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Adverse Childhood Experiences(ACEs) and Nonverbal Reasoning Skills

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Monika Malinowska

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Dedication

I would like to dedicate this project to my siblings and parents who made this research possible by making me into the person I am today.

Abstract

Severe stress and traumatic experiences in childhood have a cascade effect on an individual's physical and mental health. There is evidence that people with adverse childhood experiences (ACEs) have diminished cognitive abilities. Unfortunately, there are not enough ACE studies that show how nonverbal reasoning skills are affected by chronic stress. The purpose of the present study was to investigate the relationship between ACEs and adult nonverbal reasoning skills, which are the foundation for nonverbal problem-solving skills, spatial reasoning, and mathematics. Results contribute to the growing understanding of the effects of stressful childhood experiences, which can lead to better treatment methods and targeted early intervention programs. This retrospective study involved examining the records and psychological reports of 151 children, 68 females (45%) and 83 males (55%), between 6–16 years old treated at Will County Health Department (WCHD) Behavioral Health Services between 2012 and 2022. The sample was approximately 42% Caucasian/White, 27% Black, 23% Hispanic, and 8% biracial. The aim was to assess the multiple relationships among ACEs, nonverbal reasoning skills, and academic achievement by race and gender. The independent variable was ACE scores and the dependent variables were WISC-IV and WISC-V IQ scores, Index scores, and subtest scores, as well as academic achievement. The assumption was that the more ACEs on a scale of 0–10, the lower the WISC-IV and WISC-V scores and academic achievement. Findings of the study indicated participants with a higher number of ACEs had lower IQ on the WISC-IV and WISC-V and biracial and African American individuals had lower IQs than Whites. There was no direct significant relationship between ACEs and Visual Spatial Index (VSI), Fluid Reasoning

Index (FRI), or Perceptual Reasoning Index (PRI) scores. There were slight variations in scores that could be explained by number of ACEs when race was added. There were no differences when gender was added.

Keywords: childhood emotional trauma, adverse childhood experiences (ACEs), nonverbal reasoning abilities, cognitive functioning, neuropsychology, abuse

Adverse Childhood Experiences (ACEs) and Nonverbal Reasoning Skills

Introduction

Adverse childhood experiences (ACEs) are defined as stressful or traumatic events in a child's life. ACEs can refer to life-threatening economic adversity, a medical condition, bullying, school violence, community violence, harsh parental divorce, or witnessing domestic violence (Anda et al., 2006). The number of ACEs in the world is "tragically high" (Rutter, 2021). Although North America has the highest reported prevalence of ACEs (Hays-Grudo & Morris, 2020), the problem of trauma is present on local, national, and global levels. The study of ACEs began in the 1980s at the Kaiser Institute, when Dr. Vincent Felitti, who had a program for overweight people, noticed many people had trouble losing weight and often dropped out of the program. He interviewed 200 patients, and the results showed all these patients had experienced sexual abuse. As a result, he decided to study the link between obesity and ACEs. In 1998, Dr. Felitti and Dr. Robert Anda, a cardiovascular epidemiologist at the Centers for Disease Control and Prevention (CDC), undertook the first and largest study on cumulative ACEs and their effects on mental and physical health (Hays-Grudo & Morris, 2020).

The original ACE Study (Hays-Grudo & Morris, 2020) was significant for the field of psychology. More than 17,000 White individuals participated in the study, which included a detailed biopsychosocial questionnaire, a complete physical examination, and laboratory tests. The researchers studied multiple factors, including household dysfunction (i.e., mental illness, substance abuse, divorce, criminality, domestic violence), abuse, neglect, community violence, and poverty, that may affect a child's development and later adult functioning (Hawkins et al., 2019).

In his initial study, Felitti (Anda et al., 2006; Hays-Grudo & Morris, 2020) was surprised by how many middle-class individuals with college degrees and with health insurance were suffering from anxiety, depression, suicide, eating disorders, and physical diseases such as cancer or heart attacks early in life (Hays-Grudo & Morris, 2020). Even more surprising was the finding that these problems were closely associated with childhood adversity. The researchers were struck by how severe stress affected the participants' health and mental states. Extreme stress seems to have a cascade effect on a person's physical health, mental state, cognition, and learning. Hays-Grudo and Morris (2020) reported that Felitti's team uncovered childhood histories of abuse, neglect, and family conditions that strongly predicted poor health conditions in the participants. Dr. Anda uttered while reading the results, "[I] never imagined there was so much trauma, so much pain, all-around" (Hays-Grudo & Morris, 2020, p. 5). The results of this groundbreaking study showed ACEs are everyday events and typically co-occur together (Hays-Grudo & Morris, 2020), and that in addition to mental health and chronic health problems, ACEs have cumulative effects on the neurochemistry of the human brain, possibly affecting learning, and problem-solving skills (Hays-Grudo & Morris, 2020).

After the large ACE Study was conducted, more research was undertaken to measure the consequences of childhood trauma on cognitive function (Bremner et al., 1997; Bremner et al., 1993; De Bellis et al., 2005, 2009, 2013; Diseth, 2005; Hays-Grudo & Morris, 2020; Majer et al., 2010; Perry et al., 1995; van der Kolk, 2005, 2015), but the results were often ambiguous and the understanding of which type of experience has what exact effect on which brain structure remains limited. One reason for this ambiguity is the complexity of the human brain (Siegel & Hartzell, 2003); the human brain has close to 100 billion neurons, each connected to thousands of other neurons and resulting in trillions of synapses, makes it a real challenge for scientists to design a study that closely measures brain functions. Studies that measure brain structures, stress, and its aftermath are oversimplified and can serve only as an estimated guide to how the brain may be influenced by adverse experiences (Siegel & Hartzell, 2003). The magnitude or intensity of stress, its duration, and the person's age affect cognitive domains to a different extent (Sandi, 2013), and resilience and self-regulation also modulate how severely an individual's brain is affected by the ACEs (Wingo et al., 2010).

Stress intensity and chronicity create different outcomes for different individuals, but in general, though mild stress may motivate behaviors and improve cognitive function, high-level stress has the opposite effect (Domes & Frings, 2020). Exposure to a high level of stress for an extended time impairs the formation of explicit memories and other cognitions that involve complex reasoning and flexibility (Sandi, 2013), whereas mild stress improves the performance of implicit memory and simple or well-rehearsed tasks. These outcomes correspond with stress-induced changes in the hippocampus, amygdala, striatum, and frontal cortex (Sandi, 2013).

The prefrontal cortex houses executive function and working memory, both of which seem to be affected by prolonged stress (Girotti et al., 2018). Intact working memory is crucial for both verbal and nonverbal reasoning skills and novel problem solving, which are part of fluid intelligence (Hawkins et al., 2019). Some researchers have examined the effect of stress and trauma on verbal intelligence (De Bellis et al., 2013; Hawkins et al., 2019; Sylvestre et al., 2016), but very few studied the connections between these factors and nonverbal reasoning skills. This is surprising as a child's nonverbal reasoning skills are crucial to problem solving and learning, and the most used intelligence quotient (IQ) tests have a nonverbal aspect. The few studies conducted on the topic support that a relationship does exist in that chronic stress has a negative effect on nonverbal reasoning skills, but there is a lack of complete agreement on which aspects of nonverbal intelligence are affected (Hawkins et al., 2019; McEwen, 2011; Mougrabi-Large & Zhou, 2020; Nikulina & Widom, 2013; Su et al., 2019).

The main goal of the present research was to study the connection between cumulative ACEs and nonverbal reasoning skills to provide more evidence on how chronic stress may affect the cognitive domain. The prediction made in this study was that nonverbal functioning in children with ACEs would decrease as measured by Weschler Intelligence Scale for Children, IV and V (WISC-IV, WISC-V).

Scope of ACEs

According to the World Health Organization (WHO, 2022), child maltreatment consists of abuse and neglect and is a global problem. The WHO reported three in four children between the ages of 2 and 4 years, or 300 million children, regularly suffer from physical punishment or psychological violence. Additionally, one in five women and one in 13 men experience sexual abuse as a child between the ages of 0 and 17 years (WHO, 2022).

The United Nations (2020) reported that currently, globally one child dies from violence every 5 minutes. A groundbreaking study sponsored by the United Nations in 2006 showed approximately 40 million children worldwide under the age of 15 years experienced violence, abuse, and neglect (United Nations, 2007). Children are exposed to severe stress in their homes, schools, and neighborhoods (Parens, 2012). Current statistics indicate violence against children affects more than one billion children worldwide and costs societies up to $7 trillion a year (Stien & Kendall, 2004; United Nations, n.d.).

Ryan et al. (2017) reported similar findings and noted child abuse spans from birth to 17 years. Between 2008 and 2012, somewhere from 241,000 to 271,000 children suffered at least one episode of maltreatment and “were identified as an alternative response victim” (Ryan et al., 2017, p. 111). Some older resources from around 2007 revealed about one million reported cases of child abuse annually in the United States and countless unconfirmed reports (Rick & Douglas, 2007). Around the year 2007, approximately 22% of children ages 2–17 years were victims of trauma each year in the United States (Finkelhor et al., 2009).

In some situations, abuse happens for a shorter period in a child’s life. The problem is that the stress induced by adverse events can alter the brain’s biology and chemistry, even if the abuse happens only one time (Stien & Kendall, 2004; WHO, 2022). Continuous conflicts can lead to experiencing severe stress that leads to sensitization of body stress responses; overworked cardiovascular, digestive, and endocrine systems; and lower immune systems (Burke Harris, 2018). Experiencing multiple ACEs alters emotional regulation and cognitive performance (Burke Harris, 2018) and has been linked with many adverse psychological, physiological, and neurophysiological consequences (Burke Harris, 2018).

Because of the high prevalence of child abuse cases, some consider it a public health issue and a societal problem (Rick & Douglas, 2007). Psychologists have a professional obligation to advocate for children by studying trauma and severe stress and making the public aware of their damaging consequences. Children are a vulnerable population and need adults to advocate for them.

Types of ACEs

Child Abuse

Nkuba et al. (2018) defined, in detail, child abuse and labeled it as “abusive actions” that include “the use of words or overt actions” that “are deliberate and intentional and can involve physical, emotional, or sexual transgressions” (p. 110). It has been reported that in high-income nations, the annual prevalence of physical child abuse ranges from 4% to 16% (Norman et al., 2012), and about 10% of children are neglected or emotionally abused (Norman et al., 2012). Eighty percent of maltreatment is caused by parents or guardians who suffer from mental health problems and hold low educational achievement (Norman et al., 2012). Often, alcohol, poverty, and drugs are present in such households. Family breakdown or violence between family members are significant risk factors for parents abusing their children (Norman et al., 2012). It was noted by Norman et al. (2012) that many cases of abuse are underreported due to social stigma.

Physical Abuse. Physical abuse involves beating, punching, kicking, or other forms of bodily harm committed by parents or other people that often leave visible marks or bruising on a body due to the use of excessive force when punishing the child (Alsehaimi et al., 2019). Depending on the culture and part of the world, the definition differs slightly. In some cultures, slapping is a sign of physical abuse, whereas in others physical punishment is accepted (Alsehaimi et al., 2019). A recent meta-analysis showed there is a massive difference in the overall prevalence of physical abuse cases, from three in 1,000 (0.3%) to 226 in 1,000 (22.6%; Alsehaimi et al., 2019). The data differ depending on the culture and the collection methods (self-measures vs. gathered by a third person; Alsehaimi et al., 2019). Children who experience physical abuse may be more self-critical and present with self-inadequacy (Naismith et al., 2019). Physical abuse leads to perceived parental rejection, exacerbating any feelings of self-inadequacy (Naismith et al., 2019).

Emotional Abuse. Emotional abuse involves a persistent disregard of a child's emotional and psychological needs (Maguire et al., 2015) and often co-occurs with physical violence (Norman et al., 2012). Extensive isolation or confinement can be forms of emotional abuse (American Psychiatric Association, 2013). Other examples are criticism or humiliation from the parent, the protectors, supporters, and guiders (Norman et al., 2012).

Doyle (1997) stated it is difficult to operationalize the definition of emotional abuse, and depending on the source, author, state, or country, the definition will be different. It is an abstract concept and subjective to each person's perception. The reason it is so challenging to define and measure this phenomenon is that there are no physical marks left on a body (Doyle, 1997; Kimber et al., 2017). Hamamrman and Bernet (2000) adopted Gabarino et al.'s (1986) "action based" categories of emotional abuse: isolating, threatening, and frightening the child with guns, knives, or whips; ignoring; humiliating; and verbally assaulting. Even though there is no physical harm, emotional abuse can cause serious trauma. There is evidence in the literature that parental verbal abuse significantly alters brain functioning as it causes emotional turmoil for a child (McLean, 2016; Teicher & Samson, 2016).

Sexual Abuse. The American Psychological Association (2022) defines sexual abuse as "unwanted sexual activity, with perpetrators using force, making threats or taking advantage of victims not able to give consent" (para. 1). The definition indicates that many victims and offenders know each other (American Psychological Association, 2022). Bremner et al. (1997) reported that in the late 1990s, the rates of sexual abuse ranged from 11%–62% in women and 3%–39% in men, and 25% to 62% of children who were sexually abused developed posttraumatic stress disorder (PTSD). Statistics from the year 2013 indicated the prevalence of sexual abuse ranged from 8% to 31% for girls and 3% to 17% for boys. In other words, nine girls and three boys out of every 100 are victims of forced intercourse (Barth et al., 2013).

Child Neglect

Child neglect is defined as "a chronically impoverished parent-child relationship. The relationship between a consistent caregiver and infant is an essential experience-dependent interaction for normal development" (De Bellis et al., 2009, p. 2). Others describe neglectful behavior as "failure to provide for a child basic physical, emotional, educational, and health needs and protection of a child from harm or potential harm" (Nkuba et al., 2018, p. 111). Child neglect is the most prevalent form of child maltreatment (Nkuba et al., 2018). It is estimated that about one in seven children in the United States in 2021 was neglected and many cases are underreported (CDC, 2022). In 2020, an estimated 1,750 children died of abuse and neglect in the United States (CDC, 2022).

Physical Neglect. Physical neglect is defined as a lack of adequate clothing, food, or supervision provided by caregivers (Norman et al., 2012). There is evidence that early neglect and a lack of parental warmth are precursors for a child’s inability to soothe themselves. According to Gabor Maté (Borges, 2019), when a child has physical contact with a loving and accepting parent, oxytocin, the hormone that helps form a secure attachment, is released (Stien & Kendall, 2004). Physical contact with parents such as hugging is crucial in proper brain development that will determine cognition (Stien & Kendall, 2004). As a result of physical neglect, not only is the child–parent attachment broken, but the release of oxytocin is also diminished (Naismith et al., 2019).

Emotional Neglect. Maguire et al. (2015) defined emotional neglect as the omission of warm interactions with a caregiver. Others described emotional neglect as parents being unresponsiveness and unavailable emotionally, as well as a parent–child relationship that lacks interaction (Young et al., 2011). This type of ACE is less studied compared to physical and sexual abuse (Rueness et al., 2019). Maguire et al. (2015) concluded in their review of 13,210 articles from 1947–2012 that school-age children presenting with low grades at school, attention-deficit/hyperactivity disorder (ADHD) symptoms, or abnormal behaviors should be assessed for neglect or emotional abuse, as this could be the underlying reason for the unwanted behaviors.

Household Dysfunction

Household dysfunction can involve conditions or events where parents have a mental illness or struggle with substance abuse (Tsehay et al., 2020). Often, domestic violence and a primary caregiver’s incarceration are included in the definition (Tsehay et al., 2020). According to Sorrentino and colleagues (2020), domestic abuse may include “verbal abuse, threats, coercive control, control of economic resources and social relationships by a current or former partner” (pp. 2–3). Domestic violence has tremendous adverse effects on a growing child. The general expectation is that home should be a safe space for a child, and when a child witnesses domestic abuse, the child finds themselves in chronic stress and feels threatened (Stien & Kendall, 2004). Children often witness intimate partner violence (IPV; i.e., domestic violence), exposing them to intense stress. A few years ago, the National Survey of Children’s Exposure to Violence showed one in six children witnessed a parental attack in their lifetime (Ravi & Casolaro, 2018). Yearly, an estimated 15.5 million children witness IPV in their households. In their qualitative meta-analysis, Ravi and Casolaro (2018) emphasized that it is crucial to remember that this number might be underrepresented because of underreporting. According to some estimates, one in three women has experienced rape, physical violence, or stalking by an intimate partner during their lifetime, and nearly half of all women have been the target of psychological aggression by an intimate partner (Sorrentino et al., 2020). Children who are exposed to IPV are at risk for more violence and victimization in adulthood (Ravi & Casolaro, 2018).

Stress and the Brain

Stress is defined as a state of real or perceived threat to an organism’s well-being (Smith & Vale, 2006). The “emotional brain” is triggered when stressors occur, and an individual’s safety is at stake (Sapolsky, 2015; Smith & Vale, 2006). This process is activated by multiple internal mechanisms involving the endocrine, nervous, and immune systems, jointly known as the stress response (Sapolsky, 2015).

Acute Stress and the Brain

Acute stress lasts for a short time and induces quick alterations in the release of neurotransmitters, hormones, and cytokines (Musazzi et al., 2010). Changes in the levels of hormones release are adaptive if they happen for a short time, but even acute stress can be damaging to the brain and body and have long-term consequences if these types of events happen in excess (Sapolsky, 1996, 2015, 2018). The severity of these consequences also depends on coping skills, resiliency, and genetic makeup (Sapolsky, 1996, 2015, 2018).

When there is a threat, the amygdala registers it first and passes a signal to the hypothalamus, where hormones are released to manage stress and help the body keep homeostasis (Sapolsky, 1996, 2015, 2018). In general terms, stress is linked with the activation of the sympathetic nervous system (SNS) and the hypothalamic-pituitary-adrenal (HPA) axis (Pervanidou & Chrousos, 2011).

Sympathetic Nervous System (SNS). The autonomic nervous system (ANS) is directly affected by environmental stress and breaks down into three divisions (Hays-Grudo & Morris, 2020; Sapolsky, 2015). One of the divisions is sympathetic nervous system (SNS), which is the mechanism activated when a person sees danger (e.g., a bear). When the SNS is activated, the heart starts beating father, breathing gets faster, and the body is preparing itself to fight or to run. Once the SNS is activated, it activates the body's fight-or-flight response (Hays-Grudo & Morris, 2020; Sapolsky, 2015). Catecholamines are released into the bloodstream, including noradrenaline (norepinephrine), adrenaline (epinephrine), and dopamine, which helps the body adapt to stressful situations (Hays-Grudo & Morris, 2020; Sapolsky, 2015). SNS activation increases physiological arousal, such as heart rate, sweat production, breathing, and muscle tension, and redirects blood flow to the body's extremities to prepare for fight or flight (Sapolsky, 2015). It inhibits the digestion and reproduction systems or turns on elimination processes so the body can be prepared to run or to defend itself (McKeraan & Lucas-Thompson, 2018). Dopamine helps regulate fear-conditioning in areas of the brain such as the amygdala, nucleus accumbens, ventral tegmental area (VTA), and medial prefrontal cortex (mPFC; Hays-Grudo & Morris, 2020; Pan et al., 2018; Sapolsky, 2015).

HPA Axis. The brain areas where the stress response is mediated after the amygdala registers a threat are the paraventricular nucleus (PVN) of the hypothalamus, the anterior lobe of the pituitary gland, and the adrenal gland. This system is commonly known as the HPA axis (Hays-Grudo & Morris, 2020; Sapolsky, 2015; Smith & Vale, 2006).

In response to stress, in the PVN of the hypothalamus, corticotropin-releasing factor (CRF) is synthesized and released into the anterior pituitary gland, which induces the release of adrenocorticotropic hormone (ACTH) into the bloodstream, which stimulates the release of cortisol from the adrenal cortex (McEwen et al., 2015; Smith & Vale, 2006). Inadequate, excessive, and continuous activation of the HPA axis may alter brain functioning, which can affect cognitive and emotional parts of the brain (Barrera-Valencia et al., 2017; Beers & De Bellis, 2002; Burke Harris, 2018; Hays-Grudo & Morris, 2020) and contribute to the development of physical, mental, and cognitive symptoms (Barrera-Valencia et al., 2017; Beers & De Bellis, 2002; Hays-Grudo & Morris, 2020; McEwen et al., 2015; Smith & Vale, 2006).

The amygdala and prefrontal cortex are interconnected (Nadeau & Nolin, 2013; Sapolsky, 1996, 2015, 2018). The role of the prefrontal cortex is to “calm” the amygdala when stressors overstimulate it, in a process referred to as emotional regulation. Emotional regulation is essential for problem solving and higher thinking processes

(Sapolsky, 1996, 2015, 2018); thus, solving novel problems depends on the proper functioning of the prefrontal cortex and emotional regulation, and inappropriate stress responses can lead to mental illness in genetically predisposed individuals (McEwen et al., 2015; Musazzi et al., 2010; Sapolsky, 1996, 2015, 2018).

Devilbiss et al. (2012) studied how rats performed activities under stress and reported suppressed prefrontal cortex activity during a behavioral response under acute stress. They found that higher cognitive tasks such as planning, making choices, learning, and spatial memory were affected. Their study showed that under acute stress, some of the noradrenergic receptors in the prefrontal cortex were not working as they should and impaired working memory on specific tasks (Devilbiss et al., 2012). The authors observed that under acute stress, rats preferred habitual activities that required little working memory and decision-making tasks that required the least amount of work for reward (Devilbiss et al., 2012).

In summary, certain brain areas and cognitive functions such as learning, memory, and solving novel tasks are affected by acute stress (Devilbiss et al., 2012; Sapolsky, 1996, 2015, 2018). Under acute stress, an individual is in survival mode, which shuts down thinking and turns on an automatic mode of functioning, the fight-or-flight response (Sapolsky, 1996, 2015, 2018). Though studying the effects of acute stress is crucial, it is also important to research chronic stress as it may lead to severe and long-lasting changes in the body and the brain (McEwen et al., 2015; Sapolsky, 1996, 2015).

Chronic Stress and the Brain

Stress researchers call the effects of chronic stress on a human's body a "wear and tear" and "allostatic load" (Verbeek et al., 2019). Multiple and prolonged stressors, such as ACEs, lead to allostatic load (Hays-Grudo & Morris, 2020; Sapolsky, 2015) and the release of high levels of stress hormones, which affect the brain and may cause cognitive dysfunction (Sapolsky, 2015; Smith & Vale, 2006). When an individual experiences chronic stress and is continuously in fight-or-flight mode, the stress response systems can get desensitized, which leads to an inadequate stress response and coping skills in trauma victims (Verbeek et al., 2019). Prolonged stress influences emotional regulation, problem solving, and the skills needed to cope with daily stressors (Hays-Grudo & Morris, 2020), and can be detrimental to one’s development (Hays-Grudo & Morris, 2020; Sapolsky, 2015).

Chronic Stress and the HPA Axis. Long-term stress disrupts the equilibrium that all organisms need to maintain (Vaiserman & Koliada, 2017). Activating the HPA axis is an adaptive response used to cope with a stressor, but if stressors are prolonged or occur repeatedly, it can result in chronic alterations in physiology and a person’s behavior. (Burke Harris, 2018; Vaiserman & Koliada, 2017). The neurochemical processes in the human body are altered under chronic stress that is evident in hypersensitivity or hyposensitivity of the HPA axis, in other words, the dysregulation of the HPA axis (Vaiserman & Koliada, 2017).

The dysregulation of the HPA axis can have long-lasting effects on physical, cognitive, and behavioral functioning (Vaiserman & Koliada, 2017). Children may even stop growing or have problems with self-regulation as the HPA axis is overworked and sensitized (Burke Harris, 2018). The malfunctioning stress responses are evident in a lack of adaptation, more extended response to a problem, or an ineffective response to a challenge (Burke Harris, 2018). Continuing and repeated exposure to challenging circumstances may alter the ability to adapt to novel events or additional challenges due to the increased allostatic load of an individual under stress (Verbeek et al., 2019).

Stress affects emotional regulation (Vaiserman & Koliada, 2017), which is connected to HPA axis dysregulation. Exposure to long-term difficulties can lead to mood changes, and it has been hypothesized that a nonadaptive stress response may increase the risk of depression or anxiety (Verbeek et al., 2019). Sometimes children with ACEs respond with aggression to stressors, which is also a sign of dysregulated emotional functioning and changes in the HPA axis (Perry et al., 1995; Vaiserman & Koliada, 2017). Similarly, HPA axis dysregulation can lead to damage to the reward system and can lead to substance abuse (Stephens & Wand, 2012).

Studies on humans have shown evidence of an interwoven relationship between affect and cognition (Verbeek et al., 2019). Mood and emotions influence cognitive processing and alter how people perceive and interpret information in their environment (Verbeek et al., 2019). In children, persistent alterations in cortisol secretion have been found to have deleterious effects on both cognitive and emotional development (Pervanidou & Chrousos, 2011). Changes in the HPA axis most likely contribute to abnormal cognitive functions, including impaired learning and memory in adulthood and slower psychomotor speed.

Chronic Stress and the Limbic Areas. The limbic system in chronically traumatized children does not respond accurately, which leads to emotional dysregulation that may last a lifetime. The hippocampus is especially susceptible to harmful and prolonged experiences of stress because the hippocampus has the most glucocorticoid receptors (Jett & Morilak, 2013). Prolonged exposure to stress modifies the hippocampus volume and disrupts memory. Jett and Morilak (2013) reported that extended stress exposure and high doses of corticosterone lead to dendritic degeneration in the hippocampus. Long-term neurological changes in the brain resulting from trauma from sexual abuse cause damage to the amygdala and hippocampus. Sexually abused women show hypercortisolism, leading to hippocampal damage (Bremner et al., 1997; Herzog & Schmahl, 2018; Teicher & Samson, 2016).

In one study, when animals were repeatedly exposed to stressors, such as restraint, they exhibited altered associative learning (Gill & Grace, 2013, p. 2014). The autopsies of monkeys that died unexpectedly and had experienced severe stress right before death showed damage to the CA3 subfield of the hippocampus and hyperplastic adrenal cortices consistent with prolonged glucocorticoid release. They had multiple gastric ulcers, which may result from chronic stress (Bremner et al., 1997). The smaller size of the hippocampus is linked to memory impairment and learning disorders resulting from the toxic effect of chronic cortisol exposure (Majer et al., 2010).

The nucleus accumbens is within the prefrontal cortex and the amygdala are the components of the brain circuitry that regulate motivation (Majer et al., 2010). The system is known as the reward system, which modulates dopamine levels in the brain (Majer et al., 2010). Alteration of this system’s biochemistry as a result of chronic stress leads to unwanted psychological and neuropsychological outcomes (Anda et al., 2006). Early adverse experiences may disrupt the dopamine circuit, leading to an increased risk of substance abuse, such as smoking (Anda et al., 2006). Animals exposed to stressors show decreased responsivity to rewarding stimuli, increased aggression, and impaired shifting attention (Gill & Grace, 2013, p. 2014).

Gill and Grace (2013) estimated that the changes in the limbic system due to chronic stress most likely are long-lasting. The study showed repeated stress can alter healthy plasticity, morphology, and neurochemistry in the basolateral amygdala (BLA) and the hippocampus (Gill & Grace, 2013, p. 2013). The data from this research "support a model of stress whereby the hippocampus is inappropriately activated and dominates the information processing within this circuit via a dopaminergic mechanism after acute bouts of stress" (Gill & Grace, 2013, p. 2013). In summary, the hippocampus will be affected by stress and overactivated, which will impede learning.

Chronic Stress and the Prefrontal Cortex. The prefrontal cortex of the human brain is responsible for higher executive functions, such as planning, organizing, and inhibition. These are all very important for not only emotional regulation, but also for nonverbal reasoning skills (Diseth, 2005). Diseth (2005) wrote that there is decreased left prefrontal activity with an inhibited expression of positive emotions in abused children's brains. Majer et al. (2010) reported evidence that childhood stress induces physical, functional, and genetic alterations in brain regions that involve the prefrontal cortex. An increase in norepinephrine transmission in the medial prefrontal cortex (mPFC) that facilitates cognitive shifting is compromised by chronic stress exposure (Jett & Morilak, 2013). The dorsomedial prefrontal cortex (dmPFC), which is involved in cognition and emotion regulation, is also altered by chronic stress (Mansueto et al., 2018).

The Frontoparietal Network in the Brain and Stress. Frontoparietal areas of the brain are responsible for nonverbal reasoning skills and problem solving and are also involved in retrieving autobiographical episodic memories and assisting in emotion regulation (Harricharan et al., 2019). The frontoparietal executive control network comprises two subdivisions: sensorimotor and introspective processes. These two processes are essential for nonverbal reasoning skills, which involve internal mental processes. The sensorimotor frontoparietal division is activated by eye movements to various sensory cues in the outside environment. It helps in sensory mapping information in the environment through visual scanning. This subdivision overlaps with neural regions involved in the dorsal attentional network, including the right inferior parietal lobe (Harricharan et al., 2019).

On the other hand, the introspective frontoparietal subdivision is widely known to mediate internal thoughts and emotion processing. It overlaps with autobiographical memory and self-referential processing areas, including the medial prefrontal cortex. These two subdivisions of the frontoparietal cognitive control network are known for carrying out higher-order cognitive tasks, including emotion regulation and nonverbal reasoning skills (Harricharan et al., 2019).

The sensorimotor system is required for proper cognitive function. Chronic stress affects sensorimotor function in the brain, which influences certain cognitive functions. Harricharan et al. (2019) emphasized that the relationship between working memory and long-term episodic memory depends crucially on the brain's ability to use salient sensory information to help retrieve episodic autobiographical memories. Autobiographical memories are fundamental in forming the framework for new experiences and new knowledge. This type of memory is often fragmented in abuse victims (Harricharan et al., 2019; Stien & Kendall, 2004).

Recalling traumatic memories may trigger a stress response that changes the body's homeostasis in response to implicit or explicit memory and triggers emotions. A victim of abuse may implicitly remember a traumatic event from the past. They may have a specific fear of a person. Even though they cannot explicitly recall the trauma, they feel it with their body, which overwhelms their cognitive processes (Stien & Kendall, 2004).

Conscious top-down emotion regulation is thought to engage a frontoparietal network involving brain regions similar to those associated with oculomotion and autobiographical memory, including the right dorsolateral and ventrolateral prefrontal cortex. These brain parts may work harder to lessen the intense negative affect underlying traumatic memories (Harricharan et al., 2019). These areas also involve nonverbal reasoning skills, so if they are overworked to calm the body, their capacity for nonverbal problem solving will be severely diminished.

The dorsal attentional network comprises dorsal frontoparietal areas that consist of the frontal eye field (FEF), the supplementary eye field (SEF), and the intraparietal sulcus (Harricharan et al., 2019). Eye movements with other sensory inputs such as auditory, vestibular, and tactile are crucial for the proper functioning of the dorsal attentional network, which is vital for nonverbal reasoning. These systems are essential for estimating personal space and having an internal perspective of the world. They may be extra sensitive in trauma victims, such as in individuals with PTSD (Harricharan et al., 2019).

Brain Lateralization Under Stress. There is evidence that trauma causes significant activation of parts of the human brain involved in language, memory, perception, and emotional control. Significant right-side brain activity has been observed, indicating traumatic memories may be stored in the right hemisphere (Diseth, 2005). When emotional arousal occurs, Broca’s area in the left hemisphere can be deactivated.

Broca's area is responsible for the production of expressive language, which may explain why children or adults who face severe trauma may have problems with reading or proper expression. These areas can become overworked or, if deactivated, may become underdeveloped. Corballis (2014) pointed out that the right brain is responsible for perceiving and processing emotions stored in traumatic memories. Traumatic memories, chronic stress, and biological predisposition may contribute to distorted perception and lead to many mental disorders.

Chronic Stress and Brain Development. From the early beginning of a new life, the environment plays an essential role in forming brain structures (Ryan et al., 2017). Children and adolescents are particularly vulnerable to the effects of chronic stress because their brains and bodies are still developing. When a child is exposed to maltreatment in sensitive periods, the neurochemical systems are altered, which will affect further different types of cognition, such as learning and executive functioning (Ryan et al., 2017).

These negative brain alterations can begin in the womb. The subcortical and cortical areas of the brain are altered when a mother experiences high stress during her pregnancy. The reason for this is that stress changes the levels of neurotransmitters released, such as serotonin, dopamine, and norepinephrine (Ryan et al., 2017). There are sensitive periods in a child's neural development that can be altered by chronic stress (Ryan et al., 2017).

Castelli et al. (2020) underlined that addressing maternal gestational stress levels is crucial to ensure the proper cognitive functioning of their offspring. Glucocorticoids are the primary stress programming factors that communicate maternal stress to the fetus via the placenta. When an unborn child is exposed to high maternal stress, their stress reactivity later in life is abnormal, and they may have problems with self-regulation, which may impair cognition and fluid reasoning (Castelli et al., 2020). Castelli et al. reported evidence from prospective animal and retrospective human studies that showed a high level of glucocorticoids in the late gestation stage can lead to lifelong alterations in brain structures and functions. It may cause long-lasting alterations in developing the HPA axis.

Exposure to glucocorticoids during pregnancy increases cortisol release in the offspring, leading to a slower recovery from stressors and reducing coping strategies in aversive situations. When internal or external stress occurs, a child may lack the ability to think and problem solve later in life. In sum, prenatal exposure to emotional distress predisposes newborns to impairments in cognitive functioning such as motor or visuospatial skills (Castelli et al., 2020).

Perry et al. (1995) described that children raised in constant stress are hypervigilant and learn to be under a continuous alarm state. In such an environment, the neural response is sensitized, and as a result, a smaller stimulus can elicit intense responses. The developing brain responds to external stimuli in a “use-dependent” fashion, meaning that if the activation of specific brain areas is diminished or atypical at a certain sensitive period, the brain might develop abnormally. These use-dependent changes in the brain affect cognition, such as learning, emotional functioning, motor-vestibular functioning, and self-regulation (Perry et al., 1995). Chronic stress destabilizes children’s cognitions (Ackerman & Brown, 2010).

As mentioned above, childhood adversity alters the reward circuitry in the brain, leading to the reorganization of affective-cognitive neurocircuitry to survive in an unsafe environment. Thus, rigid mental processes can be formed that may lead to low skills in problem-solving tasks. If child experiences abuse very early in their development, abstract problem-solving abilities from an early age may be compromised (Suor et al., 2017). Children who are exposed to violence in a family (i.e., IPV), whether they are observant or direct participants, have altered brain development (Perkins & Graham-Bermann, 2012).

Further, trauma researchers claim that exposure to violence goes hand in hand with changes in the activation and connectivity of brain areas associated with emotion processing, attention, and executive function (Raver & Blair, 2016). When children hear or witness aggression between grown-ups in their household, it compromises their physiological stress response. The capacities to regulate attention and emotion are interdependent as those areas work together. Raver and Blair (2016) stated children who experience trauma from any type of abuse may have problems regulating their behavior as their executive functioning that is responsible for impulse control is affected significantly. Perkins and Graham-Bermann (2012) emphasized that children exposed to child abuse or any type of neglect are especially prone to developing mental health problems and difficulties with cognitive processing. The trauma may also affect language development (De Bellis et al., 2009). Children who experience trauma depending on their life trajectory are at a higher risk for cognitive difficulties (De Bellis et al., 2009).

The parental stress that stems from caring for children under harsh household circumstances affects children’s neurocognitive development (Chan et al., 2018; Cogill et al., 1986; Pablo & Dy, 2018). Previous research presented that negative parental thoughts and behaviors may influence parent–child interactions and affect child development over time (Buehler & Gerard, 2013; Corona et al., 2005). Corona et al. (2005) emphasized that parenting stress also affects the choice of discipline strategies, and harsh discipline does adversely affect children.

ACEs and Deleterious Effects

The initial and groundbreaking ACE Study (Hays-Grudo & Morris, 2020) results linked physical, mental, and behavioral problems to early childhood adversity. Later research confirmed the original findings and added more problems to the list. For example, according to Stien and Kendall (2004), in the United States, ACEs are a significant cause of substance abuse, mental illness, and violent crimes. Several studies have shown there is a dose-dependent relationship between ACEs and negative somatic, mental, and cognitive outcomes (Denckla et al., 2017; Merrick et al., 2017; Mougrabi-Large & Zhou, 2020).

ACEs and Physical Problems

Responding to stress involves different bodily processes that regulate behavioral, endocrine, metabolic, immune, and cardiovascular functions. Intense and chronic stress can lead to various problems, such as psychosomatic disorders, obesity, and metabolic syndrome.

Childhood trauma, such as child neglect and sudden loss, might lead to chronic fatigue syndrome (CFS; Clark et al., 2017; Kempke et al., 2013; Majer et al., 2010). According to Clark et al. (2017), it may place youngsters at 4% or two-fold increased risk compared to the general population of developing CFS. Depressive symptoms may modulate the predisposition to developing CFS (Clark et al., 2017).

In one study, individuals with four or more ACEs showed a 90% increased risk of cancer and a 60% increased risk of diabetes (Hays-Grudo & Morris, 2020). The risk for ischemic heart disease was more than double in individuals with ACEs (Hays-Grudo & Morris, 2020). The findings showed an increased risk for stroke and an almost four times increased risk for chronic obstructive pulmonary disease (Hays-Grudo & Morris, 2020). Strikingly, people with six or more ACEs typically died around 2 decades earlier (at 61 years) compared to persons with no ACEs (at age 79; Hays-Grudo & Morris, 2020). Also, ACEs increase the risk of fetal death for both first and second pregnancies (Hays-Grudo & Morris, 2020).

ACEs and Psychological Problems

There is a vast body of literature on the connection between ACEs and psychological problems in children (Burke Harris, 2018; Diseth, 2005; Hays-Grudo & Morris, 2020; Perry et al., 1995; van der Kolk, 2015). These problems can include dysfunctional stress responses, emotional-based style of functioning, hyperarousal, anxiety, irritability, impulsivity, disengaged attention, and educational underachievement (Diseth, 2005; van der Kolk, 2015).

Felitti’s team noticed that high perceived stress quadrupled the risk of having issues with controlling anger and increased the risk of experiencing IPV or being a victim of violence by five and half times (Hays-Grudo & Morris, 2020). For people with severe stress from ACEs, suicide attempts increased 12 times (Hays-Grudo & Morris, 2020).

In the United States, ACEs are a significant cause of substance abuse, mental illness, and violent crimes (Stien & Kendall, 2004). For example, Anda's team found that individuals with four or more ACEs have double the risk of smoking compared to those without ACEs (Hays-Grudo & Morris, 2020). The risk increases seven times for alcohol abuse, seven times for having early intercourse, and four and a half times for illicit drug usage (Hays-Grudo & Morris, 2020).

There is also an increased risk of unplanned and adolescent pregnancies (Hays-Grudo & Morris, 2020). The researchers emphasized that even though they controlled for potential confounders such as age and marital status at early pregnancy, unintended pregnancies were 50% more likely among women with four or more ACEs (Hays-Grudo & Morris, 2020). Prominent factors influencing this trajectory included experiencing emotional or physical abuse and witnessing IPV (Hays-Grudo & Morris, 2020).

Malarbi et al. (2017) provided evidence that severe childhood trauma may cause PTSD in children. Reininghaus et al. (2016) found that children who experienced trauma show higher sensitivity to minor stressful events in later life. They suggested exposure to trauma may "lead individuals to anticipate more unpleasant events, and the threat from their environment to create an enduring sense of threat anticipation" (Reininghaus et al., 2016, p. 2800). Perkins and Graham-Bermann (2012) and Kilpatrick and Williams (1997) conducted studies on domestic violence between parents and how this influences children's development. They discovered children might develop PTSD from experiencing severe stress resulting from intense fear, terror, and helplessness. Witnessing parents' abuse of each other may have the same effect on developing PTSD symptoms as participating directly in the conflict or just observing parents being abused.

Kilpatrick and Williams (1997) confirmed that witnessing domestic violence acts can cause behavioral problems, adjustment, and emotional disturbances. These children may exhibit withdrawal, clinging, hyperactivity, aggression, regressive behavior, and difficulties with concentration (Perkins & Graham-Bermann, 2012). Emotional abuse can be evident in children's behaviors and eating disorders, substance use, aggression, withdrawal, and criminal activity (Iram Rizvi & Najam, 2014).

ACEs and Cognitive Problems

ACEs such as traumatic events, abuse, household challenges, and neglect cause extensive neurodevelopmental disruptions in the brain and, as a result, in cognition (Hawkins et al., 2019). The evidence has been presented both in empirical animal studies and human samples (Hawkins et al., 2019). Hawkins and colleagues (2019) reported that ACEs are linked to impairment across brain structures and neurocognitive functions and are expected to cause difficulties in executive functions, memory, learning, and language development (see also Herzog & Schmahl, 2018).

It is well known that people with a history of abuse in childhood may experience cognitive dysfunction. A growing number of studies (Denckla et al. 2017; Hawkins et al., 2019; Hays-Grudo & Morris, 2020; Perkins & Graham-Bermann, 2012) examining how trauma physically changes the brain shed new light on the exact nature of these problems and possible treatment options. ACEs have various deleterious effects on a child's growing brain, affecting cognitive development, learning, emotional regulation, self-regulation, attention, and memory (Hays-Grudo & Morris, 2020).

The younger a child is when they experience trauma, depending on its severity, the more it will influence their development. Trauma that occurs in early life has severe consequences in terms of cognition. Denckla et al. (2017) emphasized that “trauma occurring in early life may have powerful effects on neurocognitive function given the multiple developmental changes in the brain that are occurring and the subsequent effects on extinction learning” (para. 21). The scientists conducted a study that showed child abuse causes stress that permanently affects learning and “fear-related memory” (para. 21). Such effects may negatively affect performing everyday activities and how the person adapts to an environment.

Perkins and Graham-Bermann (2012) conducted a study of children from birth to age 12 and argued that those who experienced early abuse had difficulties learning at school. The results were not surprising, as Anda et al. (2006) reported that early stress leads to long-term increases in glucocorticoid responses to stress as well as decreased gene expression of cortisol receptors in the hippocampus. The hippocampus is responsible for learning, and if flooded by stress, receptors will not function properly. Early environmental stress hinders hippocampal growth, leading to cognitive difficulties later in life.

Perkins and Graham-Bermann (2012) found that early life stress from violence exposure is related to neurocognitive deficits. They reported that executive functioning and problems of self-regulation are affected extensively. These functions are related to both academic and mental health problems. Perkins and Graham-Bermann highlighted that the “experience of violence alters the neurochemistry of an individual in ways that may impact learning or may mimic or create learning disabilities” (p. 96). Herzog and Schmahl (2018) stated there is diminished visual cortex and right lingual gyrus gray matter volume in young grown-ups who witnessed domestic violence in early childhood, which may lead to impairment in right hemisphere where nonverbal reasoning skills are housed.

Guinosso and colleagues (2016) reported that children exposed to complex adverse experiences are more likely to have inadequate cognitive abilities than are children with only one adversity. Therefore, it is essential to study how complex trauma and chronic stress affect cognitive domains.

Perception. Perception and cognitive functioning are close neighbors, metaphorically speaking (Sparrow & Davis, 2000). Perception is the initial step in cognition and is an essential component of children's development (Mougrabi-Large & Zhou, 2020). How children perceive the world and themselves will influence their ability to regulate and solve problems. Children who are traumatized perceive differently than children who are not traumatized. They are continually in the fight-or-flight state and are hypervigilant (Ryan et al., 2017).

Sandre et al. (2018) found children who experience abuse process social and emotional information differently. Abused children seem to overreact to emotional stimuli such as angry faces and are sensitive to ambiguous threatening information (Sandre et al., 2018). Traumatized children identify angry faces quicker than do nontraumatized children, suggesting they are preconditioned to detect threats (McLaughlin et al., 2014).

Memory and Learning. Numerous studies have shown there is a connection between stress and hippocampus damage, resulting in memory problems (Jett & Morilak, 2013; Majer et al., 2010; Raver & Blair, 2016). Early stress might alter brain functioning and cause damage to areas that are responsible for learning (Harms et al., 2018).

One study showed abused and neglected children have a higher risk of poor academic achievement (Harms et al., 2018). Identifying the type of academic achievement affected can help lead to proper treatment and interventions to address stigma (Burke Harris, 2018).

McLean (2016) reported that neglected children might have more cognitive and language development delays. Perkins and Graham-Bermann (2012) provided evidence that children who faced trauma in their school-age years have problems not only with language impairments and delayed language development but are often diagnosed with learning, reading, or math disorders. Children exposed to child abuse and neglect have twice the rate of referrals for special education. Furthermore, teachers of traumatized children have observed that they could not learn quickly and often have learning disabilities (Perry et al., 1995). De Bellis et al. (2009) reported that neglected children showed lower academic achievement and intellectual functioning than children who did not experience neglect. Results of one study showed learning was affected in Palestinian children who lived closer to the war zone (Mougrabi-Large & Zhou, 2020).

There is well-documented evidence that episodic memory (i.e., storing information about life events) is impaired in children with PTSD (Schwabe, 2017). Research indicates that when children are under stress, they have difficulties encoding information (Schwabe, 2017). Trauma-exposed adolescents have impaired factual memories (Mougrabi-Large & Zhou, 2020). De Bellis et al. (2009) found that neglected children showed lower verbal and nonverbal memory scores and speeded naming tests.

Executive Functioning. Executive function is “the flexible control of attention, shifting, the ability to hold information through working memory, and the ability to maintain inhibitory control" (Raver & Blair, 2016, p. 95). Having proper executive function is crucial for children's learning, as it enables the organization of information (Raver & Blair, 2016). The literature indicates these processes can be damaged when children experience a chronically stressful situation; children with such impairments experience difficulties with problem solving (Raver & Blair, 2016). One in eight children in the United States may have problems with executive functioning, and many of these problems are the result of a traumatic event that may be underreported (Raver & Blair, 2016).

As mentioned above, executive functioning is housed by the brain's prefrontal cortex, which sends signals to other cortical and subcortical areas, such as the basal ganglia, amygdala, and hippocampus, that are associated with emotional regulation (Raver & Blair, 2016). The emotional and cognitive areas of the brain need to communicate effectively. The "thinking brain" needs to maintain the attention, thinking, planning, and problem solving needed in daily life (Raver & Blair, 2016). Chronic emotional arousal disturbs cognitive control by hijacking attention and exhausting cognition (Raver & Blair, 2016).

Higher-order executive functions such as difficulties in pre-planning purposeful action and lower inhibitory control were discovered in a study of children who faced abuse (De Bellis et al., 2009). In another study, Barrera-Valencia et al. (2017) found that executive function in children with PTSD was significantly impaired. The researchers used widely known measures to evaluate executive function, such as the Stroop test and Wisconsin Sorting Test (WCST). The Stroop test measures inhibition and the WCST measures cognitive flexibility and preservation. Beers and De Bellis (2002) studied children who experienced ACEs and showed symptoms of PTSD and children who did not present with such symptoms. They found maltreated children performed poorly on abstract reasoning, executive function, and attention.

Working Memory and Attention. Working memory and attention are the foundation for nonverbal reasoning and problem solving and may be affected by severe stress from ACEs (Aupperle et al., 2012). Working memory is responsible for the maintenance and manipulation of information in the brain (Aupperle et al., 2012) and is crucial for problem-solving ability and nonverbal reasoning skills (Aupperle et al., 2012). Attention is the ability to attend to information simultaneously for some time and to sustain focus and switch between stimuli (Aupperle et al., 2012).

Working memory, attention, learning, and processing speed are affected in children who face physical abuse and sexual trauma (Li et al., 2017). In one study, investigators examined children living in a war zone with diagnosed PTSD. Findings showed the children's attentional control, memory problems, problem solving, planning, reasoning, and concentration were negatively affected (Mougrabi-Large & Zhou, 2020). Children exposed to chronic and severe stress have difficulty sustaining attention, leading to a decline in cognitive functioning (Mougrabi-Large & Zhou, 2020). Neglected children have more problems with complex attention (Nadeau & Nolin, 2013). In another study, researchers found diminished performance on auditory attention and working memory measures among children exposed to war (Aupperle et al., 2012). Child abuse and neglect can cause changes in the brain that may lead to ADHD symptoms (Perkins & Graham-Bermann, 2012), and a formal diagnosis of ADHD is affected by severe stress (De Bellis et al., 2005).

Emotional and Self-Regulation. Emotional regulation is “the ability to effectively regulate one’s emotions” (Dunn et al., 2018, p. 869) and is crucial for cognitive functioning, whereas emotion dysregulation refers to “deficits in several areas, including the ability to monitor and evaluate one’s emotional experiences, modulate the intensity or duration of emotions, and to manage emotional reactions to meet situational demands adaptively” (Dunn et al., 2018, p. 869). Children who experience trauma may have difficulties accessing and regulating their emotions, leading to dysregulation and cognitive and behavioral problems. Milojevich and Haskett (2018) argued that children who experience physical abuse are less capable of talking about their own emotional states and those of others. These children are prone to become frustrated quickly and have more angry outbursts. The researchers noted children who face traumatic stress disengage from emotional situations. McLean (2016) reported children with complex trauma have decreased thickness in the ventro-medial prefrontal cortex (vmPC). The effect of decreased thickness in the vmPC is that the emotional processing of social information may be impaired in abused children (McLean, 2016).

Self-regulation is defined as regulating temperament, sustaining attention, and postponing gratification (Ursache et al., 2012). Further, self-regulation is defined as the skills used to control information and organize thinking in goal-directed activities (Ursache et al., 2012). This inhibitory control mechanism (Ackerman & Brown, 2010) is severely deregulated in children who experience trauma. Self-regulation capabilities are interlinked with executive functioning (Raver & Blair, 2016). Some neuroscientists believe children who experience severe stress may have difficulties learning because they have trouble with self-regulation (Raver & Blair, 2016). An interrupted relationship between a caregiver and child results in emotional difficulties and impaired cognitive functioning (Escueta et al., 2014).

Reasoning Skills. Reasoning is a mental activity that involves using available information in a way that allows an individual to reach an outcome. Reasoning skills include using different strategies to solve a problem. People use reasoning to find uniformity between their experiences, resolve issues, and learn from past experiences (Bronkhorst et al., 2019). There are two systems in the brain involved in reasoning. Reasoning about familiar situations engages the frontal-temporal lobe network, whereas solving unfamiliar tasks or dealing with unknown circumstances requires the frontal-parietal visuospatial system (Goel et al., 2004). This network is required for spatial working memory, rehearsal, and mental manipulation of information (Goel et al., 2004).

Studies of Holocaust survivors provided evidence that unresolved sadness resulted in gaps in the monitoring of reasoning when traumatic events were discussed. The researchers called the reasoning of the survivors disorganized and scattered (Sagi et al., 2002). The survivors would remember parts or particular situations. Their memory would resemble a Swiss cheese, metaphorically speaking (Sagi et al., 2002). Palmer et al. (1997) studied girls who experienced sexual abuse and made a general conclusion that intelligence is affected.

Nonverbal Reasoning. Nonverbal reasoning is understood as using visuospatial skills and thinking strategically to solve problems without using language (Kurmanaviciute & Stadskleiv, 2017). Some nonverbal reasoning skills include concept formation, mechanical arithmetic skills, and forming visual images (Little, 1999; Nutley et al., 2011). Nonverbal skills are foundational for mathematics and predict academic success. Poor mathematic skills in ACE participants also supports that there may be a link between trauma and nonverbal reasoning skills and math difficulties. For example, adults who went through severe stress as a child may have problems with math at school or may still have math difficulties as an adult (Abd Hamid et al., 2011).

Research has provided evidence that children who experience ACEs separately such as sexual abuse, domestic violence, neglect, and physical abuse can present difficulties in auditory attention, problem solving, and planning tasks (Nolin & Ethier, 2007). However, so far there is little research on how cumulative ACEs affect a child’s cognitive functions, specifically their nonverbal reasoning skills. For example, results of one study showed children who experienced neglect and physical abuse together had more difficulties in solving, abstraction, and planning than did neglected children without physical abuse (Nadeau & Nolin, 2013). De Bellis et al. (2009) found similar results in their study as neglected children with trauma experiences had lower scores on tests measuring complex visual attention, planning, and problem solving.

Nikulina and Widom (2013) found a direct relationship between nonverbal reasoning skills and overall ACEs. They found child maltreatment in general affects cognitive flexibility and nonverbal reasoning in adulthood. Specifically, they discovered childhood neglect predicted more impaired executive functioning and nonverbal reasoning when the individual reached 41 years of age. On the contrary, physical and sexual abuse did not show such a relationship. Hawkins et al. (2019) studied college-educated Caucasian females and how ACEs are related to nonverbal reasoning skills. They used the Adverse Childhood Experiences Scale, the NIH Toolbox Cognition Battery, and the test called Automated Neuropsychological Assessment Metric. They found a higher number of ACE scores in women was negatively correlated with fluid reasoning. They concluded people with three and four or more ACEs displayed significantly lower fluid cognition scores than those with fewer ACEs. After controlling for age, sex, race, and education, higher ACE scores were associated with more mediocre performance on overall fluid reasoning (Hawkins et al., 2019).

Intelligence Quotient. Reasoning is an important aspect of intelligence, so it is not surprising that the IQs of children with ACEs tend to be affected. Neglected children and those raised in poverty may be more at risk for a lower IQ (McLean, 2016). De Bellis et al. (2009) found neglected children showed not only lower academic achievement, but also significantly lower IQs.

Results of one study showed the IQ scores of children exposed to domestic violence were 8 points lower than those of children who were not exposed to violence (McLean, 2016). Some brain areas that are affected by witnessing domestic violence are the arcuate fasciculus and the inferior longitudinal fasciculus that interconnects the visual and limbic systems (Herzog & Schmahl, 2018).

Some researchers have examined the effect of stress and trauma on verbal intelligence (De Bellis et al., 2013; Hawkins et al., 2019; Sylvestre et al., 2016), but very few have examined the connection between these factors and nonverbal reasoning skills. This is surprising as nonverbal reasoning skills are crucial to problem solving and learning, and the most used IQ tests have a nonverbal component.

***Crystallized and Fluid Intelligence*.** The terms crystallized and fluid intelligence were introduced by Cattel (Stawski et al., 2013). Crystallized intelligence relies on learned, domain-specific knowledge whereas fluid intelligence involves solving novel problems based on mostly nonverbal reasoning. Neuropsychologists define fluid intelligence as "the ability to, independent of previous knowledge, identify patterns and relations and infer and implement rule" (Nutley et al., 2011, p. 591). These skills are fundamental for understanding mathematics and solving problems at school and work. It has been noted that children who have difficulties in areas of fluid intelligence have academic challenges (Nutley et al., 2011). Some consider fluid intelligence an umbrella term for novel problem solving, decision making, and nonverbal reasoning skills (Kyttälä & Lehto, 2008).

Research indeed has shown there is a clear relationship between solving novel problems and mathematics skills (Peng et al., 2019). Fluid intelligence has shown a stronger relationship to mathematics than to reading. Within fluid intelligence activities, nonverbal reasoning (Performance IQ; Perceptual Reasoning; Perceptual Organization; Wechsler Nonverbal Scale of Ability) shows the most substantial relations with overall mathematics and numerical knowledge compared to matrix reasoning and visuospatial reasoning.

***Frontoparietal Networks and Fluid Intelligence*.** To better explain what parts of the brain are activated during fluid intelligence tasks, Yuan et al. (2018) described the connection between cortical brain areas to fluid intelligence performance using the parieto-frontal integration theory (P-FIT) of fluid intelligence. In this theory, the temporal and occipital regions are viewed as part of the fluid intelligence secondary circuitry due to their contribution to the early processing of sensory information. The parietal cortex processes sensory input after initial processing in the primary sensory cortices (Yuan et al., 2018) and interacts with prefrontal regions, which is crucial for producing the best possible solution to a given problem (Yuan et al., 2018). Raz et al. (2008) noted lower levels of fluid intelligence were associated with smaller prefrontal volumes. After controlling for age and sex, the orbitofrontal cortex, the prefrontal white matter (PFw) volume predicted fluid intelligence level. Yuan et al. (2018) found patients with lesions in the prefrontal and parietal cortex had lower performance on fluid intelligence tests when compared to healthy controls. They also reported increased activation in the frontal, parietal, and anterior cingulate cortices during fluid reasoning tasks. Activation peaks in multiple frontal, parietal, and temporal regions when working on fluid intelligence tests (Yuan et al., 2018). These brain areas seem to be affected by trauma and severe stress in childhood (Stien & Kendall, 2004).

Frontotemporal Network and Fluid Intelligence. Prefrontal and medial–temporal systems play roles in cognitive performance changes (Raz et al., 2008). Studies have depicted significant associations among brain volumes, cortical thickness, white matter integrity, and performance on the nonverbal tasks that depend on those areas (Raz et al., 2008). In the temporal lobe, many regions such as the posterior superior temporal gyrus inferior and middle temporal gyri and the fusiform gyrus exhibit activation during various fluid intelligence tasks (Raz et al., 2008).

Raz et al. (2008) reported that lower levels of fluid intelligence are associated with smaller hippocampal volumes. Until recently, the public has been convinced that fluid intelligence cannot be improved and is something people are born with; however, one study showed it may be improved (Jaeggi et al., 2008). Raz et al. (2008) examined 4-year-old children, and after receiving appropriate training, they found their fluid intelligence was significantly enhanced. This finding could mean that if lower fluid intelligence is related to trauma or severe stress, it could be improved with appropriate treatment. Children who face adverse life experiences can develop better nonverbal reasoning and problem-solving skills. They can succeed academically, just like other children who did not experience abuse (Nutley et al., 2011).

Both fluid and crystallized cognitive domains seem to be affected by stress. Fluid intelligence, which is nonverbal reasoning, may be more susceptible to daily stress reactivity. Therefore, it may be more affected by the cumulative effect of ACEs than crystallized tasks such as language (Hawkins et al., 2019). Ucok et al. (2015) reported that emotional, physical, and sexual trauma and physical and emotional neglect affect attention, processing speed, verbal learning, working memory, inhibition, sustained attention, and visuospatial skills.

Rationale and Hypotheses

Severe stress and traumatic experiences in childhood have a cascade effect on an individual's physical and mental health. In addition, there is evidence that people with complex ACEs have diminished cognitive abilities. Nonverbal reasoning abilities are part of fluid intelligence. Unfortunately, there are not enough ACE studies that show how nonverbal reasoning skills are affected by chronic stress.

The purpose of the present study was to investigate the relationship between ACEs and adult nonverbal reasoning skills, which are the foundation for nonverbal problem-solving skills, spatial reasoning, and mathematics. Results contribute to the growing understanding of the effects of stressful childhood experiences, which can lead to better treatment methods and targeted early intervention programs.

Hypothesis 1 indicated people with more ACEs would have lower IQ scores on the WISC-IV and WISC-V. The hypothesis was developed based on Felitti et al.'s (1998) research on ACEs and their effects on physical health as well as emotional and cognitive functioning. Chronic stress alters hormonal systems, mainly the HPA axis, which is the stress response system predisposing individuals to chronic physical health issues and chronic PTSD, as well as depression. There is evidence that different ACEs have negative effects on IQ, auditory attention, problem solving, planning tasks, and math skills, so cumulative ACEs can be expected to have a stronger effect on IQ scores.

The second hypothesis indicated there would be a relationship between total ACEs and VSI, FRI, and PRI Standard Scores. Hypothesis 2 predicted that total ACEs would correlate with nonverbal indexes (VSI, FRI, PRI) in the WISC-IV and WISC-V. The hypothesis was developed based on the work of researchers who studied cognitive functioning in individuals who experienced trauma (De Bellis et al., 2005, 2009, 2013; Diseth, 2005; Hays-Grudo & Morris, 2020; Majer et al., 2010; Perry et al., 1995; van der Kolk, 2005, 2015).

The third hypothesis held that there would be a relationship between different types of ACEs and each subtest in the WISC-IV and WISC-V. The goal was to determine whether there is a relationship between different types of ACEs and subtests.

The final hypothesis indicated there would be a relationship between ACEs and academics as measured by learning disorders in math, writing, and reading academic achievement in a population age 6–16 years old. Research shows children who experience multiple traumas have learning problems and lower academic achievement

(Gartland et al., 2019; Perry et al., 1995) and that interpersonal traumas affect academic achievement (Gartland et al., 2019).

In summary, the hypotheses tested in the study were:

1. The greater the number of ACEs, the lower the IQ score on the WISC-IV and WISC-V.
2. The greater the number of ACEs, the lower the scores on the nonverbal indexes (VSI, FRI, PRI) of the WISC-IV and WISC-V.
3. Each question on the ACEs Questionnaire will be associated with a lower score on each subtest of the WISC-IV and WISC-V.
4. The greater the number of ACEs, the more academic difficulties as measured by learning disorders in math, writing, and reading.

Methods

Participants

This retrospective study involved examining the records and psychological reports of 151 children, 68 females (45%) and 83 males (55%), between 6–16 years old treated at Will County Health Department (WCHD) Behavioral Health Services between 2012 and 2022. The sample was approximately 42% Caucasian/White, 27% Black, 23% Hispanic, and 8% biracial. All of the individuals were referred to WCHD to receive psychological assessments due to behavioral, emotional, and academic difficulties. Only the psychological reports of individuals with a history of interpersonal traumas (some of them did not meet criteria for PTSD), ADHD, PTSD, and mood disorders were selected for this sample. Individuals with a reported medical history or diagnosis of epilepsy/seizures, traumatic brain injury/loss of consciousness, intellectual disability, or cerebral palsy in the psychological report were excluded.

Individuals with academic difficulties or who met the diagnostic criteria for a learning disorder, reported by a parent or diagnosed by psychological testing, were included. The majority, around 95% of the participants, had low socioeconomic status (SES) and the majority of the participants' parents were separated (65%). Some of the participants' parents committed suicide or had a mental illness (15%). Some of the participants were raised by a single parent due to their other parent being in prison (22%) and some never knew at least one parent (around 10%). Also, some individuals were in foster care (7%) and some were contacted at some point in their life by the Department of Child and Family Services (32%).

Security and Data Destruction

The researcher reviewed digital archival data from the past 10 years (i.e., 2012–2022) to collect data for statistical analysis. All identifiers were removed for confidentiality purposes. Additionally, all recorded and coded information were kept on a password-protected computer to which only the principal investigator, Monika Malinowska, had access. The Excel document with the de-identified data (i.e., de-identified demographic information, ACE scores, WISC-IV PRI, and WISC-V VSI and FRI scores) has not been destroyed and has been left with WCHD so the data can be used in the future to answer other research questions that are related to the research topic.

Measures

Demographic Information

Demographic information collected included age (at the time of testing), gender, race, and ethnicity.

Adverse Childhood Experiences

The 10-item version of the Adverse Childhood Experiences Questionnaire (ACE Questionnaire; Felitti et al., 1998) records the number and types of traumas experienced. The ACE Questionnaire is embedded in every initial intake assessment by WCHD Behavioral Health as part of the IM-CANS assessment required by the State of Illinois to qualify for Medicaid. The results are stored as electronic medical records. The ACE Questionnaire has been used since 1998 and was developed by physicians. The questionnaire was created in the Center for Youth Wellness (CYW) working with the Bayview Child Health Center (BCHC) in San Francisco. The ACE Questionnaire measures physical, emotional, and sexual abuse; neglect; domestic, community, and peer violence; and various dimensions of household dysfunction. It includes screening for experiencing stress from being raised in a household where substance abuse, mental illness, or parental separation or divorce occurred. Internal consistency of the 10-item measure and construct validity were established, showing high correlations with psychological and physical health measures and childhood trauma inventories (Meinck et al., 2017). Psychometric testing has been carried out on the ACE Questionnaire. It has adequate internal consistency with a Cronbach's alpha of 0.71 (Meinck et al., 2017). A different study showed internal consistency of Cronbach's alpha .82 for Physical Abuse, .83 for Emotional Abuse, .90 for Sexual Abuse, .91 for Emotional Neglect, and .53 for Physical Neglect (Karos et al., 2014).

Wechsler Intelligence Scale for Children

The Wechsler Intelligence Scale for Children Fourth edition (WISC-IV) and the Wechsler Intelligence Scale for Children Fifth edition (WISC-V) are widely used tests to measure an individual's intelligence and are designed for ages 6–16 years. The WISC-V is the updated and newest version of the WISC test family published in 2014. The main difference between the two versions is that the WISC-IV has only one nonverbal reasoning index called Perceptual Reasoning Index (PRI) and the WISC-V divided the two nonverbal reasoning visual indexes into Fluid Reasoning Index (FRI) and Visual Spatial Index (VSI) and dropped one subtest called Picture Concepts from the nonverbal reasoning indexes. All the subtests on both versions of the WISC have the same content. The test yields a full-scale IQ score averaged from five index scales: Verbal Comprehension, Visual-Spatial, Fluid Reasoning, Working Memory, and Processing Speed, and each index scale comprises two subtests. The Visual-Spatial Index and the

Fluid Reasoning Index with their subtest scores were used for the present study. The WISC-IV has a Perceptual Reasoning Index with subsequent scores (Picture Concepts, Block Design, and Visual Puzzles).

Academic Difficulties

Information about participants' history of academic difficulty, which was provided by a parent, was taken from the Academic History section of the psychological report. Those participants met criteria for a learning disorder diagnosis during the psychological testing. Participants had accommodations at their school in form of an Individualized Educational Plan (IEP) or 504 Plan. The difficulty is understood as having the diagnosis of a specific learning disorder in math, reading, or writing. In some cases, the participants had supports in place such as a 504 Plan (2%) or IEP due to academic, behavioral, and emotional difficulties (47%).

Data Analysis and Statistical Procedures

Data collected from participants' reports were entered into SPSS. Question numbers were assigned to each variable to assist with data analyses and organization. Next, the researcher added variable labels and updated the value definitions for each of the variables needed. The recoding of items occurred as follows. For gender, a dummy variable for female was created with 1 = female and 0 = male. For the race/ethnicity categorical variable, four dummy variables were created for the categories of White, Black, Hispanic/Latino, and other. Academic difficulty was dummy coded (1 = difficulty 0 = none) because there were not enough individual items for the analyses.

The four assumptions for multiple linear regression were tested (e.g., linearity, normality, homoscedasticity, and multicollinearity) and there were no violations when models were statistically significant. For normality, histograms were created. For linearity, scatter plots were created. For homoscedasticity, residuals were created. For multicollinearity, variance inflation factor (VIF) was created. Any value that was under 10 was considered good. All of the assumptions were met.

Multiple linear regression and logistic regression were used to analyze the data in this study. Multiple linear regression is advanced linear regression analysis that takes into consideration a continuous dependent variable with more than one independent variable. In this study, the aim was to assess multiple relationships between ACEs, nonverbal reasoning skills, and academic achievement by race and gender. To measure the relationship between ACEs and nonverbal reasoning skills, multiple relationships between ACE scores and WISC-IV and WISC-V scores and academic achievement were run in SPSS software. Statistical significance was shown in the coefficient of determination R^2 and F tests. In this study, the independent variable was ACE scores and the dependent variables were the WISC-IV and WISC-V IQ scores, Index scores, subtest scores, and academic achievement. The assumption was that the more ACEs an individual endorsed on a scale of 0–10, the lower their WISC-IV and WISC-V scores and academic achievement would be. To measure such multiple statistical relationships and the variance among them, the best fit for this statistical method was to use multiple linear regression. Multiple linear regression is used to predict the value of a variable which was the goal of this study (cognitive performance, academic achievement) based on the value of two or more other variables (ACEs, traumas; Laerd Statistics, 2018). Multiple regression enables the researcher to determine the overall fit (variance) of the model and the relative contribution of each of the predictors (i.e., ACEs) to the total variance. For example, how much of the variation in cognitive scores could be explained by each of the ACE and by race and gender. In other words, multiple regression model allows a researcher to assess how much contribution in the variance is accounted for by each independent variable (i.e., ACE; Laerd Statistics, 2018).

Logistic regression analysis is appropriate to run when there is a dichotomous binary dependent variable (in this case, yes or no for race, academic difficulties, and ACEs). The logistic regression was used to determine the likelihood that variables would fall into a particular category via using the odds ratio. Logistic regression is used to describe data and to explain the relationship between one dependent binary variable (i.e., test scores by gender and race, academic achievement) and one or more nominal, ordinal, interval or ratio-level independent variables (i.e., ACEs; Statistics Solutions, 2022).

Multiple linear regressions were run to test Hypothesis 1 (total number of ACEs and combined IQ, and type of ACE and Block Design and Matrix Reasoning combined), Hypothesis 2 (total ACEs and each Index [PRI, FRI, VSI] and each subtest [Block Design, Matrix Reasoning, and so on]), and Hypothesis 3 (type of ACEs and each Index [PRI, FRI, VSI], and each subtest [Block Design, Matrix Reasoning, and so on]). Logistic regression was run to test Hypothesis 4 (type of ACEs and variables such as gender, race, and academic difficulty). Model 1 in each regression was the direct relationship, and Model 2 had the added sociodemographic variables (i.e., gender, race, academic difficulty).

Results

There were four main goals of this study. The first was to examine the relationship between the number of ACEs and IQ. The second was to examine the relationship between type of ACE and WISC Indexes (i.e., PRI, FRI, VSI). The third was to examine the relationship between type of ACE and the subtests of Block Design, Matrix Reasoning, Visual Puzzles, Picture Concepts, and Figure Weights. The fourth was to examine the relationship between type of ACE and academic difficulty.

Descriptive Statistics

Table 1 presents the results of the sociodemographic variables. The majority of the participants were male (55%). In terms of race and ethnicity, Caucasian/White made up 42.4% of the sample, representing the largest group, followed by Black (26.5%), Hispanic (23.2%), and biracial (7.9%).

Table 1

Sociodemographic Variables

	N	Percentage
Gender		
Male	83	55%
Female	68	45%
Race		
Black	40	26.5%
Hispanic	35	23.2%
Biracial	12	7.9%
Caucasian	64	42.4%

Note. *N* = 151.

Table 2 presents the results of the descriptive statistics for the ACE Questionnaire and the WISC-IV and WISC-V. Out of 151 participants, 17 did not report experiencing any ACEs and 133 participants had at least one of the ACEs. The most ACEs was nine, which means the participant endorsed having experienced almost all of the interpersonal traumas on the ACE Questionnaire as a child. The mean score for ACEs was 2.081. The ACE Questionnaire has 10 questions, so each participant had, on average, between two and three ACEs.

The WISC-IV and WISC-V IQ scores are reported in Standard Scores (SS). The average SS for IQ using the WISC is 100. The mean SS for this population on both measures were 90.544 and 91.066, which is average. The mean Combined IQ from both WISC tests was 90.755. The means for the PRI, VSI, and FRI were 95.567, 93.672, and 94.689, respectively. Last, the means for the WISC-IV and WISC-V subtests were analyzed. Performance on the WISC subtests is reported by SS with a standard deviation of 3. The average SS is 10, and they are classified as follows. The means for the subtests ranged from 8.166 on Block Design to 9.404 on Picture Concepts. The results indicate that, on average, participants performed in the average range for the WISC subtests.

Table 2

Means and Standard Deviations, Focal Variables

Variable	*M*	*SD*
ACE total score	2.081	2.033
WISC-IV IQ	90.544	15.380
PRI	95.567	14.407
Picture Concepts	9.404	3.680
Block Design	8.166	3.275
Matrix Reasoning	8.854	3.381
WICS-V IQ	91.066	14.865
VSI	93.672	14.552
Visual Puzzles	8.906	3.208
Figure Weights	8.836	3.338
FRI	94.689	13.989
Combined WISC	90.755	15.126

Table 3 shows the correlations between the study variables. Total ACE score had a weak and negative statistically significant relationship with the WISC-IV IQ score (r = -.211, p < .05). Total ACE score was not significantly related to any other variables. The WISC-IV has a strong positive statistically significant relationship with the PRI (r = .751, p < .001) and a moderate positive relationship with Picture Concepts (r = .499, p < .01), Block Design (r = .463, p < .001), and Matrix Reasoning (r = .470, p < .001). Scores for the PRI, Picture Concepts, Block Design, and Matrix Reasoning were all strongly positively related to each other, with correlations ranging from .513 to .702 (all p-values < .001).

Table 3

Bivariate Correlations for Study Variables

Measure	1	2	3	4	5	6	7	8	9	10	11
1. Total ACE score	1.00	-0.211*	-0.112	-0.007	-0.035	-0.068	-0.119	-0.193	-0.050	-0.100	-0.248
2. WISC-IV	-0.211*	1.00	0.751***	0.499**	0.463***	0.470***					
3. PRI	-0.112	0.751***	1.00	0.634***	0.513***	0.628***					
4. Picture Concepts	-0.007	0.499**	0.634***	1.00	0.540***	0.702***					
5. Block Design	-0.035	0.463***	0.513***	0.540***	1.00	0.696***	0.602***	0.739***	0.710***	0.696***	0.579***
6. Matrix Reasoning	-0.068	0.470***	0.628***	0.702***	0.696***	1.00	0.437***	0.495***	0.610***	0.723***	0.632***
7. WISC-V	-0.119				0.602***	0.437***	1.00	0.819***	0.480***	0.563***	0.846***
8. VIS	-0.193				0.739***	0.495***	0.819***	1.00	0.646***	0.577***	0.735***
9. Visual Puzzles	-0.050				0.710***	0.610***	0.480***	0.646***	1.00	0.697***	0.517***
10. Figure Weights	-0.100				0.696***	0.723***	0.563***	0.577***	0.697***	1.00	0.689***
11. FRI	-0.248				0.579***	0.632***	0.846***	0.735***	0.517***	0.689***	1.00

Note. $N = 61$. WISC-V, VIS SS, Visual Puzzles, Figure Weights, and FRI SS were only available for half the sample as such could not be correlated with other variables.

* $p < .05$. ** $p < .01$. *** $p < .001$, two-tailed tests.

Hypothesis 1 Results

Table 4 presents the results of the multiple linear regression of the total number of ACEs and Combined IQ (Hypothesis 1). Note that results are based on the standardized coefficient—the Beta *B*. The omnibus F-test in Model 1 was statistically significant (F = 4.684, $p < 0.05$). As such, the decomposition of the effects within the regression model could proceed. The coefficient of determination, also known as the R^2 value, was 0.030. This value shows 3.0% of the variation in IQ could be explained by the independent variable (total ACEs). Based on the results, a higher number of ACEs led to a lower IQ (B = -0.175, $p < 0.05$).

Model 2 added the sociodemographic variables and was tested with an omnibus F-test, which was also statistically significant (F = 4.786, $p < 0.001$). The coefficient of determination, also known as the R^2 value, was 0.142. This value shows 14.2% of the variation in IQ could be explained by the independent variables (total ACEs, race, and gender). Based on the results, a higher number of ACEs led to a lower IQ (B = 0.183, $p <$ 0.05) and African Americans had a lower IQ (B = 0.346, $p < 0.001$) compared to Whites. There were no differences when gender was added.

Table 4

Multiple Linear Regression for Total Number of ACEs and Combined IQ

	Model 1			Model 2		
Variable	B	*SE(B)*	*B*	B	*SE(B)*	*B*
Constant	94.394***	2.075		100.739***	2.605	
Total ACEs	-1.299*	0.600	-0.175	-1.363*	0.576	-0.183
African American				-11.649***	2.816	-0.346
Hispanic				-5.108	2.999	-0.143
Biracial				-7.083	4.443	-0.127
Female				-2.615	2.341	-0.086
N	151			151		
F	4.684*			4.786***		
R^2	0.030			0.142		

* $p < .05$. ** $p < .01$. *** $p < .001$, two-tailed tests.

Table 5 presents the results of the multiple linear regression for total ACEs and WISC-IV IQ (Hypothesis 1). The omnibus F-test in Model 1 was statistically significant ($F = 4.082$, $p < 0.05$). As such, the decomposition of the effects within the regression model could proceed. The coefficient of determination, also known as the R^2 value, was 0.044. This value shows 4.4% of the variation in WISC-IV IQ could be explained by the independent variable (total ACEs). Based on the results, a higher number of the ACEs led to a lower WISC-IV IQ ($B = -0.211$, $p < 0.05$).

Model 2 added the sociodemographic variables. The omnibus F-test in Model 2 was statistically significant ($F = 3.550$, $p < 0.01$). As such, the decomposition of the effects within the regression model could proceed. The coefficient of determination, also known as the R^2 value, was 0.174. This value shows 17.4% of the variation in WISC-IV

IQ could be explained by the independent variables (total ACEs and demographics). Based on the results, a higher number of ACEs led to a lower WISC-IV IQ (*B* = -0.176, $p < 0.05$). African Americans had a lower WISC-IV IQ score (*B* = -0.336, $p < 0.01$) compared to Whites. Biracial individuals had a lower WISC-IV IQ score (*B* = -0.240, $p < 0.05$) compared to Whites.

Table 5

Multiple Linear Regression for Total Number of ACEs and WISC-IV IQ

	Model 1			Model 2		
Variable	B	*SE(B)*	*B*	B	*SE(B)*	*B*
Constant	95.165***	2.787		100.478***	2.787	
Total ACEs	-1.599*	0.792	-0.211	-1.363*	0.792	-0.176
African American				-11.649**	3.607	-0.336
Hispanic				-7.681	3.981	-0.209
Biracial				-17.794*	7.636	-0.240
Female				-0.518	3.093	-0.017
N	89			89		
F	4.082*			3.550**		
R^2	0.044			0.174		

* $p < .05$. ** $p < .01$. *** $p < .001$, two-tailed tests.

Hypothesis 2 Results

Table 6 presents the results of the multiple linear regression for total ACEs and VIS SS (Hypothesis 2). The omnibus F-test in Model 1 was not statistically significant ($F = 2.272$, $p = 0.137$). As such, the decomposition of the effects within the regression model could not proceed. The coefficient of determination, also known as the R^2 value, was 0.037. This value shows 3.7% of the variation in the VIS SS could be explained by the independent variable (total ACEs).

Model 2 added the sociodemographic variables. The omnibus F-test was statistically significant ($F = 2.559$, $p < 0.05$). As such, the decomposition of the effects within the regression model could proceed. The coefficient of determination, also known as the R^2 value, was 0.189. This value shows 18.9% of the variation in the VIS SS could be explained by the independent variables (total ACEs and the sociodemographic variables). Based on the results, a higher number of ACEs led to a lower VIS SS ($B = -0.266$, $p < 0.05$). African Americans had a lower VIS SS ($B = -0.361$, $p < 0.01$) compared to Whites.

Table 6

Multiple Linear Regression for Total Number of ACEs and VIS Standard Score (WISC-V)

	Model 1			Model 2		
Variable	B	*SE(B)*	*B*	B	*SE(B)*	*B*
Constant	97.315***	3.040		105.885***	4.186	
Total ACEs	-1.363	0.905	-0.193	-1.882*	0.900	-0.266
African American				-12.110**	4.550	-0.361
Hispanic				-1.644	4.500	-0.049
Biracial				-3.139	5.435	-0.073
Female				-6.831	3.540	-0.237
N	61			61		
F	2.272			2.559*		
R^2	0.037			0.189		

* *p* < .05. ** *p* < .01. *** *p* < .001, two-tailed tests.

Table 7 presents the results of the multiple linear regression of total ACEs and FRI SS (Hypothesis 2). The omnibus F-test in Model 1 was not statistically significant ($F = 3.875$, $p = 0.054$). As such, the decomposition of the effects within the regression model could not proceed. The coefficient of determination, also known as the R^2 value, was 0.062. This value shows 6.2% of the variation in FRI SS could be explained by the independent variable (total ACEs).

Model 2 added the sociodemographic variables. The omnibus F-test was statistically significant ($F = 4.194$; $p < 0.01$). As such, the decomposition of the effects within the regression model could proceed. The coefficient of determination, also known as the R^2 value, was 0.276. This value shows 27.6% of the variation in FRI SS could be explained by the independent variables (total ACEs and sociodemographic variables). Based on the results, as the total number of ACEs increased, FRI SS decreased ($B = -0.358$, $p < 0.01$). Results showed African Americans had a lower FRI SS ($B = -0.451$, $p < 0.01$) compared to Whites.

Table 7

Multiple Linear Regression for Total Number of ACEs and FRI Standard Score (WISC-V)

	Model 1			Model 2		
Variable	B	*SE(B)*	*B*	B	*SE(B)*	*B*
Constant	99.203***	2.885		107.841***	3.801	
Total ACEs	-1.690	0.858	-0.248	-2.437**	0.817	-0.358
African American				-14.537**	4.132	-0.451
Hispanic				0.174	4.086	0.005
Biracial				-2.143	4.936	-0.052
Female				-5.751	3.215	-0.207
N	61			61		
F	3.875			4.194**		
R^2	0.062			0.276		

* $p < .05$. ** $p < .01$. *** $p < .001$, two-tailed tests.

Table 8 presents the results of the multiple linear regression of total ACEs and PRI SS (Hypothesis 2). The omnibus F-test in Model 1 was not statistically significant (F = 1.114, p = 0.294). As such, the decomposition of the effects within the regression model could not proceed. The coefficient of determination, also known as the R^2 value, was 0.013. This value shows 1.3% of the variation in PRI SS could be explained by the independent variable (total ACEs).

Model 2 added the sociodemographic variables. The omnibus F-test in Model 2 was statistically significant (F = 2.904, p < 0.05). As such, the decomposition of the effects within the regression model could not proceed. The coefficient of determination, also known as the R^2 value, was 0.147. This value shows 14.4% of the variation in PRI SS could be explained by the independent variables (total ACEs and sociodemographic variables). African Americans had a lower PRI SS (*B* = -0.253, $p < 0.05$). Biracial individuals had a lower PRI SS (*B* = -0.262, $p < 0.05$).

Table 8

Multiple Linear Regression for Total Number of ACEs and PRI (WISC-IV)

	Model 1			Model 2		
Variable	B	*SE(B)*	*Β*	B	*SE(B)*	*Β*
Constant	97.865***	2.654		103.110***	3.162	
Total ACEs	-0.796	0.754	-0.122	-0.417	0.730	-0.059
African American				-7.920*	3.434	-0.253
Hispanic				-4.253	3.790	-0.123
Biracial				-18.224*	7.269	-0.262
Female				-5.230	2.944	-0.180
N	89			89		
F	1.114			2.904*		
R^2	0.013			0.147		

* $p < .05$. ** $p < .01$. *** $p < .001$, two-tailed tests.

Table 9 presents the results of the multiple linear regression of total ACEs and Picture Concepts (Hypothesis 2). The omnibus F-test in Model 1 was not statistically significant ($F = 0.004$, $p = 0.951$). As such, the decomposition of the effects within the regression model could not proceed. The coefficient of determination, also known as the R^2 value, was 0.000. This value shows 0% of the variation in Picture Concepts could be explained by the independent variable (total ACEs).

Model 2 added the sociodemographic variables of gender and race. The omnibus F-test in Model 2 was not statistically significant ($F = 1.460$, $p = 0.081$). As such, the decomposition of the effects within the regression model could not proceed. The coefficient of determination, also known as the R^2 value, was 0.081. This value shows 8.1% of the variation in Picture Concepts could be explained by the independent variables (total ACEs and sociodemographic variables).

Table 9

Multiple Linear Regression for Total Number of ACEs and Picture Concepts (WISC-IV)

	Model 1			Model 2		
Variable	B	*SE(B)*	*B*	B	*SE(B)*	*B*
Constant	9.439***	0.686		10.621***	0.840	
Total ACEs	-0.012	0.194	-0.007	-0.047	0.194	-0.026
African American				-1.374	0.922	-0.171
Hispanic				-1.192	1.005	-0.136
Biracial				-2.925	1.928	-0.166
Female				-1.295	0.784	-0.175
N	89			89		
F	0.004			1.460		
R^2	0.000			0.081		

* $p < .05$. ** $p < .01$. *** $p < .001$, two-tailed tests.

Table 10 presents the results of the multiple linear regression of type of ACEs and PRI SS (Hypothesis 2). The omnibus F-test in Model 1 was not statistically significant ($F = 1.866$, $p = 0.063$). As such, the decomposition of the effects within the regression model could not proceed. The coefficient of determination, also known as the R^2 value, was 0.193. This value shows 19.3% of the variation in PRI SS could be explained by the independent variable (type of ACEs).

Model 2 added the sociodemographic variables of gender and race. The omnibus F-test in Model 2 was statistically significant ($F = 2.547$, $p < 0.01$). As such, the decomposition of the effects within the regression model could proceed. The coefficient of determination, also known as the R^2 value, was 0.325. This value shows 32.5% of the variation in PRI SS could be explained by the independent variables (type of ACEs and demographics). Based on the results, physical neglect decreased PRI SS ($B = -1.101$, $p < 0.01$). Losing a parent decreased PRI SS ($B = -0.228$, $p < 0.01$).

Table 10

Multiple Linear Regression for Type of ACEs and PRI Standard (WISC-IV)

	Model 1			Model 2		
Variable	B	*SE(B)*	*B*	B	*SE(B)*	*B*
Constant	101.492***	3.578		107.140***	3.816	101.492***
Physical neglect	-39.099**	14.801	-1.120	-38.424**	14.155	-39.099**
Losing a parent	-7.616*	3.838	-0.218	-8.311**	3.669	-7.616*
Mental ill/Suicide	-2.437	4.378	-0.067	-2.012	4.246	-2.437
Substance use	6.175	3.401	0.207	5.109	3.248	6.175
Domestic violence	-3.204	3.634	-0.103	-2.053	3.197	-3.204
Jail/Prison	-0.262	4.884	-0.006	2.335	4.680	-0.262
Emotional abuse	1.760	4.389	0.055	-1.310	4.212	1.760
Physical abuse	5.643	5.040	0.165	8.056	4.826	5.643
Emotional neglect	28.712*	14.420	0.838	26.707	13.852	28.712*
Sexual abuse	-1.978	3.845	-0.054	1.569	3.796	-1.978
African American				-7.794*	3.440	
Hispanic				-4.752	3.685	
Biracial				-21.991**	7.197	

	Model 1			Model 2		
Variable	B	*SE(B)*	*B*	B	*SE(B)*	*B*
Female				-4.479	2.963	
N	89			89		89
F	1.866			2.547**		1.866
R^2	0.193			0.325		0.193

* *p* < .05. ** *p* < .01. *** *p* < .001, two-tailed tests.

Hypothesis 3 Results

Table 11 presents the results of the multiple linear regression for type of ACEs and Block Design. The omnibus F-test in Model 1 was not statistically significant (F = 1.220, p = 0.284). As such, the decomposition of the effects within the regression model could not proceed. The coefficient of determination, also known as the R^2 value, was 0.081. This value shows 8.1% of the variation in Block Design could be explained by the independent variable (type of ACEs).

Model 2 added the sociodemographic variables and the omnibus F-test was statistically significant (F = 2.323, p < 0.01). As such, the decomposition of the effects within the regression model could proceed. The coefficient of determination, also known as the R^2 value, was 0.195. This value shows 19.5% of the variation in Block Design could be explained by the independent variables (type of ACEs, racial categories, and gender). None of the types of ACEs were statistically significant. African Americans had a higher Block Design score (B = 2.287, p < 0.001) compared to Whites.

Table 11

Multiple Linear Regression for Type of ACEs and Block Design WISC-IV and WISC-V Combined

	Model 1			Model 2		
Variable	B	*SE(B)*	*B*	B	*SE(B)*	*B*
Constant	8.702***	0.546		10.241***	0.646	
Physical neglect	-1.968	1.344	-0.236	-2.081	1.299	-0.249
Losing a parent	-1.132	0.588	-0.164	-1.100	0.563	-0.159
Mental ill/Suicide	0.008	0.840	0.001	-0.103	0.822	-0.011
Substance use	0.846	0.633	0.121	0.547	0.613	0.078
Domestic violence	0.215	0.642	0.030	0.496	0.617	0.069
Jail/Prison	-0.715	0.795	-0.076	-0.604	0.763	-0.064
Emotional abuse	0.741	0.750	0.108	0.402	0.729	0.059
Physical abuse	0.385	0.871	0.053	0.447	0.859	0.062
Emotional neglect	0.639	1.259	0.085	0.835	1.215	0.111
Sexual abuse	-0.713	0.717	-0.084	-0.328	0.690	-0.039
African American				-2.287***	0.630	-0.313
Hispanic				-1.015	0.681	-0.132
Biracial				-1.624	1.028	-0.135
Female				-1.231*	0.530	-0.187
N	151			151		
F	1.220			2.323**		
R^2	0.081			0.195		

* $p < .05$. ** $p < .01$. *** $p < .001$, two-tailed tests.

Table 12 presents the results of the multiple linear regression of the type of ACEs and Matrix Reasoning. The omnibus F-test in Model 1 was not statistically significant ($F = 1.320$, $p = 0.226$). As such, the decomposition of the effects within the regression model could not proceed. The coefficient of determination, also known as the R^2 value, was 0.087. This value shows 8.7% of the variation in Matrix Reasoning could be explained by the independent variable (type of ACEs).

Model 2 added the sociodemographic variables. The omnibus F-test was statistically significant ($F = 2.170$, $p < 0.05$). As such, the decomposition of the effects within the regression model could proceed. The coefficient of determination, also known as the R^2 value, was 0.185. This value shows 18.5% of the variation in Matrix Reasoning could be explained by the independent variables (type of ACEs, race categories, and gender). Based on the results, losing a parent lowered Matrix Reasoning ($B = -1.700$, $p < 0.01$). African Americans had a lower Matrix Reasoning score ($B = -1.980$, $p < 0.01$) compared to Whites. Those who were biracial had a lower Matrix Reasoning score ($B = -2.983$, $p < 0.01$) compared to Whites.

Table 12

Multiple Linear Regression for Type of ACEs and Matrix Reasoning WISC-IV and WISC-V Combined

	Model 1			Model 2		
Variable	B	*SE(B)*	*Β*	B	*SE(B)*	*Β*
Constant	9.850***	0.564		11.090***	0.674	
Physical neglect	-1.371	1.388	-0.158	-1.856	1.299	-0.249
Losing a parent	-1.628*	0.607	-0.227	-1.700**	0.587	-0.237
Mental ill/Suicide	0.065	0.868	0.007	0.052	0.857	0.005
Substance use	1.001	0.654	0.138	0.846	0.640	0.116
Domestic violence	-0.260	0.662	-0.035	-0.137	0.644	-0.081
Jail/Prison	-0.491	0.821	-0.050	-0.222	0.795	-0.023
Emotional abuse	0.206	0.774	0.029	-0.258	0.760	-0.036
Physical abuse	0.738	0.899	0.098	1.027	0.896	0.137
Emotional neglect	0.004	1.300	0.001	0.513	1.267	0.066
Sexual abuse	-0.470	0.740	-0.054	-0.328	0.690	-0.039
African American				-1.980**	0.657	-0.262
Hispanic				-0.647	0.710	-0.081
Biracial				-2.983**	1.072	-0.240
Female				-0.631	0.553	-0.093
N	151			151		
F	1.320			2.170*		
R^2	0.087			0.185		

* $p < .05$. ** $p < .01$. *** $p < .001$, two-tailed tests.

Table 13 presents the results of the multiple linear regression of type of ACEs and Picture Concepts (Hypothesis 3). The omnibus F-test in Model 1 was not statistically significant (F = 0.932, p = 0.509). As such, the decomposition of the effects within the regression model could not proceed. The coefficient of determination, also known as the R^2 value, was 0.108. This value shows 10.8% of the variation in Picture Concepts could be explained by the independent variable (type of ACEs).

Model 2 added the sociodemographic variables of gender and race. The omnibus F-test in Model 2 was not statistically significant (F = 1.419, p = 0.166). As such, the decomposition of the effects within the regression model could not proceed. The coefficient of determination, also known as the R^2 value, was 0.214. This value shows 21.4% of the variation in Picture Concepts could be explained by the independent variables (type of ACEs and sociodemographic variables).

Table 13

Multiple Linear Regression for Type of ACEs and Picture Concepts (WISC-IV)

	Model 1			Model 2		
Variable	B	*SE(B)*	*Β*	B	*SE(B)*	*Β*
Constant	9.793***	0.970		11.261***	1.062	
Physical neglect	-8.844*	14.801	-0.989	-8.637*	3.937	-0.966
Losing a parent	-0.912	1.039	-0.107	-0.986	1.020	-0.110
Mental ill/Suicide	-0.338	1.187	-0.035	-0.323	1.182	-0.034
Substance use	1.362	0.923	0.178	1.079	0.906	0.141
Domestic violence	-0.169	0.913	-0.021	0.164	0.890	0.021
Jail/Prison	0.620	1.387	0.050	1.091	1.358	0.090

	Model 1			Model 2		
Variable	B	*SE(B)*	*Β*	B	*SE(B)*	*Β*
Emotional abuse	-0.927	1.189	-0.112	-1.630	1.171	-0.197
Physical abuse	1.459	1.367	0.166	1.958	1.345	0.223
Emotional neglect	7.376	3.904	0.040	7.497	3.853	0.854
Sexual abuse	0.149	1.044	-0.016	0.988	1.058	0.106
African American				-1.922*	0.964	-0.236
Hispanic				-1.440	1.025	-0.164
Biracial				-4.040*	2.001	-0.229
Female				-1.330	0.826	-0.178
N	89			89		
F	0.932			1.419		
R^2	0.108			0.214		

* $p < .05$. ** $p < .01$. *** $p < .001$, two-tailed tests.

Table 14 presents the results of the multiple linear regression of each of the ACEs and Visual Puzzles. The omnibus F-test in Model 1 was not statistically significant (F = 0.973, p = 0.479). As such, the decomposition of the effects within the regression model could not proceed. The coefficient of determination, also known as the R^2 value, was 0.166. This value shows 16.6% of the variation in Visual Puzzles could be explained by the independent variables (each of the ACEs).

Model 2 added the sociodemographic variables. The omnibus F-test was not statistically significant (F = 1.482, p = 0.157). As such, the decomposition of the effects within the regression model could not proceed. The coefficient of determination, also known as the R^2 value, was 0.316. This value shows 31.6% of the variation in Visual

Puzzles could be explained by the independent variables (each of the ACEs and the sociodemographic variables).

Table 14

Multiple Linear Regression for Type of ACEs and Visual Puzzles (WISC-V)

	Model 1			Model 2		
Variable	B	*SE(B)*	*B*	B	*SE(B)*	*B*
Constant	9.715***	0.796		11.710***	1.045	
Physical neglect	-1.363	2.032	-0.152	-1.861	1.990	-0.207
Losing a parent	-1.719	0.940	-0.268	-1.546	0.894	-0.241
Mental ill/Suicide	-2.058	1.688	-0.193	-2.483	1.658	-0.323
Substance use	0.377	1.175	0.051	-0.051	1.135	-0.007
Domestic violence	-0.783	1.306	-0.110	-0.430	1.283	-0.060
Jail/Prison	-0.212	1.251	-0.026	-0.681	1.219	-0.082
Emotional abuse	0.212	1.170	0.033	0.150	1.160	0.023
Physical abuse	1.291	1.549	0.194	0.956	1.555	0.144
Emotional neglect	1.104	1.980	0.155	1.573	1.889	0.221
Sexual abuse	-1.853	1.265	-0.216	-2.125	1.204	-0.247
African American				-2.598*	1.059	-0.351
Hispanic				-0.700	1.098	-0.095
Biracial				-1.559	1.362	-0.165
Female				-1.598	0.848	-0.249
N	61			61		
F	0.973			1.482		
R^2	0.166			0.316		

* $p < .05$. ** $p < .01$. *** $p < .001$, two-tailed tests.

Table 15 presents the results of the multiple linear regression of each of the ACEs and Figure Weights. The omnibus F-test in Model 1 was not statistically significant (F = 0.680, p = 0.738). As such, the decomposition of the effects within the regression model could not proceed. The coefficient of determination, also known as the R^2 value, was 0.122. This value shows 12.2% of the variation in Figure Weights could be explained by the independent variables (each of the ACEs).

Model 2 added the sociodemographic variables. The omnibus F-test was not statistically significant (F = 1.610, p = 0.113). As such, the decomposition of the effects within the regression model could not proceed. The coefficient of determination, also known as the R^2 value, was 0.334. This value shows 33.4% of the variation in Figure Weights could be explained by the independent variables (each of the ACEs and the sociodemographic variables).

Table 15

Multiple Linear Regression for Type of ACEs and Figure Weights (WISC-V)

	Model 1			Model 2		
Variable	B	*SE(B)*	*B*	B	*SE(B)*	*B*
Constant	9.399***	0.850		11.502***	1.073	
Physical neglect	-0.322	2.170	-0.034	-1.246	2.044	-0.133
Losing a parent	-0.166	1.004	-0.025	-0.031	0.918	-0.005
Mental ill/Suicide	-0.318	1.803	0.029	-0.020	1.703	-0.002
Substance use	-0.505	1.255	-0.066	-0.839	1.165	-0.109
Domestic violence	-0.959	1.395	-0.129	-0.849	1.318	-0.115
Jail/Prison	0.931	1.336	0.108	0.577	1.252	0.067

	Model 1			Model 2		
Variable	B	*SE(B)*	*B*	B	*SE(B)*	*B*
Emotional abuse	-1.214	1.250	-0.182	-1.567	1.192	-0.234
Physical abuse	2.846	1.654	0.411	2.847	1.597	0.411
Emotional neglect	-1.699	2.115	-0.230	-1.052	1.940	-0.142
Sexual abuse	-1.325	1.351	-0.148	-1.722	1.236	-0.192
African American				-2.997*	1.088	-0.389
Hispanic				-0.354	1.128	-0.046
Biracial				-3.081*	1.399	-0.314
Female				-1.206	0.871	-0.181
N	61			61		
F	0.680			1.610		
R^2	0.122			0.334		

* $p < .05$. ** $p < .01$. *** $p < .001$, two-tailed tests.

Hypothesis 4 Results

Table 16 presents the binary logistic regression for the type of ACEs on academic difficulty. Academic difficulty was reported by either parent, or the student had accommodations at school in form of an IEP or 504 Plan. The difficulty was having the diagnosis of specific learning disorder in math, reading, or writing. Both Model 1 and Model 2 chi-square for the logistic regression were not statistically significant, and therefore the interpretation of the variables could not proceed. None of the individual variables were statistically significant.

Table 16

Logistic Regression for Type of ACEs and Academic Difficulty

	Model 1		Model 2	
	SE(B)	*p*	*SE(B)*	*p*
Constant	1.217	0.035	1.688	0.659
Physical neglect	1.623	0.759	2.068	0.654
Losing a parent	0.482	0.195	0.410	0.129
Mental ill/Suicide	0.406	0.181	0.373	0.160
Substance use	0.799	0.660	0.898	0.084
Domestic violence	1.206	0.704	1.070	0.094
Jail/Prison	3.858	0.071	4.313	0.062
Emotional abuse	1.380	0.622	1.400	0.622
Physical abuse	0.781	0.742	0.939	0.935
Emotional neglect	0.437	0.592	0.333	0.490
Sexual abuse	0.658	0.471	0.543	0.327
African American			0.506	0.217
Hispanic			1.200	0.757
Biracial			2.533	0.466
Female			0.648	0.362
N	151			
Chi-square	10.023	0.438	3.907	0.419

Discussion

The main goal of this study was to investigate the relationship between ACEs and nonverbal reasoning skills, which make up fluid intelligence. There has been research on ACEs and their effects on physical health, emotional well-being, and areas of cognitive functioning such as memory, attention, executive functioning, and learning (Anda et al., 2006; Bremner et al., 1997; Bremner et al., 1993; De Bellis et al., 2005, 2009, 2013; Diseth, 2005; Felitti et al., 1998; Hays-Grudo & Morris, 2020; Majer et al., 2010; Perry et al., 1995; van der Kolk, 2005, 2015). However, there is not much research on how ACEs affect nonverbal reasoning skills, so the researcher conducted the current study to measure any correlational relationship between ACEs and nonverbal reasoning skills. Nonverbal reasoning skills are fundamental to nonverbal problem-solving abilities and mathematics, and, as a result, are needed in academics and in everyday life when solving problems (e.g., while driving using spatial intelligence, organization that may require the mental rotation of an object, planning, remembering, and putting furniture together). How ACEs may affect nonverbal problem solving (i.e., fluid intelligence) is not widely researched in the field of psychology. This may be one of the first studies in which 10 of the ACEs were compared with a cognitive domain such as nonverbal reasoning abilities.

This study was designed to investigate whether the total number of ACEs was associated with a lower IQ score on the WISC-IV and WISC-V both combined and separately. Hypothesis 1 was that the more ACEs someone has the lower their IQ on the WISC-IV and WISC-V. This hypothesis was developed based on Felitti's research (Anda et al., 2006; Felitti et al., 1998; Hays-Grudo & Morris, 2020) on ACEs and their effects on physical health, emotional functioning, and cognitive functioning. In Felitti's research, the cutoff of four ACEs placed an individual at a significant risk for developing serious health conditions due to experiencing chronic stress. Results shows the more ACEs an individual endorses, the lower their overall health and the higher their risk of developing mental health issues (Felitti et al., 1998). Chronic stress alters hormonal systems, mainly the HPA axis which is the stress response system predisposing an individual to have difficulty with problem solving, attention, and emotional regulation. Children who experience chronic stress will be less motivated to acquire knowledge and learn as they try to survive, and thus their IQ may be lowered. They may skip school more often than their peers without adversities and miss out on learning concepts and they may be prone to reactivity when they perceive threats in environment, which can cause them to display troubling behaviors. Many children, especially those from a lower SES who experience ACEs, are diagnosed with mood disorders and attention deficits. What if those children are simply victims of ACEs? What if those children could be assisted by designed programs and more specific interventions in their school and home environments? What if their cognitive functioning could be improved as their trauma is processed instead of slapping them with a diagnosis of oppositional disorder, conduct disorder, ADHD, or bipolar and placing them on multiple medication trials?

All four premises tested in the current study—the relationship between ACEs and IQ; the relationship between type of ACE and Indexes (i.e., PRI, FRI, VSI); the relationship between type of ACE and the subtests of Block Design, Matrix Reasoning, Visual Puzzles, Picture Concepts, and Figure Weights; and the relationship between type of ACE and academic difficulty—were to a different extent supported by different researchers (Bremner et al., 1997; Bremner et al., 1993; De Bellis et al., 2005, 2009, 2013; Diseth, 2005; Hays-Grudo & Morris, 2020; Majer et al., 2010; Perry et al., 1995; van der Kolk, 2005, 2015). These researchers presented that cognitive performance tends to be impaired in individuals who experience traumas and chronic stress. They investigated separate types of traumas and their effects on learning, executive function, visual–spatial reasoning, learning, memory, and attention. In the current study, all 10 ACEs were investigated for the existence of relationships with nonverbal reasoning skills.

With respect to the first hypothesis, results indicated combined IQ and separate WISC-IV IQ were related the total number of ACEs, especially among biracial and African American children. As the number of ACEs increased, IQ was lower. Lower IQ being associated with the number of ACEs was reported in previous studies on child abuse and cognitive functioning (Anda et al., 2006; Hays-Grudo & Morris, 2020). In general, a lower IQ in children who experience multiple ACEs could be related to the chronic stress that comes from a lack of resources, dysfunction or chaos at home, and a lack of consistency and predictability. In such an environment, a child's primary focus will not be on learning, but rather on surviving. Chronic stress affects children's attention and lowers their problem solving, learning, and knowledge acquisition abilities. These children may be in survival mode, in which their primary goal is to look for safety (Anda et al., 2006; Hays-Grudo & Morris, 2020). Participants in the current study were from low SES households and a lack of resources may be a contributing factor to their development and IQ. Resources and stimulating environments tend to enrich children's cognitive performance. The results showed White participants had a higher IQ than biracial and African American participants, which could also be due to instrument bias and the tester's racial bias and rapport. It is important to highlight that such results do not mean biracial or African American children have lower abilities than White children. Lower IQ in biracial and African American children could be a result of lower SES, lack of resources, and lack of access to resources and medical care, even mental health access (Muvuka et al., 2020; Riley, 2012). Further, it is well known that the field of psychology lacks measures that are sensitive to culture. The test may not reflect cultural factors that may have contributed to overall performance on the test and even skewed the examiner's perception of the participant.

The second hypothesis related to the relationship between total ACEs and the VSI, FRI, and PRI. In other words, Hypothesis 2 predicted that total ACEs would be associated with nonverbal indexes (i.e., VSI, FRI, PRI) from the WISC-IV and WISC-V. The hypothesis was developed based on research on cognitive functioning in individuals who experienced trauma (Bremner et al., 1997; Bremner et al., 1993; De Bellis et al., 2005, 2009, 2013; Diseth, 2005; Hays-Grudo & Morris, 2020; Majer et al., 2010; Perry et al., 1995; van der Kolk, 2005, 2015). The results were not significant, indicating total ACEs was not associated with overall PRI scores, but there were variations in the scores. Based on the results, physical neglect was associated with PRI scores, and losing a parent was associated with lower scores on the PRI subtests (Block Design, Picture Concepts, and Matrix Reasoning). This result was somewhat surprising as the researcher's expectation was that sexual abuse would affect nonverbal skills more than would physical neglect. Sexual abuse can be regarded as a violation of the most intimate parts of a person's body especially when committed by a parent or someone trusted. Results of this study can only place more emphasis on how important it is for a child to develop an attachment with a "good enough" caregiver (Ratnapalan & Batty, 2009) to thrive and to have a trusted caregiver who will provide the basic needs for the child (van der Kolk, 2005, 2015). It is safe to conclude, as others already concluded in their research on attachment (e.g., Ainsworth, Bowlby, Winnicott; see also Boaz, 2022), that losing a parent or a caregiver or being physically neglected and not having basic needs met seem to be more detrimental to one's survival and development than being sexually abused.

There was variation in how ACEs affected PRI scores, which can possibly be explained by an individual level of resiliency and support from other people in an individual's life which all are protective factors as the literature shows (Morgan et al., 2021). Further, there was more variation between scores when race and gender were added. African American and biracial participants had lower PRI scores than White participants. Such a result could be due to the achievement gap between minorities and Whites, expectations set for the examinee, and attitudes toward school and testing based on previous experiences. There are other factors that might have contributed to the results such as types of traumas, how long the trauma lasted, the age of the child, and if the child was exposed to maltreatment in sensitive periods when the neurochemical systems are most sensitive to alteration (Ryan et al., 2017).

The second portion of this hypothesis indicated there would be variations found in VIS scores. The variations in the VIS (subtests of Block Design and Visual Puzzles) scores can be explained by the independent variable (total ACEs). More variation in VIS scores could be explained by the independent variables (total ACEs and demographics). The result showed the type of ACE was associated with overall scores for the VIS, which indicates some of the traumas may have more severe consequences on cognitive abilities than others. Also, it can be concluded that a higher number of ACEs is associated with

VIS scores. African Americans had a lower VIS score when compared to Whites, which could be due to the achievement gap and tester bias. Such findings support the hypothesis, and the findings are supported by literature on how traumas affect cognitive functioning. In summary, visual–spatial abilities seem to be associated with interpersonal traumas, which will impair problem solving and may cause challenges in mathematics. As Bremner and Wittbrodt (2020) investigated in their study, the right brain and visual association cortex seem to be affected in individuals who experienced trauma. Visual-spatial reasoning is housed in the right hemisphere. Also, it is worth further investigating which type of ACEs African American children face more and which affect them more if these differences cause differences between the races.

The last portion of this hypothesis was to examine the total number of ACEs and FRI scores. The FRI includes the Matrix Reasoning and Figure Weights subtests. The total number of ACEs was not directly associated with FRI scores, and this portion of the hypothesis was not supported due to possible confounding variables. It is possible that two or three ACEs, especially the milder ones (e.g., parents' divorce), may not affect a child as much as sexual abuse that lasted for years. A deeper look at the severity of the traumas and a child's age is recommended for future research. Because there was not any significant direct association between the total number of ACEs and FRI scores, further analysis could not be run on how each ACE affected the FRI. There was some variation in scores, which means the total number of ACEs changed the FRI slightly.

The FRI measures fluid intelligence, which is the novel knowledge not learned at school or from experiences as crystalized knowledge. Seeing patterns is a foundation for mathematic and nonverbal problem-solving abilities. The assumption was that if problem-solving skills (fluid intelligence) are located mostly in the right hemisphere, such as the frontoparietal network (Bremner & Wittbrodt, 2020; Raz et al., 2008; Yuan et al., 2018), and the frontotemporal network plays a role in nonverbal reasoning skills (Raz et al., 2008), then those areas will be affected when people experience traumatic events (van der Kolk, 2015). By the same token, a type of ACE will cause variance in FRI score.

When sociodemographic variables were added, FRI scores increased, which can be explained by the independent variables (total ACEs and sociodemographic variables). Based on the results, as the total number of ACEs increased, FRI scores decreased. Results showed African Americans had a lower FRI score compared to Whites. Testing often feels like school, so depending on the child's attitude toward school and how they believe they perform at school, it will reflect their performance on the tests. It is well known that there is an achievement gap between African American and White children (Davis-Kean et al., 2021). There are cultural differences and differences on an interpersonal level in terms of how children perform on tests (Davis-Kean et al., 2021).

The third hypothesis examined the relationship between each ACE and each subtest in the WISC-IV and WISC-V. The goal was to explore whether any of the subtest scores were lowered by the number of ACEs. There was no statistically significant relationship between types of ACEs and Block Design from the WISC-IV and WISC-V combined. The result showed 8% of the variance in the scores of the Block Design might have been caused by each ACE. The differences in scores for Block Design could be explained by the type of ACEs. When the sociodemographic variables were added to the ACEs, there were variations (19%) in Block Design scores but these were not statistically significant, possibly due to confounding variables. Overall, African Americans performed better on Block Design than Whites, which could be due to differences in how African American and White children approach nonverbal problem solving due to cultural differences or there could be a confounding variable affecting the results. Davis-Kean et al. (2021) stated cultural differences, different learning styles, and adults' expectations may influence a child's cognitive performance.

Total ACEs and Picture Concepts showed no significant result and no variation in scores. When Picture Concepts was run against each type of ACE, there was no significant relationship between the type of ACE and scores. Of the variation in Picture Concepts, 8.1% could be explained by the independent variables (total ACEs and sociodemographic variables).

There was no statistically significant relationship between type of ACEs and Matrix Reasoning. This finding did not support the hypothesis that the more ACEs a child had the lower the Matrix Reasoning score. Results like this may be due to multiple factors. First, it is possible that individuals had too few ACEs and the chronic stress from ACEs did not have a negative effect on this area of the brain and, depending what type of ACEs individuals experience, some of the ACEs are more severe than others. Furthermore, results like this may indicate there could be protective factors influencing how the brain develops even when undergoing traumas. The human brain is very complex, and this research is only the beginning of what might be going on in a child's brain under stress, how they compensate, and what coping strategies help protect the brain development from different types of damages. There is never only one contributing factor, and ACEs are interwoven, according to Bessel van der Kolk (2015).

One protective factor could be resiliency, which stems from how the human brain adapts to environmental stimuli (Ibrahim et al., 2021). It is well known that a child's brain is highly plastic, which could be an advantage and disadvantage. When traumas occur, the brain can be altered, but research on resilience has shown even one positive and nurturing connection in a child's life may make difference in how the brain wires (Bellis et al., 2018). Also, if the trauma happened after a sensitive period in a child's development, it has been shown that it would cause less damage to the brain development and stress response systems (Ibrahim et al., 2021). Children's brains go through extensive development during the first years of life, and the second time the brain goes through such significant changes and rewiring is during adolescence. If trauma occurs during a sensitive a period of development, it may cause changes in how the pathways are built in the brain. These changes can last for an extended period or even a lifetime and be reinforced when there is another trauma. In such circumstances, chronic trauma and the "allostatic overload" on the nervous system and the stress response may affect cognitive function and nonverbal problem-solving skills (Ibrahim et al., 2021).

Last, the literature presents data on adult populations (Bremner & Wittbrodt, 2020; Felitti et al., 1998). It may be worth looking at length of time after trauma exposure, the number of times the individual has been revictimized, and the chronic stress the person experienced. This writer suspectes that when children experience one incident of trauma as opposed to several, the effects would be more profound on the brain and cognitive performance. In the current sample, there was variation in Matrix Reasoning scores and type of ACEs, which could be explained by the type of trauma and its severity. There was variation in Matrix Reasoning and the independent variables (type of ACEs, race categories, and gender). African American and biracial participants had lower Matrix Reasoning scores compared to Whites. Results like this could be due to the achievement gap between minorities and Whites, a lack of quality education, and an adult's expectations and stereotypes toward biracial and African American children (Davis-Kean et al., 2021). When collecting data, it was this researcher's observation that the majority of the African American children lived in single-parent homes. When one parent is absent and the other parent is working to support the family, the single parent does not have time to ensure the child did homework or even help with homework.

There was no direct relationship between type of ACE and Visual Puzzles scores. It was expected that there would be a relationship as, according to the literature, the visual association cortex is affected by trauma. The visual association cortex plays a role in how things are perceived and transferred into meaningful information (Bremner & Wittbrodt, 2020). Also, the right hemisphere plays a larger role in visual processing information (Bremner & Wittbrodt, 2020), so if the right hemisphere is affected by trauma, it would be expected that Visual Puzzles, which is putting puzzles together and rotating them in one's mind, would be lower. Different protective factors could play role in why the Visual Puzzles subtest was not affected by ACEs as explained above. It is possible that individuals did not have "enough" ACEs for the correlational relationship to occur. There was variation in the scores for Visual Puzzles that can be explained by the independent variables (each of the ACEs). Variation in Visual Puzzles can be explained by the independent variables (each of the ACEs and the sociodemographic variables). Again, which ACE the person experienced, at what age, and how often may have caused variation in the scores.

The last part of the third hypothesis was to examine the relationship between each type of ACE and the Figure Weights subtest (Hypothesis 3). The assumption was that the more ACEs a person endorsed the lower the Figure Weights score; however, results showed no relationship between ACEs and Figure Weights. There was 12.2% of the variation in Figure Weights that could be explained by the independent variables (each of the ACEs and the sociodemographic variables), however, no significant relationship between gender and race and type of ACEs was found. It could be due to the nature of the sample used for this study or it is possible that the participants in this study had a relatively low number of ACEs (the mean score for ACEs was 2.081), so the relationship between severe trauma and cognition could not be demonstrated. It could be due to the age of the child and the frequency and severity of the trauma as well. A significant number of the participants in the sample had separated parents. However, if a child did not know a parent at all, this probably would not cause any trauma for some children, as this is simply part of children’s reality. Further research is recommended in this area.

The final hypothesis was to measure the relationship between ACEs and academic difficulties as indicated by learning disabilities stated in psychological reports of participants to check if there was any relationship between ACEs and academic achievement in the population ages 6–16 years old. Also, the researcher explored whether the results differed by gender. The results were not significant, indicating there was no significant relationship between types of ACE and academic achievement, which was surprising as the literature indicated children who experience multiple traumas have learning problems and lower academic achievement (Gartland et al., 2019; Perry et al., 1995). There is also research confirming that interpersonal traumas affect academic achievement (Gartland et al., 2019). More research in these areas is recommended.

Study Limitations

Due to the nature of the study, a cutoff point for how many ACEs would affect a child's nonverbal skills was not established. In Felitti's study (Hays-Grudo & Morris, 2020), the team was able to establish that four or more ACEs caused a significant risk for different diseases in adults. However, in the current sample the mean ACEs score was 2.81, so there was some association between multiple traumas and cognitive functioning that could not be studied. This was a limitation of the study and a recommendation for further research.

Second, archival data were used from self-rated ACE Questionnaires. Self-rating questionnaires can be biased as memory may differ and traumatic memory can be fragmented. If children still lived in the abusive household, they would not report some of the abuses as a way to protect their parents. Children often do not understand or have the words to express what happens to them.

Data for the ACE Questionnaire were collected by many clinicians in the agency and depending on the client–clinician rapport and trust, some data might have been underreported in the population. In some cases, the ACE Questionnaire may have been completed by a parent instead of the child and the data only reflect the parent perspective.

Also, data for cognitive scores were collected from psychological reports that were completed by multiple clinicians. Even though questions in the WISC are standardized, the rapport between client and clinician as well as each clinician's personal style in administering tests can affect the performance of a child and therefore their scores.

Future Research

Future study should focus on how cumulative ACEs affect nonverbal reasoning skills taking into consideration the following variables: frequency and duration of each type of ACE, the age of the child when the traumas occurred taking into consideration sensitive periods of development, and gender differences. Also, Felitti (Felitti & Anda, 2010; Hays-Grudo & Morris, 2020) completed his study on adults who experienced ACEs while growing up, so studying the immediate effects of ACEs on a child's nonverbal reasoning skills and development while the traumas are happening and right after would be recommended.

Conclusion

This research was designed to contribute to the understanding of a child holistically instead of just providing the heaviest diagnoses and medicating children. Sometimes, heavy diagnoses such as bipolar disorder, oppositional disorders, ADHD, borderline personality, and PTSD may not fully reflect what a person went through and who they are until we dive in into hearing their traumas and their meaning to them. Mental health professionals must learn what has happened to a child to truly get to know them to create the most suitable treatment plan that will help the client. This is crucial to help a child improve and lead a healthier life. Mood dysregulation in children who do not have words to express what happened them does not mean bipolar disorder and a mismatch in medication can put a child and family through a period of medication trial and hospitalization that might not be needed.

A child's brain is plastic and interpersonal trauma may be healed to a degree with proper counseling and interpersonal therapy. The research places emphasis on understanding how trauma affects brain development and cognitive functioning. A child who experienced trauma and shows symptoms of depression, PTSD or complex PTSD, or mood dysregulation may also experience effects in terms of learning and cognitive functioning. Trauma affects executive function, memory, and attention, which when paired with lower SES puts a child at risk for further life difficulties. It is this writer's hope that the results of this research can be used to help with ruling out or differentiating diagnosis between ADHD, conduct disorder, bipolar disorder, and disruptive mood dysregulation, especially in minorities and people of color. The hope is for clinicians to use the results of the study to understand that there is more to a person than defiance, borderline, or bipolar disorder—there is a person with true suffering. This research can contribute to fighting against the stigma surrounding abuse and mental health in society and bringing awareness of the effects of trauma to anyone who works with children with trauma. This research serves as advocacy for those who do not have words yet to explain or make sense of what happened to them. Patients should know they are not alone, and they do not have to suffer in secrecy because there is help available.

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