

Child Maltreatment and Neural Systems Underlying Emotion Regulation

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Objective: The strong associations between child maltreatment and psychopathology have generated interest in identifying neurodevelopmental processes that are disrupted following maltreatment. Previous research has focused largely on neural response to negative facial emotion. We determined whether child maltreatment was associated with neural responses during passive viewing of negative and positive emotional stimuli and effortful attempts to regulate emotional responses.

Method: A total of 42 adolescents aged 13 to 19 years, half with exposure to physical and/or sexual abuse, participated. Blood oxygen level-dependent (BOLD) response was measured during passive viewing of negative and positive emotional stimuli and attempts to modulate emotional responses using cognitive reappraisal.

Results: Maltreated adolescents exhibited heightened response in multiple nodes of the salience network, including amygdala, putamen, and anterior insula, to negative relative to neutral stimuli. During attempts to decrease responses to negative stimuli relative to passive

viewing, maltreatment was associated with greater recruitment of superior frontal gyrus, dorsal anterior cingulate cortex, and frontal pole; adolescents with and without maltreatment down-regulated amygdala response to a similar degree. No associations were observed between maltreatment and neural response to positive emotional stimuli during passive viewing or effortful regulation.

Conclusion: Child maltreatment heightens the salience of negative emotional stimuli. Although maltreated adolescents modulate amygdala responses to negative cues to a degree similar to that of non-maltreated youths, they use regions involved in effortful control to a greater degree to do so, potentially because greater effort is required to modulate heightened amygdala responses. These findings are promising, given the centrality of cognitive restructuring in trauma-focused treatments for children.

Key Words: child maltreatment, child abuse, trauma, emotion regulation, amygdala

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Child maltreatment is among the most robust risk factors for child psychiatric disorders.^{1,2} A majority of US children have been exposed to interpersonal violence by the time they reach adolescence, and as many as 1 in 4 experience more severe forms of maltreatment.^{3,4} Population-based studies indicate that children who have been maltreated are at elevated risk for multiple forms of psychopathology that persist into adulthood.^{2,5}

Despite the strong associations of child maltreatment with psychopathology, information on neurodevelopmental mechanisms underlying these associations remains limited. Disruptions in emotion regulation are frequently posited to be a central mechanism linking child maltreatment with the onset and maintenance of psychopathology.⁶ Existing functional neuroimaging studies of child maltreatment and emotional responses have largely examined associations between maltreatment and amygdala response to negative facial emotion. The amygdala detects salient cues in the

environment, such as facial displays of emotion,^{7,8} and is involved in detection of potential threats.^{9,10} Exposure to threatening environments early in development might lead to changes in amygdala response to negative emotional cues due to heightened salience of negative emotional information as a marker of potential threats.¹¹ Indeed, 2 prior studies have shown that children exposed to violence exhibit heightened amygdala response to facial displays of anger.^{12,13} However, the amygdala responds to both positive and negative emotional cues.^{7,8} It is unknown whether heightened amygdala response following child maltreatment is specific to potential threats or reflects heightened sensitivity to emotional salience more generally. Prior research suggests that child maltreatment is associated with more intense emotional reactions to a wide range of stressors and environmental cues.^{6,14–16} Moreover, in a study examining neural response to both faces presented preattentively, heightened right amygdala response to both happy and angry faces was observed in children exposed to violence,¹³ suggesting that maltreatment might be associated with elevated sensitivity to a wide range of emotional cues. Here we examine neural response to both negative and positive emotional cues in youths exposed to maltreatment.

Child maltreatment might also influence neural systems that modulate amygdala response to emotional cues,



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although surprisingly little research has examined this possibility. Emotion regulation involves automatic processes that occur implicitly and without effort and involve ventromedial prefrontal cortex (vmPFC) modulation of the amygdala; these processes include fear extinction,¹⁷ habituation to stress,¹⁸ and modulation of responses to conflicting emotional cues.¹⁹ An additional set of brain regions is involved in effortful emotion regulation processes that are engaged in explicitly and require cognitive resources, such as cognitive reappraisal.²⁰ Use of cognitive reappraisal engages the dorsal anterior cingulate (ACC) and regions in the lateral prefrontal cortex (PFC) that are involved in cognitive control.²⁰⁻²² Activation in these cognitive control regions during reappraisal modulates amygdala activity either through projections to the vmPFC²³ or regions of the lateral temporal cortex that alter semantic representations of

an emotional stimulus.²⁰ Reduced resting-state functional connectivity between the vmPFC and amygdala has been observed in maltreated adolescent females,²⁴ suggesting potential disruptions in systems involved in automatic emotion regulation. Although some studies have observed poor cognitive control in maltreated children and adolescents,^{25,26} we are unaware of previous research examining whether maltreatment influences neural systems involved in the effortful control of emotion.

We examined this question in the current study. Specifically, we investigated neural function during passive responses to negative and positive emotional stimuli, and active attempts to modulate such responses with cognitive reappraisal strategies, among adolescents with and without exposure to child maltreatment. Because child maltreatment is associated with heightened attention to threat and likely

TABLE 1 Distribution of Socio-Demographics and Psychopathology by Maltreatment Status (N = 42)

Characteristic	Maltreated Children		Controls		χ^2	p
	%	n	%	n		
Female	61.9	13	61.9	13	0.00	1.00
Race/ethnicity					17.06*	.002
White	9.52	2	52.38	11		
Black	22.7	8	19.05	4		
Latino	23.81	5	14.29	3		
Asian/Pacific Islander	0.00	0	14.29	3		
Other/biracial	28.57	6	0.00	0		
Parent educational attainment					9.12*	.028
High school or less	19.05	4	4.76	1		
Some college	28.57	6	4.76	1		
College degree	14.29	3	47.62	10		
Graduate school	28.57	6	28.57	6		
Right handed	85.7	18	85.7	18	0.00	1.00
Lifetime internalizing disorder ^a	33.33	7	4.76	1	4.91*	.027
Specific phobia	4.76	1	4.76	1		
Social phobia	0.00	0	0.00	0		
SAD	4.76	1	0.00	0		
Panic disorder	0.00	0	0.00	0		
GAD	14.29	3	0.00	0		
PTSD	9.52	2	0.00	0		
Major depression	14.29	3	0.00	0		
Lifetime externalizing disorder ^b	33.33	7	0.00	0	7.68*	.006
ADHD	14.29	3	0.00	0		
ODD	4.76	1	0.00	0		
CD	14.29	3	0.00	0		
	Mean	(SD)	Mean	(SD)	t	p
Age	16.26	(1.43)	16.89	(1.35)	1.07	.29
WASI total score	100.33	(15.81)	105.00	(12.23)	0.76	.45
Internalizing symptoms ^a	26.71	(13.07)	12.88	(6.69)	-4.35	<.001
Externalizing symptoms ^b	19.67	(9.70)	8.06	(4.48)	-4.78	<.001

Note: ADHD = attention-deficit/hyperactivity disorder; CD = conduct disorder; GAD = generalized anxiety disorder; ODD = oppositional defiant disorder; PTSD = posttraumatic stress disorder; SAD = separation anxiety disorder; WASI = Wechsler Abbreviated Scale of Intelligence.

^aInternalizing disorders include specific phobia, social phobia, separation anxiety disorder, panic disorder, generalized anxiety disorder, posttraumatic stress disorder, and major depression.

^bExternalizing disorders include attention-deficit/hyperactivity disorder, oppositional defiant disorder, and conduct disorder.

*p < .05, 2-sided test.

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