8-2023

Adverse Childhood Experiences Effects on Hot and Cool Executive Functioning

Miriam Gabrielle Fenton

ADVERSE CHILDHOOD EXPERIENCES EFFECTS ON HOT AND COOL EXECUTIVE FUNCTIONING

A Thesis

Presented to the

Faculty of

California State University,

San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Psychological Science

by

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Approved by:

Dr. Jason Reimer, Committee Chair, Psychology

Dr. Christina Hassija, Committee Member

Dr. Miranda McIntyre, Committee Member

ABSTRACT

Previous research has shown that adverse childhood experiences (ACEs) are related to executive functioning (EF). However, researchers have yet to explore the differences in hot and cool EF in participants who have experienced ACEs. This current study aims to measure ACEs' effects on EF while distinguishing between hot and cool EF. We did this by administering the WCST, Stroop task, and the Visual Digit Span (backward) to capture cool EF from an undergraduate sample. Additionally, we used the IGT, the emotional Stroop, and Go/No Go (EGNG) tasks to measure hot EF in the same participants. We predicted that participants who have experienced higher adverse experiences in childhood will perform worse on hot EF and cool EF tasks than those who experienced fewer ACEs. Additionally, we predicted that scores on the EGNG and emotional Stroop task will predict performance on the IGT. We found a negative correlation between the Stroop task and the Visual Digit Span (backward), such that as interference during the Stroop task increases, performance on the VDS(B) decreases. However, we found no relationships between ACEs and performance on hot EF and cool EF tasks. We also did not find a relationship between the EGNG and the IGT or the emotional Stroop and the IGT. Future research may further explore the relationship between ACEs and hot and cool EF in the same participants to further inform how hot EF research is distinct from cool EF.

ACKNOWLEDGEMENTS

I extend my deepest gratitude to Dr. Jason Reimer for his invaluable mentorship over the past few years, which has been instrumental in shaping my growth and knowledge. I would also like to express my sincere appreciation to Dr. Christina Hassija for her early guidance and support during my graduate career. Thank you, Dr. Miranda McIntyre, for graciously accepting my last-minute request to join my committee. Your expertise was crucial.

I would like to extend my heartfelt gratitude to Dr. Steven Clark. Thank you, Dr. Clark, for your unwavering belief in me when others overlooked my potential. Thank you for introducing me to Cognitive Psychology, providing me with my first research assistantship, and guiding me on my path to graduate school, where I continued to study cognition. Your mentorship has profoundly shaped my life.

A special thank you to my best friends, Alexis Nicole Martin, and Jessica Tracy Lee, for always supporting me, believing in me, and pushing me to realize my potential. I am fortunate to have friends like you. Jess, our conversation at Applebee's does not escape me.

Finally, I would also like to recognize Guadalupe Romero and Holli Fitch for helping me with data collection. This project was made possible because of the both of you.

DEDICATION

I want to dedicate this project to my brother, Raymond Fenton. Ten years ago, you said to "treat school like your life depends on it- because it does," and I have never looked back. Thank you, Ray, for all those late-night talks, all the advice, and all my favorite laughs. In addition, I wholeheartedly dedicate this project to my mom, Miriam C. Fenton, for all your sacrifice to ensure my life was mine, and nobody else’s. Thank you for empowering me to be the woman I am today and always believing I was the smartest person in the room, even when I did not feel it. Finally, I dedicate this project to my partner, David Rodriguez, for your kindness, calmness, and unwavering support. Thank you for always being my rock and seeing me through the hardest times. You make me a better person. I love you all.

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CHAPTER ONE

ADVERSE CHILDHOOD EXPERIENCES

Adverse childhood experiences (ACEs) are negative events that occur in a child's environment and require significant emotional, cognitive, or neurobiological adaptation (Linden & LeMoult, 2021). Adverse experiences may range in severity, duration, and impact on an individual's development; however, early exposures that persist over time lead to more lasting impacts (Nelson et al., 2020). When met with a traumatic event, the human brain's neurobiological processes respond with a "fight or flight (or freeze)" response (De Bellis & Zisk, 2014). The brain's development becomes irregular when there is frequent exposure to a traumatic event (e.g., physical, emotional, or sexual) in childhood. The dysregulation of the biological stress system has adverse implications for the structure and neural connectivity formed during young adolescence and adulthood (De Bellis & Zisk, 2014). Emotion regulation can be conceptualized as a construct involving the awareness, understanding, and acceptance of emotions, control of impulsivity, and engagement in goal-directed behaviors (Tull et al., 2018). Dysregularity of emotions includes the inability to regulate negative and positive emotions; this is seen in patients who have experienced trauma.

Research has shown that dysregulation of the amygdala's neural circuitry is central to developing and maintaining symptoms experienced by post-traumatic stress disorder (Duvarci & Pare, 2014). ACEs or traumatic stress can also cause lasting changes in the prefrontal cortex (PFC) and the hippocampus. Patients with post-traumatic stress disorder (PTSD) also show increased levels of cortisol and norepinephrine (Bremner, 2006). Thus, these two neurochemical systems are critical for stress response.

The hypothalamic–pituitary–adrenal (HPA) axis plays a vital role in an individual's stress response. Corticotropin-releasing – factor (CRF) is released from the hypothalamus when the amygdala signals a stressor to prepare for. The CRF stimulates the release of adrenocorticotropic hormone (ACTH) in the anterior pituitary, which stimulates the adrenal cortex to secrete cortisol (Heim et al., 2008). In a typically developed brain, the negative feedback regulation normalizes cortisol secretion when it senses too much in the blood. When a person has experienced chronic stress, particularly in childhood, the HPA axis's dysregulation causes increased releases of cortisol when subsequent stressors occur (Dunlavey, 2018).

Norepinephrine release also becomes dysregulated in the adrenal glands. Norepinephrine is critical to the fight or flight response in the body; it prepares the body to respond to a threat that has been perceived. In addition, norepinephrine constricts the blood vessels and increases blood output from the heart to increase blood pressure. Chronic stress results in noradrenergic responsiveness to subsequent stressors and an increased release of norepinephrine in brain regions like the hippocampus (Bremner, 2006). As aforementioned, elevated cortisol and norepinephrine levels cause changes in the hippocampus, amygdala, and PFC.

The hippocampus is the part of the brain that plays a significant role in learning and memory. Repeated stress due to ACEs (or trauma) has been known to reduce hippocampus size (Webb et al., 2014). Studies have shown that those who have PTSD and depressive symptoms have a reduction in hippocampal volumes. This reduction in mass correlates with an individual's cognitive dysfunction in memory and cognitive flexibility tasks (Frodl et al., 2006). Lesion studies have found that the medial PFC modulates emotional responses by inhibiting the function of the amygdala (Bremner, 2006). In studies with rodents under chronic stress, researchers have seen a strengthening of dendrites and spines in the amygdala. Moreover, chronic stress sustained through trauma induces the loss of dendrites and spines in the PFC (McEwen et al., 2016).

The implications of the HPA axis dysregulation include atypical development of the limbic system and the PFC (Lund et al., 2020). The atypical development of the PFC results in executive function deficits because the PFC is involved in cognitive processes such as planning, decision-making, inhibition, and working memory. In addition, the PFC's dysregulation decreases the ability to assess a threat and regulate the HPA axis when appropriate (Shin et al., 2006). Moreover, this dysregulation has implications for developing mental health challenges such as anxiety disorders, depression, mood disorders, and more (Felitti et al., 1998; Merrick et al., 2018; Mersky et al., 2013).

Studies have shown that individuals who experience more childhood adverse experiences (Felitti et al., 1998) are at risk of developing affective disturbances. Those who reported having more than four adverse childhood experiences also had an increased risk of panic disorders, depression, anxiety, and hallucinations by over 2-fold (Anda et al., 2006). Repeated stress and childhood trauma have been shown to atrophy the hippocampus, amygdala, and medial PFC, which mediates anxiety and mood disorders (Anda et al., 2006; Webb et al., 2014).

Felitti et al. (1998) outlined how childhood abuse is associated with adult health risk behaviors and disease. Researchers conducted a survey study where participants (N = 9,508) responded to questions about abuse sustained in childhood. Additionally, researchers had the participant's health appraisals, including medical questionnaires, biopsychosocial information, medical diagnoses, and family history. Felitti et al. (1998) found that the risk of alcoholism, illicit drug use, a high number of intercourse partners, and a history of sexually transmitted disease increased as adverse childhood experiences increased. In addition, alcohol, drugs, and nicotine are health-damaging behaviors used as coping mechanisms; when used chronically, they can lead to comorbid diseases.

CHAPTER TWO

EXECUTIVE FUNCTIONS

Executive functions are a family of top-down neurocognitive processes for working memory, cognitive flexibility, and inhibitory control (Miyake et al., 2000). Working memory is the capacity of an individual to hold information and manipulate it in the mind. Cognitive flexibility is the ability to adapt to the environment when there are changes or shift perspectives spatially (Diamond, 2013). Finally, inhibitory control is the ability to control attention, behavior, and emotions to override internal predispositions or external lures that might not be goal-directed (Diamond, 2013). It is important to note that executive functions comprise three components (i.e., working memory, cognitive flexibility, and inhibitory control). However, these constructs can be measured under emotionally charged or emotionally neutral contexts.

Traditionally, executive functions have been measured as cool EF (Zelazo & Carlson, 2012). However, as psychological science develops, researchers have distinguished the underlying mechanisms that mitigate behavior under hot and cool executive functioning domains. Metcalfe and Mischel (1999) developed a "hot-cool systems" framework that distinguished the mechanisms that underlie cognitive, coherent, and strategic executive functioning from the emotional, passionate, impulsive 'hot' counterpart. However, this framework suggested that 'hot' executive functions are not executive functions but rather a bottom-up process associated with the subcortical regions of the brain, not the orbital prefrontal cortex. More recent research has employed a broader characterization of executive function, including the top-down-control process that operates in high-stakes situations (Zelazo & Muller, 2002). Zelazo and Carlson (2012) have examined both hot and cool executive functioning when examining the roles of working memory, cognitive flexibility, and inhibitory control. Hot executive functions are now regarded as the top-down processes that operates when emotions run high in motivationally and emotionally significant situations. *Cool executive functions* are the top-down process' that operates during more effectively neutral contexts; when emotions are not a factor (Zelazo & Carlson, 2012).

The prefrontal cortex (PFC) is responsible for guiding behaviors, memory, decision-making, future orientation, and inhibiting inappropriate behaviors (Arnsten & Li, 2005). Cool executive functions are associated with the dorsolateral and ventrolateral prefrontal cortical regions (Salehinejad et al., 2021). In the PFC, the right inferior frontal gyrus (r-IFG) is involved in inhibitory control, while the anterior cingulate cortex (ACC) is involved in error detection. The left IFG is involved in verbal fluency, and working memory happens in the lateral PFC. Finally, the lateral orbitofrontal cortex is involved when conveying information to non-reward systems (Salehinejad et al., 2021). These regions are central parts of the PFC and are critical in controlling cool executive functioning.

Moreover, the ventromedial and orbitofrontal cortices mediate hot executive functions. Although linked to the PFC, hot executive functions are closely related to subcortical areas of the brain involved in emotional processing, such as the amygdala, striatum, insula, hippocampus, and brainstem (Salehinejad et al., 2021). However, brain regions involved in cool executive functioning are also involved in hot executive functioning systems, such as the lateral PFC and the anterior cingulate cortex (ACC). In addition, the anterior cingulate cortex is a structure in the brain that connects to the limbic system and the PFC. Risky decision-making is a primary "hot" executive function that has been shown to appear in the ventromedial PFC and the orbitofrontal cortex in neuroimaging studies (Hauser et al., 2015).

Recent findings suggest that adolescents have an enhanced sensitivity to motivational cues (Somerville & Casey, 2010). In a study comparing adult brains to adolescent brains using functional MRI, adolescents exhibited an increased likelihood of activation in a large brain region encompassing portions of the ventral and dorsal striatum, insula, orbitofrontal region, and amygdala. The findings in Somerville and Casey's (2010) analysis indicates that there is not a lack of activation in the adult brain when presented with a reward; rather, there is more activation in adolescent brain regions that mitigate the reward systems, thus making them more susceptible to engaging in riskier decisions.

Executive functions develop most rapidly during young childhood, suggesting that childhood is a period of high malleability (Carlson et al., 2016).

However, due to the brain's neuroplasticity, executive functions may still be improved regardless of age. Although hot and cool executive functions can be dissociated in lesioned brains, they typically work together as an adaptive function and can be improved in tandem. For example, one of the primary ways individuals solve emotionally significant problems in their lives is to reflect upon their issues, contextualize them, and consider them in the abstract before continuing to a decision (Zelazo & Carlson, 2012).

Working Memory

Working memory is a core executive function that involves holding information in the mind while mentally manipulating it and working with information that is no longer perceptually available (Baddley & Hitch, 1994). Working memory is distinguished by two domains- verbal and nonverbal (visual-spatial) working memory. Working memory is critical for making sense of written or spoken language, translating instructions into action plans, updating action plans in light of new information, and considering alternatives (Diamond, 2013). It is important to note that working memory is distinct from short-term memory. Short-term memory maintains information while working memory holds it in mind and actively manipulates it.

Working memory tasks typically include the backward Visual Digit Span; respondents say the given items back in reverse order making this task an adequate measure of working memory. If the respondent looks at the items in their mind and reads them off a mental list, this would be a measure of short-term memory. Therefore, asking respondents to reorder the list they have just seen would include the components that engage working memory (Diamond, 2013). Although these tasks may present difficulties to respondents, these are not measures of hot executive functioning but rather cool executive functioning.

Working memory is thought to operate in tandem with inhibitory control; they generally co-occur. Retention in working memory is not directly about memory; rather, it is about using attention to maintain or suppress information that is not conducive to the given goal (Diamond, 2013). For example, when relating ideas or facts together, inhibitory control facilitates an individual's ability to resist focusing on just one and to recombine ideas and facts in new ways, such as when one reorganizes a to-do list. Additionally, working memory also supports inhibitory control. When performing a task, whether in a laboratory or in life, a goal must be held in the mind to inhibit non-goal-directed behavior or responses.

There needs to be more research showing how hot working memory differentiates from cool working memory when considering hot executive functions. Instead, we can look at working memory as systematically working with inhibition to achieve a goal. The Stroop task is a measure of inhibitory control; however, participants who score high on the Stroop task typically have higher working memory scores. In a study by Kane and Engle (2003), a modified Stroop task was implemented for participants to test this phenomenon. Participants were still required to identify the colors presented, regardless of their congruency to the word presented (the color "blue" written in red ink). To test whether participants were actively following the instructions, researchers repeatedly gave the participants a color congruent with the written word ("blue" written in blue ink). When this was done consecutively, participants with low attention spans began to read the word. When the task switched back to random, the participants who did not retain the instructions continued to read the words rather than say the color of the ink the word was written in (Kane & Engle, 2003). These results support that working memory is necessary to achieve components of inhibitory control.

Cognitive Flexibility

Cognitive flexibility is the ability to adapt to the environment when there are changes and is seen as the foundation of adaptive and flexible behaviors (Diamond, 2013). Cognitive flexibility is also responsible for the shifting and switching between different task rules and the corresponding behavioral response. Cognitive flexibility allows an individual to disengage from previous tasks and reconfigure a new response to the new task (Dajani & Uddin, 2015). Switching between tasks flexibly also incorporates levels of inhibitory control because to switch efficiently, one must be able to inhibit previous task rules while flexibly switching gears to attend to the new task.

In lesion studies, researchers found that the participants with lesions in the PFC performed significantly worse on the WCST than patients with lesions elsewhere in the brain (Milner,1963; Robinson et al., 1980). In addition, in a study that compared patients with focal frontal or posterior lesions on the cognitive estimation task, results showed a significant difference in the performance of frontal and posterior patients (Cipolotti et al., 2018). Furthermore, patients with frontal lobe lesions performed worse than patients with posterior lobe lesions. These findings suggest that the cognitive estimation task is suitable for assessing frontal lobe dysfunction, therefore, an adequate measure of cognitive flexibility.

Cognitive flexibility can also be measured in an emotional context. In the context of stressful experiences, studies have examined processes related to an individual's ability to adapt to changing environments and facilitate goal-directed behavior continuously. For example, Gabrys et al. (2018) conducted a study where the Cognitive Control and Flexibility (CCFS) Scale was used after participants were asked to complete the Trier Social Stress Test (TSST), a public speaking task and difficult arithmetic task designed to elicit psychological and physiological stress. Concurrently, researchers collected saliva samples to test for cortisol levels. Researchers in this study measured the ability to flexibly cope with stressful situations and individuals' perceived ability to control intrusive thoughts and emotions with items like '*my thoughts and emotion interfere with my concentration,' 'I get easily distracted by upsetting thoughts or feelings* and '*I consider the situation from multiple viewpoints before responding*.' Results showed that individuals who ruminated more (as seen on the CCFS) predicted delayed cortisol recovery, meaning they could not recoup at a moderate rate after exposure to the TSST (measured through a saliva sample).

Inhibitory Control

Inhibitory control is the executive function domain involved in suppressing thought, action, reaction, or feeling to tailor one's responses to a situationally appropriate response. Self-control is the aspect of inhibitory control necessary to allow choice in how individuals behave rather than being driven by innate instincts or emotions (Diamond, 2013). Self-control allows people to make appropriate decisions when needed and suppress inappropriate wants. Mischel et al. (1989) reviewed the findings of self-regulation in children when postponing immediately available gratification to attain a more valued outcome after a delay in attainment. To investigate this phenomenon in young children, researchers presented toys, treats, and tokens, explaining that they would have the opportunity to indulge them later when the experimenter returned (this curated a 'hot' environment). Children were also informed that they could end the waiting period at any point and keep the less desired object, forgoing the better alternative (Mischel et al., 1972). Researchers found that under this delayed gratification environment, young children could delay the gratification if they distracted themselves with 'happy, fun' thoughts than when they thought 'sad' thoughts.

Another way to measure hot EF is to employ the Iowa Gambling Task (IGT). The IGT was designed to assess decision-making abilities in the ventromedial PFC under such conditions of complexity and uncertainty (Bechara et al., 1994). Participants are instructed to maximize winnings while repeatedly choosing from four decks of playing cards that unpredictably yield wins and losses. The Iowa gambling task is an example of decision-making. In contrast, the Stroop task is an example of suppression of automatic responses, not necessarily involving emotion regulation or reward system pathways. However, both constructs fall below the overarching inhibitory control, which also falls under executive functions.

CHAPTER THREE

RELATIONSHIP BETWEEN ACES AND COGNITIVE TASKS

In a study by Levens et al. (2017), researchers looked at the effects of distant and recent adversity on working memory in an adolescent sample by using an emotional updating task. Researchers wanted to examine whether the timing of adverse childhood experiences would impact working memory differently. They found that individuals who experienced distant adversity updated emotional content faster than individuals who experienced no adversity; also, individuals who experienced recent adversity updated emotional content slower than those who experienced distant or no adversity. However, no significant differences were found between how "adversity-related" stimuli were updated as a result of the participant having experienced distant, recent, or no adversity (Levens et al., 2016). Participants in each adversity group updated the sad, angry, and fearful stimuli similarly to when they updated happy or neutral stimuli.

To my knowledge, findings from Levens et al. (2016) are the only study that demonstrates a benefit of having experienced distant adversity during an emotional working memory task. As aforementioned, studies examining how ACEs affect EF task performance do not draw distinctions between hot and cool activating tasks. Levens et al. (2016) only used the emotion n-back task (Tottenham et al., 2009) to record participant performance but did not include a comparable cool executive functioning task. While the results of their study are one of few to add to the research on ACEs and hot executive functioning, it does not capture the full picture of how these participants might have responded to a cool executive functioning task (where the updating stimuli could be numbers and letters versus emotional faces). Thus, there continues to be a gap in the research about how participants perform across hot and cool executive functioning tasks when having experienced childhood adversity.

In a study by Kalia et al. (2021), researchers investigated whether adverse childhood experiences in a college and non-college sample reduced cognitive flexibility. Participants completed the ACE questionnaire and the perceived stress scale. In addition, participants score on the Wisconsin card sorting test (WCST) were recorded. Researchers found that the more adverse childhood experiences the participants experienced, the fewer categories they completed on the WCST. However, no significant correlation was found between the participants' perceived chronic stress and the WCST. This study's results indicate that adverse childhood experiences are associated with cognitive flexibility decline in adulthood. In addition, the WCST measures cognitive flexibility under neutral circumstances, supporting that ACEs affect cool executive functions.

Ritchie et al. (2011) conducted a study that measured cognitive functioning in older adults to assess the risk factors for cognitive decline when ACEs were present. Researchers found that only some aspects of childhood adversity impact later-life cognitive functioning. For example, physical and sexual abuse did not affect cognition, whereas environmental conditions did. This study operationalized cognitive functioning by using Benton's Visual Retention Test (to assess visual memory), the Trail Making Test B (to assess EF), the Isaacs' Set Test (to assess verbal fluency), and the 5-word test of Dubois (to assess immediate and delayed verbal memory). Ritchie et al. (2011) follow the overarching trend of cool cognitive assessment tasks used to assess EF after experiencing ACEs.

In the previously described study conducted by Kalia et al. (2021), researchers used the WCST and the PSS to determine the effects of ACEs on cognition. However, the WCST measures cognitive flexibility under cool conditions, and the PSS is a self-reported measure of stress. Thus, while this study considers adversity's implications on the HPA-axis dysregulation, it does not include a cognitive assessment that measures cognition under emotionally charged circumstances (hot EF).

Peterson and Welsh (2014) highlight that cool cognitive assessments are predominantly used in executive functioning research. Lesion studies have shown that damage to the orbitofrontal and ventromedial cortices results in poor decision-making, emotional dysregulation, and difficulties in social contexts. Nevertheless, these deficits did not appear to impact patients' traditional cold cognition definition of prefrontal cortical functions (Peterson & Welsh, 2014). These cold cognitive processes cannot fully explain goal-oriented behavior, but research has been restricted by the limited number of tasks operationalized to measure hot executive functions. Although evidence indicates differences in behavior depending on where lesions exist in the brain (Milner,1963; Robinson et al., 1980; Cipolloti et al., 2018), we still need help drawing distinctions between hot and cool mechanisms.

The Present Study

Research thus far has predominantly focused on measuring cool executive functions when assessing cognitive abilities (Halpin et al., 2021; Kane & Engle, 2003; Maja et al., 2022; Miyake et al., 2000). As a result, there is a gap in knowledge about whether adverse childhood experiences (ACEs) impact an individual's performance during cognitive assessments that measure hot executive functioning. Additionally, studies measuring adversity and executive functions typically focus on measuring one executive function domain at a time (cognitive flexibility, inhibitory control, or working memory; Kalia et al., 2021; Ritchie et al., 2011).

The current study investigated whether a history of adverse childhood experiences systematically causes difficulties in executive functioning across all three domains (inhibitory control, cognitive flexibility, and working memory) in the same participant. Additionally, we will draw distinctions between "cool" and "hot" executive functions, where possible, to see whether there are contrasts in levels of functioning. Due to the limited hot executive functioning tasks, in addition to the Iowa Gambling task, we will include the emotional Go/No Go task and the emotional Stroop task because they have shown reliability and are shown to activate subcortical areas in the brain that are thought to be our hot EF (Strauss et al., 2005; Hare et al., 2008; Tottenham, 2011).

In the present study, participants' ACEs were measured in addition to completing six executive function tasks. Specifically, we measured participants' CF under cool conditions using the Wisconsin Card Sorting Task (Kalia et al., 2021). To measure cool IC, we will implement the Stroop task; for WM, we will use the Visual Digit Span (backward). We will also use the Iowa Gambling Task to measure inhibitory control and risky decision-making under hot conditions (Buelow & Suhr, 2009). In addition, we will use the emotional Go/No Go task to measure participants' emotional regulation and recognition (Tottenham, 2011). Finally, we will use the emotional Stroop task, which is similar to the original Stroop task. However, instead of using incongruent and congruent colors to measure reaction time, the emotional Stroop uses aggression-related, positive, negative, and neutral words to measure reaction times (Smith & Waterman, 2003). WM has not been operationalized under hot conditions, so we will focus on analyzing ACE's effects on WM under cool conditions.

Because fewer tasks exist to measure hot executive functions, the Iowa Gambling Task (IGT) has been used in varying populations when conducting research that measures risk-taking behavior in the context of executive functioning (Buelow & Suhr, 2009). Due to the task's high reliability and validity, we will rely on this task in the present study to provide a baseline of our participant's hot executive functioning capacity. Additionally, we will use the IGT to validate the emotional Go/No Go and the emotional Stroop task, two tasks supported by research but have yet to be used as extensively as the IGT.

We predicted that there would be a negative correlation between participants' ACEs scores and performance on hot EF and cool EF tasks, such that as the number of ACEs increases, performance on hot and cool executive functioning tasks would decrease. Additionally, we will investigate whether the emotional Stroop task (ES) and the emotional Go/No Go (EGNG) positively correlate with the Iowa Gambling Task. A strong correlation between the IGT and the emotional Stroop and Go/No Go might add to the research by showing evidence that those who score low in the IGT would also score low in the ES and the EGNG (providing evidence of emotional dysregulation and cognitive functioning deficits). The IGT has been used more extensively in research measuring hot EF than the ES and the EGNG, so we will use it to validate the other respective tasks.

CHAPTER FOUR

METHOD

Participants

Our study's participants were an undergraduate sample (*N* = 101) from a university in Southern California. Participants were recruited through the SONA system and offered SONA units for consent and participation in the study. 225 participants signed up for Part 1 of the study, but only 105 (47%) of the participants moved on to complete Part 2. The participants who only participated in Part 1 had an average ACEs score of 3.60 (*M* = 3.60, *SD* = 2.46). The participants who completed both parts of the study had an average ACEs score of 3.77 (*M* = 3.77, *SD* = 2.83). Additionally, they were predominantly Hispanic (69%) and mostly female (83%), with an average age of 25 years old (*M* = 25.6, *SD* = 6.5). Moreover, our most reported ACE overall was having been put down by an adult and/or feeling like the adult might physically hurt them (59%) (See Table 1).

Measures

Wisconsin Card Sorting Test

The Wisconsin Card Sorting Test (WCST) measures cognitive flexibility in the dorsolateral prefrontal cortex (Franke et al., 1991). The WCST assesses flexibility in thinking and abstraction, making it a test of cognitive flexibility. In this task, several stimulus cards are presented to the participants, who are told to match the cards but not how to match them (Milner, 1963). The WCST consists of four categories (one red triangle, two green stars, three yellow crosses, and four blue circles), and no instructions are given regarding categorization rules. The WCST participants are then given feedback about whether their matching was correct or not. The cards that participants must sort into these piles have similar designs and vary in color, shape, and number. This task takes about 15 minutes to complete.

Stroop Task

The Stroop task (Stroop, 1935) requires respondents to maintain the instructions in mind while suppressing automatic responses to the stimuli they are exposed to. This suppression requires active engagement to keep the goal available when responding. For example, the Stroop task might require the respondent to say the color in which a target word is written while ignoring what the word says. A test block consists of 4 colors (red, green, blue, black) x 3 color stimulus congruency (congruent, incongruent, control) x 7 repetitions = 84 randomly sampled trials. The stimuli stay on the screen until the participant responds. The trials have an intertrial interval of 200 ms and error feedback of 400 ms. This task takes about 3 minutes to complete.

Visual Digit Span (Backward)

In the Visual Digit Span (backward), participants must repeat items they are given back in reverse order. The Visual Digit Span is a better measure of working memory because it requires the participants to hold the information in their minds and manipulate it to answer appropriately. For example, in 14 trials, participants will see digit sequences and must recall them in a reversed order by selecting the digits from a circle of digits with their mouse. Participants will move up or down a level depending on their performance. This task takes about 8 minutes to complete.

Iowa Gambling Task

The Iowa Gambling Task (IGT) was designed to assess decision-making abilities in the ventromedial prefrontal cortex under such conditions of complexity and uncertainty (Bechara et al., 1994). Participants are instructed to maximize winnings while repeatedly choosing from four decks of playing cards that unpredictably yield wins and losses. Participants are presented with four decks of cards and are asked to select a card from one of the four decks with their mouse. Once they turn over the cards, participants can win or lose money. The four different decks can be categorized as advantageous or disadvantageous. The task is set up to play one block of 100 trials, and decks 1 & 2 are disadvantageous, while decks 3 & 4 are advantageous. This task takes about 3.5 minutes to complete.

Emotional Stroop task

The emotional Stroop task is a modified version of the Stroop task, but instead of using incongruent colors, the task uses words that may elicit an emotional response (Williams et al., 1996). Emotional stimuli will delay the reaction time in participants when asked to respond to the non-emotional information in the task (i.e., the color that the word is written in). Participants are given 125 trials (5 categories x 25 trials); trials are randomly sampled without replacement. The five categories are aggressive, neutral, positive, negative, and color words presented in 4 colors (blue, red, yellow, and green). Participants are then instructed to press one of 4 response keys to indicate the color of the words regardless of their meaning. This task takes about 5 minutes to complete.

Emotional Go/No Go

During several blocks, the emotional Go/No Go task presents a series of words from affective categories (positive, negative, aggression, and neutral). Participants are given a target category and asked to select a word when it matches this category. The task assesses a participant's inhibition as the original Go/No go task but permits analysis of performance in response cues to different emotional stimuli (Tottenham et al., 2011). This task takes about 9 minutes to complete.

Adverse Childhood Experiences Questionnaire

The ACE questionnaire (Felitti et al., 1998) is a 10-item self-report questionnaire that examines different types of adverse events a participant experiences before age 18. For example, the ACE questionnaire contains items such as “Did you lose a parent through divorce, abandonment, death, or other reason? Did you live with anyone who was depressed, mentally ill, or attempted suicide? Did you live with anyone who went to jail or prison?” Scores across the ten domains are then scored where high numbers indicate more exposure to adversity while low scores indicate less exposure to adversity. This survey takes about 5 minutes to complete.

Procedures

Participants who wished to participate signed up for Part 1 of the study using the SONA scheduling system. Once signed up, participants were able to immediately access the ACEs questionnaire via a link on SONA that redirected the participant to Qualtrics. Participants provided their consent and moved on to complete the 10-item questionnaire. Once this was completed, participants could sign themselves up for Part 2 of the study, which was the in-person portion in the lab (at least 24 hours after completing the online questionnaire).

On the day of their scheduled session, participants went to SB-001 to participate in the study. Each participant was given a consent form to sign before beginning the study. Once the participant gave their informed consent, they provided their date of birth, ethnicity, and gender. We then assigned them a participant ID number (instead of taking down their names) to safeguard their privacy.

Next, the researcher administered the computerized cognitive assessments in one of the computer rooms. First, the participants completed the WCST. The WCST took about 5 minutes to complete, and the participants were prompted to alert the researcher when they were ready to move on to the next task. Then, the participant completed the Stroop task (3 minutes), Visual Digit Span (backward; 8 minutes), emotional Stroop task (5 minutes), emotional

Go/No Go task (9 minutes), and the Iowa Gambling task (3.5 minutes), while being prompted at the end of each task to inform the researcher so they can set up the next task. Tasks were counterbalanced to mitigate any carryover effects. Once finished, participants were informed of psychological services on campus, thanked for participating and awarded SONA units. A full session took about 60 minutes to complete.

Analytical Strategy

We used SPSS to investigate whether ACEs systematically predict difficulties in cognitive functioning across all three domains (inhibitory control, cognitive flexibility, and working memory) in the same participant. ACEs were operationalized using the ACEs questionnaire (Felitti et al., 1998), which was our predictor variable. The ACEs questionnaire measures adverse experiences in childhood, providing a quantifiable score for each participant. Our outcome variables were the scores obtained during each task (WCST, VDS(B), ST, IGT, EGNG, ES). We conducted linear bivariate regressions to explore the relationship between ACE scores and performance in each cool and hot executive function task separately. The significance level was set at $\alpha = 0.05$.

Cool EFs were operationalized by the scores attained through the Wisconsin Card Sorting task (WCST), Visual Digit Span (backward) (VDS(B)), and the Stroop task (ST). We then conducted linear bivariate regressions measuring if the ACE score can predict the scores in each cool EF task. Hot EFs were operationalized using the scores attained from the Iowa Gambling Task

(IGT), emotional Go/No Go (EGNG), and the emotional Stroop task (ES). On SPSS, we conducted linear bivariate regressions measuring whether ACE scores predict the scores in each hot EF task.

Finally, we ran bivariate correlations to examine whether the participants' emotional Stroop task and the emotional Go/No Go results correlated with the scores obtained from the Iowa Gambling task.

CHAPTER FIVE

RESULTS

Data Screening

Prior to hypothesis testing, data were screened for missing data. Due to a computer error during data collection, four participants' data were not recorded, so they were deleted, bringing our participant total to 101 individuals. Mean scores and *SD*s were calculated for each variable in the study (see Table 2). To examine the presence of outliers, we calculated z-scores for each variable and removed scores exceeding ± 3.0. This resulted in the removal of one WCST, IGT, and EGNG score, two Stroop task scores, and ten emotional Stroop task scores. Once the outliers were deleted, our plotted points were within the normal bounds of ± 3.3, indicating that our normality of residuals was met. Since we met the assumption, we ran several bivariate regressions using SPSS v.27 to examine relationships between variables.

Hypothesis Testing

We conducted a linear bivariate regression analysis to examine the relationship between ACEs and our cool EF tasks (VDS(B), Stroop task, WCST). We found that there was no significant correlation between ACEs and performance on the Stroop task, $R = .090$, $R^2 = .008$, $F(1, 97) = .799$, $p = .374$, the backward Digit Span, $R = .014$, $R^2 = .0002$, $F(1, 99) = .020$, $p = .889$, or the WCST, $R = .028$, $R^2 = .001$, $F(1, 99) = .076$, $p = .784$. These results suggest that performance on the Stroop task, Visual Digit Span (backward), and the WCST is not significantly related to the presence of ACEs. We did, however, find a statistically significant negative correlation between performance on the Stroop task and the backward Digit Span task, such that as interference during the Stroop task increased, performance scores on the VDS(B) decreased, $R = -.273$, $R^2 = .075$, $F(1, 97) = 7.831$, $p < .05$. We found that for every delay in response time during the Stroop task, accuracy in the VDS(B) decreased by -.001, $b = -.001$, $\beta = -.273$, $t(97) = -2.80$, $p < .05$, *CI* [-.001 – .0003].

Next, we conducted a second linear bivariate regression analysis where ACEs are our predictor variable, and the three hot EF tasks (IGT, EGNG, emotional Stroop) are our outcome variables. We found that there was no significant correlation between ACEs and performance on the IGT task, $R = .077$, $R^2 = .006$, $F(1, 99) = .594$, $p = .443$, the EGNG, $R = .176$, $R^2 = .031$, $F(1, 99) = 3.152$, $p = .079$, or the four scores that comprise the emotional Stroop task, Color: $R = .070$, $R^2 = .005$, $F(1, 98) = .483$, $p = .489$; Aggression: $R = .066$, $R^2 = .004$, $F(1, 98) = .423$, $p = .517$; Negative: $R = .147$, $R^2 = .022$, $F(1, 98) = 2.164$, $p = .144$; Positive: $R = .035$, $R^2 = .001$, $F(1, 98) = .117$, $p = .773$. These results suggest that performance on the IGT, EGNG, and the emotional Stroop task is not significantly related to the presence of ACEs (See Table 3).

To validate the EGNG and the emotional Stroop task, we ran two correlations to examine whether these tasks correlated with the IGT. We found that there was no significant correlation between the IGT and the EGNG ($r = -$

.018, *p* = .861) and the IGT and the emotional Stroop (*r* = -.013, *p* = .896). However, we did find a significant correlation between the participant's score on the EGNG and the emotional Stroop task score (*r* = -.368, *p* <.001), but only for one of the “color” scores out of four that comprise the emotional Stroop task.

We standardized each outcome variable by obtaining z-scores to further examine the relationship between ACEs and cognitive functioning. We combined the standardized values to create a composite score for hot EFs and cool EFs. We then ran a bivariate correlation to examine the relationship between ACEs and the cool and hot EF composite scores. There was no statistically significant correlation between ACEs and the hot EF composite score (*r* = .048, *p* = .649). Moreover, we found no statistically significant correlation between ACEs and the cool EF composite score (*r* = .004, *p* = .970).

Finally, we used the hot and cool EF composite scores as dependent variables to run a one-way between-subjects ANOVA where ACEs (low and high) was our independent variable. We performed a median split on the ACEs scores to create a “low” and “high” ACEs group. Individuals with scores between 0 and 3 were below the median and were considered to have “low” ACEs and individuals with scores between 4 and 10 were considered to have “high” ACEs. We found that we retained the null hypothesis because there were no significant mean differences in performance on cool EF, *F*(1, 94) = .232, *p* = .631, or hot EF, *F*(1, 90) = .133, *p* = .716, tasks as a result of low or high scores in the ACEs questionnaire.

Table 1

Percentages of ACEs

ACES Questions	*Frequency*	*Percentage*	*n*
1. Did adult swear at you or put you down?	132	59%	225
2. Did adult push, slap or throw something at you?	75	33%	225
3. Did adult or person 5 years older than you fondle you or have you touch them sexually?	76	34%	225
4. Did adults not make you feel loved or special?	106	47%	225
5. Did you felt as though you did not have enough to eat?	32	14%	225
6. Were you parents divorced or seperated?	103	46%	225
7. Was your mother pushed, grabbed, slapped, or had something thrown at her?	51	23%	225
8. Did you live with an alcoholic?	98	44%	225
9. Was there mental illness in your home?	99	44%	225
10. Did a household member go to prison?	53	24%	225

Note. These are the percentages for all participants that completed Part 1. For the full question, see Appendix A

Table 2

Descriptive Statistics for Variables

Variable	*Mean*	*SD*	*Percent Correct*	*Error Rates*	*n*
ACEs	3.77	2.83	-	-	101
Stroop Task	279.77	336.21			99
I.Congruent			98%	3.50	99
II.Incongruent			93%	9.16	99
Visual Digit Span (B)	5.2	1.4	74%	-	101
WCST	20	12.95	68%	32.17	101
Iowa Gambling Task	-10.28	23.79	-	-	101
Emotional Go/No Go	2.36	0.54	86%	12.24	101
Emotional Stroop Task					
I.Color	87.4	160.07	98%	1.96	100
II.Negative	11.07	141.83	98%	2.44	100
III.Aggressive	10.43	148.34	98%	2.40	100
IV.Positive	1.97	152.1	98%	2.24	100

Note. The emotional Stroop task is comprised of four different scores.

Not all cognitive assessments produce proportion correct and error rates for participants.

Table 3

Correlations Between ACEs and Cool and Hot Tasks

Variable	1	2	3	4	5	6	7	8	9	10
ACES	1									
Stroop Task	-0.09	1								
Visual Digit Span (B)	0.014	.273**	1							
WCST	0.028	0.047	0.098	1						
Emotional Go/No Go	0.176	.225*	0.168	0.014	1					
Iowa Gambling Task	0.077	0.012	0.059	0.072	0.018	1				
Emotional Stroop (Aggression)	0.066	0.09	0.072	0.071	0.109	0.078	1			
Emotional Stroop (Color)	-0.07	.382**	-.206*	0.059	.368**	0.013	.555**	1		
Emotional Stroop (Negative)	0.147	0.186	0.021	0.044	0.073	0.074	.493**	.429**	1	
Emotional Stroop (Positive)	0.035	0.164	0.036	0.07	-0.02	0.067	.581**	.317**	.626**	1

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

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

CHAPTER SIX

DISCUSSION

The present study aimed to investigate whether a relationship exists between adverse childhood experiences (ACEs) and difficulties in hot and cool executive functioning (EF) across three domains (working memory, cognitive flexibility, and inhibitory control). We predicted that there would be a negative correlation between participants' ACEs scores and performance on hot EF and cool EF tasks, such that as the number of ACEs increased, performance on hot executive functioning tasks would decrease. Similarly, we predicted that as the number of ACEs increased, performance on cool executive functioning tasks would also decrease. Additionally, we wanted to investigate whether the emotional Stroop task (ES) and the emotional Go/No Go (EGNG) positively correlated with the Iowa Gambling Task.

Our findings revealed no significant correlations between ACEs and the cool EF tasks, including the Stroop task, Visual Digit Span (backward), and WCST. These results suggest that ACEs do not impact performance on these specific tasks and are inconsistent with previous studies where the number of ACEs was associated with performance on the WCST (a measure of cognitive flexibility; Kalia et al., 2021). In Kalia et al. (2021), researchers found a significant negative correlation between the number of ACEs reported by college students (and non-students) and the number of categories completed on the WCST. Like our study, Kalia et al. (2021) sampled college students; however, the type of student sampled differed from those we sampled. For example, most students in their study had less than three adverse childhood experiences (91%). In contrast, most of our sample had over three ACEs (60%). This lack of generalizability might limit their study's ability to repeat these results in a more diverse population since different levels of ACEs can lead to varying outcomes. Most participants in their study experienced what our study classifies as "low" ACEs, which means their ACE scores primarily fell between zero and three. Our study had a broader range of ACE scores, with the highest recorded score being ten. This difference in the distribution of ACEs might enable their study to detect smaller patterns or effects due to the relatively narrow range of ACEs, whereas our study's wider range of ACEs could potentially reveal more substantial variations in outcomes. Kalia et al.'s (2021) study also sampled 215 students, while our study only sampled 101. Because they had over double the number of participants, researchers could detect smaller effect sizes and increased the precision due to a smaller margin of error around the estimated parameter.

Additionally, we observed a weak negative correlation between the Stroop task and the backward Visual Digit Span (VDS(B)). This implies that as interference during the Stroop task increases, VDS(B) performance scores decrease. These findings are in line with what previous research has found regarding the relationship between working memory capacity and Stroop interference. Researchers have previously found that individuals with low working memory (WM) span demonstrated worse performance than high-span individuals in the Stroop task (Kane & Engle, 2003). This is due to the Stroop task relying on WM to prevent attentional distractors and respond goal-directedly (i.e., ignore what the word says and only indicate the ink color). For this reason, WM capacity is related to performance on the Stroop task because having a higher WM span aids in inhibiting non-goal-directed behavior and maintaining accuracy in responses. The mechanisms underlying inhibition and WM overlap in the dorsolateral prefrontal cortex (PFC) (Kane & Engle, 2003). The weak correlation associated with our findings is likely due to an insufficient number of participants to study and not because the association is inherently weak.

Regarding the hot EF tasks, including the IGT, EGNG, and emotional Stroop, our results did not indicate a relationship between the hot EF tasks and ACEs scores. These findings suggest that the presence of ACEs may not be directly associated with performance on these tasks, which assess executive functioning under motivationally significant and affective conditions. Because our study is the first to attempt to find a relationship between ACEs and hot executive functioning, we do not have studies to compare our results to. However, research has shown that childhood adversity exposure affects brain development due to HPA axis dysregulation (Bremner, 2006; De Bellis & Zisk, 2014; Dunlavey, 2018; Duvarci & Pare, 2014). This dysregulation in brain development has been linked to hippocampal shrinkage (Webb et al., 2014), which correlates with dysfunction in memory and cognitive flexibility tasks (Frodl et al., 2006). Additionally, dysregulation of the norepinephrine and cortisol systems in brain development has also been linked to lasting negative effects on the PFC cortex, orbitofrontal cortex, and amygdala, which all have functions in controlling impulsivity, inhibition, motivation, and emotions (Bremner, 2006).

Tasks assessing motivational and affective executive functions have garnered interest in the past two decades, while cool executive function tasks span over a century (Tsermentseli & Poland, 2016). Therefore, it is possible that the expected results have yet to be obtained due to potential shortcomings in the measurement of the intended constructs. For instance, the traditional 'Stroop effect' involves assessing the difference in color naming performance between congruent and incongruent stimuli. In contrast, the emotional Stroop effect examines the difference in color naming performance between emotional and neutral stimuli (Algom et al., 2004). Therefore, the emotional Stroop task lacks the logical conflict between attributes present in the traditional Stroop task. When presented with emotionally charged stimuli, such as the word 'death' printed in red, there is neither more nor less congruence than when presented with a neutral stimulus like the word 'table' written in blue. Consequently, the emotional Stroop task may not capture working memory and selective attention in the same manner as the traditional Stroop task.

In a study by Smith & Waterman (2003), researchers found an emotional Stroop interference effect when they assessed a forensic and non-forensic sample. The forensic sample of participants answered slower when the stimuli were 'aggression words' versus positive, negative, or neutral words. However, Algom et al. (2004) argue that an observed difference is likely due to an emotional slowdown that occurs because the participant is reading the word. An inhibitory mechanism might be present here, but not a selective attention mechanism traditionally found in the Stroop effect. Furthermore, we explored the relationships between the hot EF tasks themselves. We found no significant correlation between the IGT and the EGNG nor between the IGT and the emotional Stroop. These results suggest that performance on the IGT, which assesses decision-making in a risky context, is not related to inhibitory control or emotional interference. However, it is more likely that the EGNG and the emotional Stroop task have not been as widely studied as the traditionally cool EF tasks and lack construct validity.

We did find a significant correlation between scores on the EGNG and one score (color stimuli) of the emotional Stroop task, suggesting a potentially shared variance between these measures. The "color" score was the only condition that did not include emotional interference during the task and is likely correlated to performance on the EGNG because of the tasks’ underlying cognitive processes involve inhibitory control and attention. The "color" score produced by the emotional Stroop task does contain the traditional Stroop effect because it involves assessing the difference in color naming performance. It is unclear if the observed correlation is due to the motivational and affective underpinnings of the "hot EF" construct or the attentional and inhibitory mechanisms underlying cool EF.

Limitations

It is important to acknowledge some limitations of our study. Firstly, our sample size was relatively small, which limited our statistical power to detect small effect sizes. Replication with larger samples would be valuable to confirm these findings. Research has shown that ACEs affect the underlying neurobiological structure of a developing brain, so a correlation between ACEs and executive functioning tasks should be present. As aforementioned, the lack of correlation could mean the cognitive assessments, especially the "hot EF tasks," might not measure what they are intended to measure. In the future, researchers might consider modifying the "temperature" of a task in order to explore differences in hot and cool EF tasks while avoiding issues associated with across-task comparisons (Peterson & Welsh, 2014). For example, in a preschool study, researchers modified the "Less is More" task by replacing the desirable stimulus (i.e., candy) with a representation (i.e., a picture of candy) (Carlson et al., 2005), which resulted in a "cooled" down assessment.

Additionally, our study relied on self-report measures of ACEs, which may be subject to recall bias and underreporting. Future research should consider utilizing more comprehensive and objective assessments of ACEs, such as interviews. While the ACEs questionnaire by Felitti et al. (1998) has been widely used to assess adversity in childhood, newer methods of collecting this information might be more telling of an individual's experience. Alternatively, treating each item of the ACEs questionnaire as a factor (instead of gauging adversity based on one total score) might also give more insight into the kinds of experiences that might lead to cognitive dysfunction. Gould et al. (2012) examined early life trauma as a construct having five factors (emotional abuse, sexual abuse, physical abuse, and emotional and physical neglect). They found that individuals had a stronger association of emotional processing impairments when neglected in childhood rather than abused.

Ritchie et al. (2011) reported similar results, showing that physical and sexual abuse did not significantly impact cognition, as assessed through four executive function tasks. In contrast, environmental conditions, such as being in the foster system, experiencing parents oversharing their problems, dealing with schoolmate issues, the loss of a parent for women, and paternal alcohol problems, had notable effects on cognition. These findings highlight the significance of considering specific adverse childhood experiences when examining a potential relationship with cognitive assessments rather than merely classifying individuals into 'low' or 'high' ACEs groups. Notably, our study had a predominantly Hispanic and female sample, suggesting the potential influence of cultural and gender-specific experiences that may not be easily extrapolated to other populations. Additionally, evidence suggests that neglect might have a more consistent impact on cognition than sexual or emotional abuse, which holds particular relevance given its higher prevalence amongst females.

Implications

Our research study contributes to the existing body of knowledge by investigating the relationship between adverse childhood experiences and executive functioning (across six different cognitive assessments). Prior to our study, the effects of ACEs on six different cognitive assessments had yet to be examined. While we did not find significant results, we have brought forth a new methodology for studying the intersection of adversity and cognition. Moreover, we have emphasized the importance of considering different ways of measuring ACEs, especially due to the sensitive questions that lead individuals to underreport. Additionally, while our study might not have found direct associations, it underscores the importance of addressing the cognitive difficulties that may arise from having experienced ACEs.

In conclusion, our study found no significant associations between ACEs and cool or hot EF abilities in our sample. These findings suggest that the relationship between ACEs and executive functioning may be complex and multifaceted, and additional factors beyond ACEs might contribute to the observed difficulties in EF. Further research is needed to better understand the mechanisms underlying the impact of ACEs on executive functioning and to identify potential protective factors that may mitigate the negative effects of ACEs on cognitive abilities.

APPENDIX A

ADVERSE CHILDHOOD EXPERIENCES 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

(Felitti et al., 1998)

APPENDIX B

INSTITUTIONAL REVIEW BOARD APPROVAL

Miriam Fenton <007433719@coyote.csusb.edu>

IRB-FY2023-117 - Initial: Psych Reviewers: Expedited Review Approval Letter

do-not-reply@cayuse.com <do-not-reply@cayuse.com> Mon, Feb 6, 2023 at 4:47 PM
To: JReimer@csusb.edu, miriam.fenton3719@coyote.csusb.edu

February 6, 2023

CSUSB INSTITUTIONAL REVIEW BOARD
Expedited Review
IRB-FY2023-117
Status: Approved

Jason Reimer Miriam Fenton
Department of CSBS - Psychology
California State University, San Bernardino
5500 University Parkway
San Bernardino, California 92407

Dear Jason Reimer Miriam Fenton:

Your application to use human subjects, titled “ACEs effects on Hot and Cool Executive Functioning” has been reviewed and approved by the Institutional Review Board (IRB). The informed consent document you submitted is the official version of your study and cannot be changed without prior IRB approval. A change in your informed consent (no matter how minor the change) requires re-submission of your protocol as amended using the Cayuse Human Ethics (IRB) system protocol change form.

Your IRB proposal (IRB-FY2023-117) is approved.
Your application is approved for one year from February 6, 2023 through --.

This approval notice does not replace any departmental or additional campus approvals which may be required including access to CSUSB campus facilities and affiliate campuses. Investigators should consider the changing COVID-19 circumstances based on current CDC, California Department of Public Health, and campus guidance and submit appropriate protocol modifications to the IRB as needed. CSUSB campus and affiliate health screenings should be completed for all campus human research related activities. Human research activities conducted at off-campus sites should follow CDC, California Department of Public Health, and local guidance. See CSUSB's COVID-19 Prevention Plan for more information regarding campus requirements.

If your study is closed to enrollment, the data has been de-identified, and you're only analyzing the data - you may close the study by submitting the closure form through the Cayuse Human Ethics (IRB) system. The Cayuse system automatically reminders you at 90, 60, and 30 days before the study is due for renewal or submission of your annual report (administrative check-in). The modification, renewal, study closure, and unanticipated/adverse event forms are located in the Cayuse system with instructions provided on the IRB Applications, Forms, and Submission Webpage. Failure to notify the IRB of the following requirements may result in disciplinary action. Please note a lapse in your approval may result in your not being able to use the data collected during the lapse in the application's approval period.

You are required to notify the IRB of the following as mandated by the Office of Human Research Protections (OHRP) federal regulations 45 CFR 46 and CSUSB IRB policy.

REFERENCES

Algom, D., Chajut, E., & Lev, S. (2004). A Rational Look at the Emotional Stroop Phenomenon: A Generic Slowdown, not a Stroop Effect. *Journal of Experimental Psychology: General, 133*(3), 323–338. https://doi.org/10.1037/0096-3445.133.3.323

Anda, R. F., Felitti, V. J., Bremner, J. D., Walker, J. D., Whitfield, C., Perry, B. D., Dube, S. R., & Giles, W. H. (2006). The enduring effects of abuse and related adverse experiences in childhood. *European Archives of Psychiatry and Clinical Neuroscience*, *256*(3), 174–186. https://doi.org/10.1007/s00406-005-0624-4

Arnsten, A. F. T., & Li, B.-M. (2005). Neurobiology of Executive Functions: Catecholamine Influences on Prefrontal Cortical Functions. *Biological Psychiatry*, *57*(11), 1377–1384. https://doi.org/10.1016/j.biopsych.2004.08.019

Baddeley, A. D., & Hitch, G. J. (1994). Developments in the concept of working memory. *Neuropsychology*, *8*, 485–493. https://doi.org/10.1037/0894-4105.8.4.485

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition*, *50*(1–3), 7–15. https://doi.org/10.1016/0010-0277(94)90018-3

Bremner, J. D. (2006). Traumatic stress: effects on the brain. *Dialogues in Clinical Neuroscience*, *8*(4), 445–461. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3181836/

Buelow, M. T., & Suhr, J. A. (2009). Construct validity of the Iowa Gambling Task. *Neuropsychology Review*, *19*, 102–114. https://doi.org/10.1007/s11065-009-9083-4

Carlson, S. M., Davis, A. C., & Leach, J. G. (2005). Less Is More: Executive Function and Symbolic Representation in Preschool Children. *Psychological Science, 16*(8), 609–616. https://doi.org/10.1111/j.1467-9280.2005.01583.x

Carlson, S. M., Faja, S., & Beck, D. M. (2016). Incorporating early development into the measurement of executive function: The need for a continuum of measures across development. *American Psychological Association,* 45-64. https://doi.org/10.1037/14797-003

Cipolotti, L., MacPherson, S. E., Gharooni, S., van-Harskamp, N., Shallice, T., Chan, E., & Nachev, P. (2018). Cognitive estimation: Performance of patients with focal frontal and posterior lesions. *Neuropsychologia*, *115*, 70–77. https://doi.org/10.1016/j.neuropsychologia.2017.08.017

Dajani, D. R., & Uddin, L. Q. (2015). Demystifying cognitive flexibility: Implications for clinical and developmental neuroscience. *Trends in Neurosciences*, *38*(9), 571–578. https://doi.org/10.1016/j.tins.2015.07.003

De Bellis, M. D., & A.B., A. Z. (2014). The Biological Effects of Childhood Trauma. *Child and Adolescent Psychiatric Clinics of North America*, *23*(2), 185–222. https://doi.org/10.1016/j.chc.2014.01.002

Diamond, A. (2013). Executive Functions. *Annual Review of Psychology*, *64*, 135–168. https://doi.org/10.1146/annurev-psych-113011-143750 *doi:10.1016/j.bandc.2008.03.003*

Dunlavey, C. J. (2018). Introduction to the Hypothalamic-Pituitary-Adrenal Axis: Healthy and Dysregulated Stress Responses, Developmental Stress and Neurodegeneration. *Journal of Undergraduate Neuroscience Education*, *16*(2), R59–R60. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6057754/

Duvarci, S., & Pare, D. (2014). Amygdala microcircuits controlling learned fear. *Neuron*, *82*(5), 966–980. https://doi.org/10.1016/j.neuron.2014.04.042

Felitti, V. J., Anda, R. F., Nordenberg, D., Williamson, D. F., Spitz, A. M., Edwards, V., Koss, M. P., & Marks, J. S. (1998). Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults. The Adverse Childhood Experiences (ACE) Study. *American Journal of Preventive Medicine*, *14*(4), 245–258. https://doi.org/10.1016/s0749-3797(98)00017-8

Frodl, T., Schaub, A., Banac, S., Charypar, M., Jäger, M., Kümmler, P., Bottlender, R., Zetzsche, T., Born, C., Leinsinger, G., Reiser, M., Möller, H.-J., & Meisenzahl, E. M. (2006). Reduced hippocampal volume correlates with executive dysfunctioning in major depression. *Journal of*

Psychiatry and Neuroscience, *31*(5), 316–325. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1557684/

Gabrys, R. L., Tabri, N., Anisman, H., & Matheson, K. (2018). Cognitive Control and Flexibility in the Context of Stress and Depressive Symptoms: The Cognitive Control and Flexibility Questionnaire. *Frontiers in Psychology*, *9*, 2219. https://doi.org/10.3389/fpsyg.2018.02219

Gould, F., Clarke, J., Heim, C., Harvey, P. D., Majer, M., & Nemeroff, C. B. (2012). The effects of child abuse and neglect on cognitive functioning in adulthood. *Journal of Psychiatric Research, 46*(4), 500–506. https://doi.org/10.1016/j.jpsychires.2012.01.005

Hallett, P. E. (1978). Primary and secondary saccades to goals defined by instructions. *Vision Research*, *18*(10), 1279–1296. https://doi.org/10.1016/0042-6989(78)90218-3

Halpin, A. B., MacAulay, R. K., Boeve, A. R., D’Errico, L. M., & Michaud, S. (2021). Are Adverse Childhood Experiences Associated with Worse Cognitive Function in Older Adults? *Journal of the International Neuropsychological Society*, 1–10. https://doi.org/10.1017/S1355617721001272

Hare, T. A., Tottenham, N., Galvan, A., Voss, H. U., Glover, G. H., & Casey, B. J. (2008). Biological substrates of emotional reactivity and regulation in adolescence during an emotional go-nogo task. *Biological Psychiatry*, *63*(10), 927–934. https://doi.org/10.1016/j.biopsych.2008.03.015015

Hauser, T. U., Hunt, L. T., Iannaccone, R., Walitza, S., Brandeis, D., Brem, S., & Dolan, R. J. (2015). Temporally Dissociable Contributions of Human Medial Prefrontal Subregions to Reward-Guided Learning. *The Journal of Neuroscience*, *35*(32), 11209–11220. https://doi.org/10.1523/JNEUROSCI.0560-15.2015

Heim, C., Mletzko, T., Purselle, D., Musselman, D. L., & Nemeroff, C. B. (2008). The Dexamethasone/Corticotropin-Releasing Factor Test in Men with Major Depression: Role of Childhood Trauma. *Biological Psychiatry*, *63*(4), 398–405. https://doi.org/10.1016/j.biopsych.2007.07.002

Kalia, V., Knauft, K., & Hayatbini, N. (2021). Adverse childhood experiences (ACEs) associated with reduced cognitive flexibility in both college and community samples. *PLoS ONE*, *16*(12), 1–17. https://doi.org/10.1371/journal.pone.0260822

Kane, M. J., & Engle, R. W. (2003). Working-memory capacity and the control of attention: the contributions of goal neglect, response competition, and task set to Stroop interference. *Journal of Experimental Psychology. General*, *132*(1), 47–70. https://doi.org/10.1037/0096-3445.132.1.47

Levens, S. M., Armstrong, L. M., Orejuela-Dávila, A. I., & Alverio, T. (2017). The two sides of adversity: the effect of distant versus recent adversity on updating emotional content in working memory. *Cognition and Emotion*, *31*(6), 1243–1251. https://doi.org/10.1080/02699931.2016.1197099

Linden, W., & LeMoult, J. (2022). Editorial Perspective: Adverse childhood events causally contribute to mental illness - we must act now and intervene early. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *63*(6), 715–719. https://doi.org/10.1111/jcpp.13541

Lund, J. I., Toombs, E., Radford, A., Boles, K., & Mushquash, C. (2020). Adverse Childhood Experiences and Executive Function Difficulties in Children: A Systematic Review. *Child Abuse & Neglect*, *106*, 104485. https://doi.org/10.1016/j.chiabu.2020.104485

Maja, R. A., Kilshaw, R. E., Garcia-Barrera, M. A., & Karr, J. E. (2022). Current Post-traumatic Stress Symptoms Mediate the Relationship Between Adverse Childhood Experiences and Executive Functions. *Psychological Reports*, *125*(2), 763–786. https://doi.org/10.1177/0033294120979690

McEwen, B. S., Nasca, C., & Gray, J. D. (2016). Stress Effects on Neuronal Structure: Hippocampus, Amygdala, and Prefrontal Cortex. *Neuropsychopharmacology*, *41*(1), 3–23. https://doi.org/10.1038/npp.2015.171

Merrick, M. T., Ports, K. A., Ford, D. C., Afifi, T. O., Gershoff, E. T., & Grogan-Kaylor, A. (2017). Unpacking the impact of adverse childhood experiences on adult mental health. *Child Abuse & Neglect*, *69*, 10–19. https://doi.org/10.1016/j.chiabu.2017.03.016

Mersky, J. P., Topitzes, J., & Reynolds, A. J. (2013). Impacts of adverse childhood experiences on health, mental health, and substance use in early adulthood: A cohort study of an urban, minority sample in the US *Child Abuse & Neglect*, *37*(11), 917–925. https://doi.org/10.1016/j.chiabu.2013.07.011

Metcalfe, J., & Mischel, W. (1999). A hot/cool-system analysis of delay of gratification: Dynamics of willpower. *Psychological Review*, *106*(1), 3–19. https://doi.org/10.1037/0033-295X.106.1.3

Milner, B. (1963). Effects of Different Brain Lesions on Card Sorting: The Role of the Frontal Lobes. *Archives of Neurology*, *9*(1), 90. https://doi.org/10.1001/archneur.1963.00460070100010

Milner, B., Corsi, P., & Leonard, G. (1991). Frontal-lobe contribution to recency judgements. *Neuropsychologia*, *29*(6), 601–618. https://doi.org/10.1016/0028-3932(91)90013-X

Mischel, W., Shoda, Y., & Rodriguez, M. L. (1989). Delay of Gratification in Children. *Science*, *244*(4907), 933–938. https://www.jstor.org/stable/1704494

Mischel, W. (1972). Direct versus indirect personality assessment: Evidence and implications. *Journal of Consulting and Clinical Psychology*, *38*, 319–324. https://doi.org/10.1037/h0032896

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex “Frontal Lobe” tasks: a latent variable analysis. *Cognitive Psychology*, *41*(1), 49–100. https://doi.org/10.1006/cogp.1999.0734

Nelson, C. A., Scott, R. D., Bhutta, Z. A., Harris, N. B., Danese, A., & Samara, M. (2020). Adversity in childhood is linked to mental and physical health throughout life. *BMJ (Clinical Research Ed.)*, *371*, m3048. https://doi.org/10.1136/bmj.m3048

Peterson, E., & Welsh, M. C. (2014). The development of hot and cool executive functions in childhood and adolescence: Are we getting warmer? *Handbook of executive functioning*, 45–65, https://doi.org/10.1007/978-1-4614-8106-5_4

Ritchie, K., Jaussent, I., Stewart, R., Dupuy, A.-M., Courtet, P., Malafosse, A., & Ancelin, M.-L. (2011). Adverse childhood environment and late-life cognitive functioning. *International Journal of Geriatric Psychiatry*, *26*(5), 503–510. https://doi.org/10.1002/gps.2553

Robinson, E. A., & Price, M. G. (1980). Pleasurable behavior in marital interaction: An observational study. *Journal of Consulting and Clinical Psychology*, *48*, 117–118. https://doi.org/10.1037/0022-006X.48.1.117

Salehinejad, M. A., Ghanavati, E., Rashid, M. H. A., & Nitsche, M. A. (2021). Hot and cold executive functions in the brain: A prefrontal-cingular network. *OSF Preprints*. https://doi.org/10.31219/osf.io/5sghe

Shin, L. M., Rauch, S. L., & Pitman, R. K. (2006). Amygdala, Medial Prefrontal Cortex, and Hippocampal Function in PTSD. *Annals of the New York*

Academy of Sciences, *1071*(1), 67–79. https://doi.org/10.1196/annals.1364.007

Smith, P., & Waterman, M. (2003). Processing bias for aggression words in forensic and nonforensic samples. *Cognition and Emotion*, *17*(5), 681–701. https://doi.org/10.1080/02699930302281

Somerville, L. H., & Casey, B. (2010). Developmental neurobiology of cognitive control and motivational systems. *Current Opinion in Neurobiology*, *20*(2), 236–241. https://doi.org/10.1016/j.conb.2010.01.006

Strauss, G. P., Allen, D. N., Jorgensen, M. L., & Cramer, S. L. (2005). Test-Retest Reliability of Standard and Emotional Stroop Tasks: An Investigation of Color-Word and Picture-Word Versions. *Assessment*, *12*(3), 330–337. https://doi.org/10.1177/1073191105276375

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, *18*, 643–662. https://doi.org/10.1037/h0054651

Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., Marcus, D. J., Westerlund, A., Casey, B. J., & Nelson, C. (2009). The NimStim set of facial expressions: judgments from untrained research participants. *Psychiatry Research*, *168*(3), 242–249. https://doi.org/10.1016/j.psychres.2008.05.006

Tottenham, N., Hare, T. A., & Casey, B. J. (2011). Behavioral Assessment of Emotion Discrimination, Emotion Regulation, and Cognitive Control in

Childhood, Adolescence, and Adulthood. *Frontiers in Psychology*, *2*, 39. https://doi.org/10.3389/fpsyg.2011.00039

Tsermentseli S., Poland S. (2016). Cool versus hot executive function: a new approach to executive function. *Encephalos*, 53, 11–14. Retrieved from: http://www.encephalos.gr/pdf/53-1-02e.pdf

Tull, M. T., Berghoff, C. R., Wheeless, L. E., Cohen, R. T., & Gratz, K. L. (2018). PTSD Symptom Severity and Emotion Regulation Strategy Use during Trauma Cue Exposure among Patients with Substance Use Disorders: Associations with Negative Affect, Craving, and Cortisol Reactivity. *Behavior Therapy*, *49*(1), 57–70. https://doi.org/10.1016/j.beth.2017.05.005

Webb, C. A., Weber, M., Mundy, E. A., & Killgore, W. D. S. (2014). Reduced gray matter volume in the anterior cingulate, orbitofrontal cortex and thalamus as a function of mild depressive symptoms: a voxel-based morphometric analysis. *Psychological Medicine*, *44*(13), 2833–2843. https://doi.org/10.1017/S0033291714000348

Williams, J. M., Mathews, A., & MacLeod, C. (1996). The emotional Stroop task and psychopathology. *Psychological Bulletin*, *120*(1), 3–24. https://doi.org/10.1037/0033-2909.120.1.3

Zelazo, P. D., & Carlson, S. M. (2012). Hot and Cool Executive Function in Childhood and Adolescence: Development and Plasticity. *Child*

Development Perspectives, *6*(4), 354–360. https://doi.org/https://doi.org/10.1111/j.1750-8606.2012.00246.x

Zelazo, P. D., & Müller, U. (2002). Executive function in typical and atypical development. *Blackwell Publishing,* 445–469. https://doi.org/10.1002/9780470996652.ch20