

Neural and behavioral correlates of child maltreatment in the context of education

The developing brain may be shaped by abusive environments to process information differently. Neural adaptations that are useful in an abusive environment may not be useful in classroom learning.

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Executive Summary

- All children have the right to be protected from violence, yet child maltreatment is a pervasive problem worldwide
- Teachers play a crucial role in recognizing and reporting maltreatment
- Maltreatment affects the development of both behavior and the brain
- The developing brain may be shaped by the abusive environment to process information differently across many domains (for example, executive function, error, reward, and socioemotional processing)
- Neural adaptations that are useful in an abusive environment may not be useful in classroom learning

Introduction

The right of all children to be protected from all forms of violence is recognized in international human rights treaties. For example, Article 19 of the UN Convention on the Rights of the Child states that all Parties “shall take all appropriate legislative, administrative, social and educational measures to protect the child from all forms of physical or mental violence, injury or abuse, neglect or negligent treatment, maltreatment or exploitation, including sexual abuse”^[1]. And yet children still suffer physical, sexual, and emotional abuse and neglect around the world.^[1] Globally, it has been estimated that 1 billion 2- to 17-year-olds experience such violence in a given year^[2].

[1] The terms “abuse and neglect” and “maltreatment” are used interchangeably in this brief.

The crucial roles of teachers

In some countries (including the United States), teachers, guidance counselors, school administrators, and staff are mandated to report suspected cases of child abuse to child protective service agencies. According to federal data, education personnel in the United States are the primary reporting source of suspected child maltreatment, as shown in **Figure 1**^[3]. Indeed, education professionals report cases that would have been missed otherwise and thus play a key role in identifying children in need of services^[4]. Why are parents not reporters? Unfortunately, federal data from the United States indicate that parents are the perpetrators of maltreatment in almost 92% of cases^[3, Table 3-11, p. 44].

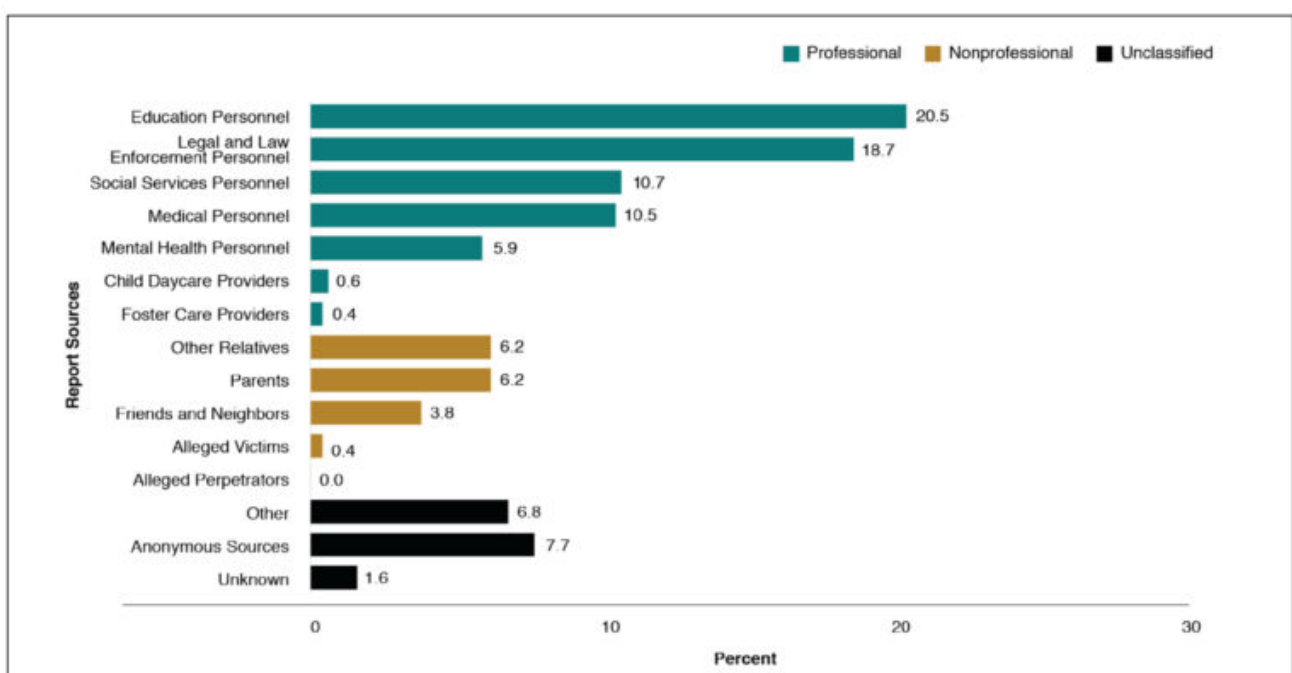


Figure 1. The most recent (2018) data from the United States indicate that education personnel are responsible for the greatest percentage of reported allegations of child maltreatment. From ref 3, Exhibit 2-D, p. 9.

Although teachers are mandatory reporters in some countries, their knowledge, training, attitudes, and work experience all influence their decisions to report^[e.g., 5,6-9]. Studies have indicated that teachers may need further training on maltreatment reporting laws, what constitutes abuse, how to report abuse, or signs of abuse across many countries, including Australia^[10,11], Belgium^[12], Canada^[13,14], Estonia^[15], India^[16], Ireland^[17], Jordan^[18], Singapore^[19], Turkey^[20,21], and the United States^[22-25]. More consistent and higher-quality training of education professionals would likely lead to more effective reporting and increased ability to help children and families^[4].

Training can also help teachers become aware of the impacts of childhood trauma related to maltreatment^[26]. As part of a team of caring adults in a child's life, teachers can provide *trauma-informed education* for their students, building reliable relationships and providing supportive, predictable, and safe environments^[e.g., 26,27,28,29]. Trauma-informed education typically focuses on helping children to learn or rebuild socioemotional, self-regulation, and relationship skills^[30]. It can also focus on strengths, such as what psychological resources the child already has that can be built on for success^[e.g., 31,32]. There are multiple guides for developing trauma-informed classrooms and schools^[e.g., 28,33,34], but little evidence of efficacy. Although classroom teachers are generally not certified to provide mental health treatment (see Appendix), they can provide socioemotional support and understand and accommodate the range of learning challenges that children who have been maltreated may have.

Potential long-term effects of maltreatment

Studies of *adverse childhood experiences*, such as maltreatment, have reported mental health, physical health, behavioral, and social consequences well into adulthood^[e.g., 35,36,37]. See **Figure 2**. For example, children who have experienced abuse or neglect are more likely to have depression and diabetes as adults, to have difficulties with relationships, to struggle with substance abuse, and to be involved in violence and criminal behavior^[e.g., 38,39-41]. How are these lifelong outcomes related to early experiences of adversity? One mechanism is through the pervasive effects of toxic stress on the brain and body (e.g., <https://developingchild.harvard.edu/science/key-concepts/toxic-stress/>). Greater exposure to adverse childhood experiences is associated with greater risk of poor outcomes^[42]. However – importantly – individual, family, and community factors interact to influence these outcomes: Many children develop *resilience*^[43] that protects against these effects (see the brief in this series *Resilience for lifelong learning and well-being*).

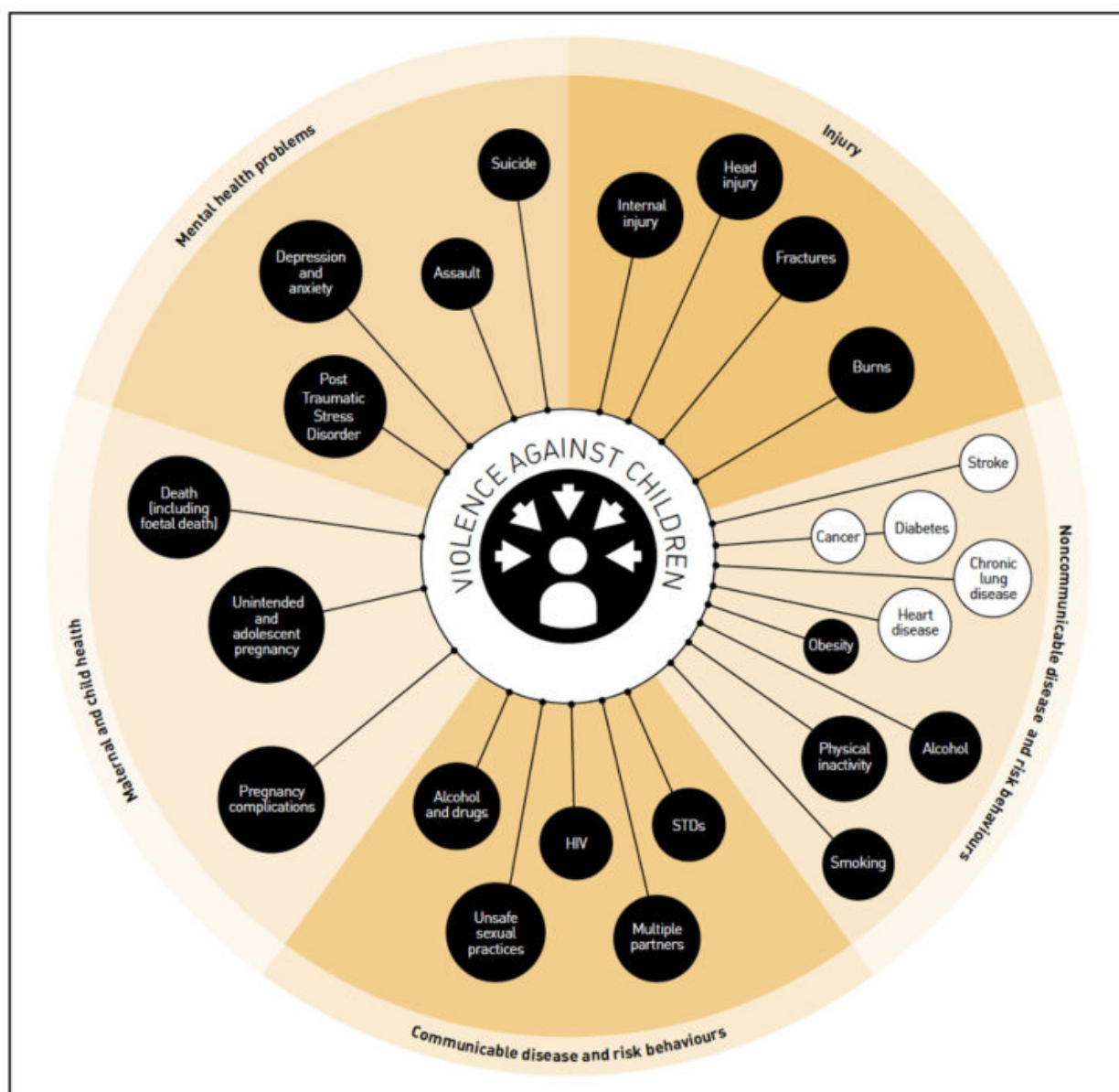


Figure 2. The long-term effects of maltreatment can be extensive and include both direct effects (dark circles) and indirect effects due to the adoption of high-risk behaviors (white circles). From ref 36, Figure 1: Potential health consequences of violence against children, p. 11. Reproduced with permission from WHO from INSPIRE: seven strategies for ending violence against children, <https://www.who.int/publications/i/item/inspire-seven-strategies-for-ending-violence-against-children>, © 2016.

Child maltreatment can also have enduring economic effects. Adults with a history of maltreatment have lower levels of employment, lower earnings, and fewer assets^[44]. At a societal level, the total lifetime economic burden resulting from new cases of maltreatment in 2008 in the United States was estimated at \$124 billion, ranging to \$585 billion in further sensitivity analyses^[45].

Globally, violence in childhood is also associated with educational outcomes, including increased risk of school drop-out and poorer academic performance^[46]. In the United States, even by the third grade, children who have been involved with child protective services score significantly lower on standardized math and reading tests, are more likely to be identified as needing special education, and are more likely to be held back a grade^[47]. The next section takes a closer look at some of the learning differences that children who have been maltreated may have.

Potential near-term effects of maltreatment: neural and behavioral correlates of maltreatment in the classroom^[2]

One of the key developmental features of the human brain is *neuroplasticity*. The brain grows and changes in interaction with the environment. Both the physical structure and the functioning of the brain are shaped by our experiences (in interaction with our genes). When those experiences involve maltreatment, the brain develops to adapt to the abusive or neglectful environment in which a child is growing up^[e.g., 49,50-54]. However, adaptations that support survival in the maltreating environment may not support successful learning in the classroom environment.

The focus of this section is classroom-relevant skills that have been investigated in functional neuroscience studies with children who have been maltreated. More extensive reviews of the structural and functional neural correlates of maltreatment in children and adults are available elsewhere^[e.g., 48,54,55,56-71]. It is important to remember that these are correlational findings^[72] and that many children are resilient^[e.g., 73]. Thus, not every maltreated child will have the same pattern of strengths and weaknesses.

Overall, research suggests that many kinds of processing develop differently in children who have experienced maltreatment. Some findings indicate that maltreatment affects two neural networks in particular: one involved in executive functions (a *fronto-striatal* system) and another involved in emotion and motivation processing (a *fronto-limbic* system), as illustrated in **Figure 3**^[e.g., 48]. Thus, maltreatment can have pervasive effects on neural systems that are fundamental for learning and development.

[2] Note that ethical research with this vulnerable population is challenging and that there are limitations to this literature such as small sample sizes and failure to control for confounding factors like comorbid psychiatric diagnoses^{[e.g.,] [48]}. Also note that the general effects of stress on learning are not addressed here, as they are addressed in other briefs in this series.

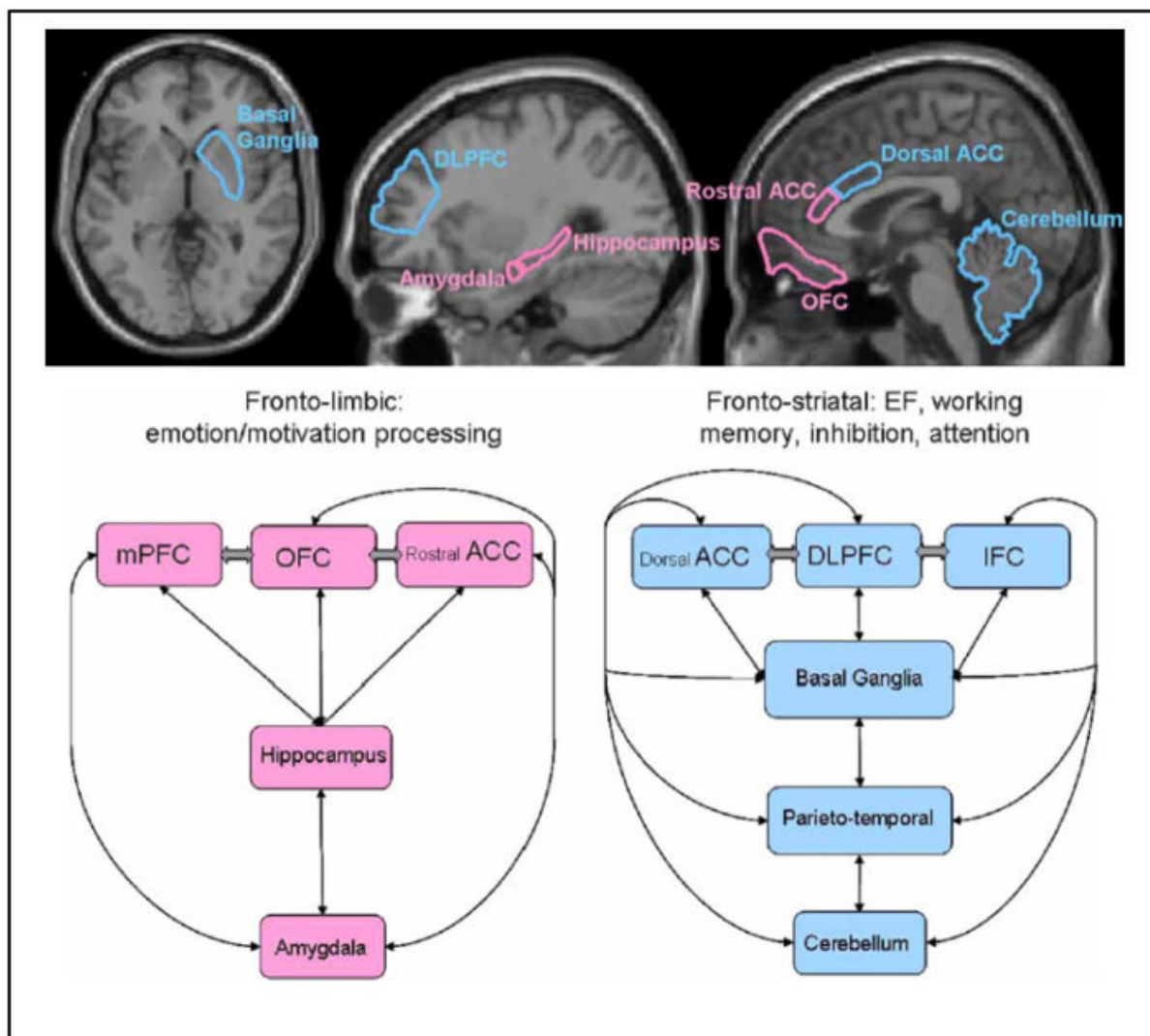


Figure 3. Neuroscience evidence suggests different processing in a fronto-limbic system involved in emotion and motivation (pink) and a fronto-striatal system involved in executive functioning (blue) in children and adolescents who have experienced maltreatment. From ref 48, Hart & Rubia, 2012, Neuroimaging of child abuse: a critical review; Figure 1, p. 8, and Figure 2, p. 17, combined. Used under CC-BY 4

Executive functions

Behavioral studies with children and adolescents with a history of maltreatment have shown that many *executive functions*, such as working memory, inhibitory control, sustained attention, cognitive flexibility, and processing speed, develop differently in this population^[e.g., 68,74,75-88]. Poorer executive functioning likely influences the poorer academic performance of children who have been maltreated^[89]. In the following paragraphs, we consider why.

How is working memory used in the classroom? Anything that requires children to keep information “in mind” requires working memory. For example, instructions (get your math books, turn to page 19, and complete all of the odd-numbered problems before noon), reading comprehension (remembering what you have just read and connecting that to what you are now reading), and remembering a teacher’s question while trying to come up with an answer all rely on working memory. Consistent with behavioral evidence of poorer working memory in children who have been maltreated, a neuroimaging study reported that 8- to 19-year-olds with a history of maltreatment and exposure to violence showed different activation in a frontoparietal network that supports working memory, in comparison to nonmaltreated controls^[90]. Processing differences for the working memory task were seen during both *encoding* (getting information into memory) and *retrieval* (recalling, or getting

information back out of memory)^[90].

What does inhibitory control look like in a classroom? You might think of it as poor impulse control. Consider blurting out an answer without raising a hand, even before the question has been completed. Or saying what comes to mind without stopping to think first. And consider what effects these sorts of behaviors have on peer relationships^[e.g., 91,92]. Consistent with behavioral findings of poorer inhibitory control in children who have been maltreated, neuroimaging studies have shown that children and adolescents with a history of maltreatment, in comparison to peers without a history of maltreatment, show different patterns of activity in a fronto-striatal network associated with inhibitory and response control during tasks requiring these skills^[93-96].

Why is attention important in the classroom? Attention is required to get information into memory and learn it, by focusing on important information (for example, what the teacher is saying) and tuning out unimportant information (for example, the whispers of classmates). A child who is attending to their own anxiety, the shadow of a figure at the classroom door, or a personal memory cannot also sustain attention to the teacher or a peer's question. A child who seems lost or confused and cannot keep up with academic activities or daily classroom rhythms may be struggling with attention. Consistent with the results of behavioral studies indicating poorer sustained attention in children who have been maltreated, neuroimaging studies have found that adolescents who have experienced severe childhood abuse, as compared to controls who have not, make more errors on attention tasks, show less connectivity in frontoparietal attention networks, and show reduced activation in frontal attention regions during sustained attention tasks^[97,98].

Increased sensitivity to error

In some neuroimaging studies, adolescents with a history of childhood abuse have been asked to perform a task designed to elicit mistakes^[e.g., 99,100]. These studies found increased activation but less connectivity in the fronto-cingulo-striatal network involved in error processing in the adolescents who had been maltreated, in comparison to nonmaltreated controls^[99,100]. These differences were limited to processing of mistakes: For correct responses, there were no differences between the two groups^[99,100]. Other neuroimaging studies have also reported more neural resources allocated to error processing – a hypersensitivity to errors – in children who have been maltreated^[101].

Further, a brainwave recording study with 6-year-olds also used a task designed to elicit mistakes^[102]. As illustrated in **Figure 4**, a specific neural response associated with recognizing that one has made an error (the *error-related negativity*) was larger in children who had experienced more hostile parenting, as compared to children raised in more responsive families^[102]. That is, children who had experienced more harsh parenting devoted more neural resources to recognizing and processing their own mistakes on the task. These children were not identified as maltreated. Hostile (harsh, punitive) parenting was defined in terms of parental expressions of anger, frustration, and criticism toward the child during a structured visit to the research laboratory when the children were three years old^[102, p. 823].

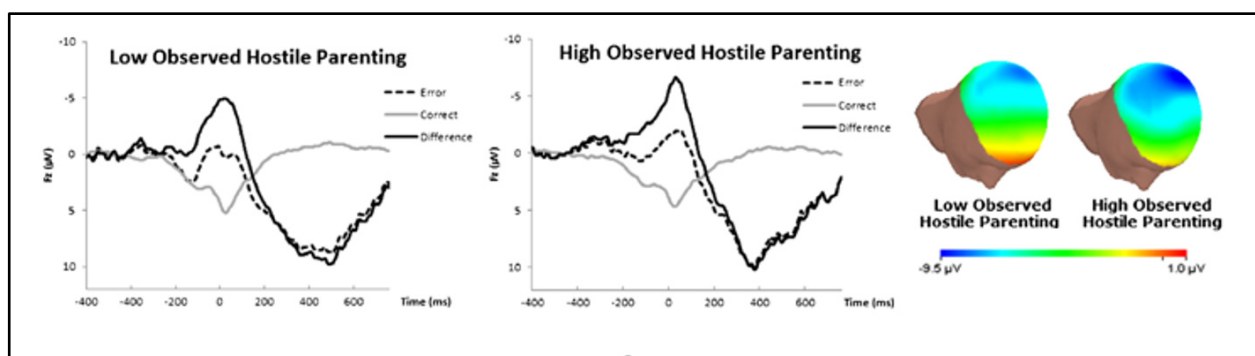


Figure 4. Left: Brainwaves to correct (gray line) and error (dashed black line) responses, as well as the mathematical difference between the two types of responses (solid black line) for children growing up with parents rated low and high in terms of hostile parenting style. Right: The difference data plotted as topographic maps; the deeper blue and greater extent of blue for children with parents rated high on hostile parenting style indicates the larger error-related negativity in this group – that is, the greater neural response to realizing that one has made a mistake. From ref 102, Figure 1, p. 826. Reprinted by permission from Springer Nature: Springer, *Journal of Abnormal Child Psychology*, Self-reported and observed

punitive parenting prospectively predicts increased error-related brain activity in six-year-old children, A. Meyer, G.H. Proudfit, S.J. Bufferd, A.J. Kujama, R.S. Laptook, D.C. Torpey, & D.N. Klein, © 2014.

Increased sensitivity in error detection and processing networks in children and adolescents who have been maltreated may be due to the "constant need to monitor their own actions in order to avoid painful mistakes, which are often associated with harsh punishment in abusive settings"^[100, p. 892]. That is, the consequences of making a mistake may be particularly salient. Hypersensitivity to errors may be a useful adaptation for an abusive environment, but maladaptive for a school environment. What might it look like in a classroom? Perhaps a math worksheet that is erased over and over and never turned in for fear of mistakes. Perhaps a child "freezing" the moment they recognize that they have made a mistake. Perhaps an unexpected over-reaction to a gentle suggestion that a student check their work.

Reward processing

A number of behavioral studies have reported decreased sensitivity to reward in children who have experienced maltreatment^[e.g., 103,104,105]. For example, in one study, 8- to 14-year-olds with a history of abuse did not change their response speed based on the likelihood of a reward, whereas children without a history of abuse responded more quickly as the chances of winning a reward increased^[103]. In another study, 12- to 17-year-olds who had been exposed to physical abuse were less able than their nonabused peers to learn which stimuli were likely to result in reward, even after repeated feedback^[105]. Less use of information about rewards may be related to the variability in how abusive caregivers respond to children^[105]. Thus, assuming that positive feedback and rewards are not consistent or reliable may be an adaptation that children develop in an abusive context^[105, p. 776] that is counterproductive for learning in the classroom.

In accord with the behavioral findings, a history of maltreatment has been associated with reduced activation in the reward network in neuroimaging studies^[e.g., 101,106,107]. For example, as shown in **Figure 5**, maltreatment experience was associated with reduced activation to reward cues in a study with 10- to 15-year-olds^[101].

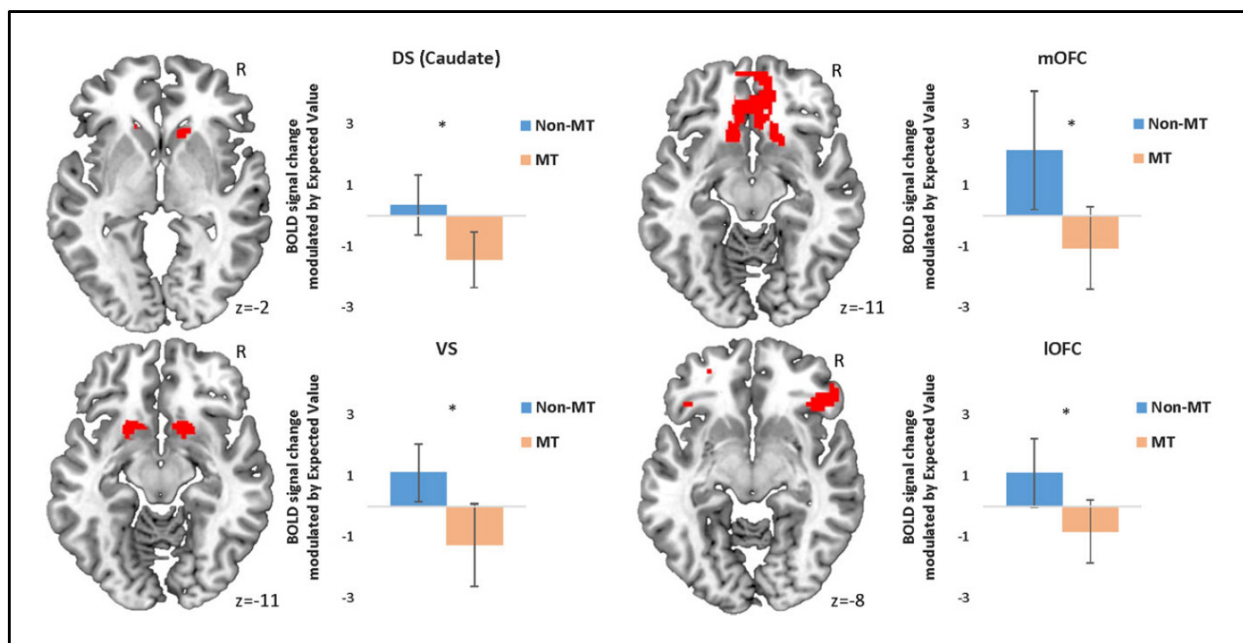


Figure 5. Reduced activation during reward processing in children and adolescents with a history of maltreatment (orange bars) in comparison to children and adolescents without a history of maltreatment (blue bars). Activation levels were modulated by expected reward (value) during avoidance responses in the dorsal striatum of the caudate (DS), the ventral striatum (VS), and the medial (mOFC) and lateral (IOFC) orbitofrontal cortex. From ref 101, Figure 3, p. 1698. Gerin et al., 2017, A neurocomputational investigation of reinforcement-based decision making as a candidate latent vulnerability mechanism in maltreated children. Used under CC-BY 4

Again, reduced responses to anticipated rewards may be learned from a negative environment in which rewards are unpredictable and scarce^[e.g., 63,105]. They may also reflect an adaptive response in a dangerous environment that "tip[s] the

balance in an approach-avoidance conflict situation to avoidance”^[54, p. 254]. That is, children who have been abused may have learned not to engage; they may be motivated to avoid and disengage (especially from potential conflict) for survival in an abusive environment. What might this look like in the classroom? Perhaps a child who is not motivated by reward, avoids engagement even when rewards are involved, or may not respond positively when rewards are given.

Emotion processing

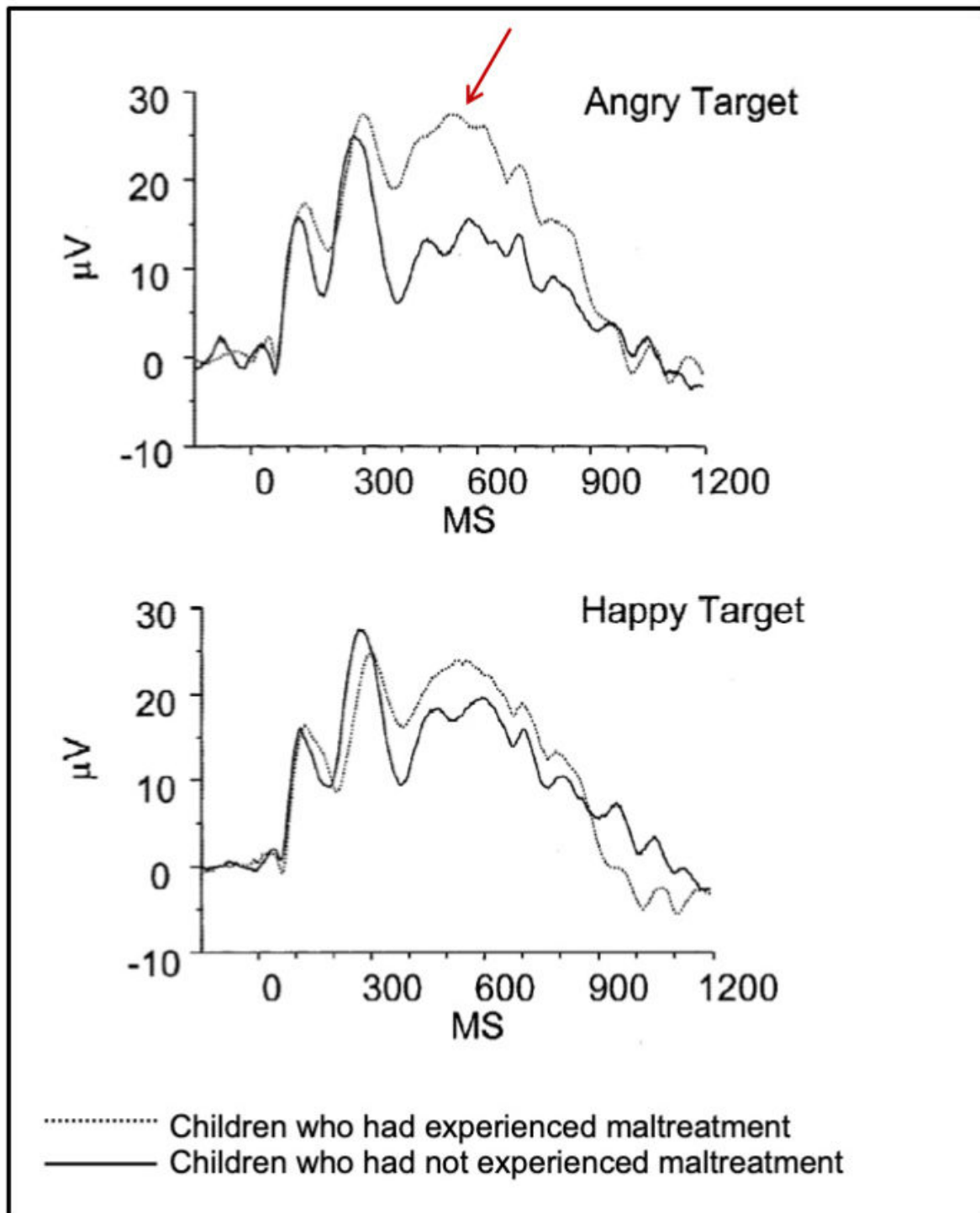


Figure 6. Children who have been maltreated show heightened sensitivity to (and devote more processing resources to) angry faces, as compared to children who have not been maltreated (see red arrow). In this study with 6- to 12-year-olds,

the two groups processed happy faces similarly. Adapted from ref 121, Figure 3, p. 272. Pollak, Klorman, Thatcher, & Cicchetti, 2001, P3b reflects maltreated children's reactions to facial displays of emotion. Used with permission of Wiley/Society for Psychophysiological Research (U.S.).

Behavioral research has shown that children who have been maltreated respond to emotional information differently than children who have not been maltreated^[108,109]. Young children who have been maltreated are less accurate at identifying and discriminating between emotional facial expressions^[e.g., 110,111,112]. They may have less emotion knowledge overall^[113], but may also have specialized emotion knowledge. For example, in one study, children who had been neglected had a lower standard for selecting sad faces and children who had been physically abused had a lower standard for selecting angry faces^[112]. Indeed, many studies have reported more sensitivity and attention to angry facial expressions in children who have been physically abused^[e.g., 114,115-117]. Overall, the pattern of results suggests that children who have been maltreated pay more attention to threatening emotional cues (like angry facial expressions)^[108].

In brainwave recording studies, infants as young as 15 months old, toddlers, and children who have been maltreated show greater responses to faces with angry expressions than other emotions^[e.g., 115,118-122]. This is illustrated in **Figure 6**^[121]. Children who have been physically abused also over-attend to visual and auditory anger cues^[e.g., 123,124]. Overall, this pattern indicates allocation of more processing resources to threatening information; in turn, this can undermine attentional control^[e.g., 121,122]. That is, focusing attention on monitoring for threatening cues may support survival in abusive situations but may interfere with shifting attention toward emotional regulation ^[e.g., 125], a more adaptive response in the classroom.

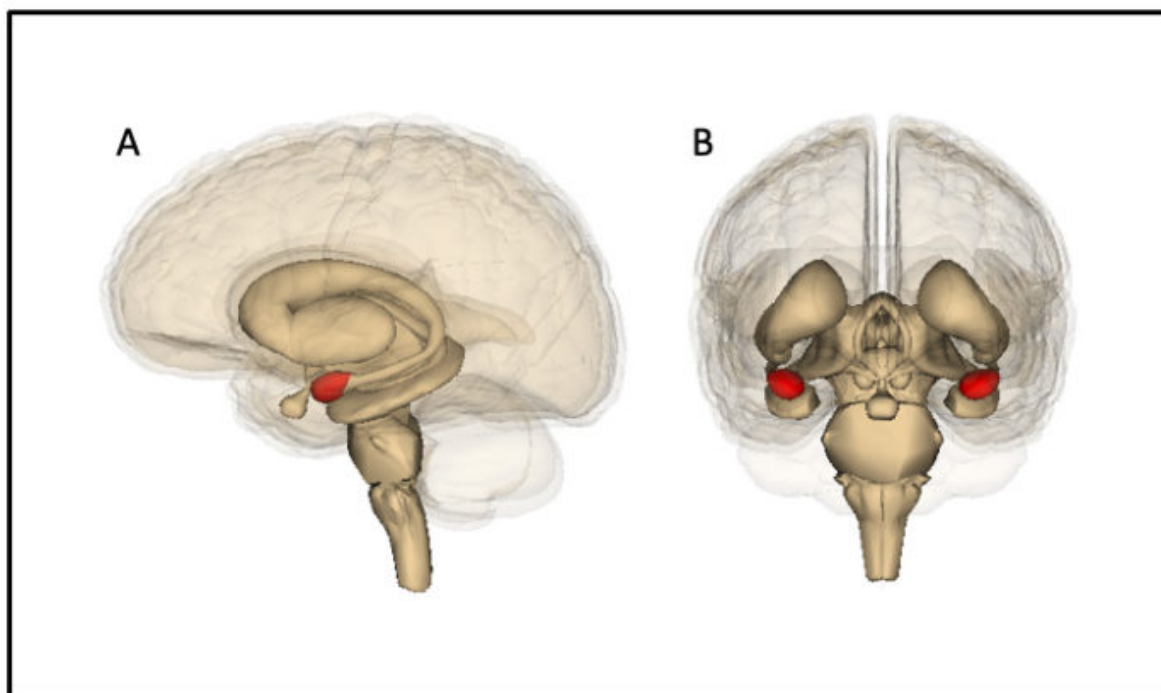


Figure 7. The amygdala (shaded red) as seen (A) from the side (left amygdala) and (B) from the front (left and right amygdalae). The amygdala is involved in emotion and fear processing. Life Science Databases(LSDB)/Wikimedia Commons, CC BY-SA 2.1 JP

Neuroimaging studies have also found that children and adolescents with a history of maltreatment respond faster to threatening information and show enhanced activation during fear or threat perception, as compared to nonmaltreated controls^[e.g., 126,127-134]. Adolescents with histories of trauma also show greater *amygdala* (see **Figure 7**) reactivity to emotional conflict (for example, the word *fear* superimposed on a happy face) than controls^[135]. Greater amygdala activation to angry as compared to neutral faces in adolescents with a history of maltreatment in comparison to controls has been observed even

when the faces were presented outside of conscious awareness^[130]. This suggests that some part of altered socioemotional processing toward threat may not be under conscious control.

However, remarkably, children and adolescents with a history of maltreatment are able to decrease their responses (down-regulate amygdala activation) to negative images (through a process called *reappraisal*) to a similar degree as nonmaltreated controls^[133,134]. They just have to recruit more neural processing resources to do so^[133,134]. Considering a different kind of resource, the availability and extent of social support may also moderate the heightened response to threat in children and adolescents with a history of maltreatment^[136].

Expertise at processing threat information "makes what is adaptive within an abusive environment maladaptive in more normative social settings"^[122, p. 371]. What might this look like in a classroom? Perhaps monitoring of a teacher's face and movements for any sign of anger or threat, to the detriment of listening to and learning what the teacher is saying. Or instantly mis-interpreting the accidental bump of a classmate in a busy hallway as threatening. It is likely that this pattern of socioemotional information processing^[55] is related to the enduring social difficulties of many children who have experienced maltreatment^[137,138].

Conclusion

Overall, this research provides a deeper understanding of how children who have been maltreated might process information differently, and why. This understanding may help teachers and school leaders to identify these children, better support them as learners, and reflect on their relationships with them. Both the neural and behavioral evidence suggests that maltreating environments can shape the brains of children to process information differently, in ways that may be adaptive in the abusive environment but not beneficial in the classroom environment.

With this knowledge, teachers might, for example, learn to reinterpret challenging behaviors as effects of trauma rather than willful noncompliance. In turn, educators might respond to such behaviors by "seek[ing] out therapeutic and positive behavioral supports, rather than responding with punitive measures such as suspensions or expulsions"^[28, p. 6]. Exclusionary discipline serves no purpose for these children: It both robs them of opportunities to learn in a positive classroom environment and may require them to spend more time in the negative abusive environment, in addition to potentially being a triggering event for additional maltreatment.

Finally, this research urges us to think differently about an exclusive focus on academic content in the classroom, and to recognize that there are additional important capacities that need to be nurtured for effective learning^[32, p. 611]. If we aspire to achieve Sustainable Development Goal 4 (<https://sdgs.un.org/goals/goal4>), ensuring inclusive and equitable quality education for all, we must carefully consider our most vulnerable students – including those who have experienced maltreatment.

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Appendix: A note on treatment

Because brains are modifiable (neuroplasticity) and can be changed through interactions with the environment, some of the effects of a negative environment can be counteracted by provision of a positive environment. Although not the focus of this brief, it is important to acknowledge treatment approaches for children, caregivers, and nations in the context of child maltreatment. In Article 19, the UN Convention on the Rights of the Child calls for protective measures including "the establishment of social programmes to provide necessary support for the child and for those who have the care of the child, as well as for other forms of prevention and... treatment and follow-up of instances of child maltreatment" [1].

In addressing the mental health symptoms of maltreatment in children, it is important to use evidence-based approaches so as not to waste time and resources on approaches that do not work; however, some practitioners may not be aware of or use evidence-based approaches [139]. The post-traumatic stress, depressive, and anxiety symptoms that can occur in children who have been maltreated are treatable with therapy. In reviews, the efficacy of Cognitive Behavioral Therapy is well-established [e.g., 139,140,141,142]. Any therapy should acknowledge the complex biological, psychological, social, and cultural contexts of development [e.g., 143], with a focus expanded beyond welfare to well-being [e.g., 144], and should only be provided with assent of the child.

Pediatric telemedicine may be a viable option for such care [145,146]. However, access to technology, lack of confidential space, and reluctance to process trauma in the absence of a safe environment may be challenges to telemedicine from home [147]. Mental health interventions in schools may be even more crucial. But more evidence is needed regarding how effective interventions can be scaled up and implemented in schools in low- and middle-income countries [148]. Integration of evidence-based mental health services within schools can democratize access [149]. Unfortunately, globally, there "has been a lack of investment and capacity to provide quality, rights-based, culturally appropriate mental health care" [150, p. 1].

Whereas treating children is key, providing additional support to reduce stress and build coping and parenting strategies in caregivers is also important, especially in terms of advancing understanding of child development and building safe, stable, and nurturing relationships between caregivers and children [e.g., 141,151,152-155]. Evidence-based parenting interventions can both decrease harsh and increase nurturing parenting practices [e.g., 156,157,158]. Along with enhancing parenting skills and changing social norms to support positive parenting, strengthening economic support to families, providing quality early care and education, and early intervention are best-evidence strategies to help prevent child maltreatment [e.g., 153].

There is evidence that affordable, flexible, evidence-informed programs for parents and children can be adapted and implemented in diverse cultural and economic contexts around the world [e.g., 156,157,159]. However, it is important to pre-determine the readiness of countries to implement evidence-based child maltreatment prevention programs on a large scale to increase the likelihood of success [160]. At the national policy level, the World Health Organization has summarized seven research-based strategies to address all violence against children [36] and UNICEF has similarly advanced a detailed theory of change to guide work on preventing and responding to all violence against children, including pathways of change and a set of evidence-based strategies [161].