NEUROBEHAVIORAL SIGNATURES IN CHILDREN-VICTIM OF BULLYING

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NEUROBEHAVIORAL SIGNATURES
IN CHILDREN-VICTIM OF BULLYING

by

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B.S., PSYCHOLOGY, UNIVERSITY OF NEW MEXICO, 2012

THESIS
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DEDICATION

To my mother, Silvia Vargas, who has always shown me what a strong woman looks like. Thank you for all of your hard work and sacrifices. I am truly blessed to be your daughter.
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First and foremost, I praise God for making the impossible possible. Next, I would like to thank my faculty mentor Dr. Kristina Rewin Ciesielski for all her time, guidance and unwavering support. Her dedication to children and science is inspiring and I will forever be grateful to be her student. I also wish to thank my thesis committee members, Dr. Julia Stephen, Dr. Bruce Smith, and Dr. Steve Verney, for providing invaluable support during this process. I sincerely appreciate their time and interest not only in this study but in my professional development. I would also like to thank Dr. Paul Lesnik for his assistance with the statistical analysis. Next, I would like to thank my research assistants Charlene McGinnis and Yesol Kim for all of their time, hard work, and dedication. I really could not have done this project without their assistance. I am deeply grateful to all the children and families who participated in this study. Their willingness to be part of this work is truly motivational. Finally, I would like to thank my family for all of their encouragement and endless love during this process.
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ABSTRACT

Experiencing bullying victimization can lead to detrimental damage to a child’s life potential, reduced long-term contributions to society, and in severe cases, to suicide or desperate acts of defensive aggression, such as school shootings. The current study aimed to examine risk factors that may increase the vulnerability of a child to become a target of bullying victimization and the related consequences of victimization, using rigorous neuropsychological and EEG measures. The end-goal is to translate these findings into a program of preventive intervention increasing the child’s resilience and improving social culture among youth in the academic environment. We propose a two-component novel model for examining child-victim characteristics: Trait Signatures, as crystalized, long-term neurobehavioral and brain neurophysiology (EEG) markers and State Signatures, the psychological, somatic, and cognitive acute consequences of bullying victimization. Results from 16 Children-Victim (VC) and 16 non-exposed to bullying, Control Children (CC), ages 6-17 are presented. Our key findings in VC as compared to CC show: In Trait Signatures significantly higher scores on measures of
anxiety and compulsivity, significantly reduced skills in visual-spatial perception and attention, but no significant group differences in oscillatory brain activity (alpha power) during visual cognitive tasks demanding top-down inhibitory control of response. In State Signatures significantly higher levels of depressive moods, significantly reduced visuospatial memory and visually mediated conceptualization, and a significantly higher rate of life-long traumatic experiences, including bullying victimization. Our findings implicate a prime significance of emotional-social difficulties in VC that may impact visual cognitive proficiency in complex social problem-solving interactions. The identified emotional-social-cognitive composite of difficulties in VC must be addressed in future studies and in prospective programs of prevention.
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INTRODUCTION

Definition of Bullying

Bullying has considerably increased in American schools within the last two decades, resulting in physical and psychological harm to the young victims' development, including loss of personal potential, school shooting tragedies, increased risk of suicide and severe family distress (Nishina, Juvonen & Witkow, 2005; Ranney et al., 2016; Srabstein, 2013; Rigby & Slee, 1999). Bullying is an aggressive and persistently repeated act of behavior with an intention to harm, and primarily related to social power differential (Olweus, 1978; 1993). Forms of bullying include social aggression (e.g., spreading rumors, social exclusion), verbal aggression (e.g., threats, name calling), physical aggression (e.g., pushing, hitting), and cyber bullying (e.g., using electronic means to hurt the reputation of another person; Olweus, 1993). Bullying transcends across age, gender, race/ethnicity and SES, and among all other environments, is most frequently recorded in academic institutions.

Bullying occurs in 30% of children and adolescents in the United States (Nansel et al., 2001; Wang et al., 2009). Other industrialized countries (e.g., Germany, United Kingdom, Spain, Australia) report a similar prevalence, ranging from 20-30% (Zych et al., 2017). Importantly, prevalence rates increase among children with special healthcare needs, as seen in children with Autism Spectrum Disorder (ASD). Their rates of victimization range from 46% to 80% of (Cappadocia, Weiss & Pepler, 2012; Sterzwing et al., 2012).
New Model of Children-Victim: State Signatures and Trait Signatures

Considering the clinical and social assessment reports below and first neuroimaging studies on children-victim (VC), we propose a novel model of investigation of children-victim characteristics: (i) Trait Signatures (TS), i.e., long-term characteristics of emotional, cognitive and social development related to pre-existent, permanent changes in basic neural functions underlying top-down inhibitory control of cognition and emotions; and (ii) State Signatures (SS), as all psychological, somatic and neuropsychiatric consequences of being a target of bullying, as compared to control children (CC). Presented below is our original study aiming to define the distinct SS and TS in the VC population in children between the age of 6-17. Understanding the significance of different TS will help us to understand the relationship between TS and SS and predict the effects of bullying on individual children. Our ultimate goal is to design well informed and effective methods for prevention of bullying victimization.

Reported Consequences of Bullying in Children of Different Age Groups

Bullying rates and forms of aggression differ across developmental stages. Contrary to popular belief, bullying begins in early childhood (Kochenderfer & Ladd, 1996; Pepler, Jiang, Craig, & Connolly, 2008; Alsaker & Gutzwiller-Helfenfinger, 2010). Pre-school aged children can identify bullying behavior, rumor spreading and social exclusion in their peers when assessed with developmentally appropriate methods (Alsaker & Nägele, 2008). Victims as young as four years of age, have reported higher levels of somatic complaints and peer problems, whereas, bullies at this age have been
more likely to have conduct problems, hyperactivity and poor pro-social behavior (Ilola, Lempinen, Huttunen, Ristikari, & Sourander, 2016).

Children in elementary school typically report higher rates of bullying compared to middle school children (Scheithauer, Hayer, Petermann & Jugert, 2006), showing a peak during school transitions (Pepler et al., 2008). Physical bullying is often reported in younger children, with the highest reported severity overserved in 8th grade (Scheithauer et al., 2006), while more sophisticated forms of verbal, social and cyberbullying emerge during early adolescence (Pepler et al., 2006). However, most of the research has focused on middle/high school and college students leaving a gap of knowledge in younger children (Mason, 2013).

It has been documented that early bullying victimization exposure may lead to long-term negative consequences in adolescence and/or adulthood. Adolescents with a history of bullying experience report higher rates of depression and emotional problems (Zwierzynska, Wolke & Lereya, 2013), increased drug and alcohol use (Kim, Catalano, Haggerty & Abbott, 2011), sleeping difficulties (Fekkes, Pijpers & Verloove-Vanhorick, 2004), and physical problems such as headaches and stomach-aches (Williams, Chambers, Logan, & Robinson, 1996). Further, Copeland and colleagues (2013) studied the consequences of childhood bullying in young adults and found that those participants who experienced bullying during childhood reported higher rates of depressive, generalized anxiety, panic and agoraphobia disorders in adulthood. Isolation and exclusion combined with long-term bullying during high school years have been shown to increase levels of stress and depression during young adulthood (Newman et al., 2005).
Gender Related Consequences in Victims of Bullying

Findings regarding gender differences are mixed. Some evidence suggests that gender differences are found in relation to the forms of aggression used, the frequency of involvement in bullying and coping strategies. Boys tend to bully both girls and boys and report higher rates of victimization compared to girls, whereas, girls tend to only bully girls (Nansel et al., 2001; Veenstra et al., 2005; Ma, 2002). Boys tend to engage more in physical aggression, while girls engage in verbal aggression (Casey-Cannon, Hayward, & Gowen, 2001; Nansel et al., 2001). Victimized females tend to internalize behaviors (Broidy & Agnew, 1997), report higher rates of lower self-esteem, risky sexual behavior and substance abuse (Bouffard & Koeppel, 2016), while victimized males tend to externalize behaviors (Broidy & Agnew, 1997). However, when the severity of bullying increases, gender differences are no longer a significant factor (Rivers & Noret, 2010; Kim, Boyce, Koh, & Leventhal, 2009; Eisenberg, Neumark-Sztainer & Story, 2003).

Participant Role Related Neurobehavioral Characteristics

Bullying incidences are often thought of as only involving a dyad (i.e., bully and victim). Those who perpetrate, i.e., target individuals, are identified as bullies, while those who are the targeted are victims (Olweus, 1978). Bully-victims are those who engage in both behaviors, but it is uncertain if they have a simultaneous origin or if one occurred before the other. However, bullying is a phenomenon that involves various social roles. Salmivalli and colleagues (1996) identified and described, aside from bullies and victims, additional roles such as assistants, reinforcers, outsiders and defenders. Assistants are defined as those who join in bullying perpetration but have a secondary
role and *reinforcers* are those who provide positive feedback to the perpetrators or may be constantly present and not assist the victim. *Outsiders* keep their distance and watch from afar and *defenders* intervene in behalf of the victim. Boys are socially accepted by their peers when assisting the bully as *reinforcers* but are typically rejected when acting as *outsiders*. However, those who are *defenders* may be either rejected or socially accepted by their peers (Salmivalli et al., 1996). Notably, the prevalence rate of bullying in typically developing children increases to 66% when considering all these roles (Rivers, Poteat, Noret & Ashurst, 2009).

Three meta-analyses for bullies, victims and bully-victims, examined the relationship between participation in bullying and psychosomatic complaints in children, ages 7 to 16 (Gini & Pozzoli, 2009). Results indicated that both victims and bully-victims share common medical problems, poor relationships with peers, low emotional adjustments and had the largest effect sizes for psychosomatic problems. All three groups involved in bullying had a significantly higher risk than in controls for psychosomatic problems, however, bullies demonstrated the lowest number of medical health problems compared to victims and bully-victims.

Witnessing bullying or helping in bullying has been linked to elevated mental health risks (Rivers, et al., 2009). For instance, children who witness victimization and are not directly involved, have been found to experience cognitive dissonance (Craig & Pepler, 1998). This results from their desire to intervene but not taking any action. Those who have witnessed victimization report a higher risk for substance abuse (Rivers et al., 2009), sensitivity to rejection, and neural activity consistent with distress (Masten, Eisenberger, Pfeifer & Dapretto, 2013).
However, the group to display the most significant levels of psychopathology are bully-victims. These individuals are victimized and display bullying behaviors. They have the highest risk for suicide attempts, depression and psychosomatic complaints (Rivers & Noret, 2010; Nansel et al., 2001), medical problems, poor relationships with peers, low emotional adjustment (Gini & Pozzoli, 2009), substance abuse and hostility (Shepherd, Sutherland & Newcombe, 2006; Nansel et al., 2001; Juvonen, Graham & Schuster, 2003). These observations may suggest that bully-victims were originally victims of bullying, and the course of prolonged abuse developed aggressive behaviors as a mechanism of defense or hopelessness.

One study found that children who were assessed as bullies and showed theory of mind (ToM) impairments, were more likely to misinterpret friendly behaviors of others as aggressive (Van Roekel, et al., 2010). ToM is defined as the ability to predict another person’s beliefs, intents, desires and knowledge (Baron-Cohen, Leslie & Frith, 1985). Adolescents with ASD who were victimized, were more likely to misinterpret friendly behaviors as threatening and bullying (Van Roekel, et al., 2010). This is consistent with the Victim Schema Model (Rosen, Milich, & Harris, 2007), which states that individuals who have been victimized, will more often misinterpret non-threatening interactions as negative or hostile. Thus, bullying becomes a self-sustaining cycle that increases the probability of future victimization.

Medical and Psychological Consequences of Bullying in Children-Victim

Chronic bullying victimization leads to both severe short- and long-term consequences in the victim’s physical and psychological health. Prolonged exposure may
lead to higher rates of anxiety, depression, reduced academic achievement, suicidal ideations and completion, uncontrolled acts of aggression and increased likelihood to become chronically bullied in adulthood (Nishina et al, 2005; Ranney et al., 2016; Rigby & Slee, 1999; Srabstein, 2013; Sharp, 1995).

Victims and bully-victims have reported higher rates of physical and psychosomatic health issues such as poor appetite, repeated sore throats, and colds compared to those who bully and non-involved children (Wolke, Woods, Bloomfield, & Karstadt, 2001). Exposure to bullying was related to frequent health complaints and absence from school in young children (e.g., 6 to 9 years of age; Wolke et al., 2001; Fekkes et al., 2004). Adolescents have reported higher frequency and severity of health problems (e.g., abdominal pain), higher rates of doctor visits and absenteeism (Vaillancourt et al., 2011).

Neuroendocrinology studies have suggested that bullying victimization has neurobiological effects in VC. There appears to be a link between bullying and the dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis (Knack, Jensen-Campbell, & Baum, 2011; Vaillancourt et al., 2011; Rudolph, Troop-Gordon, & Granger, 2011). The HPA axis promotes rapid secretion of cortisol to prepare the body for the fight-or-flight response. Further, bullying victimization appears to be a risk factor for depressive symptoms in children who displayed heightened anticipatory cortical levels, especially in girls (Rudolph et al., 2011).

Additionally, childhood bullying exposure predicts low-grade systemic inflammation in adulthood. Copeland and colleagues (2014) examined low-grade inflammation by measuring C-reactive protein (CRP) in victims, bully-victims, bullies,
and non-involved children through a longitudinal study. The authors found a positive relationship between the number of bullying incidences reported by participants and CRP levels, thus indicating higher susceptibility to inflammation in victims of bullying.

Prolonged exposure to bullying may also lead to increased risk for severe mood disorders, psychotic symptoms, behavioral adaptive problems and increased severity of symptoms in developmental disorders, such as ASD and obsessive-compulsive spectrum (OCS; Schreier et al., 2009). Bullying victimization has been linked with early onset for social phobia, OCD, and panic disorder with, or without, agoraphobia (McCabe, Antony, Summerfeldt, Liss & Swinson, 2003). Schreier and others (2009) found that children who have been severely or chronically victimized were two times more likely to report psychotic symptoms even after controlling for prior psychopathology, IQ and other experienced adversity.

Among the most severe consequences of bullying are suicide attempts and completions. Victims and bully-victims are at increased risk for suicide ideations and completion compared to the general population (Kaltaila-Heino et al., 1999; Klomek, Marrocco, Lkeinman, Schonfeld & Gould, 2007; Rivers & Noret, 2010). Male bully-victims, ages 12-16, are at the highest risk for suicide attempts (Rivers & Noret, 2010). Young adults who experienced childhood bullying victimization have reported significantly higher levels of suicidal ideations compared to the population (Copeland et al., 2013).
**Neuroimaging Evidence: Consequences of Bullying in Victimized Children**

Recent studies have examined bullying in terms of social exclusion in children and adolescents using neuroimaging techniques. A study using functional magnetic resonance imaging (fMRI) examined chronically, socially rejected adolescents while playing a virtual ball-tossing game (i.e., Cyberball; Will, Crone, van Lier & Guroglu, 2016). The authors found that rejection was associated with higher activity in the subgenual anterior cingulate cortex and the anterior insula during peer exclusion compared to the control group. These regions have been previously linked with the distress of peer rejection among adolescents. Additionally, chronically victimized adolescents were found to exhibit increased activity in the dorsal striatum and lateral prefrontal cortex compared to CC, when demonstrating prosocial behavior towards other participants. These regions are associated with cognitive control.

Further, Eisenberger and colleagues (2003) also used the virtual ball-tossing game and found that those who experienced social exclusion in the game, relative to social inclusion, showed increased activation in the dorsal anterior cingulate cortex and ventral prefrontal cortex. Both regions are implicated in functions that warn organisms of a potential predator or other dangers and to regulate distress associated with physical pain and negative affect. This suggests a neural overlap between social and physical pain systems.

**Reports on Etiology of Being a “Bully” or a Child-Victim**

Clinical and psychosocial analyses of individuals engaging in recent school shootings have shown that in most cases the performing individual, was not a bully but a
victim of bullying. Events occurring at Virginia Tech (CNN Library, 2016), Sandy Hook Elementary (Sedensky III, 2013) and Umpqua Community College (Loew, 2015) urge us to look closely at characteristics of those who were engaged in those violent crimes. These individuals were described by their community as rejected by peers, odd, with social difficulties, repetitive, strange behaviors and interests (Hughes & Johnson, 2015; Sedensky III, 2013). Letters left by the offenders described how isolated and misunderstood they felt (Keneally, 2015). Victims often displayed symptoms of clinical depression and anxiety disorders, which all have a high level of heritability (Mai-Duc, 2015). Therefore, we may be able to predict which children will demonstrate certain cognitive and emotional-social endophenotypes (i.e., elevated psychopathological markers without a clinical severity) that leaves them susceptible to becoming victims of bullying (Gottesman & Gould, 2003). However, this effort must be accompanied with prevention and intervention programs. Currently, even if victims had displayed symptoms of emotional and cognitive deficits and had been diagnosed earlier with one of the developmental psychopathological disorders prior to a tragic shooting event, there is yet no program that exists to prevent bullying victimization of children with such disorders.

*Developmental Psychopathology Endophenotype*

Prevalence rates of bullying are higher among children with behavioral and emotional difficulties. For instance, children with OCS disorders including ASD and OCD report rates ranging from 46% to 80% in comparison to 30% among typically developing children (Sterzing, et al., 2012; Cappadocia et al., 2012). Since both, OCD and ASD, demonstrate deficits in visual attention, cognition of social cues (Baron-Cohen
et al., 1985; Van Roekel et al. 2010; Newton et al., 2017; Sterzing et al., 2012), and top-down inhibitory control (Ciesielski et al., 1997; 2007; Greenberg et al., 2000; Loth, Gomez & Happe, 2010), the investigation of a marker relying on top-down inhibitory control is important for identifying children at risk for becoming victims of bullying.

Children with OCS disorders have marked severe social and communication deficits and display repetitive behaviors (Bejerot, 2007). ASD and OCD share commonalities in neurological and genetic phenomena and both have visual-spatial processing deficits, impaired social interactions and communication, have restricted interests in group activities and deficits related to ToM (Ivarsson & Melin 2008; Chasson et al., 2011; Zandt et al., 2007; Bejerot, 2007; Anholt et al., 2009). Only recently has research begun to examine the link between ASD and OCD to identify risk factors for peer victimization.

Bejerot and Mörtberg (2009) examined autistic traits and previous experiences of victimization during grade-school years on adult patients with social phobia, OCD and healthy controls. The authors predicted that autistic traits would increase the likelihood of being bullied even among those with social phobia and OCD. They found that patients with OCD had higher rates of autistic traits compared to those with social phobia and healthy controls. This group also reported higher rates of victimization (50%) compared to patients with social phobia (20%) and healthy controls (27%). Thus, having autistic traits increased the likelihood for becoming a victim among patients with OCD.

Children with ASD who reported higher levels of anxiety, hyperactivity, self-injurious, and stereotypic behaviors were more likely to experience higher levels of victimization (Cappadocia et al., 2012). These children were five times more likely to
have major communication difficulties. Victims were found to be much younger than bullies, have fewer friends at school and were 11 times more likely to have higher levels of child internalizing disorders (e.g., depression, anxiety).

*Developmental Inhibitory Neuro-Endophenotype*

Persistent poor inhibitory regulation of emotional and cognitive behavior may increase the risk for becoming a target of bullying. Behavioral evidence demonstrates that VC display deficits in top-down inhibitory control of both cognitive and emotional responses. Studies have found that girls who had difficulty regulating their anger responses were at higher risk for victimization. Boys who poorly suppressed their sadness and worry reported higher levels of victimization (Alsaker & Gutzwiller-Helenfinger, 2010). Additionally, children in kindergarten who showed deficits in top-down inhibition of distractions were at a higher risk for victimization (Alsaker & Nägele, 2008; Alsaker & Gutzwiller-Helenfinger, 2010).

Evidence suggests that proficiency for top-down attentional modulation at early stages of sensory processing continues to change during childhood and early adolescence (Bunge, Dudukovic, Thomason, Vaidya, & Gabrieli, 2002; Taylor, Chevalier, & Lobaugh, 2003). Similar findings have been reported in studies on top-down attentional control in children, as reflected in EEG oscillatory activity (Klimesch et al., 2001; Krause, Salminen, Sillanmaki, & Holopainen, 2001). Parietal-occipital alpha was reported to be mature in children ages 10 to 12 years (Krause et al., 2001; Krause, Pesonen, & Hämäläinen, 2010) and found to be a sensitive indicator of cognitive inhibitory task demands (Gevins, Smith, McEvoy, & Yu, 1997; Nunez, Wingeier, &
In our earlier study (Ciesielski et al., 2010), we used magnetoencephalography (MEG) in 10-year-old children to examine developmental differences in top-down control reflected in modulation of alpha-band (8–13 Hz) to different stages of a working memory task with high demand for inhibitory control.

A recent study suggested, that focusing only on single-peak effects or one frequency band may lead to an incomplete understanding of the mechanisms involved in signal processing in stop-response tasks (Huster et al., 2014). The authors suggested that a closer view of cortical activation to stop signal processing may be attained by using the analysis of connectivity patterns and their dynamic changes over time or spatio-temporal analysis of spectral oscillatory activity. The authors conclude that the critical time for observation of effects of inhibitory brain action is prior to 200ms post stop-stimulus presentation.

Stop-response task paradigms have been applied effectively in studies of inhibitory control development. The characteristic findings report a sharp reduction in reaction time of responses between childhood and adulthood (van den Wildenberg & van der Molen, 2004). Developmental studies have found involvement of the frontal-basal ganglia networks in response inhibition, both in adults and in children, and corresponding activation in the frontal and parietal cortex (Cohen et al., 2010). Most developmental neuroimaging studies use fMRI and mostly focus on the prefrontal cortical component of the frontal-basal ganglia network. These have reported both increases (Ordaz et al., 2013) and decreases (Durston et al., 2002) in prefrontal ventral activation related to inhibiting a response. The contrast, increasing with age, between higher activity in control regions relevant to inhibition and reduction of activity to non-specific regions has also been
reported (Ciesielski et al., 2006; Crone & Dahl, 2012; Durston & Casey, 2006; Luna et al., 2010; Stephen et al., 2006).

Summary

Deficits in inhibitory control are well associated with phenomenology of psychopathological disorders such as ASD or OCD. Early identification of such visual inhibitory cognitive deficits, may point to risks for becoming a target of bullying victimization. We aimed to examine whether abnormal top-down inhibitory control of cognitive and emotional responses and ERPs, their neurophysiological correlates, may be the elucidating fundamental neurological characteristic of all children victims and, thus, a biological marker of children at high risk for becoming a victim of bullying. Defining a reliable neural correlate of cognitive inhibitory control will be important for studying developmental changes in the brain mechanism underlying adaptive behavior in the challenging conditions of bullying victimization (Badre, Kayser & D'Esposito, 2010).
**Aims & Hypotheses**

To understand the mechanism of causes and effects of bullying in VC we aimed:

**AIM 1:** To characterize in VC, as compared to CC, the Trait Signatures considered in developmental neuroscience to reflect permanent, pre-existing cognitive and neural functions underlying top-down inhibitory control of behavior. Thus, considering the clinical and research reports we expected in VC as compared to CC:

H1: Preserved functioning in earlier learned skills (e.g., verbal knowledge) less susceptible to adverse events, but reduced performance in visual-spatial attention and memory linked to symptoms of anxiety;

H2: Increased anxiety measures (e.g., CY-BOCS) and a history of poor social interactions;

H3: Consistent reduction in alpha power and its task-related modulation, particularly in the frontal and parietal brain regions.

**AIM 2:** To characterize State Signatures (SS) in VC, as compared to CC by examining the cognitive, emotional and social effects of exposure to bullying.

Considering the aforementioned studies, we predicted in VC:

H1: Higher levels of depressive symptomology and traumatic experiences;

H2: Significant deficits in visuospatial tasks with high demands for organization and in verbal and visual memory tasks;

H3: Poor, ineffective and mostly negative peer interactions, most likely related to cognitive and emotional deficits.

**AIM 3:** The end goal was to identify risk factors for translational outcomes of this study to facilitate programs of resilience in children vulnerable to victimization.
METHODOLOGY

Participants

A total of 46 children were recruited from the community (81.3%) and others were invited from a longitudinal, developmental study (18.8%). In total, 17 children-victim of bullying (VC) and 17 age and sex matched control children (CC) participated in the study. The parents of the remaining 12 children recruited found it too time consuming to complete the testing. All participants and their parents signed informed consent and assent forms according to the guidelines of the Office of the Institutional Review Board at the University of New Mexico. Inclusion criteria for VC included repeated experiences with being a target of bullying victimization. Children in both groups were between age 6 to 17 years. Exclusionary criteria for CC included history or current clinical diagnosis of any DSM-5 disorder and any history of being a bully or a victim of bullying. History of CNS medication, traumatic brain injury, medical conditions (e.g., seizures, tuberculous, genetic disorders) were exclusionary.

Measurements/Tasks

Cluster 1. Trait Signatures: Neurobehavioral and EEG Measurements

Consistent with our predictions that anxious children with deficient inhibitory control would be in the high-risk group for bullying victimization, we clustered the psychometric tools that reflect these characteristics into CLUSTER 1, the Trait Signatures cluster. The tests included in this cluster were:

Wechsler Abbreviated Scale of Intelligence (Second Edition; Wechsler, 2011) – Vocabulary (WASI-V). WASI-V was used to assess well learned and crystalized
abilities. It measures the participants knowledge of words and verbal concepts. The subtest includes three-picture items and 38 verbal items. Participants were asked to define words presented visually and orally.

*Rey-Osterrieth Complex Figure Test* (Rey, 1941|1993; Osterrieth, 1944|1993) – *Copy* (CFT-C). CFT-C trial was used to assess visual-spatial attention, perception and organization. Participants were instructed to copy a complex visual construct, which requires low verbal mediation.

*NIH Toolbox - Flanker Inhibitory Control and Attention Test* (Hodes, Insel, & Landis, 2013; NIH-FICA). NIH-FICA was used to measures attention and executive function. The participant was asked to focus upon an arrow located in the middle of the screen while inhibiting attention to stimuli nearby (i.e., other arrows). Participants responded by pressing buttons to congruent and incongruent signals (i.e., 20 mixed trials). There were four practice trials with audio recording feedback.

*Child Yale–Brown Obsessive-Compulsive Scale* (Scahill et al., 1997; CY-BOCS). CY-BOCS was used to measure the severity of obsessive and compulsive symptoms. The scale was comprised of a symptom checklist, target symptom list and severity rating on 10-items. The scale was administered to parents only.

*The Social Communication Questionnaire* (Rutter, Bailey & Lord, 2003; SCQ). SCQ was used to measure ASD symptomatology. The screening questionnaire provided levels of severity of ASD symptoms across different samples of behavior. Sub-scores provided information on abnormal social interactions, communication and restricted, repetitive and stereotyped patterns of behavior. The scale was administered to parents only.
Structured Clinical Interview Parents provided information and records of demographic data, prenatal and postnatal early development, and medical, personal and family history. They also provided history of peer and family social interactions for their child.

The normalized CFT-C and NIH-FICA scores were combined to provide a composite score i.e., Visual Attention Index (VA-I). Scores indicate the standard deviations above or below the mean. Responses describing past peer interaction from the structural clinical interview and SCQ scores were combined to provide a Social Interactions Index (SI-I) for both VC and CC. Higher scores indicated higher levels of social interaction difficulties.

Blue Man-Stop Response Task (BM-SRT Task; Ciesielski, 2003; Bouchard et al., 2018; presented in Figure 1). BM-SRT is a visual-spatial n-back working memory task with a stop-response signal. It was designed in the form of a computer game for children. Participants were instructed to concentrate on a fixation point and carefully observe the Blue Men characters (angle size 2°) that were individually presented on the screen (each for 200 ms). When the stop-response signal (i.e., blue soccer ball) was presented, the participants were asked to decide if the two consecutive characters preceding the stop-response signal were congruent or non-congruent in visual-spatial orientation. Participants were permitted to respond when presented with the stop-release-signal (i.e., green dot). There were four awaiting-for-response periods between the soccer ball and green dot: 1000ms, 1600ms, 3200ms and 4200ms.

The experiment was presented in six separate runs, lasting about three minutes each, all consisting of 20 to 22 trials, for a total of 126 trials. All participants practiced
the task in a separate room before being prepared for the EEG to ensure familiarization. They also completed a short practice run (i.e., 12 trials) in the EEG chamber, for which the data were not recorded.

Figure 1. Schematic of Blue Man-Stop Response Task (BM-SRT). BM-SRT is a visual-spatial n-back working memory task with a stop-response signal. The task was to carefully observe individually presented Blue Men characters. When the stop-response signal (i.e., blue soccer ball) is presented, participants must decide if the last two consecutive characters were congruent or non-congruent in visual-spatial direction and respond when presented with the stop-release signal (i.e., green dot). The correct response for the sample trial above is congruent (Ciesielski, 2003; Bouchard et al., 2018).

Electrophysiological Data Acquisition.

Data for BM-SRT was collected with a BioSemi High Density EEG 64-channel recording system (BioSemi B.V., Amsterdam, Netherlands) in a dimly lit room that was noise and electromagnetic field shielded. EEG was recorded at a sampling rate of 512 Hz and pass filtered online with a frequency of 0.16-100 Hz. The 64 channels were placed
according to the international 10-20 system using the BioSemi Active2 system. Vertical and horizontal eye movements were recorded using four electrooculography (EOG) electrodes, two of which were placed on the outer eye canthi and two below and above the left eye. Two additional reference electrodes were placed on the left and right mastoids. All electrode locations were digitized using Polhemus. The experiment was conducted using the Presentation software (Version 11.3) and responses were collected using Current Designs 4 button Inline USB response box.

**Cluster 2. State Signatures: Neurobehavioral Measurements**

Consistent with the reported literature and our own hypotheses about the depressive traits and related deficits in visual attention and memory, the psychometric measurements expected to reveal the immediate consequences of victimization of bullying were clustered into a battery of tasks named **CLUSTER 2**. These elucidated the State Signatures of VC, which included:

*Rey-Osterrieth Complex Figure Test* (Rey, 1941|1993; Osterrieth, 1944|1993) – *Delayed Recall* (CFT-DR). CFT-DR trial was used to assess visual-spatial perception, attention, memory and organization. After participants were instructed to copy an abstract image, they were asked to draw the image from memory after a 30-minute delay.

*Wechsler Abbreviated Scale of Intelligence (Second Edition; Wechsler, 2011) – Block Design* (WASI-BD). WASI-BD was used to assess visual perception and organization, nonverbal concept formation, and visual motor coordination. Participants were asked to recreate two-dimensional designs from patterns in stimulus booklet using...
blocks with red and white coloring. The test was time-limited, with extra-credit points for fast rate of performance.

*Wechsler Abbreviated Scale of Intelligence (Second Edition; Wechsler, 2011) – Matrix Reasoning* (WASI-MR). WASI-MR was used to assess fluid intelligence, visual-spatial skills, and perceptual organization. The participants were asked to select response options that complete a matrix or a sequence of stimuli.

*Wechsler Abbreviated Scale of Intelligence (Second Edition; Wechsler, 2011) – Similarities* (WASI-S). WASI-S was used to assess verbal concept formation and reasoning. Participants were given two words that represent similar objects or concepts and they had to describe in their own words how these two objects were similar to each other.

*Benton Oral Word Fluency Test - FAS* (Benton & Hamsher, 1976; FAS). FAS was used to assess phonemic verbal fluency. Participants were instructed to say as many words as possible within a minute, when given the letters F, A, or S; excluding proper names, changing endings, or slang.

*Children’s Depression Rating Scale-Revised* (Poznanski & Mokros, 1996; CDRS-R). CDRS-R was used to measure depression and severity of symptoms. The questionnaire (parent version) was a semi structured interview that provided a cumulative score for interpretation of scores representing behavioral and mood characteristics of a child.

*Questionnaire on Traumatic Experiences in Early Childhood* (Tretiak & Ciesielski, 2014; QTE). QTE was used to assess the participant’s history of exposure to
potentially traumatic life experiences. The 10-item questionnaire assessed direct exposure to accidents or violence before the age of one, three, five, and ten.

*Illinois Bully Scale* (Espelage & Holt, 2001; IBS). IBS measured the frequency of bullying, fighting and victimization by peers in the last 30 days. The psychometrics are high for all subscales (i.e., bullying = 0.87; fighting = 0.83; victimization = 0.88). The same questions were used to inquire about the participant’s history of bullying victimization.

To control for multiple statistical comparisons, the normalized CFT-DR, WASI-BD, WASI-MR scores were combined into a composite score named *Visuo-Spatial Index (VS-I)*. A relationship to normative score is provided in number of standard deviations. The *Verbal Expression Index (VE-I)* included normalized WASI-S and FAS scores. The scores obtained from IBS were combined from the assessment of history of bullying victimization which provided an overall *Bullying Victimization Severity Index (BVS-I)* for VC.

**Data Analysis**

*EEG.* Data were processed using EEGLAB toolbox for MATLAB (Delorme & Makeig, 2004), which is an open source toolbox available for EEG signal processing. Data was re-referenced to the average of the signal from the two mastoid electrodes. Channel data from frontal and posterior regions were analyzed, which included left frontal (LF; i.e., F1, F3, FC1, FC3), right frontal (RF; i.e., F2, F4, FC2, FC4), left parietal (LP; i.e., P1, P3, PO3, O1), and right parietal (RP; i.e., P2, P4, PO4, O2) regions.
Only correct and congruent responses during the latency period (i.e., “waiting-to-respond” window) in the BM-SRT were analyzed. The first 150ms of the first 1000ms were removed and 150ms to 450ms after the stop-signal were averaged for analysis from all four waiting latency periods (i.e., 1000ms, 1600ms, 3200ms, 4200ms). A high pass filter of 0.01 Hz to 0.20 Hz was applied. Noisy channels were removed, and the data were re-calculated to the average reference. Data were segmented into 2400ms epochs (200ms pre-stimulus to 1000ms post-stimulus) and baseline corrected to the mean pre-stimulus baseline. Interference signals resulting from gross body movements were removed from the continuous data. An independent component analysis (ICA) was then conducted to remove eye blinks and saccades. Spatial topography maps of the ICA components were manually inspected to identify physiological activity and noisy components were removed (Onton, 2010).

For each participant, the average alpha spectral power was calculated across the four regions (i.e., LF, RF, RP, LP) using a custom written MATLAB script (The MathWorks, Inc., Natick, MA). The spectral power was calculated using the decibel (dB) conversion, which is the ratio between the strength of one signal (i.e., alpha frequency band power) and the strength of another signal (i.e., baseline power of the same frequency band; Cohen, 2014).

Statistical Analysis

Neurobehavior. Statistical data analysis was conducted using IBM SPSS version 24 and R version 3.4.3. Descriptive and frequency statistics were used to test for any significant relationship between groups. Two-tailed independent t-tests were conducted
to determine statistical significant differences between VC and CC on the neurobehavioral indices and behavioral reports of symptomology. False discovery rate (FDR) was calculated to control for multiple comparisons using the Benjamini-Hochberg (BH) method (Benjamini-Hochberg, 1995), when appropriate. Cohen’s $d$ was calculated to determine effect size, which was interpreted as .2 for small, .5 medium and .8 or greater as large effects sizes (Cohen, 1988). Pearson’s $r$ two-tailed correlations were conducted for within-group analysis.
RESULTS

Rationale

The goal of this study was to characterize Trait Signatures (TS) and State Signatures (SS) displayed by VC in contrast to CC. TS were assessed as representing the long-term, some permanent and most likely pre-existing characteristics of children (e.g., demographics, prenatal and early postnatal development of language and social interactions) that are vulnerable to becoming a target of bullying. SS, in contrast, were assessed to identify the cumulative detrimental effects of bullying victimization on cognitive, emotional and social functioning, as predicted by earlier studies. Our far-reaching goal is to investigate whether children with a specific pattern of TS may form a population that is at high-risk to becoming victims of bullying and translate these results to models of early identification and thus, offering a preventive intervention.

Presented below are three sets of data: i.) demographics of both tested populations, as a potential variable that may contribute to our understanding of a differences in pattern of TS in VC population; ii.) TS measures, including scores on anxiety tests, and pattern of alpha oscillatory activation during inhibitory control of behavioral response, that were considered a long-term physiological indicator of top-down inhibition; and iii.) SS data, that involved measures of consequences of exposure to bullying in the emotional, social and cognitive domain.

Demographics

A total of 34 children (17 VC) completed all study tests and procedures. One participant from each group were excluded due to their difficulty to follow task rules or
disclosure of exclusionary criteria during study participation. A total of 16 VC and 16 CC were included in the final analyses. Participant characteristics are described in Table 1.

Majority of the participants in the VC group identified as Hispanic (56.3%), while CC generally identified as non-Hispanic, White (43.8%). The majority of VC were in middle school (37.4%), while CC in elementary school (56.3%). There were no significant group differences observed in race/ethnicity identification or SES as reported in Table 1. The groups did not differ in terms of Verbal Comprehension Index (VCI; \( t_{24.7} = -1.53, p = .14 \)) or the Perceptual Reasoning Index (PRI; \( t_{30} = -1.74, p = .09 \)), calculated from WASI-II.
Table 1.

Participant Demographics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Children-Victim (n=16)</th>
<th>Control Children (n=16)</th>
<th>p&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>M</td>
</tr>
<tr>
<td>Age</td>
<td>12.5</td>
<td>3.01</td>
<td>10.4</td>
</tr>
<tr>
<td>SES&lt;sup&gt;b&lt;/sup&gt;</td>
<td>46.3</td>
<td>11.3</td>
<td>47.2</td>
</tr>
<tr>
<td>WASI-VCI</td>
<td>102</td>
<td>8.7</td>
<td>108</td>
</tr>
<tr>
<td>WASI-PRI</td>
<td>96.9</td>
<td>9.4</td>
<td>104</td>
</tr>
<tr>
<td>Sex</td>
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<td></td>
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<td>56</td>
<td>8</td>
</tr>
<tr>
<td>Male</td>
<td>7</td>
<td>44</td>
<td>8</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
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<td></td>
<td></td>
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<td>American Indian</td>
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<tr>
<td>Asian</td>
<td>1</td>
<td>6.3</td>
<td>0</td>
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<td>Bi-racial</td>
<td>3</td>
<td>18.8</td>
<td>0</td>
</tr>
<tr>
<td>Black/African American</td>
<td>1</td>
<td>6.3</td>
<td>0</td>
</tr>
<tr>
<td>Hispanic</td>
<td>9</td>
<td>56.3</td>
<td>8</td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td>2</td>
<td>12.5</td>
<td>7</td>
</tr>
<tr>
<td>School Grade</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elementary School</td>
<td>5</td>
<td>31.3</td>
<td>9</td>
</tr>
<tr>
<td>Middle School</td>
<td>6</td>
<td>37.4</td>
<td>3</td>
</tr>
<tr>
<td>High School or higher</td>
<td>5</td>
<td>31.3</td>
<td>4</td>
</tr>
</tbody>
</table>

Note. No group differences in demographic characteristic between Children-Victim and Control Children.

WASI-VCI=WASI-II Verbal Comprehension Index; WASI-PRI=WASI-II Perceptual Reasoning Index

<sup>a</sup>Significance was evaluated by independent sample t-tests. <sup>b</sup>According to Hollingshead socioeconomic status codes (Hollingshead, 1975).
**Trait Signatures**

*Between-Group Analysis*

*Neurobehavioral Measurements.* Independent *t*-tests were conducted to determine statistical significant differences between VC and CC on the WASI-Vocabulary (WASI-V) and Visual Attention Index (VA-I). FDR correction was employed to control for multiple comparisons and the adjusted *p*-value was estimated using the BH method (hereinafter, only adjusted *p* *BH*-values are reported when appropriate). There was a statistically significant group difference in performances between groups in WASI-V and VA-I (as reported in Appendix A).

Independent *t*-tests were used to assess group differences in the Social Interaction Index (SI-I), CY-BOCS and performance of correct responses on BM-SRT. Significant group differences were observed in the SI-I (*p* *BH* = .018), with VC reporting higher rates of poor peer relationships, evidenced even in their early school years. CY-BOCS was not statistically different between VC and CC, however, a medium effect size was observed in VC. Due to high levels of noise during BM-SRT, one VC and two CC, were removed from all related analysis, including correct responses. No significant differences were observed for correct responses in the BM-SRT across both groups (*t* *27* = 1.01, *p* = .32, *d* = .39).
Figure 2. Contrasts in Trait Signatures between Children-Victim (VC) and Control Children (CC). There was a significant difference in WASI-V, VA-I, and SI-I between VC and CC, even after adjusting for multiple corrections using the False Discovery Rate. Numerical findings are in Appendix A. WASI-V=WASI-II Vocabulary; VA-I=Visual Attention Index; SI-I=Social Interactions Index; CY-BOCS=Child Yale–Brown Obsessive-Compulsive Scale.

Alpha Amplitude for BM-SRT.

The alpha power was assessed during the delay period while awaiting to respond across four cortical regions (i.e., LF, RF, LP, RP). Independent t-tests were conducted to test for statistical significant differences between VC and CC spectral alpha power. As indicated before, one VC participant and two CC participants were removed from further data processing due to high level of motion noise in data. No significant group differences in alpha power were observed in any brain region as seen in Table 2.
Table 2.

 Trait Signatures: Alpha Amplitude for BM-SRT

<table>
<thead>
<tr>
<th>Region</th>
<th>VC</th>
<th></th>
<th>CC</th>
<th></th>
<th>t</th>
<th>df</th>
<th>p^a</th>
<th>d</th>
<th>95% CI of d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Frontal</td>
<td>0.18</td>
<td>0.24</td>
<td>0.22</td>
<td>0.26</td>
<td>-0.44</td>
<td>27</td>
<td>.67</td>
<td>-0.17</td>
<td>-0.25 to 0.08</td>
</tr>
<tr>
<td>Right Frontal</td>
<td>0.44</td>
<td>0.41</td>
<td>0.51</td>
<td>0.53</td>
<td>-0.44</td>
<td>27</td>
<td>.67</td>
<td>-0.15</td>
<td>-0.32 to 0.01</td>
</tr>
<tr>
<td>Left Parietal</td>
<td>0.56</td>
<td>0.68</td>
<td>0.57</td>
<td>0.85</td>
<td>-0.04</td>
<td>27</td>
<td>.97</td>
<td>-0.01</td>
<td>-0.28 to 0.26</td>
</tr>
<tr>
<td>Right Parietal</td>
<td>0.67</td>
<td>1.00</td>
<td>0.65</td>
<td>1.10</td>
<td>0.07</td>
<td>27</td>
<td>.95</td>
<td>0.02</td>
<td>-0.35 to 0.39</td>
</tr>
</tbody>
</table>

Note. Significance was evaluated by independent sample t-tests. \( d = \) Cohen’s \( d \) effect size; CI=Confidence Interval; LL=Lower level; UL=Upper Level.

*Uncorrected for multiple comparisons \( p \) value

Within-Group Analysis

EEG. Pearson’s \( r \) correlations revealed strong power coherence between frontal and parietal regions in both VC and CC, as indicated in Figure 3. A positive statistically significant correlation was found between the LP and RP in both VC (Pearson’s \( r(15) = .98, \ p_{BH} < .001 \) ) and CC (Pearson’s \( r(14) = .96, \ p_{BH} < .001 \) ) during the BM-SRT. Further, there were significant correlations between higher percent of correct responses in BM-SRT and high alpha power in LP, RF and LF \( (p_{BH} = .044, p_{BH} = .044, \ & p_{BH} = .049, \) respectively) regions in CC only.
Figure 3. Alpha Power Correlograms. Pearson \( r \) values are represented in the correlograms for a) Victimized Children (VC) and b) Control Children (CC) between frontal-parietal areas during BMT-SRT awaiting-to-respond period. The size of the circle indicates the strength of correlation (e.g., bigger circle, stronger relationship), while the color represents the direction of relationship (e.g., positive or negative correlation). Both correlograms demonstrate a positive correlation in frontal-parietal regions for VC and CC. Numerical findings are in Appendix B.

**Neurobehavioral.** Pearson’s \( r \) correlations were conducted to determine if alpha power was correlated with family history of anxious and OCS disorders and severity of victimization. As seen in Table 3, no significant findings were found, however, there were medium effect sizes observed in alpha power and history of DSM-5 disorders in VC. CC did not have significant findings as seen in Appendix C.
Table 3.

*Trait Signatures: Neurobehavioral Correlations in Children-Victim*

<table>
<thead>
<tr>
<th>Variables</th>
<th>H-DSM</th>
<th>BVS-I</th>
<th>LF</th>
<th>RF</th>
<th>LP</th>
<th>RP</th>
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</thead>
<tbody>
<tr>
<td>H-DSM</td>
<td>-</td>
<td>.20</td>
<td>-.42</td>
<td>-.42</td>
<td>-.38</td>
<td>-.35</td>
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<tr>
<td>BSI-I</td>
<td>-</td>
<td>-.02</td>
<td>-.09</td>
<td>-.11</td>
<td>-.10</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Pearson’s $r$ values presented. H-DSM=History of DSM-5 Disorders; BVS-I=Bullying Victimivation Severity Index; LF=Left Frontal; RF=Right Frontal; LP=Left parietal; RP=Right Parietal.

**Conclusions:** Trait Signatures displayed by VC as compared to CC involved:

(i) Significant deficits in basic cognitive and visual attention abilities;

(ii) Higher levels of anxiety characteristics prior to victimization (e.g., displayed more prevalent OCS phenomena);

(iii) No significant group differences in alpha power were recorded during top-down inhibition of motor act and the correlations between alpha power in frontal-parietal network were not statistically significant between groups either.
State Signatures

Based on the participant’s reporting, verbal victimization was the most prevalent (88%), such as being called derogative names or receiving demeaning commands. Other frequently experienced bullying acts, were social victimization expressed in exclusions and ridiculing in front of others (19%) and physical victimization including hitting and pushing (19%). Further, 25% of VC reported having experienced all three forms of bullying victimization. On average, 63% of VC had been bullied multiple times within the last 30 days as reported by the Illinois Bully Scale (Espelage & Holt, 2001). The scores on this scale suggested that severity of bullying victimization phenomena was within a moderate range.

Between-Group Analysis

Neurobehavioral Measurements. Independent t-tests were conducted to determine statistical significant differences between VC and CC on the Visuo-Spatial Index (VS-I) and Verbal Expression Index (VE-I). There were no statistically significant group effects of bullying victimization on either measure. However, there was large effect size observed for VS-I according to Cohen’s $d$ effect size (Cohen, 1988).

Independent t-tests, were used to assess group differences in SS of emotional and social functioning. Significant group differences were observed in CDRS-R ($t_{20.33} = 3.88$, $p_{BH} = 0.002$, $d = 1.47$), showing higher depression symptoms in VC relative to CC. There was a significant difference in the QTE ($t_{24.65} = 2.08$, $p_{BH} = 0.048$, $d = 0.76$) and BVS-I ($t_{30} = 6.22$, $p_{BH} < 0.001$, $d = 2.22$), which indicated VC reported higher number of
traumatic experiences and bullying victimization severity than CC. Further, large effect sizes were observed across all three measures as seen in Appendix D.

Figure 4. Contrasts in Neurocognitive State Signatures between Children-Victim (VC) and Control Children (CC). There was a significant difference in VS-I between VC and CC but was no longer significant after adjusting for multiple comparisons. There was no significant difference found in VE-I between VC and CC. Numerical findings are in Appendix D. VS-I=Visuo-Spatial Index; VE-I=Verbal Expression Index.
Figure 5. Contrasts in Clinical State Signatures between Children-Victim (VC) and Control Children (CC). There was a significant difference in CDRS-R and QTE between VC and CC, even after adjusting for multiple corrections using the False Discovery Rate. Numerical findings are in Appendix D. CDRS-R=Children’s Depression Rating Scale-Revised; QTE=Questionnaire on Traumatic Experiences in Early Childhood.

Within-Group Analysis

Neurobehavioral. Pearson’s $r$ correlations were conducted to examine if severity of cognitive and emotional deficits was correlated with current state of peer victimization (SS-PV) in VC. No statistically significant correlations were found between VS-I ($p_{BH} = .71$), VE-I ($p_{BH} = .20$), and QTE ($p_{BH} = .58$). However, there was a significant relationship in the CDRS-R ($r = .68$, $p_{BH} = .032$), indicating higher scores in depression.
symptomology and severe negative peer interactions. There was a medium effect size between SS-PV and VE-I ($r = -.44$) as reported in Table 4 (Cohen, 1988).

Table 4.

State Signatures: Neurobehavioral Correlations in Children-Victim

<table>
<thead>
<tr>
<th>Variable</th>
<th>SS-PV</th>
<th>VE-I</th>
<th>VS-I</th>
<th>CDRS-R</th>
<th>QTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS-PV</td>
<td>-</td>
<td>-.44</td>
<td>-.11</td>
<td>.68*</td>
<td>.22</td>
</tr>
</tbody>
</table>

*Note. Pearson’s $r$ values presented. Multiple comparisons controlled using False Discovery rate. SS-PV=State Signatures Peer Victimization; CDRS-R=Children’s Depression Rating Scale-Revised; QTE=Questionnaire on Traumatic Experiences in Early Childhood; VS-I=Visuo-Spatial Index; VE-I=Verbal Expression Index. *$p < .05$

**Conclusions:** Our key findings in State Signatures for VC as compared to CC were:

(i) Significantly higher levels of depressive moods;

(ii) Significant deficits in visuospatial memory and visually mediated conceptualization;

(iii) Ongoing traumatic experiences including bullying victimization.
DISCUSSION

The central aim of the present study was to characterize children-victim (VC) by peer bullying victimization on two dimensions, Trait Signatures precipitating the abuse, and State Signatures, the long-term consequences of persistent abuse. The neurobehavioral and electrophysiological assessment of VC using a battery of tests representing Trait Signatures showed, in VC as compared to CC, significantly higher levels of anxiety including social situations, in line with lower visual-spatial attentional skills and attention to visual details. VC also showed higher compulsivity as reported by CY-BOCS. This may indicate lower top-down inhibitory control which may further hinder their social interactions. It is of interest, however, that in this context the event-related potentials data did not reveal significant group differences in power of alpha oscillatory activity within the frontal-parietal network, implicated in top-down inhibitory regulation of behavior (Bressler et al., 2008).

Alpha power is the earliest maturing oscillatory rhythm in the central nervous system, which becomes relatively stable after the age of 5. This make it an ideal developmental factor to study as a TS. The above result of no group differences may result from suppression of alpha relative to baseline as compared to CC. Additionally, we found large effect sizes in the relationship between alpha power in the left frontal and right frontal regions in the first-degree familial history of psychiatric disorders in the VC group. Alpha power in these regions was negatively correlated with familial psychiatric disorders.
The no-group differences in alpha may suggest two additional possible explanations, considering that there were no group differences on the BM-SRT performance. The task we were employing to gather EEG spectral oscillatory brain activity was not specific to the population of VC and relied mostly on controlling a pure motor response. Including an emotionally charged stimuli in future studies would be more specific to VC high anxiety characteristics. The second explanation may consider the severity of anxiety, that in this study was within a mild-to-moderate level, and its impact on a child’s behavior may be modest, but, yet sufficient to make VC more susceptible to becoming a target of bullying. Participants in this study represent a healthy child population with verbal general intellectual abilities and perceptual intellectual abilities showing no significant group differences and remaining within average-to-high average intellectual level. The cognitive task we used in the EEG laboratory might have been relatively easy to take. However, in a socially challenging interaction with their peer group, these children’s anxiety and poor visual-spatial attention to details may be a challenge in responding fast and appropriately to the aggressive behavior of others. Future investigations of the mechanism of bullying in young children must include an emotionally charged stimuli and include children with higher levels of severity of victimization.

The description of a child vulnerable to victimization by bullying is complemented by our findings of State Signatures. VC, as compared to CC, showed significantly higher levels of depressive moods and, consistent with the depressive symptoms, increased difficulties in visual-spatial memory and conceptualization. The scale levels for assessing past and current traumatic experiences including bullying
victimization, was significantly higher in VC. Thus, the SS records display a child with significant depression that adds to primary existing anxious states. The past experience of traumatic events, and current low social abilities demonstrate a child at high risk for social victimization.

Of interest, are our findings on consistent visual-spatial attention and memory problems in the VC group. This abnormality in visuospatial processing is similar to children who have been maltreated and display symptoms of Posttraumatic Stress Disorder (PTSD; De Bellis, Woolley & Hooper, 2013; Vasilevski & Tucker, 2016; Barrera-Valencia, Calderon-Delgado, Trejos-Castillo, & O’Boyle, 2017). Further, both emotional processing and visuospatial processing are associated with right hemisphere functioning (Liotti & Mayberg, 2001), which has been suggested to influence the ability to properly attend to taxing emotional effort due to high levels of negative emotions.

There was no difference found in verbal functioning in either group. The FAS subtest, included in the Verbal Expression Index (i.e., FAS, WASI-S), requires flexibility but provides the ability for participants to choose their own wording. This indicates that VC have adequate ability in their expressions when they are cognitive and not emotional, which is related to relatively intact left hemisphere functions. In consistency, Beers and De Bellis (2002) also found no difference in FAS and Similarities among children who had maltreatment-related PTSD.

Parental reports of VC revealed higher levels of depression as compared to CC, which is consistent with other studies focusing on consequences of bullying in children (Nishina et al, 2005). Farrington and colleagues (2012) found that bullying victimization was a significant predictor of depression up to seven years later after controlling for other
major childhood adverse traumatic events. Additionally, VC reported higher rates of traumatic experiences in contrast to CC of other nature, not only victimization by bullying. This is of significant concern since experiencing trauma can alter developmental trajectory of a child’s emotional, behavioral, and cognitive growth as seen with children who have been maltreated or abused. Sensitive periods during development in early adolescence related to synaptic pruning and development of myelination is essential to healthy development of networks (Fair et al., 2007; Schaefer et al., 2014; Meng & Xiang, 2016; Stevens, 2016) and can be severely delayed due to trauma (Wilson, Hansen, & Li, 2011). This delay of myelination can in turn lead to functional deficits in attention, executive functions and visual-spatial processing.

Our data indicated that VC displayed TS deficits in verbal memory and knowledge. This may leave them less effective in verbal communication and more vulnerable to bullying. However, this finding may be biased due to cultural constraints of the test such as the predominate mainstream culture acceptable responses. We posit this shortcoming in vocabulary in children from minority cultures may have a significant impact in initiation of everyday social communication and may represent actual social communication in typical contexts. Parents often reported that VC were bullied because of their poor verbal communication skills.

The TS and SS data are crucial for our understanding of the roots of child’s vulnerability to becoming a victim of bullying and provide us with markers that we need to focus on to when aiming for early identification of children at risk for bullying victimization. Further, the results open a possibility to translate them into an effective intervention program that could be developed very early before children enter the primary
school environment. These preventive interventions must address emotional anxiety treatment, increase child resilience and assist in perception and interpretation of social cues.

There are many other risk factors that we need to include in a successful design of preventive programs, such as gender and SES. Although the racial and ethnic composition of both groups in our study were diverse and representative of the population in New Mexico, VC children had slightly higher rates of racial/ethnic minority backgrounds compared to CC.

Study Limitations

A potential limitation in our study was the variable and relatively moderate levels of severity and short length of exposure in tested children. This could underlie the modest spectral power effect size seen during the BM-SRT. Increasing these effects may require in future studies at least three levels of experienced bullying severity, a low to moderate, severe and prolonged, and no exposure to bullying. Therefore, it is notable, that although we tested children with only a mild-to-moderate severity of bullying exposure, children-victim still revealed high levels of depression, slowness in fluency of verbal expression and in attention to complex visual attention. Other limitations to our model of Trait and State characteristics of Children-Victim include a small sample size and relatively broad age-range of tested children, that could introduce an extra developmental variance. These properties of the design could only be addressed within a larger program of studies.
Future Studies

The current findings will form a foundation for future translational studies investigating State and Trait Signatures of victimization by social bullying in neuroimaging of cognition, psycho-motor coordination, as well as emotional and social development.

Summary

In conclusion, the study aimed to characterize risk factors for bullying victimization displayed in Trait Signatures, which were hypothesized to precipitate the susceptibility to victimization and to State Signatures resulting from bullying. We found that Children-Victim manifesting Trait Signatures, in visual attention and verbal communication along with traits of anxiety and obsessive-compulsive phenomena, although not manifesting differences in alpha power during top-down inhibition of motor responses, were at a higher risk for bullying victimization. Among State Signatures of Children-Victim, through rigorous testing of neuropsychological skills, significant deficits were found in complex visuospatial perception, memory and organization, dysfunctions that may contribute to poor interpretation of social cues. The ultimate-aim of this study was to further facilitate efforts toward designing empirically based programs of resilience against bullying for young children.
## APPENDIX A

**Trait Signatures: Neurobehavioral Measurements**

<table>
<thead>
<tr>
<th>Measure</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
<th>t</th>
<th>df</th>
<th>p*</th>
<th>d</th>
<th>95% CI of d</th>
</tr>
</thead>
<tbody>
<tr>
<td>WASI-V</td>
<td>0.044</td>
<td>0.74</td>
<td>0.61</td>
<td>0.70</td>
<td>-2.23</td>
<td>30</td>
<td>0.33*</td>
<td>-0.81</td>
<td>-1.05, -0.57</td>
</tr>
<tr>
<td>VA-I</td>
<td>-0.79</td>
<td>0.96</td>
<td>-0.12</td>
<td>0.50</td>
<td>-2.28</td>
<td>30</td>
<td>0.019*</td>
<td>-0.9</td>
<td>-1.16, -0.65</td>
</tr>
<tr>
<td>SI-I</td>
<td>3.93</td>
<td>1.74</td>
<td>2.32</td>
<td>1.37</td>
<td>2.80</td>
<td>28</td>
<td>0.009*</td>
<td>1.06</td>
<td>0.51, 1.63</td>
</tr>
<tr>
<td>CY-BOCS</td>
<td>1.19</td>
<td>1.56</td>
<td>0.38</td>
<td>0.72</td>
<td>1.89</td>
<td>21.1</td>
<td>0.072</td>
<td>0.69</td>
<td>0.28, 1.10</td>
</tr>
</tbody>
</table>

*Note. Significance was evaluated by independent sample t-tests. Multiple comparison controlled using False Discovery Rate. d=Cohen’s d effect size; WASI-V=WASI-II Vocabulary; VA-I=Visual Attention Index; SI-I=Social Interactions Index; CY-BOCS=Child Yale-Brown Obsessive-Compulsive Scale; CI=Confidence Interval; LL=Lower level; UP=Upper Level. Uncorrected for multiple comparisons p value.*

*p = .05.
APPENDIX B

Trait Signatures: Resting State Alpha Power

<table>
<thead>
<tr>
<th>Regions</th>
<th>LF</th>
<th>RF</th>
<th>LP</th>
<th>RP</th>
</tr>
</thead>
<tbody>
<tr>
<td>LF</td>
<td>-</td>
<td>.83**</td>
<td>.71**</td>
<td>.70**</td>
</tr>
<tr>
<td>RF</td>
<td>.89**</td>
<td>-</td>
<td>.93**</td>
<td>.90**</td>
</tr>
<tr>
<td>LP</td>
<td>.85**</td>
<td>.89**</td>
<td>-</td>
<td>.94**</td>
</tr>
<tr>
<td>RP</td>
<td>.85**</td>
<td>.83**</td>
<td>.97**</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note. Pearson’s r correlations presented for Children-Victim above the diagonal and Control Children below the diagonal. LF=Left Frontal; RF=Right Frontal; LP=Left Parietal; RP=Right Parietal.

*p < .05 (2-tailed) after False Discovery Rate (FDR) correction; **p < .01 (2-tailed) after FDR correction.*
APPENDIX C

Trait Signatures: Neurobehavioral Correlations in Control Children

<table>
<thead>
<tr>
<th>Variables</th>
<th>H-DSM</th>
<th>BVS-I</th>
<th>LF</th>
<th>RF</th>
<th>LP</th>
<th>RP</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-DSM</td>
<td>-</td>
<td>.02</td>
<td>-.06</td>
<td>-.27</td>
<td>-.19</td>
<td>-.16</td>
</tr>
<tr>
<td>BSI-I</td>
<td>-</td>
<td>-</td>
<td>-.27</td>
<td>-.21</td>
<td>-.38</td>
<td>-.35</td>
</tr>
</tbody>
</table>

*Note. Pearson’s r values presented. H-DSM=History of DSM-5 Disorders; BVS-I=Bullying Victimization Severity Index; LF=Left Frontal; RF=Right Frontal; LP=Left Parietal; RP=Right Parietal.*
**APPENDIX D**

*State Signatures: Neurobehavioral Measurements*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Children-Victim</th>
<th>Control Children</th>
<th>t</th>
<th>df</th>
<th>p&lt;sup&gt;a&lt;/sup&gt;</th>
<th>d</th>
<th>95% CI of d</th>
</tr>
</thead>
<tbody>
<tr>
<td>VS-I</td>
<td>-0.46 0.54</td>
<td>-0.003 0.61</td>
<td>-2.27</td>
<td>30</td>
<td>0.031</td>
<td>-0.82</td>
<td>-1.01 -0.63</td>
</tr>
<tr>
<td>VE-I</td>
<td>-0.11 0.85</td>
<td>-0.01 0.76</td>
<td>-0.36</td>
<td>30</td>
<td>0.72</td>
<td>-0.13</td>
<td>-0.40 0.14</td>
</tr>
<tr>
<td>CDRS-R</td>
<td>45.13 11.04</td>
<td>32.83 5.4</td>
<td>3.88</td>
<td>20.3</td>
<td>0.001**</td>
<td>1.47</td>
<td>-1.45 4.38</td>
</tr>
<tr>
<td>QTE</td>
<td>2.94 2.08</td>
<td>1.67 1.23</td>
<td>2.08</td>
<td>24.7</td>
<td>0.048**</td>
<td>0.77</td>
<td>0.19 1.34</td>
</tr>
<tr>
<td>BVS-I</td>
<td>2.06 0.36</td>
<td>1.22 0.41</td>
<td>6.22</td>
<td>30</td>
<td>&lt; 0.001**</td>
<td>2.25</td>
<td>2.12 2.38</td>
</tr>
</tbody>
</table>

*Note.* Significance was evaluated by independent sample *t*-tests. Multiple comparison controlled using False Discovery Rate. *d*=Cohen’s *d* effect size; VS-I=Visuo-Spatial Index; VE-I=Verbal Expression Index; CDRS-R=Children’s Depression Rating Scale-Revised; QTE=Questionnaire on Traumatic Experiences in Early Childhood; BVS-I=Bullying Victimization Severity Index; CI=Confidence Interval; LL=Lower level; UL=Upper Level.

<sup>a</sup>Uncorrected for multiple comparisons *p* value.

*<sup>*</sup>p = < .05; **<sup>p</sup> = < .01.*
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