

**THE RELATIONSHIP BETWEEN ADVERSE CHILDHOOD EXPERIENCES
AND EXECUTIVE FUNCTIONING DIMENSIONS**

Kathryn B. Wilson

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Thesis Committee Members:

Dr. Seth Marshall

Dr. James Rust

Dr. Kimberly Ujcich Ward

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Kathryn Wilson

APPROVED:

Dr. Seth Marshall, Chair

Dr. James Rust, Committee Member

Dr. Greg Schmidt, Psychology Department Chair

Dr. David Butler, Dean of the College of Graduate Studies

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ABSTRACT

More research is needed that investigates how and to what extent adverse childhood experiences (ACEs) are predicted by neurocognitive executive functioning (EF) skills. To address this, the current study analyzed how ACEs were predicted by two core dimensions of executive functioning (EF), that is, inhibition (i.e., behavior regulation skills) and working memory (i.e., metacognition skills). College students ($N = 388$) were administered the ACE Questionnaire, (Felitti et al., 1998), and the Behavior Rating Inventory of Executive Function Adult Version (BRIEF-A; Roth, Isquith, & Gioia, 2005). Results indicated ACEs significantly predicted more difficulty with global EF skills. This was also the case when each EF dimensions was looked at individually. ACEs predicted more EF inhibition and working memory problems. ACEs were slightly more associated with EF inhibition difficulties in comparison to EF working memory difficulties. These findings contribute to ACEs and EF research by utilizing an EF dimensional approach on a non-clinical US sample of college students.

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CHAPTER I: INTRODUCTION

Overview

Adverse childhood experiences (ACEs) are a critical issue in public health and well-being. A variety of health organizations, such as the Center for Disease Control (CDC) and Prevention, the American Psychological Association (APA), Substance Abuse and Mental Health Services Administration, The National Institutes of Health, the World Health Organization (WHO), and the National Alliance on Mental Illness, have recognized the powerful influence that ACEs have on numerous aspects of health across the lifespan. For example, the CDC has made ACEs awareness and prevention one of its top priorities by highly publicizing the link between childhood adversity and later-life health and well-being through the foundational research from the ACE study (Felitti et al., 1998). Likewise, the APA has published a variety of articles connecting ACEs and negative health outcomes such as depression, eating disorders, substance abuse, as well as other chronic health conditions. Understanding how childhood adversity increases the likelihood of negative mental and physical health conditions can improve attempts to intervene with this worldwide public health issue.

Multiple studies have documented that ACEs are related to many chronic health conditions and risks (e.g., Brown, Thacker, & Cohen, 2014; Dube, et al., 2003). First, regarding physical health, studies indicate that ACEs can have lasting correlations related to physical health including diabetes (Lynch, Waite, & Davey, 2013), heart disease (Pretty, O'Leary, Cairney, & Wade, 2013), and cancer (Brown et al., 2014). Many studies

linked ACEs to a number of mental health conditions involving suicide attempts (Dube et al., 2001), depression (Chapman et al., 2004), and drug use (Dube et al., 2003). Overall, a variety of research support that ACEs are associated with negative outcomes pertaining to mental and physical health (e.g., Dube et al., 2003; Edwards, Holden, Felitti & Anda, 2003).

Adverse Childhood Experiences

ACEs can be defined as emotionally disturbing childhood experiences that have potential long-term negative effects on health and wellbeing (Centers for Disease, 2016). Similarly, Felitti et al. (1998) termed ACEs as the long-term impact of abuse and household dysfunction experienced during childhood. Generally, ACEs are categorized in three main areas: abuse (physical, emotional, and sexual), neglect (physical and emotional), and household dysfunction (divorce, incarcerated relatives, mental illnesses, maltreatment of mother, and substance abuse).

Much of the existing ACEs research has documented a staircase effect. That is, as the number of ACEs that an individual experiences increases, there is a stepwise increased likelihood of negative outcomes. In other words, there is a dose-response effect. As the “dose” of ACEs increases, there is a corresponding negative response. For example, the likelihood of becoming a smoker later in life increases as the score on the adverse childhood experience index increases (0 ACEs = 7.8%, 1 ACE = 9.1 %, 2 ACEs = 10.9%, 3 ACEs = 14.3%, 4 or more ACEs = 16.6%) (Edwards et al., 2007). Similarly, the number of ACEs an individual experiences increases the likelihood of numerous severe physical conditions, such as heart disease. For example, as the total number of ACEs an individual experiences increases, the probability of developing heart disease

escalates (0-2 ACEs = 9.9%, 3-4 ACEs = 12.1%, 5-6 ACEs = 13.9%, 7-8 ACEs = 20.1%) (Dong et al., 2004). Likewise, the risk for suicide attempt increases as the total number of ACEs increases (0 ACEs = 2%, 1 ACE = 3.5%, 2 ACEs = 4.5%, 3 ACEs = 11%, 4 or more ACEs = 19%) (Thomson, Baird, & Brennenstuhl, 2016). Overall, the staircase effect has been documented to have a cumulative effect on physical and mental health, meaning that the total amount of ACEs experienced directly increases the likelihood of negative health effects.

Researchers and clinicians have noted evidence of the staircase effect, but have questioned the potential pathway of how ACEs are related to physical and mental health. (Center for Disease Control and Prevention, 2016). Below, a potential pathway adopted by the Center for Disease Control (CDC, 2016) provides a visual representation of the potential impact of childhood experiences on adult health and well-being.

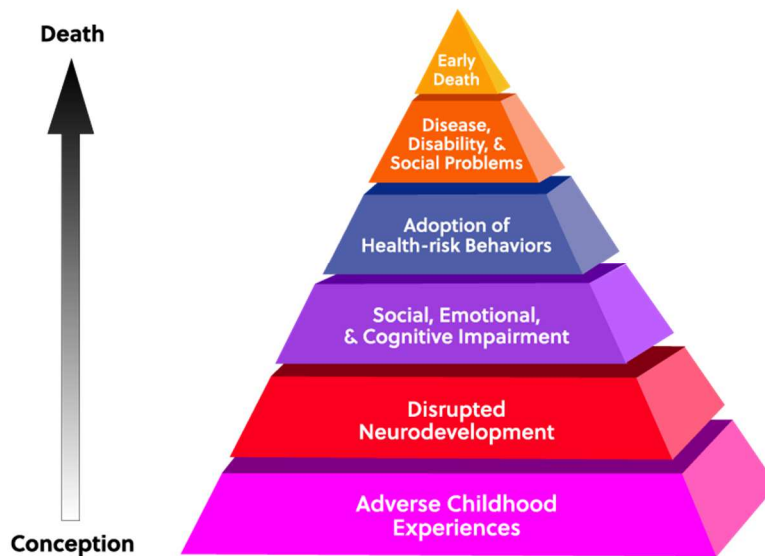


Figure 1. ACE pyramid depicting potential pathways

According to this model, as childhood adversity increases, there is a corresponding increased risk for disrupted neurodevelopment. Previous studies have tied early adversity to neurodevelopment problems (Teicher, Samson, Anderson, Ohashi, & Kyoko, 2016; Barta, 2018). Previous research (e.g., Johnson, Riley, Granger, & Riis, 2013) documented that young brains are potentially altered when exposed to toxic stress for extended periods of time. For example, when neurons are damaged by toxic stress, fewer neural connections are made within the architectural structure of the brain (Center on the Developing Child, 2007). It is noted that more research is needed to better understand what aspects of neurodevelopment are altered. This is a core premise of the current thesis that will be explored. This neurodevelopment disruption is postulated as impairing social, emotional and cognitive areas later on in life. Essentially, early childhood adversity and corresponding neurodevelopmental disrupts the development trajectory of social, emotional and cognitive skills. This disruption then contributes to the adoption of health risk behaviors, which can lead to disease, disability, and social problems. In conclusion, as the amount of childhood adversity increases, there is greater likelihood of problematic conditions regarding mental, physical, and emotional health, which increases the overall risk of early death. The ACE pyramid plays an important role in allowing researchers and clinicians to understand the various effects childhood adversities have on later life (Centers for Disease Control and Prevention, 2016). More specifically, the ACE pyramid provides a model for evaluating the mechanisms of action and potential trajectory regarding neurodevelopment.

Executive Functioning

Executive functioning (EF) is a term that refers to a set of cognitive processes such as planning, shifting attention, problem solving, inhibition, task completion, goal-oriented behavior, and cognitive flexibility (e.g., Dohle, Diel, & Hofmann, 2018, Miyake & Friedman, 2012). Executive processes begin developing during childhood, and are largely involved in cognition, behavior, emotional control, and social interactions throughout the lifespan (Perone, Almy, & Zelazo, 2018). More specifically, the development of EF occurs in the prefrontal cortex of the brain (Banich, 2009). Moran and Gardner (2007) explain EF in terms of a three-parameter model consisting of will, skill, and motivation. First, will is described as the ability to set clear future-oriented goals. Second, skill is described as what an individual is able to do or able to learn. Third, motivation is described as the motivation and perseverance to achieve set goals. Will, skill, and motivation need to operate together in order to accomplish and understand tasks. Although theoretical models regarding EF may vary, a large majority of researchers acknowledge that EF is crucial for everyday tasks. In other words, skills such as planning, organizing, attention, and memory work together to modulate human behavior and thought processes (Moran & Gardner, 2007).

Theoretical Models of EF. Various models of executive functioning have been developed over time. For example, Zelazo (2015) proposed three key executive functioning skills: cognitive flexibility, working memory, and inhibitory control. Likewise, Gioia, Isquith, Guy, and Kenworthy (2000) identified metacognition and behavioral regulation as being the two basic areas of EF. Metacognition encompasses skills related to working memory, while behavioral regulation is made up skills similar to

inhibition. While many theoretical models of EF have been proposed, inhibition and working memory remain the two core skill areas.

Inhibition is the first EF variable in the current study. This cognitive skill is associated with the orbitofrontal region of the frontal lobes of the brain (Meyer & Bucci, 2016). Inhibition can be defined as one's ability to consciously override ruling or proponent responses (Miyake & Friedman, 2012). Inhibitory control was also defined by Diamond (2013) as one's ability to control attention, behavior, thoughts, and emotions. Specifically, this area plays a significant role in higher-order processes such as decision making, reasoning, and rationalizing (Domenech & Koechlin, 2015). In sum, inhibition is a key cognitive skill that allows individuals to exert cognitive control in pressing the mental brakes that allow us to choose appropriate responses or actions while controlling for behavioral impulses.

Working memory is the second EF variable in the current study. It is associated with the dorsolateral area of the prefrontal cortex of the brain (Lara & Wallis, 2015). Working memory is best defined as the ability to take in information, change or alter the information, and then apply it in order to solve problems and make decisions (Christophel, Klink, Spitzer, Roelfsema, & Haynes 2017). Additionally, working memory can be defined as, "a holding place for information to be used temporarily, with the possibility of many working memories being held concurrently" (Cowan, 2017; Laird, 2012; Newell & Simon, 1956). Working memory is composed of two cognitive processes commonly known as shifting and updating. Shifting, otherwise known as set shifting, is the ability or flexibility to switch between two or more tasks either unconsciously, or consciously (Miyake & Friedman, 2012; Miyake, Friedman, Emerson,

Witzki, & Howerter, 2000). In other words, shifting initiates task change that usually results in stopping one task and starting a different one. In addition, working memory aids in updating. Updating involves replacing old information with new and relevant material (Carriedo, Corral, Montoro, Herrero, & Rucián, 2016). In sum, working memory is a key cognitive control variable that allows us to hold and manipulate information that leads to higher order thinking and behavior.

Current research suggests that a brain's frontal lobes can take up to thirty years to mature, and as the frontal lobes begin to mature, EF skills develop. EF development can benefit from activities such as computerized trainings, mindfulness, martial arts, and school curriculum for children and adolescents (Diamond & Lee, 2011). Research also suggest that early parenting plays a significant role in supporting EF development and self-regulation skills (Sulik, Blair, Mills-Koonce, Berry, & Greenberg, 2015). In sum, as the frontal lobes mature, EF functioning increases. If ACEs occur during early childhood there is a greater likelihood that EF inhibition and working memory will be altered, thus changing the developmental trajectory of the brain.

ACEs and EF

Recent research has begun to evaluate the relationship between early exposure to ACEs and EF problems. Below are four recent studies that document the impact of ACEs on global executive functioning, specifically inhibition and working memory. Barta (2018) researched the relationship between adverse childhood experiences and executive functioning in adolescents ages 14 through 18-year-olds attending a high school on the east coast. Participants ($N = 149$) completed the Philadelphia ACE survey, composed of twenty-two self-reported questions related to trauma and adversity. Additionally, the

participants completed the BRIEF-2 self-report questionnaire, which included items measuring reported executive functioning. The BRIEF-2 is divided into individual scales which measured inhibition, self-monitoring, shifting, emotional control, task completion, working memory, and planning/organization. Upon completing the questionnaires, participants were then given an exit survey to determine the participants' comfort factor as well as potential need for follow-up. Results indicated that there was a significant positive correlation between the total number of ACEs and self-reported global executive functioning (i.e. working memory & inhibition), indicating the more adversities the participants experienced, the higher likelihood of executive dysfunction.

Ji and Wang (2018) studied the effects of adverse childhood experiences and life events on executive functions that concentrated on inhibition, cognitive flexibility and working memory. Participants included college students recruited from 2 universities in China with a mean age of 19 years old. Participants ($N = 658$) were screened using the ACEs and Adolescent Self-rating Life Events Checklist (ASLEC). Researchers randomly selected 30 participants who had experienced childhood trauma and 30 who had not. All 60 participants completed 3 measures: Childhood Trauma Questionnaire which measured neglect or abuse before the age of 18; the Behavioral Risk Factor Surveillance System and ACEs study, which focused on family dysfunction; and the Adolescent Self-rating Life Events Checklist to determine reactions to negative life events. After completing these measures, researchers administered the experiment paradigm, software which collected data on response time and accuracy of response for inhibition, cognitive flexibility, and working memory. The results indicated a significant positive correlation between ACEs, life events, and inhibition deficits. This suggests that the individuals with

higher ACE and life event scores took longer to correctly respond during the inhibition tasks. Moreover, individuals who reported higher on the life events measure (i.e. those with more life events) showed significant differences on inhibition, working memory, and cognitive flexibility tasks compared to those with fewer life events. Specifically, the performance of the group with higher life events was worse, suggesting that life events can have a negative impact on all three components of EF (i.e. working memory, inhibition, and cognitive flexibility).

Mark, Poltavski, Petros, and King, A (2019) investigated differences in executive functioning abilities amongst individuals who had experienced childhood abuse compared to individuals who had not. Participants ($N = 43$) were recruited from the University of North Dakota. The average age of participants was 20 years old. Researchers administered 3 online screening tools to assess childhood abuse, as well as drug use and abuse. These tools included the Lifetime Report of Physical Abuse (LPAA), the Lifetime Report of Psychological Abuse (PALA), and the Lifetime Report of Sexual Abuse (SALA). Based upon the screening results, the researchers divided the participants into 3 groups, namely no abuse, low levels of abuse, and moderate to severe abuse. Further testing involved a drug use questionnaire to assess the history of drug use, and a wireless EEG system to determine brainwave activity. Additionally, researchers used the Wisconsin Card Sorting Task (WCST) to measure shifting, an executive functioning component. Second, they examined inhibition by measuring attention and impulsivity using the Connors Continuous Performance Task (Connors CPT). Lastly, general working memory was assessed by using the Operation Span Task (OSPAN). Results indicated that the moderate to high childhood abuse groups exhibited a significantly

higher omission error rate compared to the no abuse groups, suggesting that individuals who experienced childhood abuse had more difficulty with inhibitory control compared to individuals who had not experienced childhood abuse. Moreover, the OSPAN task results showed a significant difference between the moderate to high childhood abuse group and the no childhood abuse group, suggesting that individuals with a history of child abuse have greater difficulty performing working memory tasks compared to individuals who had not experienced childhood abuse. Overall, the results of this study supported the idea that individuals who have a history of child abuse are more likely to experience difficulty with tasks that involve EF dimensions (i.e. inhibition and working memory).

Philip et al., (2015) researched the relationships between early life stress (ELS) and working memory performance by examining neuroimages in adults ($N = 27$) with and without histories of physical, sexual, emotional, and psychological abuse and/or neglect. Researchers recruited from a prior study involving mood/anxiety disorders, however, data for the current study was gathered separately and is not related to the prior study. Participants were split into two groups, history of exposure to early life stress ($N = 14$) and no exposure to early life stress ($N = 13$), based on results from the Childhood Trauma Questionnaire (CTQ). The CTQ is a self-report measure that assesses the frequency of childhood experiences related to neglect, abuse, and maltreatment (emotional, physical, and sexual). Additionally, participants completed the Depressive Symptomology Self-Report scale, which measures symptoms of depression and anxiety. Working memory was assessed through the N-back, which is widely used in fMRI studies. The N-back involves two specific tasks that helps show activation and

deactivation in brain images. These two tasks, 0-back and 2-back, involve pressing “yes” or “no” in correspondence to specified directions that require working memory. During the working memory tasks, researchers gathered neuroimaging data which were later processed via the Brown University MRI Research Facility. Results indicated a significant finding suggesting that individuals who have experienced early life stress have greater difficulty with working memory tasks compared to those who have not been exposed to early life stress. Moreover, neuroimaging from the N-back task (i.e, working memory task) revealed that individuals who experienced early life stress require more cognitive resources to complete even the simplest working memory task. In addition to decreased working memory accuracy in participants who experienced early life stress, researchers also found increased activity in regions that are modestly correlated with symptoms of anxiety and depression. Overall, this study further supports previous research that links early life stress to executive functioning deficits as well as changes in brain activation.

Purpose and Hypotheses

More research is needed to better understand how ACEs are related to neuropsychological development. Specifically, more clarity is needed to understand how ACEs are connected to the core dimension of EF, inhibition and working memory. First, this study seeks to investigate whether ACEs is linked to EF neurological disruption, as illustrated in the pathway pyramid described in chapter one. Next, though research generally suggests that ACEs negatively impacts EF skills, it is unclear to what degree and which cognitive domain, inhibition or working memory, is impacted more than the other. The current study seeks to investigate how, and to what extent, each of the core EF

dimensions, namely EF Behavioral Regulation (i.e., inhibition) and EF Metacognition (i.e., working memory) predicted total ACE scores. In addition, we investigated if ACEs were tied more to EF working memory than EF inhibition when both variables are considered together at the same time.

Hypothesis One: It is hypothesized that higher ACEs scores, as measured by the ACE questionnaire, will significantly predict overall EF deficits (i.e., Global Executive Functioning Composite) as measured by the BRIEF-2.

Rationale: ACEs theoretically disrupts neurodevelopment based on the pathway pyramid, or the framework of how ACEs affects an individuals' lifelong health. In this sense, we anticipate that a link between self-reported ACEs and EF deficits.

Hypothesis Two: Looking closely at the core dimension of EF, it is hypothesized that ACEs will significantly predict individual core EF domains. In other words, more ACEs will be linked to lower EF inhibition and EF working memory skills. We also hypothesize that ACEs will have more detrimental relationship with EF working memory in comparison to EF inhibition skills.

Rationale: Theoretically, ACEs disrupt neural pathways that inhibit an individual to hold and recall information. Additionally, ACEs theoretically disrupt neural pathways that help individuals control behavior and impulses. Therefore, it is hypothesized that there will be an individual relationship linking ACEs to lower EF inhibition and EF working memory skills. Theoretically, working memory is a key component of EF that has limited capacity, plays a crucial role in decision making and reasoning, and does not fully develop until adulthood. Moreover, brain regions that encompass working memory are developed at a later stage than regions responsible for inhibitory control. Therefore, it is reasonable

to assume that the development of working memory will be impaired to a greater degree than inhibitory control due to the later development of this specific region.

CHAPTER II

Methods

Participants

Undergraduate college students ($N = 388$; 230 females and 158 males) were recruited at a regional university located in southern United States. Participants were required to comprehend spoken and written English to participate. Written consent was provided prior to participation. Participants completed individual self-reported instruments during a 30-minute laboratory session. The sample consisted of students from the following ages: (a) 25% were 18 years old ($n = 98$); (b) 31% were 19 years old ($n = 120$); (c) 18 % were 20 years old ($n = 70$); (d) 8 % were 21 years old ($n = 32$); and (e) 18% were 22 years old or older ($n = 68$). Based on the students' report of their ethnicity 57.5% were Caucasian ($n = 223$), 25.5% were African American ($n = 99$), 3.8% were Asian ($n = 15$), 3.6% were Hispanic or Latino ($n = 14$), 0.5% were American Indian or Alaskan Native ($n = 2$), 0.3% were Pacific Islander ($n = 1$), and 8.8% were other ($n = 34$).

Measures

EF measure. The Behavior Inventory Executive Function-Adult Version (BRIEF-A; Roth et al., 2005) was used to assess dimensions of EF. The BRIEF-A is a self-report questionnaire that examines an individual's ability to self-regulate in their everyday environment. The Brief is comprised of 75 questions that produce an overall score, the Global Executive Functioning Composite, and two index scores. The first index score is the Behavioral Regulation Index (BRI), which measures an individual's ability to maintain control of inhibitory responses. For example, impulse control includes

flexibility, shifting, monitoring one's emotional response to stimuli, and appropriately inhibiting thoughts and actions (e.g., I have outbursts at inappropriate places). The BRI index includes four scales (Inhibit, Shift, Emotional Control, and Self-Monitor). The second index is the Metacognition Index (MI) that measures an individual's ability to execute executive functions required for active working memory (e.g., I have trouble completing tasks that require multiple planned steps). Specifically, the MI is directly related to an individual's ability to problem-solve and make decisions. This index includes five scales (Initiate, Working Memory, Plan/Organize, Task Monitor, and Organization of Materials). For the purposes of the current study, the Global Executive Functioning Composite, the Behavioral Regulation Index, and the Metacognition Index were used to measure EF abilities. The BRIEF measure utilizes a three-point Likert scale for each of the 75 items. Response options are one (the behavior is never a problem), two (the behavior is sometimes a problem), and three (the behavior is often a problem). Participants chose the answer that best described his/her behavior over the last month. Higher scores on the BRIEF indicate increased problems with self-regulation, inhibition, and working memory related skills.

ACEs. Adverse childhood experiences were assessed with the ACE Questionnaire (Felitti et al., 1998), a self-report rating scale developed to assess the amount of adverse experiences one experiences during the first 18 years of life. The instrument is widely used by practitioners in clinical settings as well as ACE research from a variety of organizations such as the World Health Organization, US Department of Health, and the Center for Disease Control and Prevention. The ACE Questionnaire is comprised of 10 questions (see Appendix A). The first question targets emotional abuse and asks

participants “did a parent or other adult in the household often swear at you, insult you, put you down, humiliate you or act in a way that made you afraid that you might be physically hurt?” Participants indicate a yes/no response. The second question focuses on physical abuse, and asks participants to “did a parent or other adult in the household often push, grab, slap, throw something at you, or ever hit you so hard that you had marks or were injured?” Participants indicate a yes/no response. The third question focused on sexual abuse and asks participants “did an adult or person at least 5 years older than you ever touch, fondle you, have you touch their body in a sexual way, or try to actually have oral, anal, or vaginal sex with you?” Participants indicate a yes/no response. The fourth question focuses on emotional neglect and asks participants “did you often feel that no one in your family loved you, thought you were important or special, or your family didn’t look out for each other, feel close to each other, or support each other?” Participants indicate a yes/no response. The fifth question focuses on physical neglect and asks participants “did you often feel that you didn’t have enough to eat, had to wear dirty clothes, and had no one to protect you or your parents were too drunk or high to take care of you or take you to the doctor if you needed it?” Participants indicate a yes/no response. The sixth question focuses on divorce in terms of household dysfunction and asks participants “Were your parents ever separated or divorced?” Participants indicate a yes/no response. The seventh question focuses on the treatment of mothers in terms of household dysfunction and asks participants “was your mother or stepmother: often pushed, grabbed, slapped, or had something thrown at her, sometimes or often kicked, bitten, hit with a fist, or hit with something hard, ever repeatedly hit over at least a few minutes or threatened with a gun or knife?” Participants indicate a yes/no response. The

eight question focuses on substance abuse in terms of household dysfunction and asks participants “did you live with anyone who was a problem drinker or alcoholic or who used street drugs? Participants indicate a yes/no response. The ninth question focuses on mental illnesses in terms of household dysfunction and asks participants “was a household member depressed or mentally ill or did a household member attempt suicide?” Participants indicate a yes/no response. The final question focuses on incarcerated relatives in terms of household dysfunction and asks participants “did a household member go to prison?” Participants indicate a yes/no response.

Scoring procedures, outlined by the ACE Questionnaire, were followed to calculate a total ACE score for each participant. Each response of “yes” accounted for 1 point while each response of “no” accounted for 0 points. To calculate the total ACE score, all points were combined. Higher total scores reflected a higher ACE score (i.e., more experiences of childhood adversity).

Procedure

The current study utilized archival data that was collected by the thesis chair member, Dr. Seth Marshall. IRB approval was obtained (see Appendix B).

CHAPTER III

Results

Hypothesis 1

Means, standard deviations, and correlations were examined for participant's Adverse Childhood Experiences (ACE) scores and BRIEF scores (see Table 1).

Table 1

Means, Standard Deviations, and Correlations for Adverse Childhood Experiences Scores and Outcome Variables (N = 388)

Measures	<i>M</i>	<i>SD</i>	1.	2.	3.	4.
1. Adverse Childhood Experience	2.09	2.09		.17**	.14**	.17**
2. Global EF	116.5	21.54			.94**	.88**
3. EF Metacognition Working Memory	66.74	13.57				.67**
4. EF Behavioral Regulation Inhibition	49.76	9.96				

*Note. All scores based on raw scores, * $p < .05$. ** $p < .01$*

This study's first main purpose was to investigate how ACEs (i.e., the ACEs Total) predicted individuals' overall EF ability (i.e., Global Executive Functioning Composite). To address this purpose, one simple regression was conducted. Findings confirmed that the ACE Total significantly predicted Global Executive Functioning Composite ($R^2 = .07$, adjusted $R^2 = .06$, $F(2, 97) = 6.76$, $p = .01$) (see Table 1). The ACE Total scores accounted for approximately 6% of the variance of GEC scores in the sample.

Table 2

Simple Regression Analysis of Adverse Childhood Experiences Scores Predicting Global Executive Functioning Composite (N = 388)

Variable	<i>B</i>	<i>SEB</i>	<i>Beta</i>	<i>t</i>	<i>p</i>	Zero- Orde <i>r</i>	Partial	Part
Global EF	1.71	.52	.17	3.31	.01	.17	.17	.17
<i>R</i> ²		.01						

Hypothesis 2

This study's second main purpose was to investigate how, and to what extent, each of the core EF dimensions, namely EF Behavioral Regulation (i.e., inhibition) and EF Metacognition (i.e., working memory) predicted total ACE scores. Multiple regressions results indicated that there was no significant change in the prediction of ACE scores, $R^2 = .03$, adjusted $R^2 = .03$, $F(1, 386) = 10.97$, $p = .01$.

Table 3

Multiple Regression Analysis of Adverse Childhood Experiences Scores Predicting EF Metacognition and EF Behavior Regulation Indexes (N = 388)

Variables	<i>B</i>	<i>SEB</i>	<i>Beta</i>	<i>t</i>	<i>p</i>	Zero- Orde <i>r</i>	Partial	Part
EF Metacognition	.01	.01	.05	.75	.45	.14	.04	.04
EF Behavior Regulation	.03	.01	.14	1.99	.05	.17	.10	.10

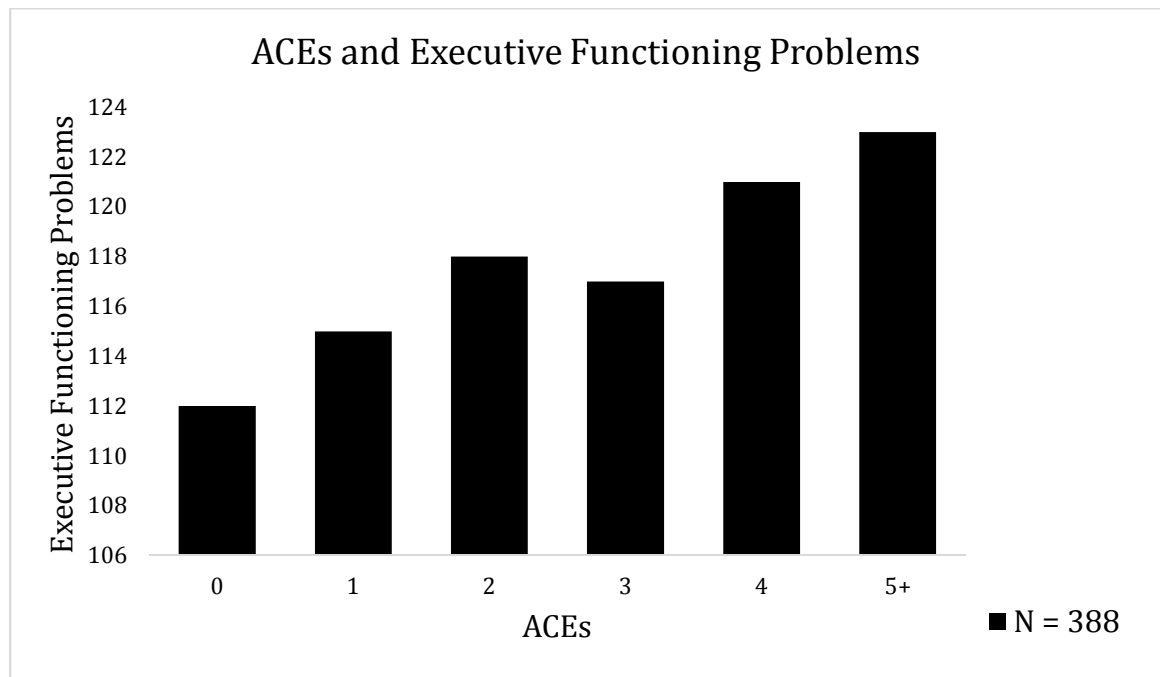


Figure 2. Table depicting ACEs and EF problems.

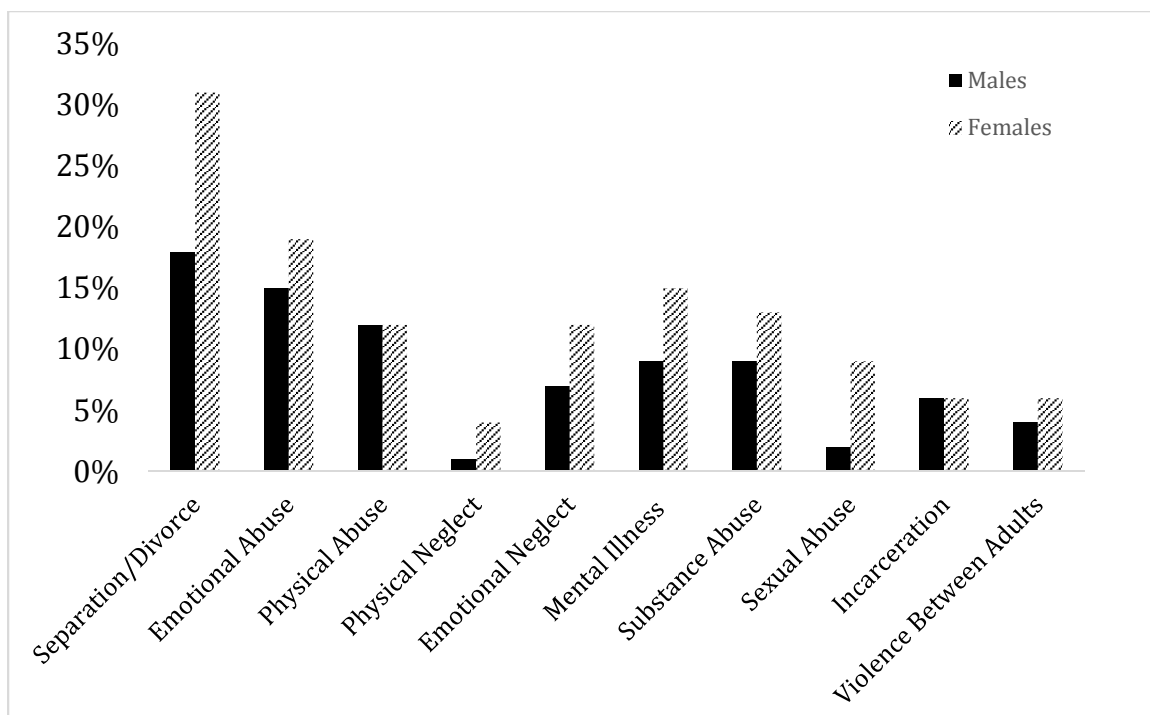


Figure 3. Table depicting ACE category and gender.

CHAPTER IV

Discussion

Hypothesis One

This study first investigated the relationship between ACEs and overall EF skills. As hypothesized, higher ACEs scores significantly predicted overall EF deficits. This a noteworthy finding that links ACEs to more difficulty regulating thought and behavior. Our study contributes to the expanding body of research that links ACEs to EF regulation disruption. One explanation for this finding is that childhood stress fundamentally alters neuropsychology. In other words, this stress can disrupt the development of brain architecture, which is closely associated with a host of stress-related difficulties (e.g. mental health and physical health issues) that can continue throughout adulthood, inhibiting core functions such as EF. This finding corresponds with previous studies that have documented similar results. For example, Barta (2018) reported that adolescents who experienced more adversity during childhood exhibited weaker global EF. Findings from this study also document a staircase effect regarding ACEs and EF. Previous research suggests the higher an ACE score, the higher likelihood of developing mental and physical health problems such as smoking, heart disease, and suicide (e.g., Edwards et al., 2007; Dong et al., 2004). Similarly, findings from the current study indicate a staircase relationship between ACEs and EF suggesting that higher ACE scores increase the likelihood of EF deficits. This can be conceptualized as a dose-response effect. That is, as the dose of ACEs increases this is correlated with increased scores on a variety of clinical and self-report EF measures.

Hypothesis Two

Secondly, this study explored how and to what extent ACEs predicted each of the two core EF components (i.e. inhibition and working memory). ACEs was significantly correlated with each of the core EF components. This suggests that increased ACEs is linked to lower EF inhibition and EF working memory skills individually. This finding helps clarify that ACEs are linked to each of the core EF domains separately. This finding also parallels previous studies that have documented a link between ACE scores and working memory (e.g., Philip et al., 2015; Ji & Wang, 2018). Likewise, existing research links childhood adversities to difficulty controlling impulses (e.g., Marshall et al., 2016). Next, we investigated if ACEs were tied more to EF working memory than EF inhibition when both variables are considered together at the same time. Our findings did not support this hypothesis. Rather, ACEs significantly predicted EF inhibition skills and did not significantly predict EF working memory skills. This provides some support that ACEs is linked more to EF inhibition difficulties in comparison to EF working memory skills.

Limitations and Future Research

There are several important limitations within this study. First, it is important to understand that the ACE Questionnaire may have a limited definition of adversity. There may be other traumatic experiences that were not addressed by this tool (i.e. health, loss of a loved one, or accidents). Second, the ACE Questionnaire does not gather specific details pertaining to adverse experiences, such as the age the trauma was experienced. Although the ACE questionnaire tells us the adversity happened prior to the

age of 18, specific ages may play a factor in the relationship between adversity and EF functioning. Third, EF is a multidimensional construct, and the current study only assessed two core dimensions of EF (inhibition and working memory). There are potentially other EF components that were not included within this study. Future research might consider other EF skills in the context of ACEs and EF. Fourth, this study was based on a large sample of college students. Therefore, generalizability beyond this age-group may be limited. Fifth, while there are significant correlations between childhood adversity and EF dimensions, causality cannot be presumed. Finally, mental health diagnoses were not controlled for in this study.

Future studies may consider investigating Positive Childhood Experiences (PCEs) to determine if positive experiences may serve as protective factors for children who undergo adversity. This would also provide an opportunity to explore possible interventions that may improve EF skills. Additionally, future researchers may examine current EF interventions to determine effective strategies that may strengthen EF development (Crandall et al., 2019).

Conclusion

Overall, self-ratings of Adverse Childhood Experiences successfully predicted college students' global EF skills, namely inhibition and working memory. Both of these skills predicted college students' ACEs score. However, inhibition predicted ACEs to a greater degree. This supports the notion that adverse childhood experiences (ACEs) play a role in the development of neurocognitive processes. Working memory was not found to predict ACEs to a greater extent than inhibition within this study. Findings from this

study extend previous ACEs research by utilizing an EF dimensional approach with a non-clinical sample of US college students.

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APPENDIX A

Adverse Childhood Experience Questionnaire

Adverse Childhood Experience (ACE) Questionnaire

Finding your ACE Score ra hbr 10 24 06

While you were growing up, during your first 18 years of life:

1. Did a parent or other adult in the household **often** ...
Swear at you, insult you, put you down, or humiliate you?
or
Act in a way that made you afraid that you might be physically hurt?
Yes No If yes enter 1 _____
2. Did a parent or other adult in the household **often** ...
Push, grab, slap, or throw something at you?
or
Ever hit you so hard that you had marks or were injured?
Yes No If yes enter 1 _____
3. Did an adult or person at least 5 years older than you **ever**...
Touch or fondle you or have you touch their body in a sexual way?
or
Try to or actually have oral, anal, or vaginal sex with you?
Yes No If yes enter 1 _____
4. Did you **often** feel that ...
No one in your family loved you or thought you were important or special?
or
Your family didn't look out for each other, feel close to each other, or support each other?
Yes No If yes enter 1 _____
5. Did you **often** feel that ...
You didn't have enough to eat, had to wear dirty clothes, and had no one to protect you?
or
Your parents were too drunk or high to take care of you or take you to the doctor if you needed it?
Yes No If yes enter 1 _____
6. Were your parents **ever** separated or divorced?
Yes No If yes enter 1 _____
7. Was your mother or stepmother:
Often pushed, grabbed, slapped, or had something thrown at her?
or
Sometimes or often kicked, bitten, hit with a fist, or hit with something hard?
or
Ever repeatedly hit over at least a few minutes or threatened with a gun or knife?
Yes No If yes enter 1 _____
8. Did you live with anyone who was a problem drinker or alcoholic or who used street drugs?
Yes No If yes enter 1 _____
9. Was a household member depressed or mentally ill or did a household member attempt suicide?
Yes No If yes enter 1 _____
10. Did a household member go to prison?
Yes No If yes enter 1 _____

Now add up your "Yes" answers: _____ This is your ACE Score

APPENDIX B

IRB APPROVAL

IRB
INSTITUTIONAL REVIEW BOARD
 Office of Research Compliance,
 010A Sam Ingram Building,
 2269 Middle Tennessee Blvd
 Murfreesboro, TN 37129

**MIDDLE
 TENNESSEE**
 STATE UNIVERSITY

IRBN001 - EXPEDITED PROTOCOL APPROVAL NOTICE

Wednesday, April 06, 2016

Investigator(s): Seth Marshall
 Investigator(s)' Email(s): seth_marshall@mtsu.edu
 Department: Psychology

Study Title: *Relationships between adverse childhood experiences, executive functioning, social systems, and physical health in college students*
 Protocol ID: #16-2238

Dear Investigator(s),

The above identified research proposal has been reviewed by the MTSU Institutional Review Board (IRB) through the **EXPEDITED** mechanism under 45 CFR 46.110 and 21 CFR 56.110 within the category (4) *Collection of data through noninvasive procedures*. A summary of the IRB action and other particulars in regard to this protocol application is tabulated as shown below:

IRB Action	APPROVED for one year from the date of this notification	
Date of expiration	4/6/2017	
Participant Size	400	
Participant Pool	Click here to enter text.	
Exceptions	Click here to enter text.	
Restrictions	Click here to enter text.	
Comments	Click here to enter text.	
Amendments	Date	Post-approval Amendments
		Click here to enter text.

This protocol can be continued for up to THREE years (4/6/2019) by obtaining a continuation approval prior to 4/6/2017. Refer to the following schedule to plan your annual project reports and be aware that you may not receive a separate reminder to complete your continuing reviews. Failure in obtaining an approval for continuation will automatically result in cancellation of this protocol. Moreover, the completion of this study **MUST** be notified to the Office of Compliance by filing a final report in order to close-out the protocol.

Continuing Review Schedule:

Reporting Period	Requisition Deadline	IRB Comments
First year report	4/6/2017	Click here to enter text.
Second year report	4/6/2018	Click here to enter text.
Final report	4/6/2019	Click here to enter text.

IRBN001

Version 1.3

Revision Date 03/06/2016