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The Effects of Executive Function between Anxiety and Math Achievement in Adolescents

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THE EFFECTS OF EXECUTIVE FUNCTION BETWEEN ANXIETY AND MATH ACHIEVEMENT IN ADOLESCENTS

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Abstract

Anxiety in children can develop into pervasive disorders in adulthood if not treated. Research shows dysfunctional Executive Function (EF) and anxiety are both shown to have a negative impact on math achievement in children and adolescents (Trezise & Reeve, 2018; Kalaycioglu, 2015; Owens, Stevenson, Hadwin & Norgate, 2012). Chung, Weyandt, and Swentosky (2014) found biological and neuropsychological support for EF as a unitary and multifaceted processor for regulating our emotional states as well as our daily procedures. Anderson's (2002) model of Executive Control System (ECS) allows the factors of EF to be examined using a developmental approach towards EF processes. He groups the EF skills into four domains: attentional control, cognitive flexibility, information processing and goal setting. The current study uses the factors inhibition, divided attention, verbal fluency, and planning to represent each domain, respectfully. We measured (n = 18) adolescent's EF skills, anxiety levels and math achievement by their scores from the DKEFs, BASC-2 and the BASC-3, the WIAT III and WJ IV- ACH, respectfully. With this small sample, the results suggest the EF domain attentional control via inhibition, as measured by the Color Work Interference Test (CWIT) from the DKEFs, mediated anxiety and math achievement. Future studies using a larger sample are necessary to replicate the current study's findings on the mediating relationship of EF between anxiety, and math achievement in adolescence due to the small sample size.

Keywords: Anxiety, Executive Function, Math Achievement, ECS Model.

Acknowledgements

The inspiration of this study was influenced by a promise to my first psychology professor to always look at biological factors before addressing any psychological symptoms.

Dedication

I would like to dedicate this dissertation to Anthony Urbinato for always being in my corner and keeping me focused throughout my journey.

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Chapter 1 Introduction

In the school setting, the disparity between the mental health needs of children and efficient interventions to support them, demands action from school psychologists to investigate the academic effects of mental disorders (Cleary & Scott, 2011). Cleary and Scott (2011) estimated "up to 15 percent of children and adolescents [are] suffering from a mental disorder severe enough to cause some level of functional impairment" (p. 1). The prevalence of anxiety disorders in children is estimated to be from 0.9 percent up to 16 percent (American Psychiatric Association, 2013). Studies have addressed the neuropsychological functioning in anxiety disorders during the past couple of decades and have shown a strong relationship between anxiety and Executive Function (EF); whereas measures of anxiety were high they found impairment with executive function (Airaksinen, Larsson, & Forsell, 2005). EF helps students to manage their academic workload, to take notes, to plan and complete projects, to navigate social relationships, and to prioritize putting schoolwork before leisure activities. This can have effects on all areas of academic performance, including math achievement (Trezise & Reeve, 2018; Owens, Stevenson, Hadwin & Norgate, 2012).

Anxiety in Youth

The importance of investigating anxiety in children arises when you understand the symptoms and the biological factors that occur when an individual experiences anxiety. The Diagnostic and Statistical Manual of Mental Disorders (5^{th} ed.; DSM-5; American Psychiatric Association, 2013) defines seven different types of anxiety disorders, including separation anxiety disorder, selective mutism, specific phobia, social phobia, panic disorder, agoraphobia, and generalized anxiety disorder. Although distinct disorders, there are some commonalities among the different types of anxiety. Common complaints of individuals who experience anxiety are excessive worry that is difficult to control, immense fear, experiencing autonomic responses out of context, difficulty concentrating and/or their mind going blank. Throughout the world, anxiety can negatively affect cognitive performance such as lowering academic performance of youth making it difficult to solve algebraic problem solving; as seen with impaired EF skills (Airaksinen et al., 2005; Trezise & Reeve, 2018; Kalaycioglu, 2015; Owens, Stevenson, Hadwin & Norgate, 2012).

The DSM-5 description of the symptoms of anxiety have some crossover symptoms with Attention Deficit Disorder where practitioners use caution when determining appropriate diagnosis due to this crossover of symptoms (American Psychiatric Association, 2013). Neuroscience and neuropsychology have helped us understand that there is this relationship between anxiety and EF through biological research, imaging studies, and use of psychometric assessments. Specifically, the fear circuit [amygdala, insula, Anterior Cingulate Cortex (ACC) and Prefrontal Cortex (PFC)] is hyperactive during intense states of anxiety (Brühl, Delsignore, Komossa, & Weidt, 2014). A dysfunction of EF processes, which mediates the fear circuit, can therefore affects a person's anxiety levels and symptoms (Hariri, 2015).

Executive Function

The discovery and developments in EF research reveal the importance of EF in daily life and the vast processes that make operationally defining EF difficult. Thanks to the researchers dating as far back as the 1800s and the famous case study of Phineas Gage who survived a railroad rod struck through his head during work, the field of studying EF has emerged. Various definitions tend to include the following cognitive processes: attention, emotion regulation, flexibility, inhibitory control, initiation, organization, planning, self-monitoring, and working memory (Naglieri, & Goldstein, 2014). McCloskey (2011) clarifies by stating, "It is helpful to think of EF as a set of independent but coordinated processes rather than a single trait" (p.2). Roberts and Pennington (1996) explain McCloskey's definition further into terms of processes as "distinct abilities such as planning, set maintenance, impulse control, working memory, and attentional control" (p. 105). Overall, there is not one definition of EF that researchers agree upon now, but all accept that EF is an umbrella term for multi-faceted cognitive processes.

Anderson (2008) conceptualized these various definitions into a working framework called Executive Control System (ECS). In the ECS model, EF encompasses four domains that are based on cognitive development: attentional control, cognitive flexibility, information processing, and goal setting (See Appendix A). This developmental model categorizes three to four factors into each domain. Examples of these factors throughout research include flexibility, planning, selective attention, fluency or working memory, concept reasoning, impulse control, and response speed (Anderson, 2008; Anderson, 2002). Best, Miller, and Naglieri (2011) provided support of this theoretical framework in their study of 2,036 participants ages 5-17 years old. Their study of age-related changes with EF skill and academic achievement suggested that complex EF skill development slowed in adolescence suggesting maturation at this stage of development. Boelem, Harakeh, Ormel, and Hartman (2013) also found supportive evidence with 2,217 adolescents between the ages of 11-19 years old in a longitude study that EF maturates in adolescence. This theory depicts the understanding of EF as multifaceted and aligns closely to McCloskey's (2011) definition of EF, whilst incorporating the processes of Roberts' and Pennington's (1996) definition.

Math Achievement

Everyday math is utilized by every person throughout the world. One example is when a person plans how much time is needed for them to wake up in the morning, get ready, then make it to work on time; they are using math to calculate the time they need. Geary (2011) found seven percent of children and adolescents suffer from a math deficiency along with another ten percent show consistently low achievement in mathematics despite having average abilities in other areas. Even with the average abilities in other areas like reading, Geary stated that individuals with low math achieving skills struggled even more to acquire employment than individuals who struggled with reading. Specifically, people who have poor mathematic skills were associated with higher rates of low-paying manual jobs, more frequent periods of unemployment, lower rates of full-time employment, and a lower ability to acquire professional development training and therefore lower rates of promotions. Geary also mentioned a memory delay and deficit that were specific to mathematic learning as a possible contributor to this achievement deficit. When looking at children, those that experience anxiety often have a hard time thinking through mathematical equations during their schoolwork and especially on tests (Trezise & Reeve, 2018; Kalaycioglu, 2015; Owens et al., 2012).

Statement of the Problem

Interplay of Anxiety, Executive Function, and Math Achievement. By looking at the individual relationships between anxiety, EF, and math achievement, an overall relationship between the three variables emerges. Anxiety symptoms have been associated with a dysfunction between the PFC and the amygdala networks (Hariri, 2015). When the topic of investigation is turned towards anxiety and math achievement, researchers around the world conducted different studies and found supportive evidence of a relationship that exists (Kalaycioglu, 2015; Owens et al., 2012). In general, individuals who experience high levels of anxiety tend to exhibit poor performance with different types of math achievement, specifically problem solving and calculations. When looking at EF and the relationship that exists with math achievement, all four factors show evidence of a predictive relationship with math achievement (Agostino et al., 2010; Yeniad, Malda, Mesman, van IJzendoorn, & Piper, 2013; Mädamürk, Kikas, & Palu, 2016; Naglieri, 2011). In conclusion, there seems to be an interplay between EF, anxiety, and math achievement.

Researchers have used a multifaceted approach when investigating the correlation between anxiety and EF. Some studies found an inverse relationship between anxiety and inhibition (Hovland, Pallesen, Hammar, Hansen, Thayer, Tarvainen, & Nordhus, 2012; Visu-Petra, Miclea, & Visu-Petra, 2013). Hovland et al. (2012) found 35 participants who met the criteria for panic disorder had anxiety measures that were inversely related to inhibition measures with neuropsychological measurements. Visu-Petra et al. (2013) found state and trait anxiety measures in 97 participants between the ages of 19-33 years old were negatively related to inhibition. Other studies found people with anxiety disorders had impairments with divided attention (Airaksinen et al., 2005; Visu-Petra et al., 2013). Airaksinen et al. (2005) compared a sample of participants that met the criteria for anxiety disorders (n = 96) with healthy adults (n = 175) and found the total anxiety group exhibited impairment with divided attention. Visu-Petra et al. (2013) also investigated divided attention with their participants and found a negatively relation with divided attention. Investigating children and adults, some studies found no relationship with anxiety and information processing while others found an inverse relationship between anxiety and information processing (Toazza, Salum, Flores, Jarros, Pine, Fumagalli de

Salles, & Manfro, 2014; Airaksinen et al., 2005). Toazza et al. (2014) conducted a study with 60 children between the ages of 6-12 years old who had a comorbid clinical diagnosis of anxiety and found no relationship with verbal fluency. However, Airaksinen et al. (2005) found no effect of anxiety when measuring verbal fluency. Finally, investigation into the relationship between anxiety and planning also gave evidence of a no relationship existing among 95 participants ages 7-15 years old (Sarkis, Sarkis, Marshall, & Archer, 2005). An inverse relationship between anxiety and inhibition and divided attention, while no relationship was found with information processing and planning.

With students, research supports a negative relationship between anxiety and math achievement around the world. One study found that as anxiety increases the accuracy and efficiency of solving mathematical processes occurring in real world context as measured by the Programme for International Student Assessment decreased ($r = -.340$; Kalaycioglu, 2015). This relationship was significant in Greece, Turkey, and the USA but not in England, Hong Kong, or the Netherlands. Using the raw mathematic scores from the National Curriculum Standard Assessment Test with UK students, another study supports higher levels of anxiety were significantly related to lower math achievement ($r = -0.43$; Owens et al., 2012). Anxiety is a universal phenomenon and the negative relationship with math achievement are global as well.

Current research on the relationship between anxiety and math achievement has focused on different mediating factors and age groups. One study of children aged 8-12 showed that working memory, self-concept, and anxiety contributed to performance on math fluency and problem solving (Justicia-Galiano, Martin-Puga, Linares & Pelegrina, 2017). A study showed that time constraints and problem difficulty affected anxiety and working memory in high school students, adversely mediating performance on algebraic problem-solving tasks (Trezise & Reeve, 2018). Comparison of male and female college students has suggested that higher levels of measured anxiety in women mediated visuospatial working memory resources, leading to gender differences in math test performance significantly favoring men (Ganley & Vasilyeva, 2014).

There is robust research on the EF factors that predict math achievement in children and adolescents. Inhibition and set shifting have shown mixed results for being a predictive factor for math achievement (Yeniad, et al., 2013; Agostino, Johnson, & Pascual-Leone, 2010; Bull & Scerif, 2001). Verbal fluency was shown to be a necessary component to math problem solving (Mädamürk, Kikas, & Palu, 2016; Meyer, 1981). Lastly, planning was shown to have the most robust and consistent evidence in support of a predictive relationship with math achievement (Best, Miller & Naglieri, 2011; Cai, Georgiou, Wen, & Das, 2016; Crook & Evans, 2013). Studies like these have prompted teachers across the nation to incorporate EF skills instruction into their lesson plans to prepare children for their success in their careers (Covey, 2014).

The studies presented here have shown a relationship between anxiety and EF. They have also shown anxiety to have a negative relationship, and EF a positive relationship, with math achievement similar to those found with students who have ADHD. Studies also support a relationship between reported DSM-5 ADHD symptoms and EF disorder in subjects (Silverstein, et al., 2018). With these relationships in mind, it is possible that the decline in math achievement seen with children suffering from anxiety may be due to the dysfunction of their EF. Along these lines, this study purports EF may be a mediator between Anxiety and math achievement in youth.

Developmental Implications. The three factors: anxiety, EF and Math achievement all have developmental implications to consider when researching them. When looking at the developmental implications, each factor has its own way of connecting to development. Anxiety looks at onset, EF looks at developmental stages in life, and math considers development in conjunction with skills acquired.

Children can acquire anxiety at different ages, but research has identified core risk periods for the onset of anxiety disorders in childhood and adolescence (American Psychiatric Association, 2013). For example, separation anxiety is the anxiety disorder with the earliest onset (typically as early as preschool age), followed by Selective Mutism. While social phobia was found to have a peak risk period in early adolescence, panic disorder and Generalized Anxiety Disorder (GAD) have their core onset periods in late adolescence. According to the American Psychiatric Association (2013), development is an important factor when investigating anxiety in children and adolescents.

Children also develop different EF skills at different stages in life (Qian, Shuai, Shan, Qian, & Wang, 2013; Kalkut, Han, Lasing, Holdriack, & Delis, 2009; Kavé, 2006; Albert & Steinberg, 2001; Beesdo, Knappe, & Pine, 2009). In addition to occurring around the age of 2 years old, the brain also goes through a process called "pruning" whereby neural connections in the brain are cut when not used or reinforced. These changes occur to make thinking more efficient for humans; and therefore, a level of maturation can occur due to the effects of the pruning process. Overall, the research suggests inhibition is stable around 12 years of age (Qian et al., 2013). Supportive evidence suggests the maturation for divided attention occurring between 14 and 15 years of age (Qian et al., 2012; Kalkut et al., 2009). Research involving verbal fluency is clear that maturation points to age of 16 (Kavé, 2006). Finally, recent research suggests a maturation of simple planning around the age of 17 (Albert & Steinberg, 2011). The ECS developmental model takes these changes for maturation into consideration as evidenced by the theory's statement that the basic EF skills (attentional control, cognitive flexibility, information processing) reach their maturation period before the complex higher order processing EF skill has matured (goal setting; Anderson, 2002).

The research of mathematical development is a fairly new topic of research. Research suggests mathematical achievement is a dynamic process that is better understood within a developmental framework (Calderón-Tena, 2016). Research of the developmental stages of mathematical skills does not directly look at age but rather at cognitive development and math skills acquired. For example, research has shown that as early as infancy humans have an innate knowledge of numerosity and ordinality and may have an implicit understanding of simple arithmetic (Geary, 2006). In early childhood, number concepts and simple addition and subtraction is implicitly understood with objects. From here, the breadth and complexity of mathematics through the lens of children's development becomes daunting and research is only in the beginning stages of fully understanding the developmental trajectory. Simple calculation, single digit arithmetic, matures in elementary school. More complex calculation, multi-digit calculation of multiplication and division, matures in middle school. In the area of problem solving the maturation period is adolescence. The higher age maturation of problem solving compared to the maturation age of computation shows a similar pattern of increasing complexity with age similar to the development of EF. These different stages of maturation point to the importance of taking an individual's stage of development into consideration while looking at math achievement.

Although all three factors have developmental implications to consider when researching them, the considerations of how development plays a role in each factor is different. These developmental implications of onset for symptoms of anxiety, stages of maturation for EF and acquired mathematical skills are built into the foundation of this study.

Importance of the Study. This study investigated the relationship between EF, anxiety, and math achievement by measuring anxiety and EF performance in comparison with math achievement in adolescents using the ECS model. Incorporating the aspects of each domain within the ECS model may help clarify the EF deficits individuals with anxiety are experiencing and the relationship between each domain.

Students use EF to solve math problems with the nature of procedures to utilize and remembering rules to follow. As mentioned earlier, studies have supported the notion that anxiety negatively impacts mathematical achievement of students. Mathematical equations help students with the process of solving problems and finding relationships among variables, both important skills for a functional life. If anxiety is left to persist into adulthood, the person will struggle with these skills to adapt to life problems and the cost of care for their anxiety increases significantly (American Psychiatric Association, 2013).

Purpose of the Study

The purpose of this study is to investigate the relationship of EF (inhibition, divided attention, verbal fluency, and planning) as a potential mediating factor between anxiety and math achievement. Studies have shown that EF is composed of many different factors. However, they focused on just a few domains like cognitive flexibility and attentional control. By using a broader scope to encompass all four domains of ECS, this study aims to clarify the relationships between EF, anxiety, and math achievement in children and adolescents.

Research Questions & Hypotheses

This study investigates the role of executive function (EF) in mediating the effects of anxiety on math achievement in adolescents, along with the moderating effects of age and gender. The relevant variables are:

Dependent variable: Math achievement as measured by WIAT-III, KTEA-3, or the WJ-IV ACH.

Independent variable: Anxiety, as measured by BASC-2 and BASC-3

Mediating variable: Executive Function factors, Attentional Control (ATTC), Cognitive Flexibility (COGF), Information Processing (INFO), and Goal Setting (GSET) as measured by DKEFs four subtests (CWIT, TMT, Verbal Fluency, and Tower Test) respectfully.

Moderating variables: Gender (Male/Female); Age group (9-11 years, 12-15 years, 16 or older)

The following research questions and associated hypotheses are posed:

Is EF a mediating factor between anxiety and math achievement?

H1: EF skills mediate the effects of anxiety on a student's math achievement. Decreased EF skills increase anxiety, lowering math performance. Conversely, increased EF skills decrease anxiety, raising math performance.

Does gender moderate the relationship between EF, anxiety, and math achievement?

H2: There is a greater negative correlation between the EF measures of INFO and GSET and anxiety measures, with a corresponding positive effect on math achievement, in male samples than in female samples.

Does age moderate the relationship between EF, anxiety, and math achievement?

H3: There is a greater negative correlation between measures of anxiety and math achievement and all EF measures in the age group of 9 to 11-year-old samples than the negative correlation in the age group of 12 to 15-year-old and 16 or older samples.

Chapter 2 Literature Review

The literature review features neurological and psychological aspects of Anxiety and EF along with developmental aspects of anxiety, EF, and mathematics. Through neuroimaging studies, neuroscience research highlights the biological features of the brain that are active with individuals who have anxiety when they are in an anxious state or when they are in a calm state (resting state; Chung, Weyandt, & Swentosky, 2014). It also gives the comparable features of the brain during EF activities resulting in the need to view the relationship between EF and anxiety as possibly reciprocal instead of unidirectional. In the past decade, neurological research has emphasized the effects of anxiety with brain imaging, pointing future research towards an executive functioning deficit instead of an emotional deficit with certain types of anxiety disorders (Hariri, 2015). On the other hand, psychological research illuminates the thoughts, feelings, and behaviors that anxiety exhibits.

The framework of this study was influenced by Anderson's model (Anderson, 2002) of viewing EF as a unitary and multifaceted construct with his ECS model to understand the relationship of EF with anxiety and math achievement within a developmental lens.

Investigation of Anxiety

Anxiety is a common disorder that research consistently finds to have a chronic course. Anxiety disorders begin to develop in childhood and affect academic success (Beesdo, et al., 2009). In addition, anxiety interferes with all aspects of life including social competence. Moreover, children and adults with anxiety have demonstrated cognitive dysfunctions that result in impaired problem-solving skills (Hariri, 2015; Ganley & Vasilyeva, 2014; Airaksinen et al., 2005; Cleary & Scott, 2001). Different subtypes of anxiety have been linked to lower academic performance of children (Owens, et al., 2012).

Anxiety disorders. As defined by the DSM-5 (American Psychiatric Association, 2013), anxiety disorders demonstrate "excessive fear and anxiety and related behavioral disturbances" (p.189). There are different types of anxiety disorders that affect the behavior of individuals in different ways. Neurosciences discuss the experience of anxiety from a state (i.e., Separation, Mutism, Social Anxiety, Phobias) or a trait (i.e., Generalized Anxiety, Panic Disorder) perspective where state anxiety is brought on by an external stimuli and trait anxiety does not need a stimulus to bring about the symptoms of anxiety (Hariri, 2014). An explanation of the different types of anxiety disorders in the DSM-5 follows as an explanation of the different types of anxiety adolescents may experience from a clinical perspective.

Firstly, separation anxiety disorder expresses fear about the separation from an attachment figure inappropriate for the developmental age (See appendix B). This fear creates such distress that the individual becomes reluctant to leave this figure to ensure their safety or avoid losing them via events out of their control. What is unique about this disorder is the lack of stimuli (i.e., attachment figure) brings about the symptoms of anxiety.

Another fear-based disorder is specific phobia (See appendix B). With this disorder, individuals avoid objects or situations, which create the fear response. With this disorder, a specific stimulus brings about the symptoms creating a state of anxiety.

In social anxiety disorder, a person avoids social situations because they are worried about being scrutinized (See appendix B). For this disorder, the situation becomes the stimulus that creates the state of anxiety and the inability to switch thoughts from what others are thinking about them to a more adaptive thought script.

Contrary to object or event-based anxieties, panic disorder occurs without a stimulus to induce the response. It is characterized by "surges of intense fear or intense discomfort" reaching peaks in minutes and the attack is accompanied by physical and/or cognitive symptoms (See appendix B; p.190). Often, the person believes they are having a heart attack (Hariri, 2014). The symptoms of this anxiety disorder only last a few minutes.

In like manner, generalized anxiety disorder does not have a specific stimulus for the response. It creates overwhelming worry within a variety of domains: work, school performance, etc., sometimes accompanied by physical symptoms (See appendix B). This "free-floating" anxiety has general and pervasive symptoms that range from mild nervousness to continuous dread in an individual (Hariri, 2014).

Neuroimaging studies and anxiety. The fear circuit [comprising the amygdala, insula, Anterior Cingulate Cortex (ACC), and PFC] is hyperactive during intense states of anxiety (Brühl et al., 2014). Several studies have investigated specific areas of the brain that are activated with anxiety; however, more research is needed to understand the dynamics of all anxiety disorders on EF. Authors suggest the temporal cortex and temporal areas are activated in distressed times and during social interaction. (Milrod, Markowitz, Gerber, Cyranowski, Altemus, Shapiro, Hofer, & Glatt, 2014). This is suggested by the authors to explain how the brain is functioning with children who have separation anxiety. Due to the young age of children who experience separation anxiety, it is difficult to research the brain activation via an fMRI or PET scan.

Brühl et al. (2014), through a meta-analysis of 36 studies, found confirmation of hyperactivation of the fear circuit with individuals experiencing social anxiety disorder. In addition to this result, the investigation yielded support of a reduction in the connectivity between the limbic and executive network regions. This reduction in the functional connectivity between the amygdala and the mPFC causes hyperactivity in the amygdala (Hariri, 2015). The amygdala is involved in the functions of arousal, autonomic responses associated with fear, and emotional responses. The executive network helps regulate the amygdala in the limbic network. Peterson, Thome, Frewen and Lanius (2014) conducted a meta-analysis on the resting state of different anxiety disorders. They believed the resting state was a better measurement of brain connectivity because the brain is still consuming 20 percent of the total body's energy requirement compared to a 5 percent increase when people are in a task engagement. In their research, they found 8 studies involving Social Anxiety Disorder (SAD). Their research yielded results supporting alteration within the salience network in SAD. This network is theorized to switch between the central executive network (CEN), where the PFC functions, and the default mode network, where theory of mind functions. The alteration within the CEN were found to have a decrease in connectivity in several studies.

A systematic review of literature on specific phobia was conducted with 38 fMRI, single photon emission tomography (SPECT), and/or positron emission tomography (PET; Linares, Trzesniak, Chagas, Hallak, Nardi, & Crippa, 2012). These authors found a greater activation in the whole fear circuit and orbitofrontal cortex when anxious adults with specific phobia disorder were compared to healthy adults. Hariri (2015) explains there is an apparent decrease in activity in the mPFC during the distress, causing hyperactivity in the amygdala (areas of the fear circuit causing anxiety symptoms). Peterson et al. (2014) conducted a literature review of resting-state neuroimaging studies for specific phobia and were not able to extrapolate any results.

The limbic network supports a variety of functions including emotion and behavior. It is also tightly connected to the PFC, specifically the mPFC. Neuroimaging of the resting-state of panic disorder (PD; n=11) found support of differences in connectivity with frontal and occipital-parietal areas compared to normal images which process somatosensory information, attentional control and self-awareness (Pannekoek, Veer, van Tol, van der Werff, Demenescu, Aleman, Veltman, Zitman, Rombouts, & van der Wee, 2013). This study also found abnormalities of activity in the limbic network where the amygdala resides. Peterson et al. (2014) conducted a meta-analysis and only found this one study related to PD.

A functional connectivity analysis utilizing a standard fMRI to examine the functional neurocircuitry in adolescents (n=10) with GAD observed an increase mPFC and a decrease in the connectivity between the ventral lateral PFC (VLPFC) and the mPFC (Strawn, Bitter, Weber, Chu, Whitsel, Adler, Cerullo, Eliassen, Strakowski, & DelBello, 2012). The VLPFC mediates some of the cognitive responses to negative emotions. In sum, the decrease in the mPFC activity, the VLPFC, and functional connectivity between the amygdala and the mPFC causes the amygdala to stay in a hyperactive state (Hariri, 2015). As far as the resting-state for GAD, neuroimaging showed an increase in the connectivity with the mPFC with their GAD control group (Etkin, Prater, Schatzberg, Menon, & Greicius, 2009). This connectivity was negatively correlated with anxiety, suggesting a structural abnormality between the PFC and the amygdala in individuals with GAD. This negative correlation also suggests a compensatory neural adaptation with participants who have GAD and are less anxious than individuals with GAD who experience more anxious states. Their results support Harari's findings: a decrease in the connectivity between the amygdala and the PFC causes a hyperactive state of the amygdala with individuals who have GAD.

Similar to the neuroimaging of these anxiety disorders showing dysfunctions in the networking in both agitated and resting state, the deficits with EF may be observable under conditions that do not involve affective material. This in-depth overview of biological functions of anxiety helps to lay the foundation of the connection between anxiety and EF that current psychological research is just now starting to pierce with their assessments and research focus.

Intervention for anxiety. If the right interventions are not implemented in childhood, then anxiety disorders persist into adulthood and increase the cost of care (American Psychiatric Association, 2013). Although Cognitive Behavior Therapy (CBT) is an empirically based treatment for anxiety, further investigation of anxiety is warranted because not all individuals with anxiety respond to CBT. Even researching Evidence Based Therapy and anxiety yielded outcomes to point towards CBT or microbiome biological factors showing a need for further investigation of anxiety whilst considering biological factors in the foundation of the research. Therefore, further investigation into anxiety is first necessary to become a springboard for supplemental or new treatments.

Carrion, Wong, and Kletter (2013) recommended utilizing a different approach with studies on children with anxiety to achieve concise data and for future creation and implementation of intervention and treatments. Specifically, they suggested designing therapies to improve specific symptoms and cognitive deficits that also target brain functions and associated regions of interest. Moreover, they explained creating interventions that target behavioral improvements and facilitate an extinction of the fear response along with strengthening EF. This may also be reflecting a parallel improvement in PFC functioning, such as enhancing prefrontal inhibition of amygdala fear conditioned processes. The overarching suggestion from this study was to use neuroimaging alongside interventions to guide treatment development and selection. Most of this research has been limited due to cost, amount of time, and the extensive training required to become proficient in imaging techniques.

Another avenue for intervention is based on past studies that have shown specific brain regions of the PFC activated when participants were completing assessments that measure EF skills, and therefore, an inexpensive measure of EF is utilizing these psychometric assessments, instead of neuroimaging, in conjunction with anxiety therapies that include strengthening EF control. Perhaps the implementation of these targeted interventions will be delivered by school psychologists further reducing the cost of care throughout the nation. As a result, investigating further into the relationship between anxiety and EF may open new avenues for exploring other outcomes.

Components of Executive Function

As far back as 1840, investigators propose that vast amounts of cognitive processes are within EF and are carried out by the prefrontal areas of the frontal lobes (Goldstein, Naglieri, Princiotta, & Otero, 2014).

> EF is not exclusive to cognitive processes (anticipation and deployment of attention, initiation of activity, working memory, mental flexibility and utilization of feedback, planning ability and organization, and selection of efficient problem-solving strategies) but is also characterized in emotional responses and behavioral actions (impulse control and self-regulation; Gioia, Isquith, Guy, & Kenworthy, 2000, "Executive Function", para. 1, in Anderson, Jacobs, & Anderson, 2010).

Due to the numerous cognitive processes along with the emotional responses and behavioral actions encompassed in EF, a clear definition has yet to emerge. Since the 1840's, researchers have been discussing the concept of a "control mechanism" to explain cognitive processes (Goldstein et al., 2014). Recently, the concept of EF evolved into a unitary and multifaceted construct (Chung et al., 2014; Anderson, 2002). Simply put, EF organizes thoughts and behaviors in a goal directed manner (Boelem, Harakeh, Ormel, Hartman, Vollebergh, & Van Zandvoort, 2014).

Defining the factors in research. One way to investigate each domain of the ECS model, is by measuring the factors via subtests on EF assessments. It is common for researchers to study EF in clusters encompassing some of the factors in the ECS model. Some prevalent factor clusters found in these studies include working memory, divided attention, and inhibition (Visu-Petra et al., 2013); and inhibition and cognitive flexibility (Hovland et al., 2012). Although these clusters address at least two domains within the ECS model, little research has touched on all four domains at once when researching EF with factor clusters.

Studies with children also sometimes utilize clusters of EF factors. One common factor cluster researched in children is inhibition and cognitive flexibility (Yeniad et al., 2013; Agostino et al., 2010; Bull & Scerif, 2001). However, there is sufficient research with verbal fluency (Mädamürk et al., 2016; Toazza et al., 2014), and planning in children (Best et al., 2011; Cai et al., 2016; Crook & Evans, 2013). Utilizing one factor from each domain for a factor cluster in research allows researchers to regard the multifaceted aspect of EF without becoming too complex in the analysis.

Neuroimaging studies help define EF factors by investigating the areas of the brain that are activated during different tasks as measured by diagnostic assessment tools. Three areas appear to be specifically associated with EF processing in the brain: The Dorsolateral Pre-Frontal Cortex (DLPFC), the orbitofrontal cortex, and the Medial Pre-Frontal Cortex (mPFC). Research points to inhibition activating the orbitofrontal cortex by considering distractibility as a major factor (Rathi & Vijayvergia, 2012). Wager, Jonides, and Reading (2004) found the DLPFC involved in set shifting activities. Another study found the DLPFC activated during verbal fluency tests (Cabeza & Nyberg, 2000). Furthermore, planning was found to activate the DLPFC with neuroimaging during an EF assessment (Goethals, Audenaert, Jacobs, van der Wiele, Pyck, Ham, Hamphrey, Vandierendonck, van Heeringen, & Dierckx, 2004; Owen, Doyon, Petrides, & Evans, 1996). These biological findings suggest EF is both unitary and multifaceted; therefore, all these factors are examined in relation to each other and in isolation, simultaneously (Chung et al., 2014). By investigating EF through the ECS model, each domain addressing these four factors: inhibition (ATTC), set shifting (COGF), verbal fluency (INFO), and planning (GSET); are measured.

ECS domains. Anderson (2002) explored the research of EF processes and organized factors into domains, to help with the conceptualization of so many factors. He took into consideration what neuroscience has discovered about the brain and utilized this information to construct four distinct domains and grouped similar factors together. When his work was completed, he found three to four factors that fell within each domain. The distinct domains are attentional control (ATTC), information processing (INFO), cognitive flexibility (COGF), and goal setting (GSET). A description of each domain follows.

Attentional control is described as “the capacity to selectively attend to specific stimuli and inhibit proponent responses, and the ability to focus attention for a prolonged period” (Anderson, 2002, p.73). When individuals have deficits in this domain, they are impulsive, commit procedural mistakes, fail to complete tasks, and respond inappropriately. Factors included in this domain are selective attention, self-regulation, self-monitoring, and inhibition. Inhibition is said to be the result of rejecting an automatic tendency in each situation. In other words, it is the ability to suppress one’s responses. Furthermore, inhibition may play a role in controlling one's thought process when in a state of fear. Children with anxiety are unable to successfully regulate their fear and/or worry; therefore, investigating inhibition when exploring the cognitive process of EF is important to further the research of anxiety.

Children, who have attentional control, demonstrate consistent regulation of emotions, behaviors, and thoughts, which are all areas of regulation in anxiety. In research, inhibition has received a lot of attention; however, the results in these studies are conflicting (Chung et al., 2014). One explanation about these conflicting results concerns the type of inhibition the person is demonstrating and how it effects the results of the study (i.e., verbal, behavioral, etc.). In addition, research does not have a clear picture of anxiety and the ability to inhibit thoughts, behaviors, and emotions. Therefore, further research is needed to separate the regulation of the cognitive processes and anxiety, filling the gaps of confounding results. One way to control for these confounding results is by utilizing, "the Color Stroop Test", which has a high cognitive load. Anxiety tends to reduce a person's availability to focus on tasks or reduce their cognitive load; therefore, this type of inhibition seems to be the best measure for this EF process.

Cognitive flexibility is the "ability to shift between response sets, learn from mistakes, devise alternative strategies, divide attention, and process multiple sources of information concurrently" (Anderson, 2002, p. 74). A person who demonstrates inflexibility will perseverate and they will continually make the same mistake. The measurable factors within this domain are divided attention/switching, working memory, conceptual transfer and feedback utilization. Divided attention or set switching encompasses flexibility by switching back and forth between tasks, operations, or mental tasks. Anxiety is known to disrupt the availability of cognitive resources, which are needed to divide a person's attention (Airaksinen et al., 2005). Therefore, the measurement of cognitive flexibility through the factor of divided attention is appropriate when researching the relationship with anxiety and math achievement.

"Information processing refers to fluency, efficiency, and speed of output" (Anderson, 2002, p.74). People who demonstrate deficits in this area have delayed responses, reduced output, and slow reaction time. Measurable factors within this domain are efficiency, fluency, and speed of processing. Anxiety affects people when delivering presentations or speeches. Toazza et al. (2014) found support of deficits with verbal fluency in anxious adolescents. Verbal fluency is defined as the ability to recall and produce words within a particular amount of time and the measurement of verbal fluency is associated with either a particular pre-specified category or beginning with a letter (Chung et al., 2014). In children, this may manifest by having difficulty with conversing with their peers in social situations when anxiety levels are elevated.

Goal setting includes the "ability to develop new initiatives, and concepts, as well as the capacity to plan actions in advance and approach tasks in an efficient and strategic manner" (Anderson, 2002, p.74). The factors under this domain are initiative, concept reasoning, planning, and strategic organization. Specifically, planning includes judgment, decision-making, and evaluation (Anderson, 2008). When a person has difficulty within this domain, they are disorganized, have difficulties developing efficient strategies, lack conceptual reasoning, and demonstrate inadequate planning. As a result, anxious adolescents have a heightened avoidance of undesirable goals, such as planning. Anxiety floods the person's thoughts with worried thoughts and reduces their ability to strategically plan (American Psychiatric Association, 2013). Again, children with anxiety will have difficulty with planning projects in school or mathematical solutions to problems, especially with undesirable assignments.

Boelem et al. (2014) utilized the ECS model and found from 11 to 19 years of age adolescents are continuing to develop EF to maturation. The ECS model also purports the four domains mature according to the complexity of the process (attentional control, cognitive flexibility, information processing, and goal setting, respectfully). These processes influence a person's affect and their response to environmental factors, like an adolescent experiencing anxiety and unable to complete mathematical equations. Research suggests a relationship is present between anxiety and EF (Airaksinen et al., 2005; Hariri, 2015) and the factor of development is an important consideration when investigating anxiety and EF (Beesdo et al., 2009; Best et al., 2011; Anderson, 2008). Using the ECS model will allow the investigation of isolating EF factors as a mediator between anxiety and math achievement while taking development into consideration with adolescents.

Neuroscientific Imaging of Executive Function. Structural cerebral imaging supports the prefrontal cortex (PFC) involvement in EF (Chung et al., 2014). The PFC contains three large areas: dorsolateral prefrontal cortex (DLPFC), the orbitofrontal cortex, and the medial prefrontal cortex (mPFC). Studies have deduced the regions of PFC associated with EF by means of functional neuroimaging techniques during tasks utilized in psychology in their diagnostic assessments measuring one factor of EF.

Attentional Control. The complexity of inhibition became apparent when several studies investigated what areas are activated during assessments and produced differing results. Nigg (2000) postulates different types of inhibition exist. For example, these types included response or motor inhibition, cognitive inhibition, motivational inhibition, and automatic inhibition of attention. When researching further into the effects of lesions within certain PFC regions, people with lesions in the Orbitofrontal Cortex demonstrated disinhibition and distractibility (Rathi &

Vijayvergia, 2012). Due to the various types of inhibition found in studies, and distractibility as a component of concentration included in the research of the Orbitofrontal Cortex, this area's attribution to inhibition when considering a relationship with anxiety is the best option. As mentioned before, the Stroop test was recommended to use when assessing for this type of inhibition.

Cognitive Flexibility. Divided attention or set shifting was measured by means of the DKEFS Trail Making Test (Delis, Kaplan, & Kramer, 2001) by Zakzanis, Mraz, and Graham (2005). In their study, they compared shifting and non-shifting by means of the Trail Making Test and found statistically significant increased activation in the DLPFC and the mPFC during the shifting trail. Additionally, they conducted a meta-analysis and found seven regions showing significant activation during shifting. Within these seven regions, the mPFC was activated during the divided attention tasks. In conclusion, the mPFC is associated with divided attention.

Information Processing. Ravnkilde, Videbech, Rosenberg, Gjedde, and Gade (2002), by means of a Positron Emission Tomography (PET), found support of verbal fluency as a measure of frontal lobe function, including the DLPFC with 46 healthy adults. The role of the DLPFC in the performance on the verbal fluency is two folds according to the authors: a semantic role and an initiating and moderating role. The initiating and moderating role was assessed in this study as evidenced by the type of verbal fluency test used: generating words that begin with the letter "T". Cabeza and Nyberg (2000) conducted an empirical review of 275 PET and fMRI studies, exploring the neuroanatomical structure of cognitive functions with a variety of tests. During their exploration, the authors found the DLPFC activated during verbal fluency tests that require the subjects to generate words. Following this trend to measure verbal fluency the DKEFs Verbal Fluency Test utilizes this same format in the subtest to measure this EF.

Goal Setting. Several researchers studied strategic planning through neuroimaging by using a computerized version of the Tower of London with 10 healthy adults and found the DLPFC and VLPFC activated (Goethals et al., 2004). Increases in blood flow in the caudate and thalamus during difficult versions of the Tower of London tasks supported activation in the frontostriatal network, which connects the frontal lobe regions with the basal ganglia that mediates motor, cognitive, and behavioral functions, during planning (Owen et al., 1996). In Cabeza and Nyberg (2000) empirical review, they found the DLPFC activated during the Tower of London tests to extrapolate the brain areas activated during planning. In conclusion, the area of the PFC involved with planning are the DLPFC and the VLPFC; giving support to Goethals et al.'s findings. As a result of these studies, the use the Tower Test from the DKEFs to measure the EF factor planning is appropriate.

Executive function and the school setting. When looking at EF through the ECS model with math achievement, studies show different EF processes are used when solving math problems. When investigating further into each factor within the domains, research showed mixed results with most studies supporting inhibition as a predictor for math achievement (Agostino et al., 2010) and some research showed no correlational relationship between inhibition and math achievement (Bull & Scerif, 2001). These differences may be explained through the different types of measurements for inhibition and math achievement. Yeniad, et al. (2013) found substantial support for the relationship between set shifting and math achievement. However, other results did not find the factor set shifting correlating to math achievement (Agostino et al., 2010). These mixed results may also be due to differences in measurements of the variables. Studies have shown a positive relationship between verbal fluency and math achievement (Mädamürk et al., 2016; Meyer, 1981). Finally, the factor planning was found to have support for a positive relationship with math achievement as well (Best et al., 2011; Cai et al., 2016; Crook & Evans, 2013).

In general, some researchers have focused on the effects of anxiety on EF (Visu-Petra et al., 2013), and other researchers have found EF plays a very important part in academic performance in children and adolescents (Yeniad et al., 2013). Nonetheless, there is very little research involving children and adolescents when investigating the relationship between EF, anxiety, and math achievement.

Examination of Anxiety, Executive Function and Math Achievement

Research supports a relationship between anxiety and EF (Hariri, 2015); anxiety and math achievement (Kalaycioglu, 2015; Hadwim and Norgate, 2012; Trezise and Reeve, 2018; Justicia-Galiano, et al., 2017); and EF and math achievement (Agostino et al., 2010; Bull and Scerif, 2001; Yeniad et al., 2013; Meyers, 1981). Teasing out the relationship between anxiety and math achievement is still under investigation. EF and math achievement research demonstrates a positive relationship exists; however, utilizing the ECS model when investigating the relationship has yet to be conducted.

Anxiety and Executive Function. Hariri (2015) approaches the neurological findings from many studies about the different types of anxiety through evidence supporting the "shared dysfunction of the corticolimbic circuit" (p. 92). Each type of anxiety uniquely demonstrates a dysfunction between the PFC areas and the amygdala. This neurological dysfunction is demonstrated through a variety of behaviors and physical sensations documented in the DSM-5 criteria for anxiety (American Psychiatry Association, 2013). Researchers have demonstrated the results of these dysfunctions using neuroimaging and psychological assessments of EF.

Interestingly, the neurological dynamics of adults compared to adolescents differ and therefore as a result EF ability, alongside, differ. Consequently, when studying anxiety, EF processing plays an important part of the picture. As a result, psychologists and school psychologists can utilize this information to help adolescents with their academic success.

The impairment of EF, or executive dysfunction, not only presents academic concerns with adolescents but also concerns with interpersonal relationships (Anderson, 2008). As mentioned earlier, inhibition has shown a variety of results with neuroimaging, and the literature on anxiety produced similar results. First, a study with 36 adults investigated the relationship of anxiety (Panic Disorder) and inhibition (Hovland et al., 2012). The scores from the participants indicated no effect on inhibition ($M=10$, $SD=3$); however, they did find a correlation of heart rate increasing for both time and error performance on the color word inference test ($r =. 30$, $p< .05$; $r = .43$, $p < .001$; respectfully). Although performance was still within the normal range of the test, anxiety did present a physiological effect. Moreover, the authors found anxiety is associated with poor performance on the Stroop Test. Likewise, Visu-Petra et al. (2013) found support of a relationship between anxiety and inhibition on two different types of Stroop tests: a classic color-word Stroop list and negative priming Stroop list. As mentioned above, during inhibition tasks subjects produced activation in different brain regions. This was hypothesized as the result of different types of inhibition being measured. To eliminate this, the author investigated the measurement of inhibition on Stroop tasks. By the studies employing the same task, the results of the studies found a positive and negative relationship between anxiety and inhibition depending on the type of anxiety presented. This study gives evidence to add to this literature under the construct of the ECS model.

Anxiety has been shown to affect divided attention or set shifting. In a study with college students (n=97), anxiety was shown to be a predictor of having poor divided attention skills (Visu-Petra et al., 2013). Airaksinen et al. (2005) found their total anxiety group of adults (n=112) resulted in needing significantly greater time to complete form B of the trail making test denoting difficulty with the cognitive flexibility factor: divided attention. These studies support the hypothesis of an inverse relationship between anxiety and divided attention.

Furthermore, anxiety showed a negative relationship with verbal fluency in several studies. For example, Toazza et al. (2014) found a negative correlation between verbal fluency scores in their sample (n=57 adolescents, 12-18 years old) and the number of anxiety diagnoses ($r = -0.45$, $p<0.001$). Although their sample was comorbid with other disorders, Airaksinen et al. (2005) kept their sample (n=112) solely within the category of anxiety disorders and compared them to a group of healthy adults (n=175). They explored verbal fluency by the Word Association Test and segregated out different types of anxiety in adults. When conducting an ANCOVA, the results showed Specific Phobia (n=24) generated reliably fewer words ($F\ (1,203) = 2.75$, $p = .999$). Although these studies show a negative relationship between anxiety and verbal fluency, more research is needed with children and adolescents.

Research on strategic planning with anxiety disorders did not supply many results when investigating anxiety and excluding Obsessive Compulsive Disorder and Post Traumatic Stress Disorder. Only one study, with children, was found comorbid with ADHD. In the study, 42 children (7-15 years old) out of the 95 children, were found comorbid with an anxiety disorder (Sarkis, et al., 2005). The authors sought to distinguish if there were any additional impairments of EF by comparing the comorbid group to the sole ADHD group. No significant difference was found with the comorbid groups with the measures of their ‘move score’, initiation time, and rule violation on the Tower of London tasks and the sole ADHD group. With the population of children in the school setting more exploration of the relationship between anxiety and planning is needed to add to the research.

Anxiety and Math Achievement. Numerous studies have been conducted looking at the relationship between anxiety and math achievement. However, researchers have received confounding results which motivated them to look closer at the level of anxiety and level of math to find consistent results.

A study has even investigated worldwide the relationship between anxiety and math achievement and found a relationship only in countries with low math achievement including Turkey, Greece, and the USA (Kalaycioglu, 2015). In Kalaycioglu's study (2015), 8,806 students were selected from 510,000 students who participated in the 2012 Program for International Student Assessment. The results indicated that countries with low math achievement also had the highest reports of anxiety from these students. Owens, Stevenson, Hadwim and Norgate (2012) investigated deeper looking at the relationship between anxiety and math achievement with two studies with 12- to 13-year-old in the UK. Their first study was with 80 participants to assess the direct correlation between anxiety and math achievement. They utilized a self-assessment measure for anxiety and the National Curriculum Standard Assessment Tests to extract the data of their performance in mathematics. In this initial study, they found that adolescents with high anxiety also had lower math scores. The researchers had the students take a separate self-assessment for worry from anxiety and found worry to be a mediating factor between anxiety and math achievement. However, the researchers wanted to look further at this issue and assess if working memory, which have EF components within it, is a mediating factor between anxiety and math achievement. For their second study, they recruited 31 adolescents between the ages of

12 to 13 years old. This group did another self-report measure, and they utilized the *Cambridge neuropsychological test automated battery (CANTAB)* to measure EF. And to measure the math achievement, they used the *Wide Range Achievement Test (WRAT)* mathematics for math computation and their SAT mathematics scores. They found higher levels of anxiety was related to decrease in EF ($r = -0.40$, $p<0.05$). Both studies combined show a mediating relationship exists between anxiety and math achievement however, more research is needed to tease out exactly what the mediating factor really is. In their study, they focused on worry as a factor and mixed EF with working memory and other factors.

Trezise and Reeve (2018) narrowed the lens to look at the relationship between anxiety and the level of math, specifically algebraic problem solving. In their study, they assessed 129 adolescents around the age of 14 in Australia. They assessed the adolescents in two sessions with differing problem-solving levels of difficulty. After each problem, the adolescents rated their level of anxiety with solving the math problem. They found an increase of anxiety was reported alongside an increase in problem difficulty and/or time pressure. Trezise and Reeve (2018) were curious to see if this trend changed with age so they conducted a second study with 257 adolescents between the ages of 13 and 15. An immediate limitation to this study that should be noted is the number of subjects in each age group. While the 13-year-old and 14-year-old had about 100 participants, there were only 40 participants in the 15-year-old age group. They found the older age group reported less worry than the younger age group. The importance of this study reveals that although higher levels of anxiety have a direct relationship with lower math scores, there are other factors to consider when looking at this relationship.

Justicia-Galiano, Martín-Puga, Linares and Plegrina (2017) narrowed their lens to investigate the mediating factor of working memory simultaneously with math self-concept with two types of anxiety and math achievement. In their study, they assessed 167 children between the ages of 8 and 12 years. After calculating several Pearson correlation coefficients and finding moderate relations between the factors, the authors conducted a hierarchal analysis of the type of anxiety experienced by children. This analysis revealed that trait anxiety showed a weaker relationship with math achievement than math anxiety. This supports Harriri's (2015) findings that generalized anxiety disorder (trait anxiety) showed different results in their brain scans than did the other anxiety disorders, which are brought on by a situation (e.g., situations, separation, objects) and can be closely related to math anxiety as researched by Justicia-Galiano et al. (2017). In Hariri's research, he explained that generalized anxiety disorder is an overactive amygdala whereas the other anxiety disorders showed a dysfunctional EF neuropathway to the amygdala. The weaker relationship between trait anxiety and math achievement found by Justicia-Galiano et al., supports the findings of Hariri's findings with different results with different types of anxiety. Justicia-Galiano et al. (2017) also conducted a set of multiple mediation analyses to look at working memory and math self-concept as a mediation between anxiety and math achievement. By narrowing their view to two mediating factors, the authors found the total effects of math anxiety on math achievement became non-significant when the mediator variable were considered adding support that working memory, which utilizes EF, was a mediating factor between anxiety and math achievement.

While Trezise and Reeve (2018) looked at levels of math difficulty and Justicia-Galiano et al. (2017) looked at the mediating factor of working memory, Ganley and Vasilyeva (2014) narrowed their lens on gender basing their interest in past studies that have revealed females performing better on computation tasks and tasks that rely heavily on recall of procedures and information, whereas males perform better on complex math problems involving problem solving and spatial thinking. They conducted two studies. Their first study with 87 undergraduates in the United States, they assessed anxiety as a self-reported scale and had the participants solve algebra and geometry mathematic problems. Through their regression analysis they found gender was not a predictor of math achievement ($\acute{c}$ = 1.31, $s_{\acute{c}}$ = 5.09, p = .80). However, they did find anxiety (b_1 = -2.78, s_{b1} = 1.11, p = .014) and working memory (b_2 = 1.13, s_{b2}n= 0.31, p = .0005) were predictors. In their second study, they sought to find a weakness in this study and started with a larger sample size (118 diverse undergraduates around the age of 20 in the United States). In this study, they found gender was a predictor of math achievement (c = 20.47, s_c = 4.04, p < .0001) and anxiety (a_1 = -1.65, s_{a1} = 0.39, p = .0001). They also found gender as a predictor of working memory performance (a_2 = 3.64, s_{a1} = 0.39, p = .0001). What was revealing in their analysis, is although anxiety was originally a predictor of math achievement (a_3 = -0.90, s_{a3} = 0.27, p = .0001), after their final regression analysis, anxiety was not a predictor (b_1 = -1.46, s_{b1} = 0.88, p = .10) yet gender ($\acute{c}$ = 13.67, $s_{\acute{c}}$n= 4.36, p = .002) and working memory (b_2 = .86, s_{b2} = 0.31, p = .007) were still predictors of math achievement.

Anxiety appears to have a relationship with poor math achievement. However, more research is needed to clearly define the relational pathway between anxiety and math achievement. Although these researchers have investigated from a general view if a relationship exists, and there is strong evidence suggesting one does exist, to a narrower view of mediating factors between the relationship of anxiety and math achievement, none have ventured into the relational pathway of looking at EF factors of attentional control, divided attention, verbal fluency, and planning as mediating factors between anxiety and math achievement when considering gender as a moderating factor.

Executive Function and Math Achievement. There is a robust amount of research on EF and math achievement. There are studies that have shown a positive and even a predictive relationship between EF and math achievement. However, there has also been studies that yield mixed results when looking at each factor separately. No studies were found investigating all four domains of the ECS model in the literature review. Inspecting all four domains in research illustrates how each factor is unitary yet multifaceted.

Attentional Control. Research on inhibitions effects with math achievement has yielded mixed results. Some research yielded evidence for a positive correlation between inhibition and math achievement via multiplication word problems (Agostino et al., 2010). Agostino, Johnson and Pascual-Leone (2010) utilized multiplication word problems against three different types of inhibition tests: Antisaccade Test, and two types of the Stroop Test. A deeper analysis of this correlational relationship indicates a predictive relationship between inhibition and math achievement. While this study showed a positive relationship between inhibition and math achievement, there is evidence supporting no relationship. Specifically, Bull and Scerif (2001) did not find that inhibition did not relate to math achievement through the measurement of the Group Mathematics Test by means of unique variance using the Stroop Test. The math measured in this study was single- and multidigit addition and subtraction problems. The differing results of these studies may be due to the different types of math measurements used.

Cognitive Flexibility. The literature review on divided attention or set shifting resulted similar to the review on inhibition. However, the study that found inhibition related to math achievement found divided attention did not (Agostino et al., 2010) and vice versa (Bull & Scerif, 2001). Again, this difference may be due to the different types of mathematical problems being assessed. Nonetheless, set shifting has more research supporting a predictive relationship with math achievement (Yeniad et al., 2013). In a meta-analysis, Yeniad et al. (2013) analyzed the effect sizes of 18 different studies involving math achievement using a weighted regression analysis. They purport the association between set shifting and math achievement has empirical support of a positive relationship.

Information Processing. The research found studying the relationship between verbal fluency and math achievement support a relationship is present. Meyers (1981) compared good and poor problem solvers amongst 179 fourth-grade students on a battery of 19 separate tests of intellectual abilities including verbal fluency. In her stepwise regression analysis, she found verbal fluency a significant predictor of math achievement. She further purported that verbal fluency is important for successful math achievement. In 2016, Mädamürk, Kikas, and Palu conducted a study involving Estonian children (n=882) to investigate the importance of verbal skills and math achievement. They found similar results to Meyers study where student's verbal skills were closely related to solving math problems correctly. They concluded that to better support math skill development, children would benefit from enhancing their verbal skills.

Goal Setting. Unlike the other factors, the literature review on the relationship between planning and math achievement was found to be very robust. Specifically, Best, Miller and Naglieri (2011) studied planning and math achievement using the *Woodcock Johnson Revised (WJ-R)* with children and adolescents aged 5 to 17 (N = 2036). They found planning correlates to applied math and quantitative concepts. Crook and Evans (2013) used the WJ-R and the Tower of Hanoi in their longitudinal study with 8 to 11-year-olds (N = 1009). They found a positive correlation between planning and broad math achievement scores. Cai, Georgiou, Wen, and Das (2016) researched planning and problem solving (N = 80) in children from Shanghai, China.

They found a predictive relationship between planning and math problem solving and math reasoning.

These studies show strong support for a relationship between the four EF factors in the ECS model and math achievement. The mixed results of inhibition and divided attention may be due to the differences in assessing the factors and/or the differences in the focus of math achievement.

Developmental Considerations

The factor of development with Anxiety, EF, and mathematics plays an important role when researching children. As a child grows older, different types of anxiety that can manifest emerge and this factor is so important that the DSM-5 is structured according to the developmental trajectory of the onset of the different types of anxiety. Similarly, the different domains of EF in Anderson's ECS model scaffolds as the child matures (Boelem et al., 2014). Finally, the research in mathematics connecting the skills to development is not as clear cut as the research with anxiety and EF; however, it does follow a pattern throughout the different grade levels allowing some developmental process to appear.

Developmental stages of the onset of Anxiety. As mentioned earlier, the onset of anxiety is structured in the DSM-5 according to the development of the etiology. Beesdo, Knappe, and Pine (2009) were passionately at the forefront of the research of anxiety with their meta-analysis that helped to change the framework of the DSM-5. The first type of anxiety that emerges in research is separation anxiety. It is normal for an infant to demonstrate stranger anxiety from around 6 months to 12 months old and can last up to 3 years of age. However, separation anxiety manifests as a severe distress whenever separated from an attached caregiver

(See appendix B for further details of criteria). This type of anxiety can emerge as young as early childhood around the age of 3 and is rarely occurs in adolescence (American Psychiatric Association, 2013). Selective Mutism is seen in children who "do not initiate speech or reciprocally respond when spoken to by others" (See appendix B; pp.195). The typical age of onset for Selective Mutism is usually before the age of 5. Children can also develop specific phobias which "may be expressed by crying, tantrums, freezing, or clinging" (pp. 200). However, phobias are also seen throughout the lifespan into adults as well with the onset (See appendix B). The median onset age for phobias is usually between 7 and 11 years old. Social anxiety is different from performance anxiety, in that, individuals who have performance anxiety tend not to have the anxiety in any other situation outside of being required to perform. In children, social anxiety must occur in peer settings (see appendix B). The median age for the onset of social anxiety in the United States is 13 years old, where 75 percent of the onset is between the ages of 8 and 15 years old. Panic disorder is characterized as "an abrupt surge of intense fear or intense discomfort that reaches a peak within minutes" (pp. 209). The median onset for panic disorder is between 20 and 24 years old in the United States. It is rare for panic disorder to manifest in childhood and often occurs as a "fearful spell" (pp. 210). Panic disorder has been noted to have an onset in adolescents. Generalized anxiety disorder (GAD) is a bit different from the other anxiety disorders as it is described as "excessive anxiety and worry about a number of events or activities" and is not tied to a specific stimulus (pp. 222). The reports of people with GAD state that they have felt anxious and nervous their whole life. However, the median onset for GAD is 30 years old.

Development of executive function. A developmental dive into the four factors from current research, shows a trend that lines up with the ECS model. The maturation of inhibition is the first to mature in adolescence. Anderson's (2002) research was unclear if the domains of divided attention or verbal fluency matured first; however, he did point to the maturation of information processing (verbal fluency) around the age of 15. Recent studies have supportive evidence that divided attention matures first and verbal fluency quickly follows. Finally, the research supports that planning is the last factor to maturate in adolescence. The developmental trajectory of maturation with these four factors support the use of the ECS model when investigating EF in adolescence.

Attentional Control. Anderson (2002) concluded that infants gain their first ability to utilize inhibition around the age of 12 months. By the age of 3, children have the capacity to inhibit "instinctive" behaviors and can start to learn self-control like using the restroom instead of a diaper. The factor of inhibition has supportive evidence to occur around the age of 12. Qian, Shuai, Chan, Qian, and Wang (2013) conducted a study which included 249 healthy children and adolescents between 11 and 15 years old to investigate the developmental trajectories of EF for further use in comparing the group to children and adolescents with ADHD. For their assessment of inhibition, they utilized the Stroop Color Word Test. For their data analysis, they grouped the subjects into 4 groups according to their age. After using a MANOVA analysis to reveal an effect of age, the authors used a post hoc LSD comparison for pairwise contrast with the factor of age and EF. They compared the oldest group against the younger groups and found supporting evidence of the maturation around the age of 12 years old. Their finding supports Anderson's research along with others in the field.

Cognitive Flexibility. Sustained attention is needed before a person can switch between tasks and maintain their focus on that task efficiently. Qian et al. (2013) included divided attention in their study by means of set shifting through their use of the Trail-Making Test. They found maturation occurred in the oldest age group (13-15). Kalkut, Han, Lansing, Holdriack, and Delis (2009) found similar results with their study which included 649 subjects (n=649) between the ages of 8-30 years old. They compared the switching conditions of the Trail-Making Test, Verbal Category switching component, Design Fluency switching component, Color-Word Interference switching component, and Card Sorting Test. They utilized a post hoc Bonferroni t-test for each task and found overall maturation between the ages of 14-15 years old. These results are aligned with Anderson's (2002) discussion of divided attention continuing to develop into adolescents.

Information Processing. In early childhood, rapid verbal fluency development is observed between 3 to 5 years old (Anderson, 2002). Anderson noted that efficiency and fluency occurs around adolescence. Maturation of verbal fluency is the peak at which a person can quickly produce information verbally exhibiting their stable rate at which they can be efficient with information. Kavé (2006) conducted a developmental trajectory study of verbal fluency to help further research around communication disorders. In his study, he assessed 150 healthy children and adolescents who were native Hebrew speakers and between the ages of 8 to 17 years old along with 30 healthy adults who also spoke Hebrew and were between the ages of 18 to 29 years old. They utilized a phonemic fluency test similar to the verbal fluency test of the DKEFs; words generated using the same beginning sound. In their analysis, they used a pairwise comparison of the age groups and a post hoc Bonferroni correction and found maturation around the age of 16 on the phonemic fluency task. They concluded that their results support the research that has been conducted by other researchers in other languages and had reached the same conclusion. It is in later adolescence that humans develop efficiency and fluency maturation.

Goal Setting. Planning seems to be the most complex of EF a person can develop. When looking at the research, the onset age also reveals the complexity of this cognitive ability by the late age at which humans show their first signs of planning. Anderson (2002) noted that simple planning skills and conceptual reasoning skills are exhibited by 4 years old. He also aligned this skill as the last EF to develop in adolescence. Albert and Steinberg (2011) investigated strategic planning with subjects (n=935) between 10 to 30 years old to find the developmental trajectory of maturation including the period in which the PFC maturation occurs. They assessed planning and problem solving by using the Tower of London test. After using an ANCOVA and univariate ANCOVAs as a follow-up on the significant ANCOVA findings, the authors utilized a post hoc Bonferroni pairwise comparison at an alpha of .05 between age groups. They found a significant interaction between the age groups and problem difficulty, so they ran a further analysis of the data using a univariate ANCOVA at each level of problem difficulty. Through their analysis, Albert and Steinberg found maturation around the age of 17 with simple three move problems. The maturation of complex seven move problems occurred around the age of 23 years old. Their findings support the research already conducted with the Tower of London where mastery performance was reached by this age.

Mathematical development. While the research of the development of anxiety and EF was presented in terms of age, the research around the development of math is more complex and is presented in terms of skill development. This is due to the interindividual and intraindividual aspects of acquiring math skills. Nonetheless, the trajectory of the development of math still has a clear path throughout the development of children and adolescents. As mentioned, numerosity and ordinality begin in infancy and simple addition and subtraction with the use of concrete objects is mastered in preschool (Geary, 2006). When children attend formal school, the intricacies of developing math skills become complex.

Although simple calculations have shown up in early development across cultures implying some form of inherit development, the research on older children's development is based off of school taught competencies (Geary, 2006). The acquisition of these biologically secondary abilities relies on cultural invention (e.g., base-10 arithmetic). A primary ability of commutativity (combining sets of toys) is implicitly understood around the age of 4. However, when taking this concept to addition, first graders struggle with the commutative property (a + b = b + a), whereas second and third graders did not. Due to the structure of explicit instruction, it is difficult to decipher if this is developed explicitly or implicitly. This is the main difficulty of researching the development of mathematics. What is clear about the research is that the use of concrete items to understand a mathematical concept comes first, then children can express the problem in a representation or written form and finally grasp the concept abstractly. Geary (2006) explained the dilemma of the influence of instruction in the development of math skills with noting a study in 2001 done by Naito and H. Miura with Japanese children. They found the ability to use base 10 structure of numerals to solve arithmetic problems was due to instruction. Fractions and estimation and arithmetic operations are all fully developed in elementary school as well.

Problem solving starts in elementary grade but continues to progress in complexity well into high school. The problem-solving process involves translating each sentence into numerical sentences, integrating the information and the relationships of the numerical sentences, then executing the necessary procedures, along with solution planning on more complex problems (Geary, 2006). Once the focus of research turns to the complex problems, the development of these skills is correlated with EF, not grade level. This may be due to the interindividual and intraindividual aspects of acquiring mathematical skills.

Summary

Research on anxiety shows that it is a significant mental health condition that affects children and adults alike, with a prevalence of up to 16 percent in youth (American Psychiatric Association, 2013). Studies from the fields of neuroscience, neuropsychology, and psychology have demonstrated that there is a definite connection between anxiety and EF, specifically involving anatomical structures and neural networks activated. All individuals with anxiety disorders have been shown to have abnormal or dysfunctional neural network connectivity. Furthermore, a dysfunction of EF and anxiety separately have shown negative impacts on math achievement. Specifically, Owens et al. (2012) and Justicia-Galiano et al. (2017) have demonstrated that EF appears to mediate anxiety and math achievement in children. As such, there is a need for further investigation on the relationships between EF, anxiety, and math achievement to better inform mental health interventions and educational practices for a vulnerable population of youth.

Chapter 3 Methodology

Participants

The data for this study consists of archived client records solicited by the UNLV PRACTICE. This data is de-identified by the practice prior to releasing the information for the study. A total of 18 participants were gathered for this study according to the exclusionary criteria that follows.

The following criteria is used for participants from the archive database:

(1) Clients between the ages of 9 to 19;

(2) Measure of anxiety score exists in their file;

(3) Completion of the subtests for each of the four EF domains; and

(4) Measure of math achievement score exists in their file

Materials

Demographics are collected via completion of a standard history form. Information extracted includes descriptors of the participant (age and gender) detailed medical history with any prior diagnoses, family history including any prenatal concerns together with any known mental health issues of the family and extended family.

Instruments. Multiple instruments are used as there are multiple areas of functioning being investigated in this study.

Executive Function (EF). *The Delis-Kaplan Executive Function System (D-KEFS*; Delis et al., 2001; Mitchell & Miller, 2008) is a comprehensive assessment designed to measure verbal and non-verbal executive functions (reasoning, problem-solving, planning, etc.) for individuals aged 8 to 89 years. It is comprised of nine tests and are organized according to the cognitive functioning areas of Concept Formation, Flexibility, Fluency and Productivity, and Planning. Administration time varies from 15 minutes for an individual test to 90 minutes for the full battery. Raw scores are tabulated before being converted to scaled score or cumulative percentile ranks. Each test is designed to be a stand-alone measure of executive functioning and there are no indexes or composite scores.

The D-KEFS normative sample is based on a nationally representative, stratified sample of 1750 individuals. Data collected in the 2000 U.S. Census provided the basis of stratification according to age, sex, race/ ethnicity, education level and geographic region. Test-retest reliability coefficients varied substantially across tests, but the majority of the scores fell in the moderate range ranging from .24 (Twenty Questions test) to .76 (Proverb test). Internal consistency also varies widely by test, ranging from .32 (Sorting and Twenty Questions tests) to .90 (Verbal Fluency test). The D-KEFS Technical and Interpretive Manual (Delis et al., 2001) suggests the validity for most of the tests have been previously established. While concerns are raised related to low reliability and validity, it is argued that the nature and demands of measuring executive functioning may limit greater psychometric stability analyses. The D-KEFS system is found to be the most thorough and precise comprehensive battery used to measure individual executive functioning (Shunk, Davis, & Dean, 2006).

For this study, the following D-KEFS subtests are chosen as measurements for EF because they match the ECS model: The Color Word Interference Test (CWIT); the Trail Making Test (TMT); the Verbal Fluency Test: Letter Fluency (VERFLU); and the Tower Test (TOWER). This psychological assessment of EF is normed by a standard sample of children, adolescents, and adults (n = 1,750).

Attentional control. The CWIT is considered as a version of the Stroop Test measuring inhibition of verbal responses by naming dissonant ink colors instead of the color written (Shunk, Davis, & Dean, 2006). Making up the complete test are four different conditions evolving in complexity. The internal consistency coefficients determining interdependence with this subtest was high (r = .62 to .86). The Stroop Test that it is modeled after is considered as the evidence of the validity of this subtest.

Cognitive flexibility. The TMT consists of 5 conditions which assess number-letter switching as a cognitive set shifting procedure (Shunk, Davis, & Dean, 2006). Baseline measures of visual scanning and motor speed are obtained in one of the conditions allowing the examiner to extract normative data to compare with the switching task performance. The internal consistency coefficients determining interdependence with this Trail Making subtest is high (.57 to .81).

Information processing. The D-KEFS Verbal Fluency Test allots 60 sec for the examinee to name all the words they can think of that begin with designated letters (i.e., F and S) and then words contained within categories (Shunk, Davis, & Dean, 2006). This test measures fluency of verbal responses. The internal consistency coefficients determining interdependence with the Verbal Fluency Test subtest is also high (.32 to .90).

Goal setting. The D-KEFS Tower Test is a measure of planning and problem solving in (Shunk, Davis, & Dean, 2006). The TOWER demonstrates the participant's ability to formulate a plan and carry out those plans to a desired goal. A wooden fixture with three vertical pegs sits upon the table in front of the child and a total of 5 discs that vary in size. The child then arranges the disks onto the pegs matching the arrangement presented in a picture; however, the examiner puts the discs in a prearranged starting position. Only one disk at a time can be moved, at the same time, a larger disk is not permitted to be placed on top of a smaller disk. In addition, the child must use the least amount of moves as possible. The D-KEFS Tower improved on its predecessors by creating a lower basal level which increases sensitivity for use with younger children. The internal consistency coefficients determining interdependence with the Tower Test subtest is also high (.43 to .84; Delis et al., 2001).

Anxiety. The *Behavior Assessment System for Children- Second Edition (BASC-2)* is a behavioral assessment designed for use in evaluating children and adolescents with cognitive, emotional, and learning disabilities (Reynolds & Kamphaus, 2004). The BASC-2 has comprehensive rating scales that assess the child's behavior from teacher, parent and self-report perspectives. The BASC-2 was created to be a "multimethod, multidimensional system used to evaluate the behavior and self-perception of children and young adults aged 2 through 25 years" (Reynolds & Kamphaus, 2004, p. 1). It is designed to assess the different aspects of behavior via clinical and content scales (i.e., Anxiety, Attention Problems, Hyperactivity, Atypicality, Somatization, Withdrawal) and it is purported as a useful tool to identify clinical diagnosis of disorders that are usually apparent in childhood or adolescence (Tan, 2007). Raters observe and rate behaviors on a four-point frequency scale (i.e., 0=*Never*, 1=*Sometimes*, 2=*Often*, and 3=*Almost Always*). Item raw scores are summed and converted into standardized T-scores (*M*=50, *SD*=10). For clinical scales, higher scores represent more problematic behaviors, with T-scores between 60 and 69 considered at-risk, and T-scores of 70 or above being clinically significant. Authors of the BASC-2 report adequate reliability and validity.

When investigating the correlation between the BASC-2 and the *Achenbach System of Empirically Based Assessment (ASEBA)*, Tan (2007) found the construct validity to be high and reliability in the general norm sample to be adequately high. Internal consistency estimates for scales in the general and clinical norm samples were nearly all adequately high (.61-.89 for the general sample and .64-.90 for the clinical sample).

The *Behavior Assessment System for Children- Third Edition (BASC-3)* is found to retain much of the same structure and research as the second edition (Konold, & Medway, 2017). The standardization sample was based on data collected between April 2013 and November 2014 with 4,400 participants between the ages of 2 and 25 years. Internal consistency estimates for scales in the general norm samples are nearly all adequately high (.77-.97). The test-retest reliability coefficients also adequately high (.80-.94). When investigating the Covariance Structure Analysis (CSA) between the BASC-2 and the BASC-3, the correlation coefficient is found to be consistently high as are the findings of the correlation between the BASC-3 and the ASEBA. This indicates that the use of the BASC-3 to extract a measurement of an elevated state of anxiety is valid.

Math achievement. Two achievement measures are utilized to assess for math achievement.

The *Wechsler Individual Achievement Test – Third Edition (WIAT-III;* Wechsler, 2009) is a comprehensive achievement test for individuals ages 4 to 50 years. It includes 15 subtests that make up composite measures of achievement which includes mathematics, and math fluency. The scores allow for seasonal developmental changes by segregating their scores and interpretation of the scores by Fall, Winter, and Spring. The mathematics section includes a numerical operations and math problem solving. The numerical operations measure written math calculations without time limits. The math problem solving subtest measures a person's ability to solve math problems using both verbal and visual prompts. The standardization sample is based on data collected between 2006 to 2008 with 2,755 participants between the ages of 2 and 25 years. Reliability estimates for math subtests in the general norm samples are nearly all adequately high (.85-.93). Also, the mathematics composite correlates highly with another commonly used achievement battery, *the Kaufman Test of Educational achievement- third Edition (KTEA-3;* .90).

Woodcock Johnson IV- Test of Achievement (WJ-IV ACH) is an assessment measure used to measure academic achievement of individuals ranging in age from 2 to 90+ years (Schrank, McGrew, Mather, & Woodcock, 2014). It is designed to align with the CHC theory of human cognitive abilities and examine the client's relative strengths and weaknesses. The normative data was collected over a 2-year period with a total of 7,416 participants from the United States. The individual test's reliability coefficients range from .74 to .97 with a median reliability of .89. Reliability coefficients for cluster scores range from .86 to .97, with a median reliability of .89. The tests are found to have strong convergent and discriminant validity with intercorrelations ranging from .30 to .60, suggesting the tests measure skills that are different from one another.

The WJ-IV ACH includes the same domains as the third edition (Applied Problems for problem solving and concept skills, Calculations and Fluency) but also extends the academic scope to include a new area of measurement called Number Matrices in the extended version (Schrank, 2014). This new measurement also combines with math problem-solving skills with story problems and quantitative reasoning with number matrices to yield a cluster domain: Problem Solving. Math Calculation Skills and Broad Mathematics clusters are still available in the fourth edition as it was offered in the third edition, as well as a new two-test Mathematics cluster which is comprised of measures of calculation ability and problem solving.

Procedures

Prior to the services rendered in the PRACTICE, caregivers are required to sign informed consent to participate in the evaluation as well as research. Participant demographics, history, standard scores on the DKEFs four subtests (CWIT, TMT, Verbal Fluency, and Tower Test), anxiety T-scores on the BASC and math achievement standard scores are gathered from PATC clinic files, and the data is formulated into a standard Microsoft® Excel® database and exported into a statistical analysis software.

Statistical Analysis

Data Entry

Executive Function. On the DKEF-S, scores are reported as scaled scores, with a mean of 10, and standard deviation of 3. The scaled scores are collected then entered into the database. Originally, we proposed to enter the data in a binary format; however, due to the quantitative nature of the data we decided to use the values in their original form which gave a clearer picture of the relationship between the variables.

Anxiety. On the BASC-2 and BASC-3, scores are reported as T-scores, with a mean of 50, and standard deviation of 10. The T-scores from the Anxiety subscale are collected then entered into the database. Originally, we proposed to enter the data in a binary format; however, due to the quantitative nature of the data we decided to use the values in their original form which gave a clearer picture of the relationship between the variables.

Math Achievement. On the WIAT-III, scores are reported as standard scores, with a mean of 100, and standard deviation of 15. The standard scores are collected then entered into the database. The two subtests in the WIAT-III are Numerical Operations and Math Problem

Solving. In addition, to understand effects on math achievement, a cut-off score of 90 is used to differentiate between those with average math achievement and those with low math achievement. This cut-off score is selected based off of the normalized cut off range to identify achievement performance in the below 25 percentile range. Originally, we proposed to enter the data in a binary format; however, due to the quantitative nature of the data we decided to use the values in their original form which gave a clearer picture of the relationship between the variables.

On the WJ-IV ACH, scores are reported as standard scores, with a mean of 100, and standard deviation of 15. The standard scores will be entered into the database. The two subtests in the WJ-IV ACH are Applied Problems and Calculations. In addition, in order to understand effects on math achievement, a cut-off score of 90 is used to differentiate between those with average math achievement and those with low math achievement. This cut-off score is selected based off the normalized cut off range to identify achievement performance in the below 25 percentile range. Originally, we proposed to enter the data in a binary format; however, due to the quantitative nature of the data we decided to use the values in their original form which gave a clearer picture of the relationship between the variables.

Regression Research

A multiple regression analysis is conducted to examine the mediating relationship of EF on anxiety and math achievement. Multiple regression analysis allows three levels to be investigated: (1) the general relationship between EF and math achievement when anxiety is included into the analysis, (2) what mediational influence of each of the four EF domains on anxiety and math achievement, and (3) comparing these effects between sex and age groups.

Using a multiple regression analysis, the mediation of EF on anxiety and math achievement can be thoroughly investigated.

Further measurement using a MANOVA and/or MANCOVA allows an elimination of any covariant effects between variables. For example, when investigating the effects of ATTC on Anxiety and Math Achievement, the covariant effects of COGF, INFO, and GOAL are eliminated through this statistical analysis allowing for a clearer view of how ATTC may mediate anxiety and math achievement.

Chapter 4 Results

This study is aimed to find the relationship between executive functions (EF) domains (i.e., attentional control (ATTC), cognitive flexibility (COGN), information processing (INFO), and goal setting (GSET)); anxiety; and math achievement within a sample of adolescents. Results from this study are presented in this chapter. The content of Chapter Four is organized as follows: (a) Demographic characteristics of the sample, (b) Analysis of research questions, and (c) Summary.

Demographic Characteristics of The Sample

The UNLV PRACTICE provided the data for the present study. Before releasing the information for this study, the data were de-identified. The data contained age, gender, and test scores (anxiety, math achievement, and EF domains scores). Of the 26 participants, only 18 have complete assessment results. For this reason, only 18 participants' data were analyzed for the current study. There were 13 females (72.2%) and 5 (27.8%) males, with ages ranging from 9 to 19 years (M = 14.89, SD = 2.59). Based on the age groups, most of the participants are in the age range of 12-15 (44.4%) and 16-19 (44.4%), followed by 9-11 (11.1%). Table 1 summarizes the characteristics of the research participants.

Table 1

Demographic Characteristics of the Research Participants

		N	Percentage
Gender	Male	5	27.8%
	Female	13	72.2%
	Total	18	100%
Age Group	9-11	2	11.1%
	12-15	8	44.4%
	16-19	8	44.4%
	Total	18	100%

Analysis of Research Questions

RQ1. What Are the Relationships Between EF, Anxiety, and Math Achievement?

This research question investigates the general relationship between anxiety and math achievement and whether each of the four EF domains has a mediational effect on anxiety and math achievement. Therefore, the data analysis was conducted in two main steps. First, preliminary correlational analyses were conducted on anxiety and math achievement, anxiety and EF domains, and EF domains and math achievement.

The anxiety variable was estimated by the anxiety t-scores from either the *Behavior Assessment System for Children - Second Edition (BASC-2)* or *Behavior Assessment System for Children - Third Edition (BASC-3)*. The EF domain variables are (1) Attention control, which was assessed using the Color-Word Interference Test (CWIT), (2) Cognitive flexibility, which was assessed using the Trail Making Test (TMT); (3) Information processing, which was assessed using the D-KEFS Verbal Fluency Test; and (4) Goal Setting, which was assessed using the Tower Test (TOWER). The math achievement variable used for the analysis going forward is the composite math score assessed using either the *Wechsler Individual Achievement Test – Third Edition (WIAT-III)* or the *Woodcock-Johnson IV- Test of Achievement (WJ-IV ACH)*. Details of the assessments' descriptive statistics from the sample can be found in Table 2.

Table 2

Descriptive Statistics of Anxiety, Math Achievement, and EF Domains

	N	Mean	Std. Deviation	Range of scores
Anxiety	26	60.46	13.58	32-93
Math Achievement	25	100.60	14.43	69-120
Attention Control	23	9.43	2.56	3-14
Cognitive Flexibility	24	8.50	2.72	3-14
Information Processing	19	10.37	3.95	2-19
Goal Setting	23	9.30	2.82	5-15
Valid N (listwise)	18			

Preliminary Correlational Relationships Among Anxiety, Math Achievement, and EF Domains. The first step of the analysis used Pearson product-moment correlations to evaluate the relationships among Anxiety, Math Achievement, and EF Domain variables. The results can be seen in Table 3. Pearson correlations show that anxiety is negatively and strongly correlated with math achievement, $r(17) = -.534$, $p = .022$. The results indicate that as anxiety increased, math achievement worsened (and vice versa).

Of the four EF domains, attention control is the only variable that is significantly correlated with anxiety, $r(17) = -.702$, $p = .001$. These results indicate that as anxiety increased, attention control declined. Attention control was also positively correlated with math achievement, $r(17) = .678$, $p = .002$. The findings indicate that as attention control increased, so did math achievement.

The other EF domains did not have a statistically significant correlation with either anxiety or math achievement, $p > .05$. Therefore, the subsequent analysis only assessed the mediation effect of attention control on the relationship between anxiety and math achievement.

Table 3

The Correlations Among Anxiety, Math Achievement, and EF Domains (Listwise N = 18)

	1	2	3	4	5	6
1. Anxiety	—					
2. Math Achievement	$-.534^{*}$	—				
3. Attention Control	$-.702^{**}$	$.678^{**}$	—			
4. Cognitive Flexibility	-.306	.344	.260	—		
5. Information Processing	-.418	.466	$.535^{*}$	.247	—	
6. Goal Setting	-.103	-.097	.162	.309	-.194	—

Note. *. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

Mediation Analysis. A mediation analysis followed the correlation analysis to assess whether attention control mediated the relationship between anxiety and math achievement. For the relationship to be mediated by attention control, the following four assumptions must be true:

(1) Anxiety must predict math achievement, (2) Anxiety must predict attention control, (3) Attention control must predict math achievement, and (4) The relationship between anxiety and math achievement should be lesser when mediated by attention control (Baron & Kenny, 1986). The mediation analysis was analyzed using the PROCESS procedure for SPSS Version 4.0 by Andrew Hayes (2013). PROCESS procedure computed a series of linear regressions, and the outcomes can be found in Table 4.

Table 4

Outcome Matrix for Mediation Analysis Using PROCESS (N = 18)

OUTCOME VARIABLE: ATTC

Model Summary

R	R-sq	MSE	F	df1	df2	p
.7021	.4930	3.4152	15.5586	1.0000	16.0000	.0012

Model

	coeff	se	t	p	LLCI	ULCI
constant	16.4174	1.9028	8.6279	.0000	12.3832	20.4515
Anxiety	-.1276	.0323	-3.9444	.0012	-.1961	-.0590

OUTCOME VARIABLE: Composit

Model Summary

R	R-sq	MSE	F	df1	df2	p
.6826	.4660	152.1044	6.5445	2.0000	15.0000	.0091

Model

	coeff	se	t	p	LLCI	ULCI
constant	71.8194	30.1915	2.3788	.0311	7.4607	136.1781
Anxiety	-.1313	.3031	-.4331	.6711	-.7774	.5148
ATTC	3.7597	1.6684	2.2534	.0396	.2031	7.3162

TOTAL EFFECT MODEL

OUTCOME VARIABLE: Composit

Model Summary

R	R-sq	MSE	F	df1	df2	p
.5340	.2852	190.8717	6.3839	1.0000	16.0000	.0224

Model

	coeff	se	t	p	LLCI	ULCI
constant	133.5433	14.2253	9.3877	.0000	103.3841	163.7025
Anxiety	-.6108	.2418	-2.5266	.0224	-1.1234	-.0983

TOTAL. DIRECT. AND INDIRECT EFFECTS OF X ON Y

Total effect of X on Y

Effect	se	t	p	LLCI	ULCI	c_cs
-.6108	.2418	-2.5266	.0224	-1.1234	-.0983	-.5340

Direct effect of X on Y

Effect	se	t	p	LLCI	ULCI	c'_cs
-.1313	.3031	-.4331	.6711	-.7774	.5148	-.1148

Indirect effect(s) of X on Y:

	Effect	BootSE	BootLLCI	BootULCI
ATTC	-.4796	.2179	-.8915	-.0453

Note. Y = Composit (Math achievement), X = Anxiety, M = ATTC (Attention control)

Assumption 1: Anxiety Must Predict Math Achievement. Results for the *total effect*, which indicates the effect of anxiety on math achievement when attention control was not present in the model, show that anxiety significantly predicted math achievement, b = -.61, p = .0224, 95%CI [-1.1234, -.0983], t = -2.52, R^2 = 28.52%. Similar to the previous finding in the correlation analysis, anxiety was negatively correlated with math achievement, as shown by the negative b-value. These findings also indicate that the first assumption was met.

Assumption 2: Anxiety Must Predict Attention Control. Using PROCESS, Linear regression shows that anxiety significantly predicted attention control (ATTC), b = -.13, p = .0012, 95%CI [-1.12, -.10], t = -2,52. Anxiety explained 70.21% of attention control. The negative *b*-value shows that anxiety was negatively correlated with attention control. These results show that the second assumption was also met.

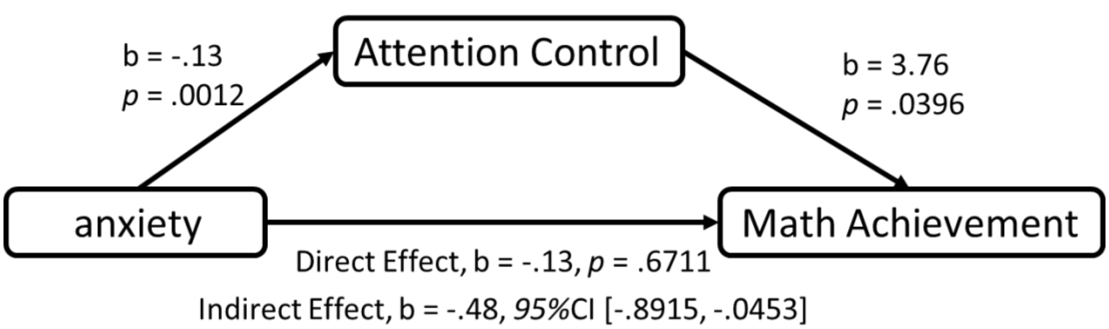
Assumption 3: Attention Control Must Predict Math Achievement. Results from Table 4 show that attention control (ATTC) significantly predicted math achievement, b = 3.76, p = .0396, 95%CI [.20, 7.32], t = 2.25. Attention control explained 46.60% of math achievement. The positive *b*-value indicates that attention control was positively correlated with math achievement. As attention control increased, math achievement increased also. These results show that the third assumption for mediation analysis was met.

Assumption 4: The Relationship Between Anxiety and Math Achievement Should be Lesser When Mediated by Attention Control. The *direct effect* of anxiety on math achievement, which indicates the effect of anxiety on math achievement when the mediator (attention control) is included, showed a lower b-value (b = -.13) when compared to the total effect (b = -.61). The correlation between the predictor variable (anxiety) and the outcome variable (math achievement) was also changed to non-significant, $p = .6711$.

Conclusion of Mediation Analysis. Findings from assumptions one through four confirm that attention control had a moderate meaningful effect on the relationship between anxiety and math achievement. The findings were further confirmed by the results of the *indirect effect* of anxiety on math achievement, which indicates the effect of anxiety via attention control. The indirect effect shows that anxiety predicted math achievement through attention control, $b = -.48$, *95%* BCa CI [-.89, -.045]. This relationship is significant because the confidence interval does not contain zero. Figure 1 illustrates the model showing the relationships of anxiety as the predictor variable, math achievement as the outcome variable, and attention control as the outcome variable.

Figure 1

Model of Anxiety as a Predictor of Math Achievement With Attention Control as the Mediator



Note. *The confidence interval (CI) for the indirect effect is based on 5000 bootstrapped samples.

RQ2. Does gender moderate the relationship between EF, anxiety, and math achievement?

To answer this research question, the moderating role of gender on the relationships between anxiety, math achievement, and EF was examined using a series of moderation analyses. Moderation analyses were conducted using Hayes' PROCESS version 4.0 Model 1 with 5000 bootstrap samples (Hayes, 2013). Due to the findings from the first research question, only the attention control domain of EF was warranted. Excepting gender, which is measured at a binary measurement scale, all predictor variables were mean-centered. The following subsections present the results of moderation analyses using gender as the moderator on the relationship of anxiety and math achievement, anxiety and attention control, as well as attention control and math achievement.

Gender, Anxiety, and Math Achievement. A moderation analysis was conducted to study the moderation effect of gender on the relationship between anxiety and math achievement. The analysis shows that age did not moderate the relationship between anxiety and math achievement, as shown by a non-significant interaction effect of gender and anxiety, b = -.34, t = -.40, 95%CI [-2.17, 1.49], p = .6964. The results show that gender did not moderate the relationship between anxiety and math achievement.

Gender, Anxiety, and Attention Control. A moderation analysis was also conducted to assess the moderation effect of gender on the relationship between anxiety and attention control. The interaction effect of gender and anxiety did not significantly predict attention control, b = -.65, t = .81, 95%CI = [-.11, .24], p = .2373. These results indicate that the relationship between anxiety and attention control was not moderated by gender.

Gender, Attention Control, and Math Achievement. The same moderation analysis was run to evaluate the moderation effect of gender on the relationship between attention control and math achievement. Results from the analysis showed no significant interaction effect of gender and attention control on math achievement, $b = 2.91$, $t = .71$, 95%CI = [-5.88, 11.69], $p = .4894$. These findings indicate that gender did not moderate the relationship between attention control and math achievement.

Does Gender Moderate the Relationship Between EF, Anxiety, and Math Achievement? Three moderation analyses were conducted to examine the moderating effect of gender in the relationship between attention control, anxiety, and math. The results of the analyses indicate that gender did not moderate the relationship.

RQ3. Does age moderate the relationship between EF, anxiety, and math achievement?

A series of moderation analyses were also conducted to answer this research question. Attention control, anxiety, and age variables were mean centered in the analyses. The following subsections present the results of moderation analyses using age as the moderator on the relationship of anxiety and math achievement, anxiety, and attention control, as well as attention control and math achievement.

Age, Anxiety, and Math Achievement. The first moderation analysis was conducted to assess the moderating effect of age in the relationship between anxiety and math achievement. The results of the analysis showed no significant interaction effect of age and anxiety on math achievement, $b = .23$, $t = 1.79$, 95%CI = [-.05, .51], $p = .0956$. These findings indicate that age did not moderate the relationship between anxiety and math achievement.

Age, Anxiety, and Attention Control. The second moderation analysis was run to examine whether age moderated the relationship between anxiety and attention control. Findings from the statistical analysis showed that the interaction of age and anxiety did not have a significant effect on attention control, $b = .03$, $t = 1.54$, 95%CI = [-.02, .08], $p = .1461$. These outcomes indicate that age did not moderate the relationship between anxiety and attention control.

Age, Attention Control, and Math Achievement. Lastly, the moderation analysis was conducted to determine the moderation effect of age on the relationship between anxiety and attention control. The analysis showed no significant interaction effect of age and attention control on math achievement, $b = -.28$, $t = -.52$, 95%CI = [-1.44, .88], $p = .6096$. These findings indicate that age did not moderate the relationship between control and math achievement.

Additional Findings. Linear regression analyses were conducted to assess whether age groups predict attention control, anxiety, or goal setting to help explain the findings from RQ3 analysis. Following Anderson (2002), the participants' age was categorized into four age categories: (a) 9-11 years old, (b) 12-15 years old, (c) 16 or older. Since the age variable comprises three age groups, two dummy variables were created, using the 16 or older age category as the baseline against which all the other groups were compared. The two dummy variables were lower_dummy (16 or older vs. 9-11) and upper_dummy (16 or older vs. 12-15). The 16 or older age group was chosen since it represented the majority of the age groups. Results from linear regression analyses show that lower dummy (16 or older vs. 9-11) significantly predicted math achievement, $p = .015$, $t = -2.732$, 95%CI [-49.175, -6.075], $b = -27.625$. These findings suggest that Math achievement scores increased significantly as a patient's age group changed from 9 to 11 years old to 16 or older. Other linear regression analyses did not yield significant findings.

Does Age Moderate the Relationship Between EF, anxiety, and Math Achievement?

A series of moderation analyses were conducted to study whether age had a moderating effect on the relationship between attention control, anxiety, and math achievement. The findings from the moderation analyses indicate that age did not moderate the relationship between anxiety and math achievement, anxiety, and attention control, as well as attention control and math achievement.

Summary

This chapter presents the findings from the study to evaluate the relationships among anxiety, math achievement, and the EF domains (attention control, cognitive flexibility, information processing, and goal setting). Findings from the study show that only the attention control domain of EF mediated the relationship between anxiety and math achievement. Attention control moderately mediated the relationship between anxiety and math achievement. The study also investigates the moderating effect of gender as well as age on the relationships between EF domains (attention control), anxiety, and math achievement. The findings from the moderation analyses show that neither gender nor age moderated the relationship between attention control, anxiety, and math achievement. Discussion of the findings is presented in Chapter 5.

Chapter 5

Discussion

Introduction

Past studies have addressed the neuropsychological functioning in anxiety disorders (Airaksinen et al., 2005). These studies have also examined the relationships between executive function (EF), anxiety, and math achievement, primarily in adults. However, reports on these relationships in adolescents are still limited. For this reason, the present study evaluated the relationships of EF domains, anxiety, and math achievement using test reports from adolescents. Furthermore, the moderating effect of age and gender on the relationships of EF, anxiety, and math achievement were also analyzed.

This chapter discusses the research findings, limitations, and implications of the study for future study. Summaries of each research question's findings and their interpretations are presented in the research findings section. Following this, we also discuss the implications of the findings for future research. The chapter concludes with a conclusion of the study in the summary section.

Research Findings

RQ1. What Are the Relationships Between EF, Anxiety, and Math Achievement?

With a small sample size, this study shows evidence of a relationship between anxiety, math achievement, and anxiety. Anxiety negatively correlated with math achievement, which is consistent with past studies on the relationship between anxiety and math achievement (Kalaycioglu, 2015; Owens et al., 2012). The accuracy and efficiency of solving mathematical processes decrease as anxiety scores increase and vice versa.

Interestingly, not all domains were correlated with either anxiety or math achievement. Cognitive flexibility, information processing, and goal setting failed to show any significant correlation with anxiety or math achievement with this small sample. Attentional control is the only EF domain that significantly correlated with anxiety and math achievement. Attention control was also negatively correlated with anxiety while positively correlated with math achievement. Participants with higher attention scores were more likely to have lower anxiety scores and higher math scores. These findings are generally in line with past studies on the correlations between EF and anxiety (Airaksinen et al., 2005; Hadwin & Norgate, 2012; Trezise & Reeve, 2018) and between EF and math achievement (Kalaycioglu, 2015; Owens et al., 2012).

Results from the present study, supporting EF's effect on the relationship between anxiety and math achievement, are also consistent with previous reports (Aostino et al., 2010; Mädamürk et al., 2016; Naglieri, 2011; Yeniad et al., 2013). Of the EF domains evaluated, only attentional control showed a significant mediation effect on the relationship between anxiety and math achievement within the small sample size used. Anderson (2002, p.73) describes attentional control as one's ability to "selectively attend to specific stimuli and inhibit proponent responses, and the ability to focus attention for a prolonged period." Individuals with attentional control deficits tend to exhibit impulsive behavior, inattentiveness to instructions, and failure to complete tasks.

Attentional control includes selective attention, self-regulation, self-monitoring, and inhibition. This study measured attentional control using the Color-Word Interference Test (CWIT), which assesses the inhibition of verbal responses (Shunk et al., 2006). People with attention deficits tend to show diminished inhibition, which plays a crucial role in controlling thoughts in fear or worry (Owens et al., 2012; Trezise & Reeve, 2018). Lack of inhibition could lead to ineffective regulation of their fear or worry, leading to difficulty focusing on cognitive tasks, including thinking through mathematical problems during schoolwork and tests (Airaksinen et al., 2005; Kalaycioglu, 2015). Students with high anxiety levels tended to perform poorly on their math assessments, while those with lower anxiety levels tended to perform better on their math assessments. This study provides supportive evidence of the role of attentional control through inhibition as a mediating factor in the relationship between anxiety and math achievement within a small sample size.

The other three factors (cognitive flexibility, information processing, and goal setting) did not yield significant findings with the small sample used. Although mixed results have been reported on the role of EF factors on anxiety (Agostinno et al., 2010, Bull & Scerif, 2001; Owerns et al., 2012; Yeniad et al., 2013), it is implausible for one to perform well in their math assessments with only attentional control. The results may be due to the small sample size. Therefore, future studies using a larger sample are needed to confirm this study's findings.

RQ2. Does gender moderate the relationship between EF, anxiety, and math achievement?

There have been mixed reports on the role of gender on EF, anxiety, and math achievement. For example, Ganley and Vasilyeva (2014) found that, in females, the EF domains had a stronger negative relationship with anxiety when compared to males. However, other studies have also reported no gender differences in math anxiety (e.g., Harari et al., 2013; Kucian et al., 2018). In present study, gender did not moderate the relationship between attentional control, anxiety, and math achievement with the small sample size used. This finding could be due to the growing evidence showing that sex differences in anxiety, particularly math anxiety, have not yet developed in adolescent students (e.g., Hariri, 2014).

RQ3. Does age moderate the relationship between EF, anxiety, and math achievement?

Moderation analyses evaluating the moderating effect of age and gender on the relationship between anxiety, math achievement, and executive function (i.e., attentional control) did not yield any statistically significant effect. In the present study, age did not moderate the relationship between anxiety, math achievement, and attentional control in the small sample. Even so, math achievement scores increased significantly as a patient's age group changed from 9-11 years old to 16 or older, but not from 12-15 years old to 16 or older. These results are consistent with Thoren et al. (2016) that age effects on math development decreases over time. However, the data for this study did not present students' information across time, limiting us to confirming the current findings.

Limitations of the Study

Although the findings of this study support some of the past research conducted involving EF and its effect on the relationship between anxiety and math achievement, a major limitation of this study that needs consideration is its sample size. This study should be seen as a preliminary study for future studies to explore the relationship between EF, anxiety, and math achievement in children and adolescents. Another consideration about size is the imbalance between females and males in this current study. This limits the representation of males (n =5; 27.8%) in the study and may have affected the outcome for gender as a moderating factor.

Data from this study were from participants assessed using different types of anxiety tests. The anxiety tests used were either the *Behavior Assessment System for Children - Second Edition* (BASC-2) or the *Behavior Assessment System for Children - Third Edition* (BASC-3). Although both assessment tools are valid assessment tools of anxiety, and both tests have high test-retest reliability, having data assessed using a single tool could control for assessment differences. Furthermore, this study did not differentiate between the types of BASC tests the data was taken from (i.e., parent report, teacher report, self-report). It is common knowledge in the field of school psychology that self-perception is different from how others perceive us. It is also highly likely that setting (i.e., home setting vs. school setting) can affect the anxiety levels of adolescents due to the setting structure and stress levels in those settings.

Implications for Future Study

Future studies using a larger sample are necessary to replicate the current study's findings. If future studies, based on this proposed study, investigating EF interventions for anxiety yield positive effects on anxiety, then children and adolescents may benefit from this research. This finding may also lead to the cost of mental health care leading into adulthood drastically declining.

One area for future studies on the relationship of gender, EF, anxiety, and math achievement could glean from separating out the two types of math achievement measured on academic achievement tests, computations and problem-solving. These data could provide additional data to the study done by Ganley and Vasilyeva (2014) on gender where they found gender to be a predictor of working memory and females performing better on computation tasks and males performing better on problem-solving tasks. Understanding the relationship among these variables would enable educators, administrators, and school psychologists to design interventions taking into consideration developmental factors between genders.

Future studies on the relationship of age, EF, anxiety, and math achievement could also benefit from multiple data points collected across time from a patient. These data could provide more precise information on the role of age in the relationship between EF, anxiety, and math achievement. A better understanding of the relationships among these variables would enable educators, administrators, mental health professionals, and school psychologists to design better interventions to help curb the negative effects that anxiety can have on math achievement due to dysfunctional EF.

Other future studies on the relationship of EF, anxiety, and math achievement in a population of adolescents could benefit from collecting anxiety measures from a different psychometric measure like The State-Trait Anxiety Inventory (STAI) assessment. A deeper look into how the two types of anxiety relate to EF and math achievement could add more supportive evidence to Hariri's (2014) findings that state anxiety is believed to be a dysfunction of the EF and trait anxiety is believed to be an overactive amygdala according to the PET scans and fMRI scans. Comparing these findings to data that measures math anxiety could add yet another layer to the evidence. These findings could suggest school psychologists may benefit from including EF measures into their interventions for children and adolescents with anxiety.

Summary

The present study examined the mediation effect of EF domains on the relationship between anxiety and math achievement. Results from the small sample size show that attentional control was the only EF factor that mediated the relationship between anxiety and math achievement. Children and adolescents with higher attention scores were more likely to have lower anxiety scores and higher math scores, and vice versa. This preliminary finding is consistent with previous findings on adults. Additionally, the current study examined the moderation effect of gender and age on the relationship between attention control, anxiety, and math achievement. There was no evidence to support a moderation effect of gender or age on the relationships of the variables in the small sample. However, a statistically significant change in math achievement was found when the age groups changed from 9-11 years old to 16 years or older. The small sample size limits the generalizability of these findings. Therefore, this should be considered a preliminary study to understand the relationships of the variables. A better understanding of the relationships among these variables would enable us to design better interventions to help curb the negative effects that anxiety can have on math achievement due to dysfunctional EF and lower the costs of mental health care.

Appendices

Appendix A

Proposed ECS model of executive function:

1. COGNITIVE FLEXIBILITY
    a. Divided attention
    b. Working memory
    c. Conceptual transfer
    d. Feedback utilization
2. ATTENTIONAL CONTROL
    a. Selective attention
    b. Self-regulation
    c. Self-monitoring
    d. Inhibition
3. INFORMATION PROCESSING
    a. Efficiency
    b. Fluency
    c. Speed of processing
4. GOAL SETTING
    a. Initiative
    b. Conceptual reasoning
    c. Planning
    d. Strategic organization

Appendix B

Anxiety Disorders:

1. Separation Anxiety
    a. Developmentally inappropriate and excessive fear or anxiety concerning separation from those to whom the individual is attached, as evidenced by at least three of the following:
        i. Recurrent excessive distress when anticipating or experiencing separation from home or from major attachment figures.
        ii. Persistent and excessive worry about losing major attachment figures or about possible harm to them, such as illness, injury, disasters, or death.
        iii. Persistent and excessive worry about experiencing an untoward event (e.g., getting lost, being kidnapped, having an accident, becoming ill) that causes separation from a major attachment figure.
        iv. Persistent reluctance or refusal to go out, away from home, to school, to work, or elsewhere because of fear of separation.
        v. Persistent and excessive fear of or reluctance about being alone or without major attachment figures at home or in other settings.
        vi. Persistent reluctance or refusal to sleep away from home or to go to sleep without being near a major attachment figure.
        vii. Repeated nightmares involving the theme of separation.
        viii. Repeated complaints of physical symptoms (e.g., headaches, stomachaches, nausea, vomiting) when separation from major attachment figures occurs or is anticipated.
    b. The fear, anxiety, or avoidance is persistent, lasting at least 4 weeks in children and adolescents and typically 6 months or more in adults.
    c. The disturbance causes clinically significant distress or impairment in social, academic, occupational, or other important areas of functioning.
    d. The disturbance is not better explained by another mental disorder, such as refusing to leave home because of excessive resistance to change in autism spectrum disorder; delusions or hallucinations concerning separation in psychotic disorders; refusal to go outside without a trusted companion in agoraphobia; worries about ill health or other harm befalling significant others in generalized anxiety disorder; or concerns about having an illness in illness anxiety disorder.
2. Specific Phobia
    a. Marked fear or anxiety about a specific object or situation (e.g., flying, heights, animals, receiving an injection, seeing blood).
        Note: In children, the fear or anxiety may be expressed by crying, tantrums, freezing, or clinging.
    b. The phobic object or situation almost always provokes immediate fear or anxiety.
    c. The phobic object or situation is actively avoided or endured with intense fear or anxiety.
    d. The fear or anxiety is out of proportion to the actual danger posed by the specific object or situation and to the sociocultural context.
    e. The fear, anxiety, or avoidance is persistent, typically lasting for 6 months or more.

f. The fear, anxiety, or avoidance causes clinically significant distress or impairment in social, occupational, or other important areas of functioning.
g. The disturbance is not better explained by the symptoms of another mental disorder, including fear, anxiety, and avoidance of situations associated with panic-like symptoms or other incapacitating symptoms (as in agoraphobia); objects or situations related to obsessions (as in obsessive-compulsive disorder); reminders of traumatic events (as in posttraumatic stress disorder); separation from home or attachment figures (as in separation anxiety disorder); or social situations (as in social anxiety disorder).

3. Social Anxiety
    a. Marked fear or anxiety about one or more social situations in which the individual is exposed to possible scrutiny by others. Examples include social interactions (e.g., having a conversation, meeting unfamiliar people), being observed (e.g., eating or drinking), and performing in front of others (e.g., giving a speech).
        Note: In children, the anxiety must occur in peer settings and not just during interactions with adults.
    b. The individual fears that he or she will act in a way or show anxiety symptoms that will be negatively evaluated (i.e., will be humiliating or embarrassing; will lead to rejection or offend others).
    c. The social situations almost always provoke fear or anxiety.
        Note: In children, the fear or anxiety may be expressed by crying, tantrums, freezing, clinging, shrinking, or failing to speak in social situations.
    d. The social situations are avoided or endured with intense fear or anxiety.
    e. The fear or anxiety is out of proportion to the actual threat posed by the social situation and to the sociocultural context.
    f. The fear, anxiety, or avoidance is persistent, typically lasting for 6 months or more.
    g. The fear, anxiety, or avoidance causes clinically significant distress or impairment in social, occupational, or other important areas of functioning.
    h. The fear, anxiety, or avoidance is not attributable to the physiological effects of a substance (e.g., a drug of abuse, a medication) or another medical condition.
    i. The fear, anxiety, or avoidance is not better explained by the symptoms of another mental disorder, such as panic disorder, body dysmorphic disorder, or autism spectrum disorder.
    j. If another medical condition (e.g., Parkinson’s disease, obesity, disfigurement from burns or injury) is present, the fear, anxiety, or avoidance is clearly unrelated or is excessive.
4. Panic Disorder
    a. Recurrent unexpected panic attacks. A panic attack is an abrupt surge of intense fear or intense discomfort that reaches a peak within minutes, and during which time four (or more) of the following symptoms occur:
        Note: The abrupt surge can occur from a calm state or an anxious state.
        i. Palpitations, pounding heart, or accelerated heart rate.
        ii. Sweating.
        iii. Trembling or shaking.
        iv. Sensations of shortness of breath or smothering.
        v. Feelings of choking.

vi. Chest pain or discomfort.
vii. Nausea or abdominal distress.
viii. Feeling dizzy, unsteady, light-headed, or faint.
ix. Chills or heat sensations.
x. Paresthesias (numbness or tingling sensations).
xi. Derealization (feelings of unreality) or depersonalization (being detached from oneself).
xii. Fear of losing control or "going crazy."
xiii. Fear of dying.

Note: Culture-specific symptoms (e.g., tinnitus, neck soreness, headache, uncontrollable screaming or crying) may be seen. Such symptoms should not count as one of the four required symptoms.

b. At least one of the attacks has been followed by 1 month (or more) of one or both of the following:
    i. Persistent concern or worry about additional panic attacks or their consequences (e.g., losing control, having a heart attack, "going crazy").
    ii. A significant maladaptive change in behavior related to the attacks (e.g., behaviors designed to avoid having panic attacks, such as avoidance of exercise or unfamiliar situations).
c. The disturbance is not attributable to the physiological effects of a substance (e.g., a drug of abuse, a medication) or another medical condition (e.g., hyperthyroidism, cardiopulmonary disorders).
d. The disturbance is not better explained by another mental disorder (e.g., the panic attacks do not occur only in response to feared social situations, as in social anxiety disorder; in response to circumscribed phobic objects or situations, as in specific phobia; in response to obsessions, as in obsessive-compulsive disorder; in response to reminders of traumatic events, as in posttraumatic stress disorder; or in response to separation from attachment figures, as in separation anxiety disorder).

5. Generalized Anxiety Disorder
    1. Excessive anxiety and worry (apprehensive expectation), occurring more days than not for at least 6 months, about a number of events or activities (such as work or school performance).
    2. The individual finds it difficult to control the worry.
    3. The anxiety and worry are associated with three (or more) of the following six symptoms (with at least some symptoms having been present for more days than not for the past 6 months):

        Note: Only one item is required in children.
        i. Restlessness or feeling keyed up or on edge.
        ii. Being easily fatigued.
        iii. Difficulty concentrating or mind going blank.
        iv. Irritability.
        v. Muscle tension.
        vi. Sleep disturbance (difficulty falling or staying asleep, or restless, unsatisfying sleep).
    1. The anxiety, worry, or physical symptoms cause clinically significant distress or impairment in social, occupational, or other important areas of functioning.

2. The disturbance is not attributable to the physiological effects of a substance (e.g., a drug of abuse, a medication) or another medical condition (e.g., hyperthyroidism).
3. The disturbance is not better explained by another mental disorder (e.g., anxiety or worry about having panic attacks in panic disorder, negative evaluation in social anxiety disorder [social phobia], contamination or other obsessions in obsessive-compulsive disorder, separation from attachment figures in separation anxiety disorder, reminders of traumatic events in posttraumatic stress disorder, gaining weight in anorexia nervosa, physical complaints in somatic symptom disorder, perceived appearance flaws in body dysmorphic disorder, having a serious illness in illness anxiety disorder, or the content of delusional beliefs in schizophrenia or delusional disorder).

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Curriculum Vitae

Mckenzie Hall, Ph.D.

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University of Nevada, Las Vegas
Las Vegas, NV 8911
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EDUCATION

University of Nevada Las Vegas, Las Vegas, NV
Ph.D in School Psychology **2022**
Dissertation: Passed
Current GPA: 3.87

University of Nevada Las Vegas, Las Vegas, NV
M.A. in Special Education **2010**
Comprehensive Exam: passed
GPA: 4.0

University of Santa Barbara, Goleta, CA
B.A. in Psychology
GPA: 3.15 **2004**

AWARDS

Honor Society 2010- 2022

PROFESSIONAL EXPERIENCE

Educational Psychologist 2017-2021
Canyons School District

- Gave Functional Behavior Assessments to help create Behavior Intervention Plans
- Created, implemented, and trained teachers on Behavior interventions for social/emotional regulation and executive function regulation
- Train teachers on classroom management techniques and interventions for internalizing and externalizing maladaptive behaviors
- Gave psychoeducational assessments to help determine eligibility for Special Education
- Created psychoeducational evaluation
- Implemented interventions with students in a group and one on one counseling session for improved wellbeing, prosocial skills, functional communication skills, emotional regulation, executive

function skills, self-awareness, self-management, and responsible decision making.

- Analysis of system's approach for Response to Intervention
- School climate analysis
- Created and implemented wellness center
- Curriculum design for improved wellbeing, prosocial skills, functional communication skills, emotional regulation, executive function skills, self-awareness, self-management, and responsible decision making.
- Coordinated and conducted Multidisciplinary Team Meetings and Individual Education Program meetings
- Trained staff on variety of mental health topics and RTI processes for internalizing and externalizing behaviors.

Internship 2016-2017
Canyons School District

- Gave Functional Behavior Assessments to help create Behavior Intervention Plans
- Created, implemented, and trained teachers on Behavior interventions for social/emotional regulation and executive function regulation
- Gave psychoeducational assessments to help determine eligibility for Special Education
- Created psychoeducational evaluation
- Implemented interventions with students in a group and one on one counseling session for improved wellbeing, prosocial skills, functional communication skills, emotional regulation, executive function skills, self-awareness, self-management, and responsible decision making.

  Curriculum design for improved wellbeing, prosocial skills, functional communication skills, emotional regulation, executive function skills, self-awareness, self-management, and responsible decision making.
- Coordinated and conducted Multidisciplinary Team Meetings and Individual Education Program meetings

Advanced Practicum Summer 2015
Clark County School District

- Made observations of student behavior in several settings
- Gave psychoeducational assessments to help determine eligibility for Special Education
- Created psychoeducational evaluation
- Completed a case from start to finish independently

The Neuro clinic at UNLV Fall 2015

- Observed assessments for Autism

Practicum 2014-2015
Clark County School District

- Made observations of student behavior in several settings
- Gave psychoeducational assessments to help determine eligibility for Special Education
- Created psychoeducational evaluation reports
- Observed progressive muscle relaxation intervention to help with mutism

The PRACTICE

- Completed intakes with a variety of ages
- Completed psycodiagnostic assessments for evaluations
- Created psychodiagnostic evaluation reports
- Presented feedback to families

Early Childhood Special Education Teacher 2009 to 2016
Clark County School District

- Give district, Curriculum based, functional behavior, and psychoeducational assessments.
- Responsible for creating a safe learning environment where students can explore their true learning potential
- Progress monitoring on IEP goals and standards appropriate for grade level.
- Developing IEPs for all students and conducting a 6-month review or trimester review on all goals for all students

PUBLICATIONS AND PAPERS

Anxiety, Depression and Processing Speed: Is there a predictive relationship? Submitted 2014

MEMBERSHIPS

Alpha Gamma Delta Sorority
Phi Kappa Phi Fraternity
National Association of School Psychologist