as the "attention controller" that evaluates the need for adaptation and adjustment of received information

and the PAR is regarded as a “workspace” enabling sensory or perceptual processing (Chai et al., 2018; Chen et al., 2018).

Anxiety Disorders

According to the American Psychiatric Association (APA, 2022), anxiety disorders are described by excessive fear, worry, and panic that occur absent of a real threat. Anxiety affects 28% or higher of the population in the U.S. and European countries (Yang et al., 2021), with a substantial deleterious impact on an individual’s well-being (Lisica et al., 2022). Lukasik et al. (2019) characterized anxiety as a heightened vigilance state associated with an increase in global sensory sensitivity in response to conflict or uncertainty.

In agreement with APA (2022), Lukasik et al. (2019) noted an individual’s limited ability to control worrying and added there is a tendency of attentional biases related to the increased focus on negative thoughts. Hirsch and Mathews’ (2012) cognitive model and Eysenck and Derakshan’s (2011) attentional control theory both postulate that impaired executive function (EF) and other cognitive components are linked to excessive and unmanageable worry, which is the core feature of the generalized anxiety disorder (GAD). In the Nur and Newman (2018) longitudinal study, results showed EF impairments in various cognitive processes (global cognition, WM, updating, inhibition, set-shifting, and inductive reasoning) may be risk factors for a diagnosis of GAD. In alignment, a Lukasik et al. (2019) study showed that anxiety interferes with cognitive processes. However, Petkus et al. (2017) posited a transdiagnostic relationship between anxiety and cognitive impairments, indicating the relationship works both ways:

cognitive impairments may lead to increased anxiety, and anxiety may lead to cognitive impairments.

Anxiety and Working Memory

Beloe and Derakshan (2020) and Kavanaugh et al. (2021) identified WM as one cognitive process involved in anxiety. Lisica et al. (2022) investigated deficits in WM performance in individuals with varying levels of anxiety symptoms (low, high, and severe). Results indicated that the high and severe anxiety scores demonstrated lower accuracy on all WM tasks when compared with the low anxiety group (Lisica et al., 2022). Held et al. (2020) found that higher levels of worry negatively impact WM and individuals with GAD and other anxiety and mood disorders showed WM impairments. In a sample of 130 children and adolescents (ages six to 17 years), Murphy et al. (2018) investigated whether symptoms of anxiety would predict facets of executive function deficits. The results showed that participants that exhibited anxiety symptoms also exhibited poorer WM (Murphy et al., 2018).

In a meta-analysis to evaluate mixed study results on the relationship between WM capacity and anxiety Moran (2016) found that anxiety is reliably associated with poorer WM capacity, yet that under some circumstances anxiety inductions did adversely affect WM performance, but not all. Related to mixed results, Jarros et al. (2017) and Pan et al. (2022) found that individuals with mild anxiety seem to have better WM when compared with both healthy and severe anxiety adolescents. In support of literature that anxiety impacts cognitive processes adversely, Figueira et al. (2017) found that an unpleasant emotion when compared with a neutral one, was capable of restricting the number of task-relevant items an individual could hold in WM. In alignment, Waechter et

al. (2018) found that poorer WM performance is associated with higher anxiety levels in individuals with clinical anxiety disorders. Considering the results of Jarros et al. (2017), Pan et al. (2022), and Waechter et al. (2018), a question arose regarding whether levels of anxiety, mild versus clinical anxiety, could influence mixed results found in studies.

Neurodevelopmental Disorders

At an increasing rate, neurodevelopmental disorders (NDDs) are being recognized as a leading cause of suffering in youth, their parents, and families and they represent a significant cost to society (Hansen et al., 2018). According to Valentine et al. (2020) and Barkley (2020), the chronic nature of NDDs represents serious health and financial burdens for society and families, related to parental time off work, loss of earnings, and mental health concerns. Hurley-Hanson et al. (2019) reported the estimated annual cost for autism by 2025 will be $461 billion in the U.S. Similarly, the cost burden for ADHD in the U.S, according to Barkley (2020), is between $143 to $266 billion annually.

NDDs contribute to impairments in cognition, social interactions, behavior, academic attainment, and reduced quality of life in children and as well as persist across the human lifespan (Daley et al., 2019; Hansen et al., 2018; Poulton, 2021; Shulman et al., 2020). It is estimated that up to 10% of youth are diagnosed as having one or more NDDs (Astle et al., 2022). According to APA (2022), NDDs include intellectual disabilities, learning disabilities, communication disorders, autism spectrum disorders (ASD), attention deficit hyperactivity disorder (ADHD), motor disorders, and others. NDDs have their onset during the developmental period (APA, 2022; Doering et al., 2022), and are believed to be present from birth or at an early age (APA, 2022).

Individuals with neurodevelopmental disorders commonly have co-occurring diagnoses (Astle et al., 2022). For example, learning difficulties exist in 65%–85% of children diagnosed with ASD and 44% diagnosed with ADHD. Further, ADHD and ASD have co-occurrence rates between 30%–70% of individuals (Astle et al., 2022). Tajik-Parvinchi et al. (2021) reported that NDDs and comorbidity have shown a link between executive function deficits, such as those related to WM, and links to symptoms of anxiety.

Neurodevelopmental Disorders And Working Memory

Research supports that people with neurodevelopmental conditions such as ADHD and Autism, display challenges with WM (Golshan et al., 2019; Kofler et al., 2018). ADHD is the most frequently diagnosed neurodevelopmental disorder, with an estimated prevalence of 7% - 10% of children and 2% - 5% of adults (Al-Saad et al., 2021; Poulton, 2021). Kofler et al. (2019) reported that 62% of youth with ADHD showed impairment in WM. In a study investigating the differences between healthy controls and those with ADHD, Arjona Valladares et al. (2020) examined the slow wave, which is associated with the retention process. The results also found deficits in the WM task performance and suggested a delayed maturation in the neural processes supporting the centro-parietal slow wave as a potential underlying cause (Arjona Valladares et al., 2020).

ASD incidence has increased and today is considered of the second most common developmental disabilities with an estimate of 1 in 59, according to Shulman et al. (2020). Habib et al. (2019) agreed with the increase in diagnosis reporting a higher incidence of 1 in 68 and a 30% increase in prevalence since 2012. In a meta-analysis of

34 studies investigating WM impairments in ASD individuals, Habib et al. (2019) found that individuals with ASD had significantly lower WM scores in both the visuospatial and phonological domains when compared to typically developing controls. In alignment, Rabiee et al.'s (2020) study of adolescent ASD participants found that WM was impaired even in ASD individuals considered to be high functioning.

Neurodevelopmental Disorders And Anxiety

Youth with NDDs experience clinically significant internalizing symptoms of anxiety and depression (40 – 70%) at higher rates than peers without NDDs (Tajik-Parvinchi et al., 2021), and childhood NDDs and anxiety are thought to predict adolescent anxiety and depression (Doering et al., 2022). These internalizing symptoms and individuals' academic achievements are affected by the presence of NDDs, according to Doering et al. (2021). In the van der Meer et al.'s (2018) study, results showed that ADHD and comorbid anxiety were associated with reduced neural activity during the performance of visual WM tasks in brain regions responsible for information gathering. In a study seeking to explore comorbidity among NDDs, Hansen et al.'s (2018) study also found that anxiety is co-occurring with NDDS, specifically, anxiety was the most frequently occurring comorbidity across ADHD, ASD, and tick disorders (TD).

Biblical Foundations Of The Study

Mental health and religion have previously been viewed as allies, providing needed solace in distressful times and as a means of strength (Francis et al., 2019; Walker, 2020). It is noteworthy that man (i.e., male and female) was create in the image and likeness of God (Genesis 1:26). From this scripture it is safe to believe man created having full cognitive abilities. The creation perspective of illness is that one man (Adam)

sinned allowing sin to enter the world, and death through sin spread to all men (Roman 5:12). As a consequence of the fall of man, man experience afflictions, that are not individual or personal judgements, but for all men. In John 9:1-3, Christ confirms this when the disciplines asked, “Rabbi, who sinned, this man or his parents, that he was born blind?” Christ responded that neither sinned: “But that the works of God might be displayed in him.” There is comfort for those afflicted with even mental health challenges, as Deuteronomy 31:8 reads, “The Lord himself goes before you and will be with you; he will never leave you nor forsake you. Do not be afraid; do not be discouraged.” For some people, Deuteronomy 31:8 may be a verse used to cope or encourage themselves and to reduce or eliminate anxiety, excessive fear, worry, and panic. Still, underlying neural networks, transdiagnostic features, cognitive impairments, heritability, and comorbidity contribute to a greater level of complexity for some individuals (Astle et al., 2022; Kushki et al., 2019; Li et al., 2021).

The concept of memory was established in the word study sources and the Bible. Strong’s Concordance references zeker and mnémé characterize memory as “remembrance” or “memorial” (Green, 2011, p. 75). Isaiah 46:8-9 speaks to remembering and recalling the one true God, recording, “Remember this and stand firm, recall it to mind, you transgressors, remember the former things of old; for I am God, and there is no other.” John 14:26 also speaks of remembrance, referencing the Holy Spirit, the helper, that the Father sent to teach all things and bring to remembrance what Christ had spoken. In Exodus 12 the scripture describes the institution of Passover, where lamb’s blood is placed on doorposts so that death will pass-over the firstborn inside. God directed Moses and Aaron that the day shall be a memorial and should be kept as a feast

to the Lord throughout generations (Exodus 12:1-14; NKVJ). Another reference is a tenet of Christian worship, the taking of communion, which was instituted at the Passover meal known as the Lord's Supper. After Christ gave thanks and gave bread and the cup, he instructed the disciples to "do this in remembrance of me" (Luke 22:19; NKJV).

As one of the most common emotional issues experienced by humans, anxiety is noted in several passages throughout the Bible. Strong Concordance characterizes anxiety as "to be anxious or concerned, to fear" or "anxious care" or promerimnaó, which is to be to be anxious beforehand (Green, 2011, p.59). Adam and Eve exhibited anxiety after eating from the Tree of Good and Evil then sewing fig leaves to hide after they sinned (Genesis 3:7-8). Peter 14:29-30 records the anxiety that overcame Peter, experienced when he was commanded to come to Jesus, who was walking on the water. In faith, Peter exited the boat and began walking on the water toward Jesus, yet when he saw boisterous wind Peter became afraid and began to sink (Peter 14:29-30). Exodus 4 records Moses' anxiety, specifically his fear or apprehension of expectations that Pharaoh and Israel would not believe him or heed his voice (v.1).

Villani et al. (2019), Abdel-Khalek et al. (2019), and Garssen et al. (2021) have examined religiosity and its relationship with anxiety, and well-being, of which findings are discussed below. In a meta-analysis to assess the longitudinal positive effect of religion or spirituality on mental health, Garssen et al. (2021) summarized 48 studies using a random effects model. Results showed only specific activities, the importance of religion, and participation in public activities were significantly associated with mental health (small effect size) (Garssen et al., 2021). Villani et al.'s (2019) study of 267 Italian adults aged 18-77 (*M*age = 36.68; 59.9% female) found that among religious participants

religious identity positively predicted satisfaction with life. A meta-analysis of Arab citizens by Abdel-Khalek et al. (2019) found religiosity may have a buffering effect and a coping mechanism against anxiety.

Fatima et al. (2018) sought to explain the known associations between psychological well-being (PWB) and religiosity by investigating the roles of perceived social support and self-efficacy. Participants encompassed 331 adolescents and emerging adults ages 19-24 (mean age 21.67 years, SD 3.92, 68% male). Correlation and regressions confirmed that religious coping and practices were significant predictors of PWB outcomes. Further, the study showed that religious coping is a stronger predictor of PWB than religious practices. (Fatima et al., 2018).

The adolescent and emerging adult periods are known to be a time of heightened risks for psychopathology (Pozzi et al., 2021). The great commission of making disciples of people who value and practice their faith in a supportive community and the fostering of self-efficacy seems to be one path to developing resilience, coping abilities, and psychological well-being in adolescents. We see this positive focus encapsulated in the social construct of neurodiversity, which is trending in society as against the concepts of normal, disorders and cures, but towards a more open minded and optimistic approach to human differences with a focus on strengths and enhancing individual flourishing (Leidenhag & King, 2023). Through wisdom and understanding as written in Proverbs 3:13, individuals challenged with mental health issues can leverage available resources whether psychoeducational, skills training, mental health professionals, and where appropriate pharmacological and nutraceutical assistance. The wisdom and understanding

according to Proverbs 14-18 will bring the blessings of profitability, long life, riches and honor, and peace.

Summary

Current research indicates that WM plays a vital role in the ability to manipulate information in one's mind which is useful in various aspects of life including problem-solving, making sense of the written and spoken language, planning, reasoning, and decision-making. The literature supports a transdiagnostic interplay between WM and anxiety. Golshan et al.'s (2019) and Kofler et al. 's(2018) studies identified that WM deficits can be influenced by anxiety symptoms as well as the reverse; symptoms of anxiety can influence deficits in WM. Further, the research indicates that individuals with NDDs such as ADHD and ASD frequently experience comorbid deficits in WM and internalizing symptoms of anxiety (Tajik-Parvinchi et al., 2021). A biblical perspective points to the support, religious identity, religious coping as buffers against some mental health issues.

CHAPTER 3: RESEARCH METHOD

Overview

This quantitative correlational study examined archived data collected from the ABCD study to determine if a correlation exists between NDDs and WM and Anxiety. The aim was to determine if there is a higher incidence of WM deficits and anxiety in adolescents with NDDs when compared with typically developing adolescents. This chapter comprises of the methodology including research questions and hypotheses, research design, participants, study procedures, limitations/measures, operationalized variables, data analysis, delimitations, assumptions, and limitations.

Research Questions And Hypotheses

RQ1: What is the difference in WM deficits between adolescents with NDDs and typically developing adolescents?

Hypothesis 1: Adolescents with WM deficits will not have a higher incidence of NDDs than typically developing adolescents.

RQ2: What is the difference in anxiety between adolescents with NDDs and typically developing adolescents?

Hypothesis 2: Adolescents with high anxiety measures will not have a higher incidence of NDDs than typically developing adolescents.

RQ3: What is the relationship between WM deficits, anxiety, and NDDs in adolescents?

Hypothesis 3: There is not a significant correlation between WM deficits and anxiety, but there is a significant correlation between anxiety and neurodevelopmental disorders.

Research Design

This study is a quantitative correlational study. Bloomfield and Fisher (2019) characterized quantitative research as a formal, objective, systematic process that describes variables, test relationships between variables, and analyzes cause-and-effect relationships between variables. Additionally, a correlational research design seeks to determine if two or more variables are related and, if so, to explore the nature of the relation (Bloomfield & Fisher, 2019). In contrast, Denny and Weckesser (2019) offered that the qualitative research design aims to provide an understanding and insight into the lived experience and the meaning attached, such as why individuals think or act the way they do. The current study did not include participants' lived experiences. Further, this study tested the relationship between variables; thus, a quantitative correlation study was a more appropriate research design.

Participants

The archived participant data from the ABCD study was used in this study. According to Casey et al. (2018) and Volkow et al. (2018), the ABCD study is a longitudinal study that assessed 11,874 kids that ranged from 9 to10 years old across 21 sites in the U.S. Initially conceived to examine predictors of substance abuse disorders, the ABCD study involved a comprehensive collection of neurobiological, clinical, psychosocial, and demographic measures that provides insight into the influences of cognitive and human brain development from early adolescence to emerging adulthood. The ABCD study included a collection of the mental health, cognitive, structural, resting state, and functional magnetic resonance imaging (fMRI) at baseline and which repeats every two years throughout adolescence into early adulthood (Casey et al., 2018; Volkow

et al., 2018). The current data release available, at the time of this study was 5.1. The term "release" is directly from the ABCD study's data release site and information site at abcdstudy.org. The current release included data from the entire cohort from baseline, two-year follow-up, and 4-year follow-up for study participants.

Garavan et al. (2018) reported that sampling included public, private, and charter schools, with supplementation through referrals from participant families. Within the study, a population-based sample procedure was employed with a multi-stage probability approach. Sampling targets were developed using demographic data (e.g., gender, age, ethnicity/race, socioeconomic and urbanicity) from school enrollment data from the National Center of Education Statistics and the American Community Survey. The sampling procedures aimed to include a group of participants that reflect the ethnic/racial and socioeconomic diversity of the U.S. (Garavan et al., 2018). Garavan et al. (2018) and Volkow et al. (2018) offered a detailed review of participant recruiting, design, and procedures for the ABCD study.

Study Procedures

This study is based on archival data from the ABCD study. The ABCD study is an ongoing, longitudinal study designed to assess the brain development of 11,874 adolescents aged 9 to 10 years. The study funded by the National Institutes of Health (NIH), will track adolescents' behavioral and biological development for 9-10 years into early adulthood (Barch et al., 2018). A request for access to curated ABCD study data was submitted to and approved by the U.S. National Institute of Mental Health (NIMH) (https://nda.nih.gov/abcd). Data used in this study was downloaded from the most current data 5.1 release. The inclusion criteria included archived data of female and male

adolescents having WM, anxiety, and NDD measures for ADHD and ASD diagnoses. The G* Power calculation indicate the target sample size for this study was 128 participants for a power of .80 and medium effect size.

Instrumentation And Measurement

Measurements

The archived data from the ABCD Study included a battery of assessments completed by the participants. This study utilized measures from the National Institute of Health Toolbox (NIH-TB), specifically the List Sort Working Memory measure to assess WM, the GAD-7 measure for assessing generalized anxiety disorder (GAD), the Kiddie Schedule for Affective Disorders and Schizophrenia for DSM-5 (KSADS-5) for assessing attention deficit hyperactivity disorder (ADHD) and parent report of their adolescent's diagnosis for Autism Spectrum Disorder (ASD).

NIH Toolbox - List Sorting Working Memory Test

The List Sorting Working Memory Test assesses WM as a component of the NIH Toolbox Cognition Battery. The test includes sequencing tasks that require children and adults to sort and sequence stimuli presented auditorily and visually. The List sort test has been found to have construct validity as a measure of WM and has high correlations with other WM measures (convergent validity). The List Sort test has excellent test and re-test reliability and confirmed expected changes over the lifespan (Thompson et al., 2019; Tulsky et al., 2014). According to Tulsky et al. (2013), participants are presented with computerized, illustrated pictures depicting an item and its auditory name for two seconds. Participants are asked to remember the stimuli and then verbally repeat from smallest to largest. Repeated series increase in items and thus taxing the participant's

WM system when asked to remember longer sequences (Tulsky et al., 2013). Casaletto et al. (2015) informed that to increase clinical interpretation of the LSWMT, cut-points were calculated at one standard deviation below the mean (T <40) to denote WM "impairment" across the fully corrected scores.

Kiddie Schedule For Affective Disorders And Schizophrenia For DSM-5

The KSADS has an extensive history as a valid and reliable measure of psychopathology in children and adolescents, including mood, psychotic, anxiety, and disruptive behaviors (Chambers et al., 1985; Kaufman et al., 1997, 2000; Orvaschel et al., 1982). Interrater reliability ranged from 93% to 100% and test-retest reliability is good to excellent for most present and lifetime diagnoses (.77 to 1.00). With regard to ADHD and Post-Traumatic Stress Disorder diagnosis, reliability was good, ranging from .63-.67 (Kaufman et al., 1997).

According to Kaufman et al. (2013) and Townsend et al. (2020), updates made to the KSADS in 2013 included DSM-5 diagnoses and the creation of three web-based computerized assessments, two self-administered versions (parent and youth) and a clinical professional version. The pen and pencil version was converted to computerized assessments of the DSM-5 for 26 diagnoses including ADHD, ASD, other neurodevelopmental disorders, GAD, other mood, anxiety, eating disorders, and psychotic disorders. Specific to the ABCD study, Barch et al. (2018) reported several changes to the KSADS-5 computerized versions (KSADS-COMP) including the wording of some items, tailoring of algorithms to allow for the past 12-months diagnosis, and modularization of components. Spanish translation was also completed to support the ABCD study (Barch et al., 2018). Townsend et al. (2020) reported that the diagnoses

generated by the three KSADS-COMP versions showed good congruent validity when compared with established clinical rating scales. The two self-administered (parent and youth) versions demonstrated good to excellent concordance with the clinician-administered version (0.89–1.00) (Townsend et al., 2020).

Operationalization Of Variables

Anxiety. This variable is a categorical variable and measured by KSADS-COMP Generalized Anxiety Disorder (GAD) score on the 7-item GAD-7 youth report instrument (Townsend et al., 2020).

Working Memory. Variable two is a continuous variable measured by the List Sort Working Memory Test (LSWMT; Tulsky et al., 2014).

Neurodevelopmental Disorder. The third variable is a categorical variable measured by the KSADS-COMP for ADHD and parent report of ASD.

Data Analysis

This study uses IBM SPSS Statistics v.29 to perform data analysis. Descriptive analysis was performed to generate descriptive statistics for all variables. Prior to examining relationships between variables, a test for assumption of normality was conducted, which determined non-parametric testing would be appropriate. Additionally, a Mann-Whitney U Test, Chi-Square Test of Independence, and Kendall's Tau-b correlations analysis was performed. The null hypotheses were tested utilizing alpha of .05. The variables to be evaluated were WM, anxiety, and NDD diagnosis. The sample size for this study is 11,400 participants. Similar to this study, Doering et al. (2021, 2022) studies were longitudinal and had a large sample size comprising 4492 and 4497 participants, respectively.

Delimitations, Assumptions, And Limitations

Delimitations

This study is limited to adolescent participants, in the ABCD study cohort. This study is also limited to adolescents in the United States. Although the ABCD study's assessment protocol was inclusive of physical, social, emotional, cognitive, substance use, academic, neuroimaging, and biospecimen collection, this study analyzed specific measures related to anxiety, WM, and NDDs.

Assumptions

A key assumption of the study was that access to the ABCD study archival data would be granted. Data analysis would include measures collected at baseline (ages nine - 10), year two (ages 11-12), and year four (ages 13-14). Thus, there was an assumption that archival data existed for participants for at least two collection points to allow for an adequate sample size and assessment results.

Limitations

There were several potential limitations and challenges considered. First, the methodology is quantitative, which according to J. W. Creswell (2013), topics are described statistically, theories tested, and generalizations are made. This contrasts with qualitative studies which provide the participant's experiences, explore phenomena, or develop theories (Creswell, 2013). This study also included a correlational research design, which according to Curtis et al. (2016), does not establish causal relations between variables but instead seeks to determine whether there is a relationship between two or more variables (Curtis et al., 2016; Martin, 2012).

Another limitation was that the List Sorting Working Memory Test is different from a single modality measure used frequently to evaluate the cognition of the visual-spatial sketchpad (e.g., visual) or phonological loop (e.g., auditory) subsystems that contribute to the working memory process (Tulsky et al., 2013). However, Tulsky et al. (2013) favor the LSWMT, explaining the subsystems distinction (e.g., visuospatial and phonological loop) is less important than the assessment of cognitive function over the human lifespan. A potential limitation regarding the generalization of study results beyond the U.S. exist. The research team responsible for developing the population criteria for the ABCD study aimed to align the demographics with that of an existing population-based, selecting participants from 21 sites in the U.S. (Garavan et al., 2018; Heeringa & Berglund, 2020).

The bulk of the work on the MDM has been cross-sectional. Hence, an ongoing limitation of the multiple deficit model is that it is unclear whether the associations between symptoms and cognitive deficits are bi-directional, causal, consequence, or attributable to third variables. Caution is recommended in assuming NDDs are static across ages, and further research is suggested to consider the MDM framework trajectory over time (McGrath et al., 2020).

Summary

The intent of this quantitative, correlational study was to examine the relationships between WM and anxiety among adolescents leveraging archival data from a large cohort from the ABCD study. The study's aim was to determine whether there is a higher incidence of WM deficits and anxiety in adolescents with NDDs when compared to adolescents without an NDD diagnosis. This chapter included the methodology

inclusive of research questions, hypotheses, operationalized variables, and research design. The participants, study procedures, and data analysis were outlined. Finally, delimitations, assumptions, and various limitations of the study were discussed.

CHAPTER 4: RESULTS

Overview

The purpose of this quantitative study was to explore relationships between WM, anxiety and NDDs. The study began with a literature review describing the impact of WM deficits and anxiety on the academic and workplace success, career progression, other mental health issues, and real-life adversities. Prior research supports a link between WM deficits and anxiety; however, the literature review identified a gap in studies involving the adolescent population. Further, a gap in adolescent anxiety research overall was identified during the literature review. This chapter discusses research components presented in earlier chapters regarding the research questions and the hypotheses. A discussion on the measures used, sample demographics, data analysis, findings, a summary of results, and a research design evaluation is included.

Research Questions And Hypotheses

RQ1: What is the difference in WM deficits between adolescents with NDDs and typically developing adolescents?

Hypothesis 1: Adolescents with WM deficits will not have a higher incidence of NDDs than typically developing adolescents.

RQ2: What is the difference in anxiety between adolescents with NDDs and typically developing adolescents?

Hypothesis 2: Adolescents with high anxiety measures will not have a higher incidence of NDDs than typically developing adolescents.

RQ3: What is the relationship between WM deficits, anxiety, and NDDs in adolescents?

Hypothesis 3: There is not a significant correlation between WM deficits and anxiety, but there is a significant correlation between anxiety and neurodevelopmental disorders.

Descriptive Results

Data Screening

Archived data used for analysis was provided by the NIMH in the form of multiple large excel files with results from their initial screening, mental health and cognitive assessments. Longitudinal data for four years was available for analysis. Preliminary actions were required to extract and combine only the data relevant to the variables for this study, anxiety, WM and NDDs. Although the original dataset contained a sample of 11,861 subjects, 461 subjects were missing assessment scores for WM. Therefore, the new combined excel file included 11,400 for analysis. The combined excel file was imported into IBM SPSS (Version 29) for analysis. Descriptive statistics was run to check for missing values and no missing values were found. A G* Power calculation indicated a target sample sized for this study was 128 participants, for a power of .80, and a medium effect size. The sample size requirement for this study was met for this study.

Table 1.

Descriptive Statistics Show No Missing Values

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Generalized Anxiety Disorder Diagnosis	11400	0	1	.07	.257
Neurodevelopmental Disorder Diagnosis	11400	0	1	.24	.428
Working Memory Fully-Corrected T-score	11400	9	108	48.13	9.645
Valid N (listwise)	11400				

Frequency distributions (Table 1) were conducted for adolescents' sex and the presence of an NDD or GAD diagnosis. Similar to findings by Heeringa and Berglund (2020), males made up 52.00% (*N* = 5933) of the sample subset and females 47.90% (*N*= 5464). Adolescents without an NDD diagnosis accounted for 75.80% (N = 8644), while 24.20% (N = 2756) had a confirmed diagnosis of an NDD. Regarding generalized anxiety disorder (GAD), the frequency distribution revealed that 92.90% (N = 10592) of adolescents assessed did not have a diagnosis for GAD, while 7.10% (N = 808) were confirmed as having a GAD diagnosis.

Table 2.

Distribution of Participants Sex and Diagnosis (N=11,400)

	Frequency	Percent	Cumulative Percent
Male	5933	52	52
Female	5464	47.9	100
Typically developing adolescent	8644	75.8	75.8
Adolescent with NDD	2756	24.2	100.0
No GAD Present	10592	92.9	92.9
GAD Present	808	7.1	100.0

Descriptive statistics for the working memory scale are presented in Figure 2. The overall mean score was 48.13 (*SD* = 9.645). The minimum and maximum scores of 9 to 108, have a range of 99, which suggests the potential for outliers. Further, skewness (0.385) is not equal to zero, and kurtosis (0.396) is not equal to three, suggesting the data is not normally distributed.

Figure 2.

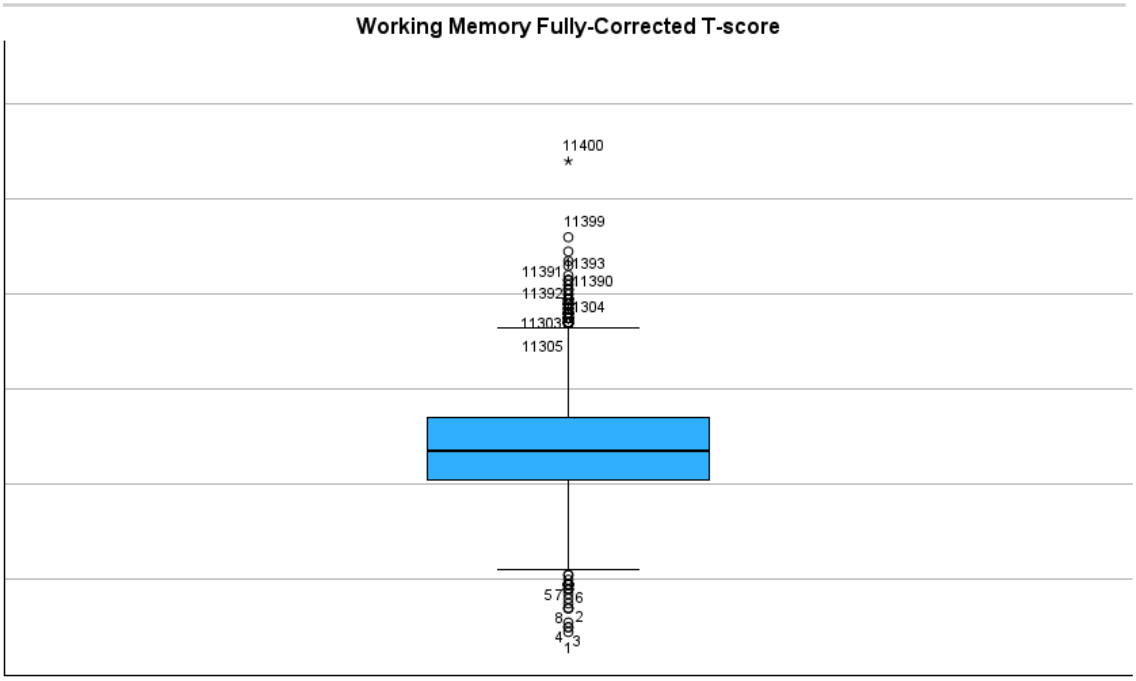
Descriptive Statistics for Working Memory (N=11,400)

NIH Toolbox List Sorting Working Memory						Skewness		Kurtosis	
	Range	Minimum	Maximum	Mean	Std. Deviation	Statistic	Std. Error	Statistic	Std. Error
	99	9	108	48.13	9.645	0.385	0.023	0.396	0.046

To further explore outliers, descriptive statistics explore was used to create a boxplot found in Figure 3. Outliers are displayed below the whiskers (bottom 25% WM scores) and above the whiskers (top 75% WM scores). The outliers are represented with a circle and not an asterisk, thus the outliers are not extreme. Considering the WM scores are fully-corrected T-scores within the original dataset, the scores are assumed legitimate and valid scores for the. Domański (2020) noted that outliers suggested as legitimate should be included in the study. However, the outliers further point to concerns with normality and the potential requirement for non-parametric analysis.

Figure 3.

Boxplot Showing Outliers for Working Memory Fully-Corrected T-scores



Study Findings

Hypothesis One

The research question addressed was this:

RQ1: What is the difference in WM deficits between adolescents with NDDs and typically developing adolescents?

Ho1: Adolescents with WM deficits will not have a higher incidence of NDDs than typically developing adolescents.

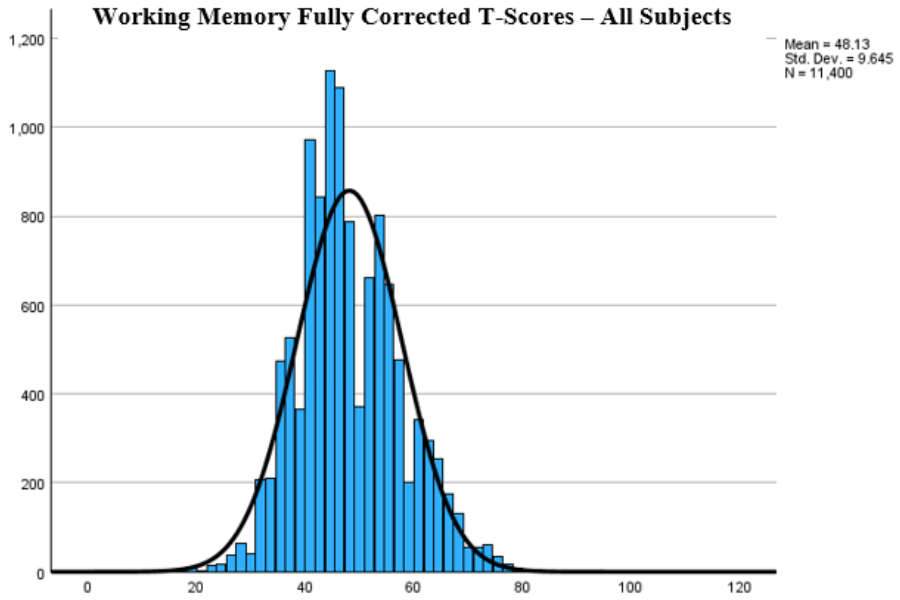
Ha1: Adolescents with WM deficits will have a higher incidence of NDDs than typically developing adolescents.

Assumption Of Normality

Considering the concerns with skewness, kurtosis, and outliers noted in the descriptive statistics, the WM data was tested for the assumption of normality of distribution using histogram and Kolmogorov-Smirnov test. Visual inspection of histograms in Figure 4 confirmed the data is not normally distributed.

Figure 4.

Working Memory Histogram Indicating Lack of Normally Distribution



The null hypothesis for the Kolmogorov-Smirnov test is that the data is distributed normally (Khatun, 2021). Table 3 displays Kolmogorov-Smirnov test results for the WM fully corrected T-scores. The results indicate the data does not follow a normal distribution, D(11,400) = .074, p = <.001. Therefore, the null hypothesis is rejected. Demir (2022) reported normality tests are affected by sample sizes and frequently give results that are significant. For large samples sizes, such as this study, it was suggested to use the skewness and kurtosis, reported earlier, or the histograms to determine normality. In this study, the skewness and kurtosis, the histogram and the

Kolmogorov-Smirnov test are aligned that the null hypothesis should be rejected. Consequential, non-parametric testing was performed.

Table 3.

Kolmogorov-Smirnov Test of Normality Indicates Significance

Tests of Normality

	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Working Memory Fully Corrected T-score	.074	11400	<.001

a. Lilliefors Significance Correction

Data Analysis

The Mann-Whitney U test, a non-parametric test, was used to test Ho1, *Adolescents with WM deficits will have a higher incidence of NDDs than typically developing adolescents.* The Mann-Whitney U test, also known as the Wilcoxon test for independent samples, is an alternative to the parametric, independent samples t-test and can effectively assess the differences between two groups by comparing their means to see how they relate, without assuming a normal distribution (Wall Emerson, 2023). Effect sizes for the Mann-Whitney U test are small effect if <.03, medium effect if between .03 and .05 and large effect if greater than 0.5.

The Mann-Whitney U test was used to evaluate the differences in WM deficits between adolescents with NDD (N = 2756) and typically developing adolescents (N = 8644). The test results showed a statistically significant difference between the adolescent groups in WM deficit, with U = 11400, z = -11.87, p < .001. See Table 4. Utilizing z in Table 5, the effect size was computed as r = -.11 (z/sq root of N), which is a small effect size. The null hypothesis is rejected, indicating there is a higher incidence of WM deficits

in the group diagnosed with a NDD. Figure 5 also shows that the WM deficit are more pronounced in the NDD group than in the typically developing group.

Table 4.

Mann-Whitney U Test Show Difference Between The NDD Groups

Independent-Samples Mann-Whitney U Test Summary	
Total N	11400
Mann-Whitney U	10127150.000
Wilcoxon W	13926296.000
Test Statistic	10127150.000
Standard Error	150355.780
Standardized Test Statistic	-11.867
Asymptotic Sig.(2-sided test)	<.001

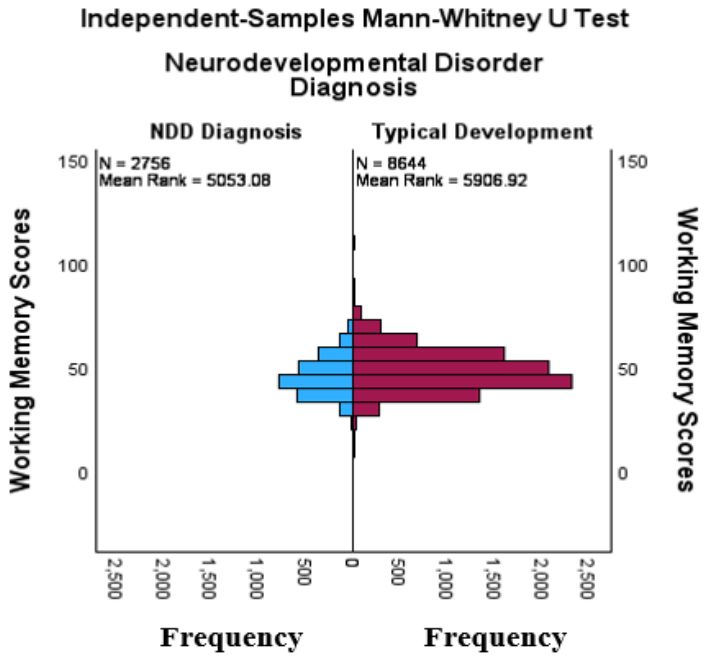
Table 5.

Mann-Whitney U Standardized Test Statistic of Z

Test Statistics	
	Working Memory Scores
Mann-Whitney U	10127150.000
Wilcoxon W	13926296.000
Z	-11.867
Asymp. Sig. (2-tailed)	<.001
a. Grouping Variable: NDD Diagnosis	

Figure 5.

Mann-Whitney U Test Showing More Pronounced WM deficits in NDD Group



Hypothesis Two

This section discussed analysis related to RQ2: *What is the difference in anxiety between adolescents with NDDs and typically developing adolescents?*

Ho2: Adolescents with higher anxiety measures will not have a higher incidence of NDDs than typically developing adolescents.

Ha2: Adolescents with high anxiety measures will have a higher incidence of NDDs than typically developing adolescents.

Assumptions Testing For Chi-Square Test Of Independence

Chi-Square test of independence, another non-parametric tests, was conducted to compare whether there was a difference in GAD between adolescents with NDDs and typically developing adolescents. The assumptions of chi-square test of independence are

(1) that each participant contributes to only one category and (2) minimum size of 5 is the expected frequency for all categories (Willard, 2020). IBM SPSS automatically test for these assumptions when the test is performed. In Chi-Square tests, Cramer's V may be used to determine effect size where small effect is 0.1, medium is 0.3, and larger effect is 0.5.

Data Analysis

The anxiety variable refers to an adolescent's General Anxiety Disorder (GAD) diagnosis, whose status was determined based on whether they had been previously or were currently diagnosed with GAD. A GAD diagnosis represent as clinical or higher measures of anxiety and it is a categorical variable (present or not present). Table 6 and Figure 6 displays observed frequencies and crosstabulation between NDD and GAD diagnoses among the adolescents. The results suggest that the likelihood of experiencing GAD differs between those with NDD and those without a NDD diagnosis as most of the GAD diagnoses were associated with the smaller NDD group.

Table 6.

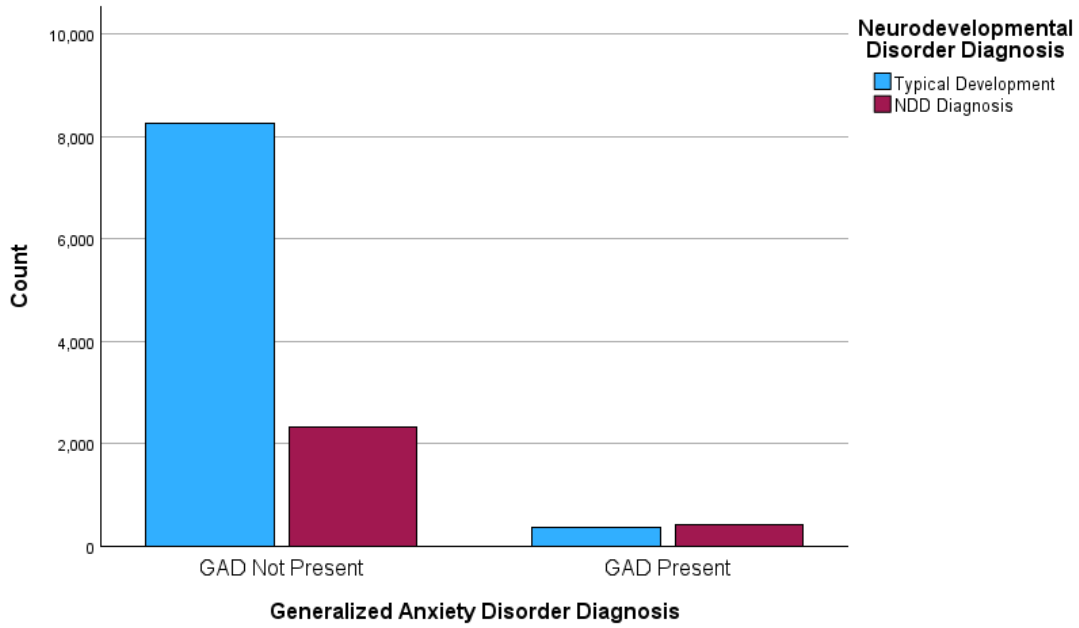
Observed Frequencies and Percentages of NDD and GAD (N = 11400)

GAD Diagnosis * NDD Crosstabulation

		NDDs					
		Typical Development		NDD Diagnosis		Total	
		N	%	N	%	N	%
GAD Diagnosis	GAD Not Present	8268	95.7%	2324	84.3%	10592	92.9%
	GAD Present	376	4.3%	432	15.7%	808	7.1%
Total		8644	100.0%	2756	100.0%	11400	100.0%

Figure 6.

Crosstabulation of GAD and NDD Diagnosed and Typical Adolescents



The Chi-Square test of independence results (Table 7) showed a statistically significant difference in the prevalence of GAD between adolescents with NDD and typically developing adolescents, $X^2(1) = 407.00$, $p = < .001$, with a small effect size (Cramer's *V = .19)*. The null hypothesis is rejected. The results suggest that the likelihood of experiencing GAD differs significantly between those with NDD and those without NDD, with the NDD group having a higher incidence of a GAD diagnosis. However, the Phi coefficient score in Table 8 is .19, which indicated a relatively weak association between NDD and GAD. This suggests that having an NDD increases the likelihood of experiencing GAD but only to a small extent.

Table 7.

Chi-Square Difference Between NDD-Diagnosed and Typical Adolescents.

Chi-Square Tests					
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	406.996[a]	1	<.001		
Continuity Correction[b]	405.278	1	<.001		
Likelihood Ratio	348.095	1	<.001		
Fisher's Exact Test				<.001	<.001
Linear-by-Linear Association	406.960	1	<.001		
N of Valid Cases	11400				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 195.34.

b. Computed only for 2x2 table

Table 8.

Phi Coefficient Suggests a Weak Association Between NDD and GAD

Symmetric Measures			
		Value	Approximate Significance
Nominal by Nominal	Phi	.189	<.001
	Cramer's V	.189	<.001
N of Valid Cases		11400	

Hypothesis Three

Next, the discussion focuses on RQ3: *What is the relationship between WM deficits, anxiety, and NDDs in adolescents?*

Ho3a: There is not a significant correlation between WM deficits and anxiety.

Ha3a: There is a significant correlation between WM deficits and anxiety.

Ho3b: There is not a significant correlation between anxiety and NDDs.

Ha3b: There is a significant correlation between anxiety and NDDs.

Assumptions Testing For Kendall's Correlation

Earlier it was discussed that the Kolmogorov-Smirnov test demonstrated that WM scores did not meet the assumption of a normal distribution, Accordingly, the reseacher employed Kendall's Tau-b to determine correlations. According to Robitzsch (2020) and de Raadt et al. (2021), Kendall's Tau-b is a non-parametric test used when ordinal (categorical) or continuous variables exist. The Mann-Whitney U independent samples test was performed to determine if variables met the continuous and ordinal assumption. Figures 7, 8, and 9 confirmed the variable assumptions are met.

Figure 7.

Mann-Whitney U Test Displaying WM Scores as a Continuous Variable

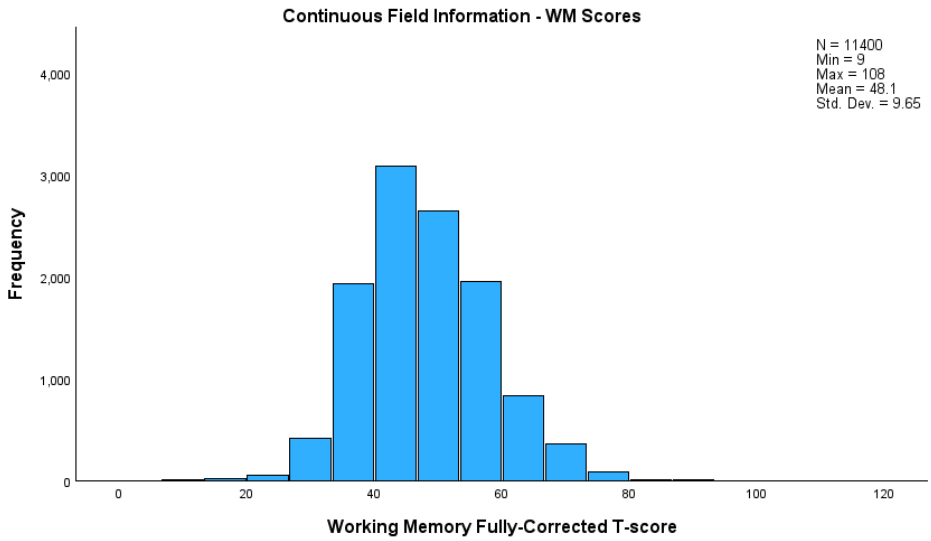


Figure 8.

Mann-Whitney U Test Showing NDD as a Categorical (ordinal) Variable

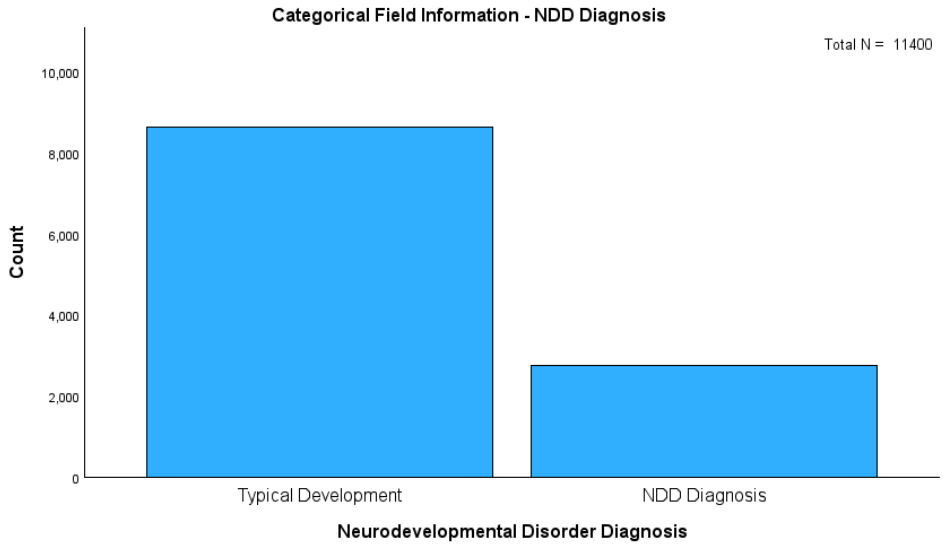
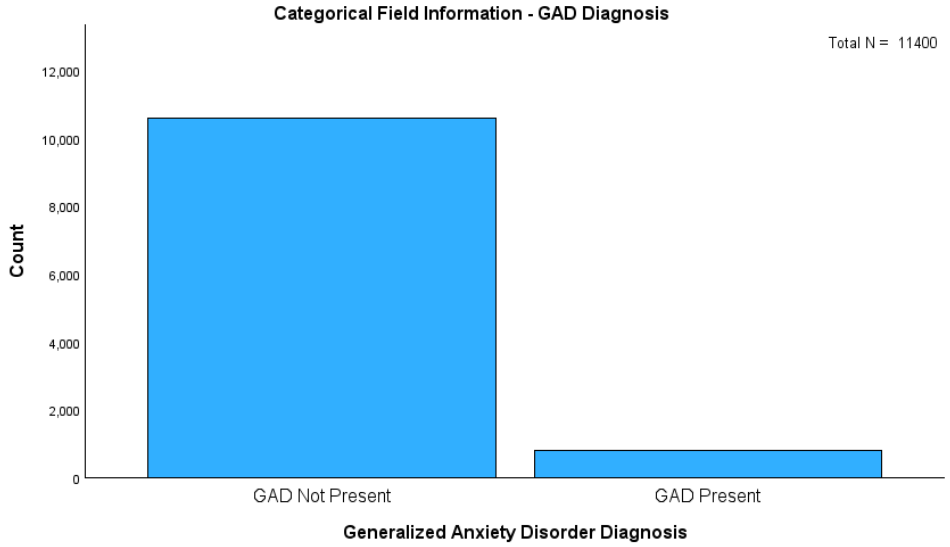


Figure 9.

Mann-Whitney U Showing GAD s As a Categorical (Ordinal) Variable



The second assumption inquires whether there is a monotonic relationship (autocorrelation) between the variables. According to Hamed (2009), running the Kendall's Tau-b correlation test informs on the presence of a monotonic relationship. If a

monotonic relationship exists, Schober et al. (2018) noted that as one variable increases the other variable increases or when a variable increases the other decreases. Schober et al. (2018) suggests interpreting monotonic relationships as -1, 0 and, +1 where -1 is a perfect negative monotonic relationship, 0 indicates no monotonic relationship, and +1 denotes a perfect positive monotonic relationship. Ferguson (2009) recommended effect sizes for determining strength of association when working with social science data where a minimum effect is .2, a moderate effect is .5, and a strong effect is =.8.

Data Analysis

Relationship Between WM Deficits And GAD

Kendall's Tau-b correlation was conducted to explore relationships between WM deficits and GAD. The results of Kendall's Tau-b correlation revealed a statistically significant but negligible and negative correlation between WM and GAD, τ_b (11400) = .-.020, p = < .011, therefore rejecting the null hypothesis that there is not a significant correlation between WM and anxiety. Although the results in Table 9 confirms an association, the correlation coefficient (<0.2) suggests a negligible, but minimum association. However, the results suggest that an increase in WM scores there is a tendency for a decrease a GAD diagnosis (Figure 10) and the reverse is so, which supports the assumption of a monotonic relationship.

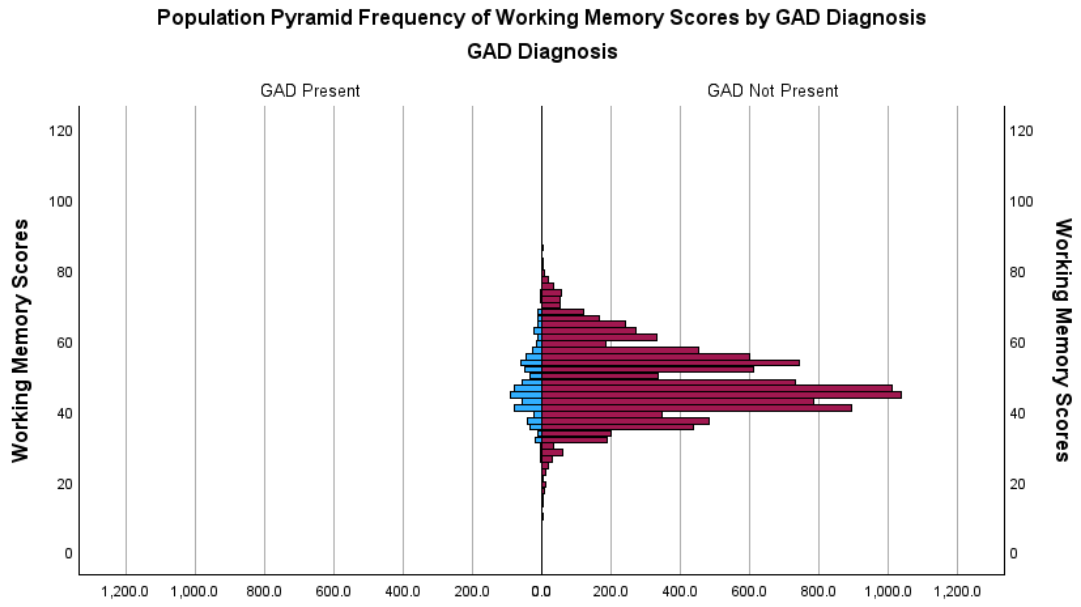
Table 9.

Correlation Matrix Between Working Memory and GAD (N = 11400)

Correlations				
			GAD Diagnosis	Working Memory Scores
Kendall's tau_b	GAD Diagnosis	Correlation Coefficient	1.000	-.020*
		Sig. (2-tailed)	.	.011
		N	11400	11400
	Working Memory Scores	Correlation Coefficient	-.020*	1.000
		Sig. (2-tailed)	.011	.
		N	11400	11400
*. Correlation is significant at the 0.05 level (2-tailed).				

Figure 10.

Higher Working Memory Scores Indicate Lower GAD Diagnosis



Relationship Between GAD And NDDs

To analyze the relationship between GAD and NDDs, a correlation test was conducted. The result of the Kendall's tau-b correlation revealed a statistically significant correlation between GAD and NDD, τ_b (11400) = .19, $p < .001$, therefore the null hypothesis is rejected as there is a statistically significant correlation exists between GAD and NDD. The correlation coefficient in Table 10 suggests a minimum association between GAD and NDD. This finding indicates a likelihood for a GAD diagnosis to correlate with the presence of an NDD (Figure 10). However, the minimum association indicates that a GAD diagnosis does not strongly predict the presence of a NDD.

Table 10.

Correlation Matrix Between GAD and NDD For Sample (N =11400)

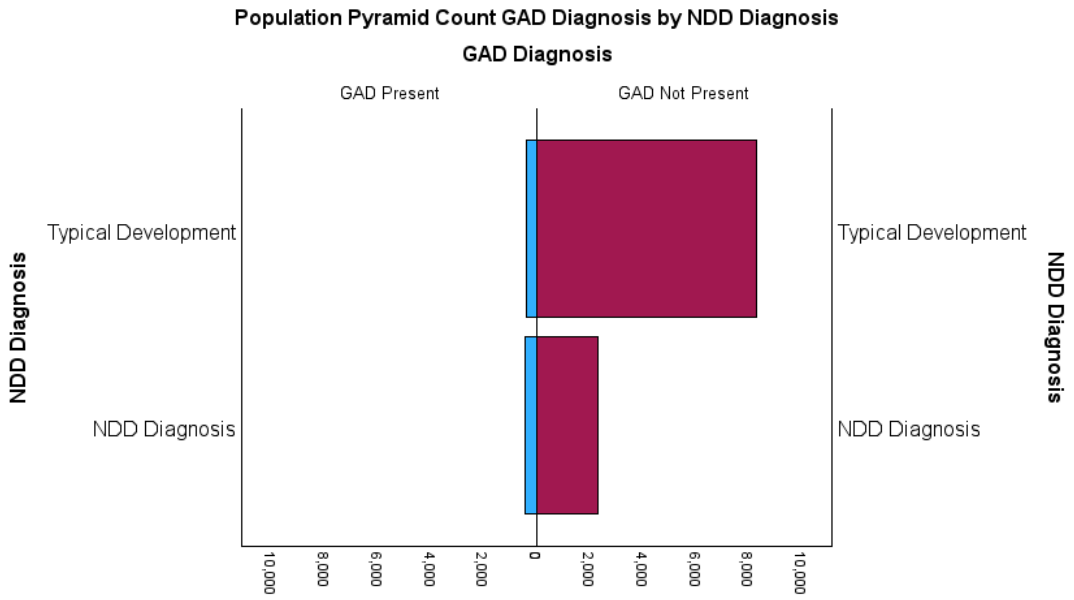
Correlations

			NDD Diagnosis	GAD Diagnosis
Kendall's tau_b	NDD Diagnosis	Correlation Coefficient	1.000	.189**
		Sig. (2-tailed)	.	<.001
		N	11400	11400
	GAD Diagnosis	Correlation Coefficient	.189**	1.000
		Sig. (2-tailed)	<.001	.
		N	11400	11400

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

Figure 11.

Displays an Increase in GAD Diagnosis When an NDD is Present



Summary

There is limited research relating to adolescent anxiety and working memory and few studies with large sample sizes and a longitudinal design. The purpose of this study was to examine the relationship between WM and GAD. The study also sought to discover if there were relationships between NDDs and WM and GAD. An independent samples test was performed to explore the difference between WM deficits among adolescents with and without an NDD diagnosis. The results demonstrated a statistically significant difference between the groups in WM deficits, $U = 11400$, $z = -11.87$, $p < .001$, with a small effect size.

To examine whether there is a difference between anxiety and NDD and typically developing groups, a test of independence was performed. The results showed a statistically significant difference in the prevalence of GAD between the groups, $X^2(1) =$

407.00, p = < .001, with a small effect size. The final analysis was to investigate what relationships exist between WM deficits and anxiety and what relationships exist between anxiety and NDDs. The results revealed a statistically significant correlation between WM and GAD, τ_b (11400) = .-.020, p = < .011, with a minimum association. The results suggest that with an increase in WM scores, GAD diagnosis tends to decrease, and the reverse when there are lower WM scores. Further, the results indicated that a statistically significant correlation exist between GAD and NDDs, τ_b (11400) = .19, p < .001, with a minimum association. The findings indicated a likelihood for a GAD diagnosis to correlate with a presence of a NDD, however, a GAD diagnosis does not strongly predict an NDD.

CHAPTER 5: DISCUSSION

Overview

The purpose of the quantitative correlational study was to examine relationships between adolescents working memory (WM), anxiety, and neurodevelopmental disorders (NDDs). The participants for the study were from the ABCD study adolescent cohort. This study examined participants' scores for working memory and participants' past and present diagnosis of generalized anxiety disorder and a neurodevelopmental disorder (ADHD or ASD). In this chapter a summary of findings from the data analysis is presented. A discussion of findings illuminated significant results, followed by contributions to theoretical constructs, a biblical foundation, and key take-a-ways from the study.

Summary Of Findings

The study sought to understand the difference between WM deficits among adolescents with a NDD and a non-NDD group. Hypothesis 1 indicated adolescents with WM deficits will have a higher incidence of NDDs than the typically developing adolescents, the non-NDD group. Results indicated a statistically significant difference between the NDD and non-NDD groups and indicates that WM deficits were more observable in the NDD group. A correlation analysis also found a statistically significant result, suggesting WM deficits are likely to correlate with the presence of an NDD. Results confirmed a significant increased occurrence in working memory deficits among the group of adolescents diagnosed with neurodevelopmental disorder (NDD).

Another goal of the study was to determine what, if any, difference exists in anxiety between adolescents with NDDs and typically developing adolescents?

Hypothesis 2 predicted adolescents with high anxiety measures would have a higher incidence of NDDs than typically developing adolescents. Results showed a significant correlation between generalized anxiety disorder (GAD) and the presence of an NDD. The results suggested that adolescents diagnosed with an NDD has an increased likelihood of having a GAD diagnosis, but only to a small extent as indicated by the Phi coefficient of .19, which suggests a weak association between NDD and GAD.

The final goal of the study was to examine relationships between WM deficits, anxiety, and NDDs in adolescents? Hypothesis 3 expected to find a significant correlation between WM deficits and anxiety, but not a significant correlation between anxiety disorder and neurodevelopmental disorder. Results showed a significant correlation indicating that WM deficits are relational to anxiety, albeit negligible, which suggest that WM deficits do not strongly predict GAD and there could be other factors involved in GAD diagnosis among the adolescent cohort. Regarding a correlation between anxiety and an NDD, counter to the hypothesis, a statistically significant correlation was found, thus supporting the null hypotheses. However, observed frequencies of the cohort showed 47.00% of adolescents diagnosed with GAD did not have a NDD diagnosis, which further suggests other factors at play for adolescents with GAD.

Discussion Of Findings

The adolescent and emerging adult periods coincide with elevated risks for psychopathology (Pozzi et al., 2021). This study included archived data from a cohort of adolescents from the ABCD study. The literature review pointed to the comorbid nature of anxiety, WM, and NDDs. Hansen et al. (2018) noted that anxiety is the most frequent comorbid condition across individuals with ASD and ADHD. Kofler et al. (2019) found

that 62% of youth with ADHD presented with WM deficits. While Tajik-Parvinchi et al. (2021) reported a link between NDDs, WM and anxiety. The results of the current study of the adolescent cohort found alignment with prior research noted above, indicating support for the comorbidity nature of NDDs, WM, and anxiety.

Working memory (WM) is a core component of executive function (EF) which governs an individual's top-down cognitive processing and facilitate goal-directed behavior (Diamond, 2013; Tajik-Parvinchi et al., 2021). The researcher examined Strong's Concordance reference to memory earlier, which is today as it was thousands of years ago, to remember or remembrance. Researchers Baddeley and Hitch's (1974) theory described WM as temporarily retaining and manipulating information for further action, such keeping two numbers in mind and subtracting one from the other (Zelazo, 2020). Impairments in WM have been found in individuals with ASD, ADHD, and GAD (Hasslinger et al., 2022; Lisica et al., 2022; Rabiee et al., 2020). The current study examined a large sample of adolescents with and without an NDD for differences in WM deficits. The expectation was the WM deficits would not have a higher occurrence in the NDD group. The study found statistically significant differences, noting more pronounced WM deficits in the NDD diagnosed group. The study also examined relationships between WM deficits and anxiety between groups, expecting not to find a correlations between WM deficits and anxiety. The study found a statistically significant correlation, indicating that as WM scores decreased, there was a tendency for an increase in a GAD diagnosis, and the reverse. This study adds to Baddeley and Hitch's (1974) theory of working memory by demonstrating the negative implications of NDDs and

anxiety as they relate to WM and how WM impairments might influence anxiety symptoms in an adolescent population.

This study examined relationships between WM and anxiety and between anxiety and NDDs. A theory related to both WM and anxiety is the Attention Control Theory (ACT). The theory was put forth by Eysenck et al. (2007), is an integration of the WM model of Baddeley and Hitch (1974) and the Processing Efficiency Theory (PET) of anxiety and performance by Eysenck and Calvo (1992). The ACT posits that a deficit in attention control is key to developing anxiety symptoms (Eysenck & Calvo, 1992; Eysenck et al., 2007). More specifically, ACT suggested that the central executive, an attention-like, limited capacity component of the Baddeley and Hitch (1974) WM model, is impaired by anxiety. The Strong' Concordance, defined anxiety as "to be anxious or concerned, to fear" or "anxious care" or promerimnaó, which is to be to be anxious beforehand. The definition is quite similar to how the APA (2022) characterize anxiety today, "excessive fear, worry, and panic that occur in the absence of a real threat" (p. 215).

Exploring the relationship between WM and anxiety, constructs related to the ACT model, the expectation is that a significant correlation would not be found. A statistically significant, but negligible and negative relationship was found. Hirsch and Mathews' (2012) cognitive model and Eysenck and Derakshan's (2011) ACT both conjectured that impaired executive function (of which WM is a component) and other cognitive components are linked to excessive and unmanageable worry, which is a core feature of the GAD. This study results alignment with the more recent ACT theory in its finding of a statistically significant, minimum relationship between WM deficits and

GAD, which indicated lower WM scores coincided with an increase in GAD diagnosis, and vice-versa.

The current study also looked at neurodevelopmental disorder and in relation to WM and anxiety. The research of Golshan et al. (2019) and Kofler et al. (2018) research reported findings of WM challenges in ADHD and ASD conditions. Astle et al. (2022) reported that NDDs often have co-occurring diagnosis, such as the co-occurrence of ADHD and ASD, which co-occurs in 30% - 70% of individuals with an ASD diagnosis. In the current study, we examined the NDDs ADHD and Autism due to the increased rate of co-occurrence. Although co-occurrence was not examined, the study investigated the difference in WM deficits between adolescents with and without an NDD. The expectation was that WM deficits would not be higher in the NDD group. Instead, the results were statistically significant and were aligned with Golshan et al. (2019) and Kofler et al. (2018) showing the WM deficits were more pronounced in the NDD group than the typically developing adolescents.

Doering et al. (2022) noted that an individual's anxiety symptoms and academic achievements are affected by the presence of an NDDs and that the presence of a NDDs during childhood predicts anxiety in adolescent years. Hansen et al. (2018) reported anxiety as the most frequently co-occurring comorbidity across ADHD and ASD. The current study did not specifically look at childhood anxiety, rather the study sought to understand the differences in anxiety between adolescents with and without a NDD. The researcher expected that adolescents with higher levels of anxiety would not have a higher incidence of NDD diagnosis. However, the results showed a statistically

significant difference between the adolescent groups, suggesting that having a NDD increases the chances of experiencing anxiety.

The results of this study are supportive of Pennington's (2006) Multiple Deficit Model (MDM), which is a multi-level framework for understanding NDDs inclusive of etiology, brain mechanisms, behavioral symptoms, and neuropsychology (McGrath et al., 2020). The tenets of the MDM are that multiple probable risk factors contribute to NDDs and that shared risk factors contribute to comorbidity. The tenets multiple potential risk factors and shared risk factors are confirmed in the works of researchers Doering et al. (2022) and the APA (2022) which informs that NDD comorbidity includes intellectual and learning disabilities, ASD, ADHD, communication disorders, motor disorders and other cognitive disorders. This study investigated a relationship between NDDs and anxiety, hypothesizing there is not a significant correlation. The results found a statistically significant, minimum association between anxiety and NDDs, indicating that the likelihood of a GAD diagnosis correlates with the presence of an NDD. However, the minimum association suggests a GAD diagnosis does not strongly predict the presence of an NDD. Related to difference between the NDD and non-NDD group, the research predicted that adolescents with WM deficits would not have a higher incidence of NDDs. The results showed that WM deficits were more pronounced in the NDD group than the non-NDD group. he results described above confirms the comorbidity of NDDs with anxiety and NDDs with. The results align with the comorbidity aspect of the MDM.

The scripture instructs us to be kind and have compassion of one another (Ephesians 4:32); there is also a blessing in finding wisdom and gaining understanding (Proverbs 3:13). Some adolescents are at an increased risk comorbid symptoms when a

NDD is present according to Tajik-Parvinchi et al. (2021), Through wisdom and understanding, as written in Proverbs 3:13, caregivers we can educate themselves and work with professionals to develop a course of treatment for their adolescent. Proverbs 14-18 noted that caregiver wisdom and understanding can potentially bring profitability, long life, riches and honor, and peace to their adolescent. For individuals challenged with NDDs, anxiety, WM and other cognitive and mental health issues, comfort and encouragement are offered in Deuteronomy 31:8, which is a reminder that God is with us, will never forsake us, and that we are not to be afraid or discouraged. Chapter 2 also discussed the movement of neurodiversity, an optimistic and forward approach for society to appreciate and acknowledge the gifts, talents, and uniqueness the entire body of Christ.

The findings from this study aligns with the literature reviewed in Chapter 2 of this manuscript, where most of the studies involved either a small sample, adult population, and/or the study was not a longitudinal design. This study examined some of the same constructs (anxiety, WM and NDDs) as the other studies, but from an archived dataset of a large adolescent population (N=11400). This study results and discission are congruent with the biblical foundations, also found in Chapter 2, which offers grace and compassion while at the same time calling on caregivers to be informed and take action to improve the quality of life now and in the future.

Implications

This study underscores the significance of relationships and comorbidity of anxiety, working memory, and neurodevelopmental disorders in an adolescent population as these constructs have been identified as negative contributors to academic success,

occupational achievement, functioning in the workplace, additional mental health problems, and real-life advertise (Barkus, 2020; East-Richard et al., 2020; Hasslinger et al., 2022; Yoon et al., 2018). As discussed earlier, research of adolescent anxiety is an area of opportunity (Barker et al., 2019), therefore this study contributes to the body of literature of anxiety in adolescents. This study also adds to the research regarding the relationship between anxiety and WM, with the additional aspect of a longitudinal design which is noted as a gap by several researchers (Barker et al., 2019; Lisica et al., 2022; Lukasik et al., 2019; Murphy et al., 2018; Stout et al., 2020). Finally, this study addressed a gap noted by Donolato et al. (2019) and Murphy et al. (2018) who proposed large sample sizes and longitudinal studies. Relevant theoretical and practical implications follow.

Theoretical Implications

The concept of WM first emerged during the cognitive revolution in the 1950s as a computer system term employed by Newell and Simon (1956) to represent temporarily accessible information required the computer complete calculations. The term was later used to describe human problem solving and processing (Miller et al., 1960). The most longstanding theoretical model today was proposed by Baddeley and Hitch (1974), which characterized WM as limited capacity storage for holding and manipulating information in the mind to be used in subsequent processing. As an example, math problems with multiple steps are reliant on WM, according to Baddeley and Hitch (1974) and Zelazo (2020). The current study's findings align with the proposition of temporary storage and limited processing capabilities of WM. This study examined constructs that might lead or

has transdiagnostic relationships to deficits in working memory, such as anxiety and NDDs.

The Eysenck et al. (2007) Attentional Control Theory (ACT) draws from the Baddeley and Hitch (1974) WM model, specifically the central executive, an attention-like limited capacity, that is impaired by anxiety. The ACT model suggests that deficit in attention control is a key contributor to developing anxiety. APA (2022) characterized anxiety as excessive fear, worry, and panic that occur in the absence of a real threat. Shi et al. (2019) reported that anxiety (threats or threatening stimuli) captures one's attention and that the more frequently one experiences anxiety, there is an increased chance of ambiguous information being interpreted and a threat and thus captures the individual's attention. Healthy attentional control is required to release or disengage the perceived threat (Shi et al., 2019). This study found a statistically significant relationship between WM and anxiety (measured as GAD). The results lend some support for the ACT attentional control deficits theory and anxiety's influence on WM. However, the results found negligible association indicating WM deficits may not strongly predict GAD.

The multiple deficit model (MDM, proposed by Pennington (20026) was in response to the limitation of the single deficit model (SDM) due to the SDM's failure to address the multiple factors of symptom, genetics, and cognitive overlaps between neurodevelopmental disorders (NDDs) such as ASD and ADHD. The SDM also could not explain empirically the pervasive comorbidity and inter-individual variations in individuals with atypical neuropsychology. The MDM has advanced to a multi-tiered framework for understanding NDDs. Fundamental tenets of the MDM framework that multiple probable risk factors corresponded with NDDs and that shared risk factors

contribute to comorbidity (McGrath et al., 2020; Pennington, 2006). Research indicates that 89% of youth with ADHD also show impairment in one or more executive function domains (Kofler et al., 2019) and Kofler et al. (2018) found children with ADHD displayed expansive impairments in organization skills, directly and indirectly due to WM role in regulation attention, which we discussed earlier as attention control. The study is supportive of the MDM model, specifically the frequent comorbidity, which this study found to exist. This study showed deficits in WM where higher in the NDD adolescent group than typically developing adolescents. In addition, this study revealed an increase in clinical anxiety diagnosis (GAD) in correlation with the presence of an NDD. Finally, and as discussed earlier, this study also found comorbid WM and anxiety as statistically significant.

Practical Implications

Findings from the quantitative correlational study helps to illuminate the complexity, comorbidity, and bi-directional features of anxiety, working memory and neurodevelopmental disorders. The challenge of diagnosing might be challenging when a caregiver, educator or individual complains of a single behavior or issue, such as maladaptive emotional regulation. Anxiety among of United States adolescents is on the rise according to Parodi et al. (2022), rising from 34.1% to 44% between 2012 to 2018. Tajik-Parvinchi et al. (2021) found that executive function components of WM, shifting, and inhibitory control predicted increase emotional dysregulation which contributed to internalizing (anxiety and depressive symptoms) in addition to externalizing issues in children with NDDs. This study demonstrated comorbid conditions among the sample

studied, suggesting a more comprehensive assessment approach, with differential diagnosis as described in Barch et al. (2018) and Burnette et al. (2020).

Technological advances are gaining interest as the future of diagnosing and treating comorbid conditions. A recent article by Vashisht and Jatain (2023) suggests an artificial intelligence (AI) Deep Learning (DL) model that places diagnostic tools in the hands of caregivers, teachers, and individuals. Ribas et al.'s (2023) systematic review reported that machine learning (ML), magnetic resonance imaging (MRI), functional magnetic resonance imaging (*f*MRI), electroencephalogram (EEG), magnetic resonance imaging (MRI) and neurofeedback (NFB) were the most popular technologies used in diagnosing and treating NDDs. The comorbid and complex results of the current study demonstrates there is potential benefit from technological advances in a few ways: (1) aid in clarifying complex symptomology, diagnosis and developing treatment plans, (2) making technology more accessible to clinicians, caregivers and teachers, and (3) facilitate early symptom-based detection, intervention and prevention of undesirable outcomes and more severe mental disorders, such as depression, suicide, or encounters with the criminal justice systems. The current study revealed a relationship between anxiety and WM deficits. Current literature supports a relationship between WM deficits and anxiety in academic performance (Cumming et al., 2023). The literature also provides support for comorbid features of NDDs (Antolini & Colizzi, 2023; Doering et al., 2022; Tajik-Parvinchi et al., 2021). Daley et al. (2019), Hansen et al. (2018), Poulton (2021), and Shulman et al. (2020) agree that NDDs reduce the quality of life in children and NDDs may persist across the lifespan causing impairments in cognition, academic attainment, earning potential, behavior, and in social relationships and interactions.

Clinicians are encouraged to be aware of the comorbidity that exists among the constructs of this study and expand clinical assessment batteries. Another opportunity for professionals actively treating adults with known comorbid and heritable conditions, to discuss with their patients or clients the potential for their offspring to present with the same or other conditions and encourage early diagnostic assessments and treatment for such conditions as ADHD, anxiety, executive function, depression and other conditions (Abushalbaq et al., 2021; Astle et al., 2022; Thapar et al., 2023; Zelazo, P. D., 2020).

The Church And Organization

The World Health Organization (2022) reported that the COVID-19 pandemic worsened the mental health of the general population. Iheanacho et al. (2021) indicated that churches can play a key role in promoting mental health. The results of the current study might be used by church leadership, pastoral care, and lay counselors to develop congregation awareness campaigns including the comorbid conditions discussed in this study, thereby building a more welcoming and supportive environment for church members and families. Lloyd et al. (2023) offered that Christianity has an opportunity to facilitate positive coping with mental illness among parishioners. Church community belonging can be supportive of coping when delivered with non-judgmental care and broader forms of social support (Lloyd et al., 2023).

Therefore, the church, local community programs, and employers are in a unique position to model Christ, when he replied, neither the man nor his parents had sinned, causing the man's blindness (John 9:1-3). Christ's response effectively dissociates physical and mental health challenges and suffering from sin. Further the church and other organizations can offer opportunities that recognize talents and skills, provide

support, and encouragement to individuals and families, so that “the works of God might be displayed” (John 9:3) in those we are to care for.

Limitations

Limitations were identified for this quantitative correlational study. Correlational studies do not establish causal relations between variables but instead seek to determine whether there is a relationship between variables (Curtis et al., 2016; Martin, 2012). In correlational studies variables are not manipulated and nothing is controlled, (Jhangiani et al., 2019; Mohajan, 2020), thus this study was not experimental. Generalizability is another limitation of the study results, an external threat to validity. Generalizability allows study results to be applied to the larger population (Mohajan, 2020). The ABCD study participants were recruited from 21 sites across the U.S. (Garavan et al., 2018; Heeringa & Berglund, 2020). Although the ABCD study researchers included a group of participants that reflected the ethnic/racial and socioeconomic diversity of the U.S. (Garavan et al., 2018), this limits the generalizability of this study’s results to other countries. However, results may be applicable to the U.S adolescent population.

Using an archived dataset from a longitudinal study was another limitation. Drawbacks existed at several points throughout this study with the first beginning with approvals to use the dataset. In addition to IRB approval, approval was required from both the university official signatory registered with the NIMH and the NIMH ABCD study supervisory team. The approval process took a significant amount of time. Other issues included inoperable and/or difficult data download tools, retiring of dataset during the study which required new approvals for the next data release, and dataset quality issues. The approvals and issues noted above could exceed the typical data collection

period and require the researcher to re-enroll in courses while working to resolve issues, resulting in additional expense to researcher. Caution is recommended when considering the use of archived datasets that require approvals and that are ongoing longitudinal design. There is potential for unexpected delays, data quality issues (e.g., incomplete or missing data), and implications to study results, especially when the study releases a new dataset annually, yet assessments of the total population may take up to two years for a large sample size.

Recommendations For Future Research

Future research emerged from this study's findings. This study found statistically significant associations between all variables of the study, NDDs, WM, Anxiety. A future study using the archived dataset might evaluate if there are differences between males and females. Additional demographic data that is available such as socioeconomic factors, parent education level, parents in the household, heritability of constructs, and shared risk factors offer opportunities for further research paring the same variables with demographic data. As an example, a future study might inform of communities at higher risk levels and lead to interventions and programs for specific demographic groups. In addition to the demographic data, the ABCD dataset offer a large number of cognitive, mental health, and physical assessments that could be analyzed with variables of this study, individually or together.

The archived data from the KSADS and NIH Toolbox computerized assessments was utilized in this study for confirmed diagnosis and low working memory scores. A future study might use results from the ABCD study's *f*MRI imaging data and n-back assessment for WM, replacing or consolidating the WM results from the LSWMT.

Earlier we mentioned that the KSADS ASD assessment results were not available for inclusion in this study. The ASD assessment data could potentially reveal more participants with an ASD diagnosis. Replication of the current study including both parent report and ASD assessment results might enhance the current study, perhaps in strength of associations between NDDs and other variables. A U.S. adolescent dataset was used in this study. The current study might be replicated with adolescents from other countries where archived datasets include variables used in this study.

Theoretical constructs used in this study included a Working Memory multi-component model (Baddeley & Hitch, 1974), the Attention Control Therory (Eysenck et al. (2007) and the Multiple Deficit Model (MDM) theory of NDDs (Pennington, 2006). The theories explored in this study were support by findings of comorbidity and potential transdiagnostic implications. A contemporary research framework that is aligned with tenets of the aforementioned theories is the Research Domain Criteria framework (RDoC). According to Pacheco et al. (2022), the RDoC, funded by the NIMH, was implemented in response to shortcomings in the field of symptom driven diagnoses that were not associated with biological and physiological symptoms. Since inception, the RDoC has gain prominence in influencing clinical interventions and treatments and training further generation of scientists (Pacheco et al., 2022). The RDoC includes six domains: Negative Valence Systems, Positive Valence Systems, Cognitive Systems, Social Processes, Arousal and Regulatory Systems and Sensorimotor Systems. The RDoC matrix maps a construct, such as working memory or anxiety, across genes, molecules, cells, circuitry, physiology, behavior, self-report (assessments), and paradigms. Considering the ABCD study cognitive and mental health data used in this

study, a future study utilizing the RDoC as the framework would contribute to the NIMH catalog of research and the larger body of knowledge. future..

Summary

This study sought to understand to what extent WM deficits and anxiety exist in adolescents with a NDD diagnosis versus typically developing adolescents in the United States (U.S.). Analyzing the U.S. based ABCD study archived dataset, the study found statistically significant relationships between WM and GAD, between WM and NDDs, between GAD and NDDs. Results showed negligible, negative relationship, suggesting a monotonic relationship between WM and GAD, which indicates that adolescents with lower WM scores tend to have an increased chance of a GAD diagnosis. The study also reveals that having a NDD diagnosis increases the likelihood of experience GAD, but only to a small extent, due to a small effect size. Finally, the study showed that WM deficits were more pronounced in the adolescents diagnosed with an NDD.

This study is one of many utilizing the large, longitudinal dataset from the ABCD study with focused on U.S. adolescents. Like other studies utilizing the data set, this study adds to the literature regarding adolescent anxiety, and the commodity of NDDs, WM, and anxiety. This study could inform mental health and medical professionals of the need for more comprehensive assessments, with differential diagnosis, to develop more thorough treatments plans for adolescents.

REFERENCES

References

Abdel-Khalek, A. M., Nuño, L., Gómez-Benito, J., & Lester, D. (2019). The Relationship Between Religiosity and Anxiety: A Meta-analysis. *Journal of Religion and Health, 58*(5), 1847-1856. https://doi.org/10.1007/s10943-019-00881-z

Abushalbaq, O. M., Khdour, H. Y., Abo Hamza, E. G., Moustafa, A. A., & Herzallah, M. M. (2021). Investigating Principal Working Memory Features in Generalized, Panic, and Social Anxiety Spectrum Disorders. *Frontiers in Psychiatry, 12*, 701412. https://doi.org/10.3389/fpsyt.2021.701412

Alba, L. A., Flannery, J., Shapiro, M., & Tottenham, N. (2019). Working memory moderates the association between early institutional care and separation anxiety symptoms in late childhood and adolescence. *Development and Psychopathology, 31*(3), 989-997. https://doi.org/10.1017/S0954579419000452

Al-Saad, M. S. H., Al-Jabri, B., & Almarzouki, A. F. (2021). A Review of Working Memory Training in the Management of Attention Deficit Hyperactivity Disorder. *Frontiers in Behavioral Neuroscience, 15*, 686873. https://doi.org/10.3389/fnbeh.2021.686873

American Psychiatric Association. (2022). Diagnostic and Statistical Manual of Mental Disorders. https://doi.org/10.1176/appi.books.9780890425787

Angelopoulou, E., & Drigas, A. (2021). Working memory, attention, and their relationship: A theoretical overview. *Research, Society and Development, 10*(5), e46410515288. https://doi.org/10.33448/rsd-v10i5.15288

Antolini, G., & Colizzi, M. (2023). Where Do Neurodevelopmental Disorders Go? Casting the Eye Away from Childhood towards Adulthood. *Healthcare (Basel), 11*(7), 1015. https://doi.org/10.3390/healthcare11071015

Arjona Valladares, A., Gómez, C. M., Rodríguez-Martínez, E. I., Barriga-Paulino, C. I., Gómez-González, J., & Diaz-Sánchez, J. A. (2020). Attention-deficit/hyperactivity disorder in children and adolescents: An event-related potential study of working memory. *The European Journal of Neuroscience, 52*(10), 4356-4369. https://doi.org/10.1111/ejn.14767

Astle, D. E., Holmes, J., Kievit, R., & Gathercole, S. E. (2022). Annual Research Review: The transdiagnostic revolution in neurodevelopmental disorders. *Journal of Child Psychology and Psychiatry*, *63*(4), 397-417. https://doi-org.ezproxy.liberty.edu/10.1111/jcpp.13481

Avery, E. W., Yoo, K., Rosenberg, M. D., Greene, A. S., Gao, S., Na, D. L., Scheinost, D., Constable, T. R., & Chun, M. M. (2020). Distributed Patterns of Functional Connectivity Predict Working Memory Performance in Novel Healthy and Memory-impaired Individuals. *Journal of Cognitive Neuroscience, 32*(2), 241-255. https://doi.org/10.1162/jocn_a_01487

Baddeley, A. (2000). *The episodic buffer: a new component of working memory?*. Elsevier Ltd. https://doi.org/10.1016/S1364-6613(00)01538-2

Baddeley, A. (2010). Working memory. *Current biology*, *20*(4), R136-R140. https://doi.org/10.1016/j.cub.2009.12.014

Baddeley, A., & Hitch, G. (1974). Working memory. *Psychology of Learning and Motivation* (Vol. 8, pp. 47-89). Academic press. https://doi.org/10.1016/S0079-7421(08)60452-1

Baddeley, A., Hitch, G., & Allen, R. (2021). A multicomponent model of working memory. In R. H. Logie, V. Camos, & N. Cowan (Eds.), *Working memory: State of the science* (pp. 10–43). Oxford University Press. https://doi.org/10.1093/oso/9780198842286.003.0002

Barch, D. M., Albaugh, M. D., Avenevoli, S., Chang, L., Clark, D. B., Glantz, M. D., Hudziak, J. J., Jernigan, T. L., Tapert, S. F., Yurgelun-Todd, D., Alia-Klein, N., Potter, A. S., Paulus, M. P., Prouty, D., Zucker, R. A., & Sher, K. J. (2018). Demographic, physical and mental health assessments in the adolescent brain and cognitive development study: Rationale and description. *Developmental Cognitive Neuroscience, 32*, 55-66. https://doi.org/10.1016/j.dcn.2017.10.010

Barker, M. M., Beresford, B., Bland, M., & Fraser, L. K. (2019). Prevalence and Incidence of Anxiety and Depression Among Children, Adolescents, and Young Adults with Life-Limiting Conditions: A Systematic Review and Meta-analysis. *Archives of Pediatrics & Adolescent Medicine, 173*(9), 835-844. https://doi.org/10.1001/jamapediatrics.2019.1712

Barkley, R. A. (2020). The High Economic Costs Associated with ADHD. *The ADHD Report, 28*(3), 10-12. https://doi.org/10.1521/adhd.2020.28.3.10

Barkus, E. (2020). Effects of working memory training on emotion regulation: Transdiagnostic review. *PsyCh Journal, 9*(2), 258-279. https://doi.org/10.1002/pchj.353

Beloe, P., & Derakshan, N. (2020). Adaptive working memory training can reduce anxiety and depression vulnerability in adolescents. *Developmental Science, 23*(4), e12831-n/a. https://doi.org/10.1111/desc.12831

Bloomfield, J., & Fisher, M. J. (2019). Quantitative research design. *Journal of the Australasian Rehabilitation Nurses' Association (JARNA)*, *22*(2), 27–30. https://doi.org/10.33235/jarna.22.2.27-30

Brumariu, L., Waslin, S., Gastelle, M., Kochendorfer, L., & Kerns, K. (2022). Anxiety, academic achievement, and academic self-concept: Meta-analytic syntheses of their relations across developmental periods. *Development and Psychopathology,* 1-17. Doi:10.1017/S0954579422000323

Burnette, J. L., Babij, A. D., Oddo, L. E., & Knouse, L. E. (2020). Self-Regulation Mindsets: Relationship to Coping, Executive Functioning, and ADHD. *Journal of Social and Clinical Psychology, 39*(2), 101-116. https://doi.org/10.1521/jscp.2020.39.02.101

Casaletto, K. B., Umlauf, A., Beaumont, J., Gershon, R., Slotkin, J., Akshoomoff, N., & Heaton, R. K. (2015). Demographically Corrected Normative Standards for the English Version of the NIH Toolbox Cognition Battery. *Journal of the International Neuropsychological Society, 21*(5), 378-391. https://doi.org/10.1017/S1355617715000351

Casey, B. J., Cannonier, T., Conley, M. I., Cohen, A. O., Barch, D. M., Heitzeg, M. M., Soules, M. E., Teslovich, T., Dellarco, D. V., Garavan, H., Orr, C. A., Wager, T. D., Banich, M. T., Speer, N. K., Sutherland, M. T., Riedel, M. C., Dick, A. S., Bjork, J. M., Thomas, K. M., . . . Dale, A. M. (2018). The Adolescent Brain Cognitive

Development (ABCD) study: Imaging acquisition across 21 sites. *Developmental Cognitive Neuroscience, 32*, 43-54. https://doi.org/10.1016/j.dcn.2018.03.001

Caviola, S., Toffalini, E., Giofrè, D., Ruiz, J. M., Szűcs, D., & Mammarella, I. C. (2022). Math performance and academic anxiety forms, from sociodemographic to cognitive aspects: A meta-analysis on 906,311 participants. *Educational Psychology Review*, *34*(1), 363-399. https://doi.org/10.1007/s10648-021-09618-5

Chai, W. J., Abd Hamid, A. I., & Abdullah, J. M. (2018). Working Memory from the Psychological and Neurosciences Perspectives: A Review. *Frontiers in Psychology, 9*, 401. https://doi.org/10.3389/fpsyg.2018.00401

Chambers, W. J., Puig-Antich, J., Hirsch, M., Paez, P., Ambrosini, P. J., Tabrizi, M. A., & Davies, M. (1985). The Assessment of Affective Disorders in Children and Adolescents by Semistructured Interview: Test-Retest Reliability of the Schedule for Affective Disorders and Schizophrenia for School-Age Children, Present Episode Version. *Archives of General Psychiatry, 42*(7), 696-702. https://doi.org/10.1001/archpsyc.1985.01790300064008

Chen, T., Becker, B., Camilleri, J., Wang, L., Yu, S., Eickhoff, S. B., & Feng, C. (2018). A domain-general brain network underlying emotional and cognitive interference processing: evidence from coordinate-based and functional connectivity meta-analyses. *Brain Structure and Function, 223*(8), 3813-3840. https://doi.org/10.1007/s00429-018-1727-9

Cowan, N. (2017). The many faces of working memory and short-term storage. *Psychonomic Bulletin & Review, 24*(4), 1158-1170. https://doi.org/10.3758/s13423-016-1191-6

Cowan, N. (2022). Working memory development: A 50-year assessment of research and underlying theories. *Cognition, 224*, 105075. https://doi.org/10.1016/j.cognition.2022.105075

Creswell, C., Waite, P., & Hudson, J. (2020). Practitioner Review: Anxiety disorders in children and young people – assessment and treatment. *Journal of Child Psychology and Psychiatry, 61*(6), 628-643. https://doi.org/10.1111/jcpp.13186

Creswell, J. W. (2013). *Qualitative inquiry & research design* (Third edition ed.). SAGE.

Crisci, G., Caviola, S., Cardillo, R., & Mammarella, I. C. (2021). Executive Functions in Neurodevelopmental Disorders: Comorbidity Overlaps Between Attention Deficit and Hyperactivity Disorder and Specific Learning Disorders. *Frontiers in Human Neuroscience, 15*, 594234. https://doi.org/10.3389/fnhum.2021.594234

Cumming, M. M., Oblath, R., Qiu, Y., Frazier, S. L., Zelazo, P. D., Flores, H., & Park, J. (2023). Executive Function, Perceived Stress, and Academic Performance Among Middle Schoolers With and Without Behavior Problems. *Remedial and Special Education,* https://doi.org/10.1177/07419325231176762

Curtis, E. A., Comiskey, C., & Dempsey, O. (2016). Importance and use of correlational research. *Nurse Researcher (2014+), 23*(6), 20. https://doi.org/10.7748/nr.2016.e1382

D'Agati, E., Curatolo, P., & Mazzone, L. (2019). Comorbidity between ADHD and anxiety disorders across the lifespan. *International Journal of Psychiatry in Clinical Practice, 23*(4), 238-244. https://doi.org/10.1080/13651501.2019.1628277

Daley, D., Jacobsen, R. H., Lange, A. M., Sørensen, A., & Walldorf, J. (2019). The economic burden of adult attention deficit hyperactivity disorder: A sibling

comparison cost analysis. *European Psychiatry, 61*, 41-48. https://doi.org/10.1016/j.eurpsy.2019.06.011

Dellapiazza, F., Audras-Torrent, L., Michelon, C., & Baghdadli, A. (2021). Clinical characteristics of children with ASD and comorbid ADHD: Association with social impairment and externalizing and internalizing behaviours. *Research in Developmental Disabilities, 113*, 103930. https://doi.org/10.1016/j.ridd.2021.103930

Demir, S. (2022). Comparison of Normality Tests in Terms of Sample Sizes under Different Skewness and Kurtosis Coefficients. *International Journal of Assessment Tools in Education, 9*(2), 397-409. https://doi.org/10.21449/ijate.1101295

Denny, E., & Weckesser, A. (2019). Qualitative research: what it is and what it is not: Study design: qualitative research. *BJOG : An International Journal of Obstetrics and Gynaecology, 126*(3), 369. https://doi.org/10.1111/1471-0528.15198

de Raadt, A., Warrens, M. J., Bosker, R. J., & Kiers, H. A. L. (2021). A Comparison of Reliability Coefficients for Ordinal Rating Scales. *Journal of Classification, 38*(3), 519-543. https://doi.org/10.1007/s00357-021-09386-5

Diamond, A. (2013). Executive Functions. *Annual Review of Psychology, 64*(1), 135-168. https://doi.org/10.1146/annurev-psych-113011-143750

Doering, S., Larsson, H., Halldner, L., Gillberg, C., Kuja-Halkola, R., & Lundström, S. (2022). Internalizing symptoms in adolescence are modestly affected by symptoms of anxiety, depression, and neurodevelopmental disorders in childhood. *BMC Psychiatry, 22*(1), 233. https://doi.org/10.1186/s12888-022-03875-6

Doering, S., Lichtenstein, P., Gillberg, C., Kuja-Halkola, R., & Lundström, S. (2021). Internalizing and neurodevelopmental problems in young people: Educational

outcomes in a large population-based cohort of twins. *Psychiatry Research*, *298*, 113794. https://doi.org/10.1016/j.psychres.2021.113794

Domański, P. D. (2020). Study on Statistical Outlier Detection and Labelling. *International Journal of Automation and Computing, 17*(6), 788-811. https://doi.org/10.1007/s11633-020-1243-2

Donolato, E., Giofrè, D., & Mammarella, I. C. (2019). Working memory, negative affect, and personal assets: How do they relate to mathematics and reading literacy?. *PloS one*, *14*(6), e0218921. https://doi.org/10.1371/journal.pone.0218921

East-Richard, C., R. -Mercier, A., Nadeau, D., & Cellard, C. (2020). Transdiagnostic neurocognitive deficits in psychiatry: A review of meta-analyses. *Canadian Psychology / Psychologie canadienne, 61*(3), 190–214. https://doi.org/10.1037/cap0000196

Eysenck, M. W., & Calvo, M. G. (1992). Anxiety and Performance: The Processing Efficiency Theory. *Cognition and Emotion, 6*(6), 409-434. https://doi.org/10.1080/02699939208409696

Eysenck, M. W., & Derakshan, N. (2011). New perspectives in attentional control theory. *Personality and Individual Differences*, *50*(7), 955-960. https://doi.org/10.1016/j.paid.2010.08.019

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and Cognitive Performance: attentional control theory. *Emotion (Washington, D.C.), 7*(2), 336-353. https://doi.org/10.1037/1528-3542.7.2.336

Ezell, J., Hogan, A., Fairchild, A., Hills, K., Klusek, J., Abbeduto, L., & Roberts, J. (2019). Prevalence and Predictors of Anxiety Disorders in Adolescent and Adult Males with Autism Spectrum Disorder and Fragile X Syndrome. *Journal of*

Autism and Developmental Disorders, 49(3), 1131-1141. https://doi.org/10.1007/s10803-018-3804-6

Fatima, S., Sharif, S., & Khalid, I. (2018). How Does Religiosity Enhance Psychological Well-Being? Roles of Self-Efficacy and Perceived Social Support. *Psychology of Religion and Spirituality, 10*(2), 119-127. https://doi.org/10.1037/rel0000168

Ferguson, C. J. (2009). An Effect Size Primer. *Professional Psychology, Research and Practice, 40*(5), 532-538. https://doi.org/10.1037/a0015808

Figueira, J. S. B., Oliveira, L., Pereira, M. G., Pacheco, L. B., Lobo, I., Motta-Ribeiro, G. C., & David, I. A. (2017). An unpleasant emotional state reduces working memory capacity: electrophysiological evidence. *Social Cognitive and Affective Neuroscience, 12*(6), 984-992. https://doi.org/10.1093/scan/nsx030

Finell, J., Sammallahti, E., Korhonen, J., Eklöf, H., & Jonsson, B. (2021). Working Memory and Its Mediating Role on the Relationship of Math Anxiety and Math Performance: A Meta-Analysis. *Frontiers in Psychology, 12*, 798090. https://doi.org/10.3389/fpsyg.2021.798090

Fosco, W. D., Kofler, M. J., Groves, N. B., Chan, E. S. M., & Raiker, J. S. (2020). Which 'Working' Components of Working Memory aren't Working in Youth with ADHD? *Journal of Abnormal Child Psychology, 48*(5), 647-660. https://doi.org/10.1007/s10802-020-00621-y

Francis, B., Gill, J. S., Yit Han, N., Petrus, C. F., Azhar, F. L., Ahmad Sabki, Z., Said, M. A., Ong Hui, K., Chong Guan, N., & Sulaiman, A. H. (2019). Religious Coping, Religiosity, Depression and Anxiety among Medical Students in a Multi-Religious

Setting. *International Journal of Environmental Research and Public Health, 16*(2), 259. https://doi.org/10.3390/ijerph16020259

Garavan, H., Bartsch, H., Conway, K., Decastro, A., Goldstein, R. Z., Heeringa, S., Jernigan, T., Potter, A., Thompson, W., & Zahs, D. (2018). Recruiting the ABCD sample: Design considerations and procedures. *Developmental Cognitive Neuroscience, 32*, 16-22. https://doi.org/10.1016/j.dcn.2018.04.004

Garssen, B., Visser, A., & Pool, G. (2021). Does Spirituality or Religion Positively Affect Mental Health? Meta-analysis of Longitudinal Studies. *The International Journal for the Psychology of Religion, 31*(1), 4-20. https://doi.org/10.1080/10508619.2020.1729570

Golshan, F., Soltani, A., & Afarinesh, M. R. (2019). The study of executive function domains in children with high-functioning autism. *Learning and Motivation*, *67*, 101578. https://doi.org/10.1016/j.lmot.2019.101578

Gontard, A., Hussong, J., Yang, S. S., Chase, J., Franco, I., & Wright, A. (2022). Neurodevelopmental disorders and incontinence in children and adolescents: Attention-deficit/hyperactivity disorder, autism spectrum disorder, and intellectual disability—A consensus document of the International Children's Continence Society. *Neurourology and Urodynamics, 41*(1), 102-114. https://doi.org/10.1002/nau.24798

Green, J. (2011). *The interlinear Bible: Hebrew-Greek-English; with Strong's concordance numbers above each word*. Hendrickson Publishers.

Grol, M., Schwenzfeier, A. K., Stricker, J., Booth, C., Temple-McCune, A., Derakshan, N., Hirsch, C., Becker, E., & Fox, E. (2018). The worrying mind in control: An

investigation of adaptive working memory training and cognitive bias modification in worry-prone individuals. *Behaviour Research and Therapy, 103*, 1-11. https://doi.org/10.1016/j.brat.2018.01.005

Habib, A., Harris, L., Pollick, F., & Melville, C. (2019). A meta-analysis of working memory in individuals with autism spectrum disorders. *PloS ONE, 14*(4), e0216198. https://doi.org/10.1371/journal.pone.0216198

Hamed, K. H. (2009). Effect of persistence on the significance of Kendall's tau as a measure of correlation between natural time series. *The European Physical Journal. ST, Special Topics, 174*(1), 65-79. https://doi.org/10.1140/epjst/e2009-01090-x

Hansen, B. H., Oerbeck, B., Skirbekk, B., Petrovski, B. É., & Kristensen, H. (2018). Neurodevelopmental disorders: prevalence and comorbidity in children referred to mental health services. *Nordic Journal of Psychiatry, 72*(4), 285-291. https://doi.org/10.1080/08039488.2018.1444087

Hasslinger, J., Jonsson, U., & Bölte, S. (2022). Immediate and Sustained Effects of Neurofeedback and Working Memory Training on Cognitive Functions in Children and Adolescents with ADHD: A Multi-Arm Pragmatic Randomized Controlled Trial. *Journal of Attention Disorders, 26*(11), 1492-1506. https://doi.org/10.1177/10870547211063645

Heeringa, S. G., & Berglund, P. A. (2020). A guide for population-based analysis of the Adolescent Brain Cognitive Development (ABCD) Study baseline data. *BioRxiv*. Doi**:** https://doi.org/10.1101/2020.02.10.942011

Held, J., Vîslă, A., Zinbarg, R. E., Wolfer, C., & Flückiger, C. (2020). How do worry and clinical status impact working memory performance? An experimental

investigation. *BMC Psychiatry, 20*(1), 317. https://doi.org/10.1186/s12888-020-02694-x

Hirsch, C. R., & Mathews, A. (2012). A cognitive model of pathological worry. *Behaviour research and therapy*, *50*(10), 636-646. https://doi.org/10.1016/j.brat.2012.06.007

Høj Jørgensen, T. S., Osler, M., Jorgensen, M. B., & Jorgensen, A. (2023). Mapping diagnostic trajectories from the first hospital diagnosis of a psychiatric disorder: a Danish nationwide cohort study using sequence analysis. *The Lancet. Psychiatry, 10*(1), 12-20. https://doi.org/10.1016/S2215-0366(22)00367-4

Hudson, J. L., Murayama, K., Meteyard, L., Morris, T., & Dodd, H. F. (2019). Early Childhood Predictors of Anxiety in Early Adolescence. *Journal of Abnormal Child Psychology, 47*(7), 1121-1133. https://doi.org/10.1007/s10802-018-0495-6

Hur, J., Stockbridge, M. D., Fox, A. S., & Shackman, A. J. (2019). Dispositional negativity, cognition, and anxiety disorders: an integrative translational neuroscience framework. *Progress in Brain Research, 247*, 375-436. https://doi.org/10.1016/bs.pbr.2019.03.012

Hurley-Hanson, A. E., Giannantonio, C. M., & Griffiths, A. J. (2019). *Autism in the Workplace : Creating Positive Employment and Career Outcomes for Generation A* (1st ed. 2020 ed.). Springer International Publishing. https://doi.org/10.1007/978-3-030-29049-8

Iheanacho, T., Nduanya, U. C., Slinkard, S., Ogidi, A. G., Patel, D., Itanyi, I. U., Naeem, F., Spiegelman, D., & Ezeanolue, E. E. (2021). Utilizing a church-based platform for

mental health interventions: Exploring the role of the clergy and the treatment preference of women with depression. Global Mental Health, 8, e5.

Jarros, R. B., Salum, G. A., Silva, C. T. B. d., Toazza, R., Becker, N., Agranonik, M., Salles, J. F. d., & Manfro, G. G. (2017). Attention, memory, visuoconstructive, and executive task performance in adolescents with anxiety disorders: a case-control community study. *Trends in Psychiatry and Psychotherapy, 39*(1), 5-11. https://doi.org/10.1590/2237-6089-2016-0032

Jhangiani, R., Chiang, I. A., Cuttler, C., & Leighton, D. C. (2019). *Research Methods in Psychology* (4th edition ed.)

Kaufman, J., Birmaher, B., Axelson, D., Perepletchikova, F., Brent, D., & Ryan, N. (2013). Schedule for affective disorders and schizophrenia for school-age children-present and lifetime version (K-SADS-PL 2013, DSM-5). *Western Psychiatric Institute and Yale University*.

Kaufman, J., Birmaher, B., Brent, D., Rao, U., Flynn, C., Moreci, P., Williamson, D., & Ryan, N. (1997). Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime Version (K-SADS-PL): Initial Reliability and Validity Data. *Journal of the American Academy of Child and Adolescent Psychiatry, 36*(7), 980-988. https://doi.org/10.1097/00004583-199707000-00021

Kaufman, J., Birmaher, B., Brent, D. A., Ryan, N. D., & Rao, U. (2000). K-SADS-PL. *Journal of the American Academy of Child and Adolescent Psychiatry, 39*(10), 1208. https://doi.org/10.1097/00004583-200010000-00002

Kavanaugh, B. C., Fryc, A., Temereanca, S., Tirrell, E., Oberman, L., Carpenter, L. L., & Spirito, A. (2021). A preliminary investigation of childhood anxiety/depressive

symptomatology and working memory across multiple units of analysis. *Psychiatry Research, 298*, 113786. https://doi.org/10.1016/j.psychres.2021.113786

Khatun, N. (2021). Applications of Normality Test in Statistical Analysis. *Open Journal of Statistics, 11*(1), 113-122. https://doi.org/10.4236/ojs.2021.111006

Kibby, M. Y., Newsham, G., Imre, Z., & Schlak, J. E. (2021). Is executive dysfunction a potential contributor to the comorbidity between basic reading disability and attention-deficit/hyperactivity disorder? *Child Neuropsychology, 27*(7), 888-910. https://doi.org/10.1080/09297049.2021.1908532

Kofler, M. J., Irwin, L. N., Soto, E. F., Groves, N. B., Harmon, S. L., & Sarver, D. E. (2019). Executive functioning heterogeneity in pediatric ADHD. *Journal of abnormal child psychology*, *47*(2), 273-286. Doi https://doi.org/10.1007/s10802-018-0438-2

Kofler, M. J., Sarver, D. E., Harmon, S. L., Moltisanti, A., Aduen, P. A., Soto, E. F., & Ferretti, N. (2018). Working memory and organizational skills problems in ADHD. The Journal of Child Psychology and Psychiatry and Allied Disciplines, 59(1), 57–67. https://doi.org/10.1111/jcpp.12773

Kushki, A., Anagnostou, E., Hammill, C., Duez, P., Brian, J., Iaboni, A., Schachar, R., Crosbie, J., Arnold, P., & Lerch, J. P. (2019). Examining overlap and homogeneity in ASD, ADHD, and OCD: a data-driven, diagnosis-agnostic approach. *Translational Psychiatry, 9*, 1-11. https://doi.org/10.1038/s41398-019-0631-2

Leidenhag, J., & King, P. E. (2023). Neurodiversity and Thriving: A Case Study in Theology-Informed Psychology. *Studies in Christian Ethics, 36*(4), 827-843. https://doi.org/10.1177/09539468231187784

Li, T., Franke, B., Arias Vasquez, A., & Roth Mota, N. (2021). Mapping relationships between ADHD genetic liability, stressful life events, and ADHD symptoms in healthy adults. *American Journal of Medical Genetics. Part B, Neuropsychiatric Genetics, 186*(4), 242-250. https://doi.org/10.1002/ajmg.b.32828

Licari, M. K., Finlay-Jones, A., Reynolds, J. E., Alvares, G. A., Spittle, A. J., Downs, J., Whitehouse, A. J. O., Leonard, H., Evans, K. L., & Varcin, K. (2019). The Brain Basis of Comorbidity in Neurodevelopmental Disorders. *Current Developmental Disorders Reports, 6*(1), 9-18. https://doi.org/10.1007/s40474-019-0156-7

Ling, D. S., & Diamond, A. (2019). Review of the Evidence on, and Fundamental Questions About, Efforts to Improve Executive Functions, Including Working Memory. *Cognitive and Working Memory Training* (). Oxford University Press. https://doi.org/10.1093/oso/9780199974467.003.0008

Lisica, D., Koso-Drljević, M., Stürmer, B., Džubur, A., & Valt, C. (2022). Working memory impairment in relation to the severity of anxiety symptoms. *Cognition and Emotion, ahead-of-print*(ahead-of-print), 1-16. https://doi.org/10.1080/02699931.2022.2081535

Lloyd, C. E. M., Cathcart, J., Panagopoulos, M. C., & Reid, G. (2023). The experiences of faith and church community among Christian adults with mental illness: A qualitative metasynthesis. *Psychology of Religion and Spirituality,* https://doi.org/10.1037/rel0000511

Lukasik, K. M., Waris, O., Soveri, A., Lehtonen, M., & Laine, M. (2019). *The Relationship of Anxiety and Stress With Working Memory Performance in a Large Non-depressed Sample*. Frontiers Media SA. https://doi.org/10.3389/fpsyg.2019.00004

Martin, W. E. (2012). Quantitative and Statistical Research Methods: From Hypothesis to Results. *Quantitative and Statistical Research Methods* (). John Wiley & Sons, Incorporated

McGrath, L. M., Peterson, R. L., & Pennington, B. F. (2020). The Multiple Deficit Model: Progress, Problems, and Prospects. *Scientific Studies of Reading, 24*(1), 7-13. https://doi.org/10.1080/10888438.2019.1706180

Melrose, R. J., Zahniser, E., Wilkins, S. S., Veliz, J., Hasratian, A. S., Sultzer, D. L., & Jimenez, A. M. (2020). Prefrontal working memory activity predicts episodic memory performance: A neuroimaging study. *Behavioural Brain Research, 379*, 112307. https://doi.org/10.1016/j.bbr.2019.112307

Mikels, J. A., & Reuter-Lorenz, P. A. (2019). Affective Working Memory: An Integrative Psychological Construct. *Perspectives on Psychological Science, 14*(4), 543-559. https://doi.org/10.1177/1745691619837597

Miller, G. A., Galanter, E., & Přibram, K. H. (1960). *Plans and the structure of behavior*. Holt, Rinehart & Winston.

Minh, A., McLeod, C. B., Reijneveld, S. A., Veldman, K., van Zon, S. K., & Bültmann, U. (2023). The role of low educational attainment on the pathway from adolescent internalizing and externalizing problems to early adult labour market

disconnection in the Dutch TRAILS cohort. *SSM - Population Health*, *21*, 101300. https://doi.org/10.1016/j.ssmph.2022.101300

Mohajan, H. K. (2020). Quantitative Research: A Successful Investigation in Natural and Social Sciences. *Journal of Economic Development, Environment and People, 9*(4), 50-79. https://doi.org/10.26458/jedep.v9i4.679

Moran, T. P. (2016). Anxiety and working memory capacity: A meta-analysis and narrative review. Psychological Bulletin, 142(8), 831–864. https://doi.org/10.1037/bul0000051

Murphy, Y. E., Luke, A., Brennan, E., Francazio, S., Christopher, I., & Flessner, C. A. (2018). An Investigation of Executive Functioning in Pediatric Anxiety. *Behavior Modification, 42*(6), 885-913. https://doi.org/10.1177/0145445517749448

Newell, A., & Simon, H. (1956). The logic theory machine--A complex information processing system. *I.R.E. Transactions on Information Theory, 2*(3), 61-79. https://doi.org/10.1109/TIT.1956.1056797

Nur, H. Z., & Newman, M. G. (2018). Executive function and other cognitive deficits are distal risk factors of generalized anxiety disorder 9 years later. *Psychological Medicine, 48*(12), 2045-2053. https://doi-org.ezproxy.liberty.edu/10.1017/S0033291717003579

Oberauer, K. (2019). Working Memory and Attention – A Conceptual Analysis and Review. *Journal of Cognition, 2*(1), 36. https://doi.org/10.5334/joc.58

Operto, F. F., Smirni, D., Scuoppo, C., Padovano, C., Vivenzio, V., Quatrosi, G., Carotenuto, M., Precenzano, F., & Pastorino, G. M. G. (2021). Neuropsychological Profile, Emotional/Behavioral Problems, and Parental Stress in Children with

Neurodevelopmental Disorders. *Brain Sciences, 11*(5), 584. https://doi.org/10.3390/brainsci11050584

Orvaschel, H., Puig-Antich, J., Chambers, W., Tabrizi, M. A., & Johnson, R. (1982). Retrospective Assessment of Prepubertal Major Depression with the Kiddie-SADS-E. *Journal of the American Academy of Child Psychiatry, 21*(4), 392-397. https://doi.org/10.1016/S0002-7138(09)60944-4

Pacheco, J., Garvey, M. A., Sarampote, C. S., Cohen, E. D., Murphy, E. R., & Friedman-Hill, S. R. (2022). Annual Research Review: The contributions of the RDoC research framework on understanding the neurodevelopmental origins, progression and treatment of mental illnesses. *Journal of Child Psychology and Psychiatry, 63*(4), 360-376. https://doi.org/10.1111/jcpp.13543

Pan, D., Hoid, D., Wang, X., Jia, Z., & Li, X. (2022). When expanding training from working memory to emotional working memory: not only improving explicit emotion regulation but also implicit negative control for anxious individuals. *Psychological Medicine, 52*(4), 675-684. https://doi.org/10.1017/S0033291720002275

Parodi, K. B., Holt, M. K., Green, J. G., Porche, M. V., Koenig, B., & Xuan, Z. (2022). Time trends and disparities in anxiety among adolescents, 2012–2018. *Social Psychiatry and Psychiatric Epidemiology, 57*(1), 127-137. https://doi.org/10.1007/s00127-021-02122-9

Peisch, V., & Arnett, A. B. (2022). Neural activation, cognitive control, and attention deficit hyperactivity disorder: Evaluating three competing etiological

models. *Development and Psychopathology,* , 1-11. https://doi.org/10.1017/S095457942200116X

Pennington, B. F. (2006). From single to multiple deficit models of developmental disorders. *Cognition, 101*(2), 385-413. https://doi.org/10.1016/j.cognition.2006.04.008

Petkus, A., Reynolds, C. A., & Gatz, M. (2017). Longitudinal Association of Anxiety and Cognitive Performance: Genetic and Environmental Influences. *Innovation in Aging, 1*(suppl_1), 84. https://doi.org/10.1093/geroni/igx004.348

Pfeifer, J. H., & Allen, N. B. (2021). Puberty Initiates Cascading Relationships Between Neurodevelopmental, Social, and Internalizing Processes Across Adolescence. *Biological Psychiatry (1969), 89*(2), 99-108. https://doi.org/10.1016/j.biopsych.2020.09.002

Plana-Ripoll, O., Weye, N., Knudsen, A. K., Hakulinen, C., Madsen, K. B., Christensen, M. K., Agerbo, E., Laursen, T. M., Nordentoft, M., Timmermann, A., Whiteford, H., Øverland, S., Iburg, K. M., & McGrath, J. J. (2023). The association between mental disorders and subsequent years of working life: a Danish population-based cohort study. *The Lancet. Psychiatry, 10*(1), 30-39. https://doi.org/10.1016/S2215-0366(22)00376-5

Poulton, A. (2021). Recognising attention deficit hyperactivity disorder across the lifespan. *Australian Journal of General Practice, 50*(3), 110-113. https://doi.org/10.31128/AJGP-09-20-5623

Pozzi, E., Vijayakumar, N., Rakesh, D., & Whittle, S. (2021). Neural Correlates of Emotion Regulation in Adolescents and Emerging Adults: A Meta-analytic

Study. *Biological Psychiatry (1969), 89*(2), 194-204. https://doi.org/10.1016/j.biopsych.2020.08.006

Rabiee, A., Vasaghi-Gharamaleki, B., Samadi, S. A., Amiri-Shavaki, Y., & Alaghband-Rad, J. (2020). Working Memory Deficits and its Relationship to Autism Spectrum Disorders. *Iranian Journal of Medical Sciences, 45*(2), 100-109. https://doi.org/10.30476/IJMS.2019.45315

Ribas, M. O. (previously Marzena Szkodo), Micai, M., Caruso, A., Fulceri, F., Fazio, M., & Scattoni, M. L. (2023). Technologies to support the diagnosis and/or treatment of neurodevelopmental disorders: A systematic review. *Neuroscience and Biobehavioral Reviews, 145*, 105021. https://doi.org/10.1016/j.neubiorev.2022.105021

Robitzsch, A. (2020). Why Ordinal Variables Can (Almost) Always Be Treated as Continuous Variables: Clarifying Assumptions of Robust Continuous and Ordinal Factor Analysis Estimation Methods. *Frontiers in Education (Lausanne), 5* https://doi.org/10.3389/feduc.2020.589965

Rosenberg, M. D., Martinez, S. A., Rapuano, K. M., Conley, M. I., Cohen, A. O., Cornejo, M. D., Hagler, J., Hagler, D. J., Meredith, W. J., Anderson, K. M., Wager, T. D., Feczko, E., Earl, E., Fair, D. A., Barch, D. M., Watts, R., & Casey, B. J. (2020). Behavioral and Neural Signatures of Working Memory in Childhood. *The Journal of Neuroscience, 40*(26), 5090-5104. https://doi.org/10.1523/JNEUROSCI.2841-19.2020

Schober, P., Boer, C., & Schwarte, L. (2018). Correlation Coefficients: Appropriate Use and Interpretation. *Anesthesia and Analgesia, 126*(5), 1763-1768. https://doi.org/10.1213/ANE.0000000000002864

Sepp, S., Howard, S. J., Tindall-Ford, S., Agostinho, S., & Paas, F. (2019). Cognitive Load Theory and Human Movement: Towards an Integrated Model of Working Memory. *Educational Psychology Review, 31*(2), 293-317. https://doi.org/10.1007/s10648-019-09461-9

Shi, R., Sharpe, L., & Abbott, M. (2019). A meta-analysis of the relationship between anxiety and attentional control. *Clinical Psychology Review, 72*, 101754. https://doi.org/10.1016/j.cpr.2019.101754

Shulman, C., Esler, A., Morrier, M. J., & Rice, C. E. (2020). *The Psychiatric Clinics of North America, 43*(4), 583-603. https://doi.org/10.1016/j.psc.2020.08.001

Spinhoven, P., van Hemert, A. M., & Penninx, B. W. (2018). Repetitive negative thinking as a predictor of depression and anxiety: A longitudinal cohort study. *Journal of Affective Disorders, 241*, 216-225. https://doi.org/10.1016/j.jad.2018.08.037

Stout, D. M., Bomyea, J., Risbrough, V. B., & Simmons, A. N. (2020). Aversive Distractors Modulate Affective Working Memory in Frontoparietal Regions. *Emotion (Washington, D.C.), 20*(2), 286-295. https://doi.org/10.1037/emo0000544

Tajik-Parvinchi, D., Farmus, L., Tablon Modica, P., Cribbie, R. A., & Weiss, J. A. (2021). The role of cognitive control and emotion regulation in predicting mental

health problems in children with neurodevelopmental disorders. *Child : Care, Health & Development, 47*(5), 608-617. https://doi.org/10.1111/cch.12868

Thapar, A., Livingston, L. A., Eyre, O., & Riglin, L. (2023). Practitioner Review: Attention-deficit hyperactivity disorder and autism spectrum disorder – the importance of depression. *Journal of Child Psychology and Psychiatry, 64*(1), 4-15. https://doi.org/10.1111/jcpp.13678

Thompson, W. K., Barch, D. M., Bjork, J. M., Gonzalez, R., Nagel, B. J., Nixon, S. J., & Luciana, M. (2019). The structure of cognition in 9 and 10 year-old children and associations with problem behaviors: Findings from the ABCD study's baseline neurocognitive battery. *Developmental cognitive neuroscience*, *36*, 100606. doi: 10.1016/j.dcn.2018.12.004

Townsend, L., Kobak, K., Kearney, C., Milham, M., Andreotti, C., Escalera, J., Alexander, L., Gill, M. K., Birmaher, B., Sylvester, R., Rice, D., Deep, A., & Kaufman, J. (2020). Development of Three Web-Based Computerized Versions of the Kiddie Schedule for Affective Disorders and Schizophrenia Child Psychiatric Diagnostic Interview: Preliminary Validity Data. *Journal of the American Academy of Child and Adolescent Psychiatry, 59*(2), 309-325. https://doi.org/10.1016/j.jaac.2019.05.009

Tulsky, D. S., Carlozzi, N., Chiaravalloti, N. D., Beaumont, J. L., Kisala, P. A., Mungas, D., Conway, K., & Gershon, R. (2014). NIH Toolbox Cognition Battery (NIHTB-CB): List Sorting Test to Measure Working Memory. *Journal of the International Neuropsychological Society, 20*(6), 599-610. https://doi.org/10.1017/S135561771400040X

Tulsky, D. S., Carlozzi, N. E., Chevalier, N., Espy, K. A., Beaumont, J. L., & Mungas, D. (2013). V. NIH toolbox cognition battery (CB): measuring working memory. *Monographs of the Society for Research in Child Development*, *78*(4), 70-87. https://doi.org/10.1111/mono.12035

Uljarević, M., Hedley, D., Rose-Foley, K., Magiati, I., Cai, R. Y., Dissanayake, C., Richdale, A., & Trollor, J. (2020). Anxiety and Depression from Adolescence to Old Age in Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders, 50*(9), 3155-3165. https://doi.org/10.1007/s10803-019-04084-z

Valentine, A. Z., Brown, B. J., Groom, M. J., Young, E., Hollis, C., & Hall, C. L. (2020). A systematic review evaluating the implementation of technologies to assess, monitor and treat neurodevelopmental disorders: A map of the current evidence. *Clinical Psychology Review, 80*, 101870. https://doi.org/10.1016/j.cpr.2020.101870

van der Meer, D., Hoekstra, P. J., van Rooij, D., Winkler, A. M., van Ewijk, H., Heslenfeld, D. J., Oosterlaan, J., Faraone, S. V., Franke, B., Buitelaar, J. K., & Hartman, C. A. (2018). Anxiety modulates the relation between attention-deficit/hyperactivity disorder severity and working memory-related brain activity. *The World Journal of Biological Psychiatry*, *19*(6), 450–460. https://doi.org/10.1080/15622975.2017.1287952

van Ede, F., & Nobre, A. C. (2022). Turning Attention Inside Out: How Working Memory Serves Behavior. *Annual Review of Psychology, 74*(1), 137-165. https://doi.org/10.1146/annurev-psych-021422-041757

Vashisht, P., & Jatain, A. (2023). A Novel Approach for Diagnosing Neuro-Developmental Disorders using Artificial Intelligence. *Inteligencia Artificial, 26*(71), 13-24. https://doi.org/10.4114/intartif.vol26iss71pp13-24

Villani, D., Sorgente, A., Iannello, P., & Antonietti, A. (2019). The Role of Spirituality and Religiosity in Subjective Well-Being of Individuals With Different Religious Status. *Frontiers in Psychology, 10*, 1525. https://doi.org/10.3389/fpsyg.2019.01525

Volkow, N. D., Koob, G. F., Croyle, R. T., Bianchi, D. W., Gordon, J. A., Koroshetz, W. J., Pérez-Stable, E. J., Riley, W. T., Bloch, M. H., Conway, K., Deeds, B. G., Dowling, G. J., Grant, S., Howlett, K. D., Matochik, J. A., Morgan, G. D., Murray, M. M., Noronha, A., Spong, C. Y., . . . Weiss, S. R. B. (2018). The conception of the ABCD study: From substance use to a broad NIH collaboration. *Developmental Cognitive Neuroscience, 32*, 4-7. https://doi.org/10.1016/j.dcn.2017.10.002

Waechter, S., Moscovitch, D. A., Vidovic, V., Bielak, T., Rowa, K., & McCabe, R. E. (2018). Working Memory Capacity in Social Anxiety Disorder: Revisiting Prior Conclusions. *Journal of Abnormal Psychology (1965), 127*(3), 276-281. https://doi.org/10.1037/abn0000341

Walker, A. R. (2020). “God is my doctor”: mindfulness meditation/prayer as a spiritual well-being coping strategy for Jamaican school principals to manage their work-related stress and anxiety. *Journal of Educational Administration, 58*(4), 467-480. https://doi.org/10.1108/JEA-06-2019-0097

Wall Emerson, R. (2023). Mann-Whitney U test and t-test. *Journal of Visual Impairment & Blindness, 117*(1), 99-100. https://doi.org/10.1177/0145482X221150592

Warren, S. L., Heller, W., & Miller, G. A. (2021). The Structure of Executive Dysfunction in Depression and Anxiety. *Journal of Affective Disorders, 279*, 208-216. https://doi.org/10.1016/j.jad.2020.09.132

Willard, C. A. (2020). Chi-Square. In *Statistical Methods : an introduction to basic statistical concepts and analysis /* (pp. 254–271). Routledge/Taylor & Francis Group,. https://doi.org/10.4324/9780429261039-16Yang, X., Fang, Y., Chen, H., Zhang, T., Yin, X., Man, J., Yang, L., & Lu, M. (2021). Global, regional and national burden of anxiety disorders from 1990 to 2019: results from the Global Burden of Disease Study 2019. *Epidemiology and Psychiatric Sciences, 30*, e36. https://doi.org/10.1017/S2045796021000275

World Health Organization. (2022). Mental Health and COVID-19: Early evidence of the pandemic's impact [Scientifc brief]. Retrieved February 10, 2023, from https://www.who.int/publications/i/item/ WHO-2019-nCoV-Sci_Brief-Mental_health-2022.1

Yang, X., Fang, Y., Chen, H., Zhang, T., Yin, X., Man, J., Yang, L., & Lu, M. (2021). Global, regional and national burden of anxiety disorders from 1990 to 2019: results from the Global Burden of Disease Study 2019. *Epidemiology and Psychiatric Sciences, 30*, e36. https://doi.org/10.1017/S2045796021000275

Yoon, K. L., LeMoult, J., Hamedani, A., & McCabe, R. (2018). Working memory capacity and spontaneous emotion regulation in generalised anxiety disorder. *Cognition and Emotion, 32*(1), 215-221. https://doi.org/10.1080/02699931.2017.1282854

Zelazo, P. D. (2020). Executive Function and Psychopathology: A Neurodevelopmental Perspective. *Annual Review of Clinical Psychology, 16*(1), 431-454. https://doi.org/10.1146/annurev-clinpsy-072319-024242