

Neurological Correlates of Violent Behavior in Persons with a History of Childhood Adversities

Dr. Steven Rondeau BCN (EEG) | September 2022



The childhood abuse “excuse.”

In the last few decades, the news of men and women of all ages engaging in highly aggressive and violent behavior at the expense of harmless citizens has become more and more frequent, especially in those regions where access to weapons is more easily granted to the general population.

In many cases, the perpetrators of these assaults have been found to suffer from psychiatric illnesses, often linked to abuse experienced during childhood. Unfortunately, in the attempt to protect society from experiencing further violence and pain, the general opinion and, most importantly, prosecutors have often dismissed childhood trauma as an “excuse” for a criminal offense, even though there is an abundance of evidence indicating that it has a highly disruptive neurobiological impact on the abused person who is, in most cases foreordained to experience psychological distress in the long term.

Whether the abuse of a child is of physical, psychological, or sexual origin, it has been proposed that the associated stress response triggers a cascade of biochemical changes throughout the central nervous system as a result of the child’s attempt to cope with a hostile world.

In the following sections, proof of evidence is offered to support the hypothesis that early traumatic experiences **stimulate the brain to develop survival mechanisms** that may contribute to establishing in the long term irritable, impulsive, and suspicious mental states, which the rational mind may be unable to control. Moreover, and most importantly, neural correlates of aggressive, impulsive, and violent behavior in persons with a history of child maltreatment will be discussed, suggesting neuroimaging and electroencephalography (EEG) as methods **to objectively and reliably detect high-risk brain anomalies in this clinical population.**

Early Effects of childhood maltreatment on child development and behavior

Adversities experienced during childhood have been shown to have detrimental effects on mental health [1]. In particular, **childhood maltreatment** is an early life stressor that can have a profound impact on brain development and behavior, with hundreds of studies indicating its highly disruptive effects on cognition and emotional regulation throughout life.

Child maltreatment or abuse is defined as an act or acts perpetrated by a parent or caregiver that can potentially result in harm to a child [2].

Child maltreatment is generally subdivided into **four separate subgroups** [3-7].

1. **Neglect** (failure to provide adequate shelter, supervision, nutritional needs, education, and healthcare)
2. **Physical abuse** (injury inflicted by non-accidental means)
3. **Emotional abuse** (rejection, isolation, terror infliction, ignoring or corrupting)
4. **Sexual abuse** (a sexual act involving the child, performed by an adult or older child)

It is well established that early child abuse may be associated with **internalizing behavioral symptoms**, most commonly including:

- Reduced resilience to stress
- Anxiety
- Affective instability
- Depression
- Suicidality
- Post-traumatic stress disorder (PTSD)
- Dissociative behavior
- Hallucinations

Externalizing behavior has also been reported in children with a history of early maltreatment [e.g., 8, 9-14]. In particular, the following diagnoses can be found:

- Poor impulse control
- Episodic aggression
- Substance abuse
- Attention deficit hyperactivity disorder (ADHD)
- Conduct disorder (CD)

Neuropsychological considerations

Physical, sexual, and psychological trauma experienced as a child have been shown to increase the risk of psychiatric illness in the short, medium, and long term. Emotions or states of anger, shame, and despair can be directed “inward” and trigger affective disorders or “outward,” increasing aggressive behavior, impulsiveness, and hyperactivity [15].

Reduced cognitive competence may play a key role in the manifestation of violent behavior [16]. In particular, neurodevelopmental **maturational deficits affecting the left brain hemisphere** may be linked to a relative inability to use inner speech to effectively modulate affect, thought, and, ultimately, behavior. Under conditions of social frustration, for example, individuals with such a neurological profile may turn to developmentally immature response strategies as their only way to resolve conflict or simply respond to a negative emotional state [17].

These considerations are in line with the hypothesis suggesting that stress may have a disruptive effect on fronto-limbic networks, which may be linked to the high density of glucocorticoid receptors and (stress-susceptible) dopaminergic projections present in the corresponding brain regions [18].

Neuroimaging

In addition to behavioral and cognitive disorders, there is evidence that persons with a history of early life adversity may exhibit physiological, neurochemical, and hormonal anomalies most often associated with maladaptive changes in brain structure and function [19, 20].

Structural magnetic resonance imaging (MRI) studies provide evidence for volumetric changes in gray and white matter in multiple brain regions. In abused children, dorsolateral and ventromedial prefrontal cortex but also hippocampus, amygdala, and corpus callosum, have been detected, suggesting a link with cognitive and emotion regulation deficits most often found in this population. Other studies employing **diffusion tensor imaging (DTI)** studies have also found evidence for deficits in microstructural insults involving inter-regional connectivity between these areas, suggesting altered intra- and inter- neural network abnormalities [21, 22].

Functional MRI (fMRI) evidence in children with a history of early deprivation indicates atypical activation in regions that are key to cognitive functions and emotional regulation [23]. Importantly, functional anomalies in these areas were associated with altered response inhibition, working memory, and emotion processing [24-26].

In summary, MRI evidence suggests that in persons with a history of childhood maltreatment, fronto-limbic networks are predominantly disrupted. As these pathways are key to emotion and motivation processing [27-30] as well as to the control of **aggressive behavior [31]**, it can be proposed that their disruption may underpin **deficits in emotion and reward processing**, which can also be associated with increased aggressive or violent behavior [for a review see Heide and Solomon 32].

Electroencephalography

Because human brain waves reflect consciousness [33, 34] EEG has extensively been employed over the years to explore how specific emotional states underpin behavior. In this context, functional asymmetries between the left and right parietal or frontal lobes have been shown to affect arousal states [35, 36].

In children with a history of maltreatment, **non-specific EEG abnormalities** have been reported [37, 38], although studies in adolescents with a history of abuse have revealed **specific patterns of EEG slowing (low frequency)** in the temporal and parietal lobes [39].

An EEG measure that may increase the risk for developing **poorer resilience** among maltreated children is **frontal alpha asymmetry (FAA)** at rest [e.g., 40, 41], a measure that is thought to reflect emotional and behavioral responses to changing environmental conditions. Individuals with higher alpha activity in the frontal region may consistently exhibit bias towards negative emotions, self-reflection, and withdraw-related behaviors [42, 43]. There is also evidence of a link between physical and sexual abuse with **fronto-parietal abnormalities** in the left brain hemisphere. Further, sexually abused children have been found to exhibit **hypercoherence** in the left brain hemisphere, when compared with control (with no history of abuse) children, suggesting altered left hemisphere differentiation, reversed hemisphere asymmetry, and **impaired limbic regulation [37]**. On the other hand, research on women with a history of child abuse has revealed left frontal hypo-coherence in the theta and beta bands and hypercoherence in posterior central regions across all frequency bands [44]. These findings might support fMRI research with orphan children, indicating reduced metabolism in the orbital frontal gyrus, intralimbic prefrontal cortex, amygdala, hippocampus, lateral frontal cortex, and brainstem [23].

A large number of studies have demonstrated EEG abnormalities in **violent offenders**. In persons with problematic behavior [45, 46], history of criminal offense [47] or high violence scores [48], distinct EEG signature profiles have been shown to reflect **unique mental states**. For example, there is evidence that **dysregulation of prefrontal activity** is linked to a **greater anger** [49, 50] and that comorbidity of neurological/psychiatric illness can increase the likelihood for **focal slow wave EEG anomalies** in the left brain hemisphere to enhance the **propensity for violent behavior** [48].

Final considerations

Persons with a history of child maltreatment are at risk for developing brain anomalies that can lead to maladaptive behavior driven by impulsiveness, anger, and aggressiveness. Combining neurobehavioral investigations with the description of the nature and extent of brain anomalies is recommended to help clarify brain-behavior relationships that can potentially increase the risk for violent outbursts and criminal offenses in this population.

In addition to objective testing such as EEG, the neuropsychiatric evaluation of violent patients should also include the assessment of executive functions and the analysis of frontal lobe activity, particularly in patients with a history of recurrent, impulsive aggressive behavior.

Further progress requires an interdisciplinary approach that integrates neuropsychiatric, neuropsychological, and psychophysiological investigations, collectively geared towards interpreting neurobehavioral dysfunctions, cognitive performance anomalies, and dysregulation of affect. Such an approach can potentially benefit medical, public health, and social policy interventions, ultimately predicting, preventing, or at least reducing violence in the community.



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