Maltreatment and Emotional Development

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Abstract

The family environment has strong impacts on children's emotional development. Although children can adapt to a high degree of variation in the type of input they receive, child maltreatment is a species-atypical experience that disrupts the biological systems that underlie children's social and emotional development. In this chapter we describe the consequences of maltreatment on children's emotional development, focusing on alterations in (1) emotion perception, recognition, and attention, (2) emotion expression, (3) regulation of negative emotions and stress, and (4) reward processing. We consider several target mechanisms through which child maltreatment impacts these aspects of emotion processing, including behavioral, physiological, cognitive, and neurobiological pathways. We also discuss clinical implications of this body of research, including the potential for designing effective interventions aimed at targeting specific emotional biases associated with the experience of maltreatment.

Child maltreatment is a widespread problem throughout the world. The Center for Disease Control (CDC) defines child maltreatment as "any act or series of acts of commission or omission by a parent or other caregiver that results in harm, potential for harm, or threat of harm to a child" (Leeb, Paulozzi, Melanson, Simon, & Arias, 2008). Researchers who study the impact and outcomes of child maltreatment typically discuss child maltreatment in terms of acts of commission and acts of omission (Pollak, Cicchetti, Hornung, & Reed, 2000). Acts of commission include physical, sexual, and psychological or emotional abuse, while acts of omission include failures to provide for and supervise children (e.g., neglect and exposure to violent environments).

Subtypes of maltreatment have similarly been categorized in terms of the presence of harmful input (abuse/trauma) or inadequate input (neglect/deprivation; Humphreys & Zeanah, 2015). Subtypes of maltreatment are difficult to examine separately because children who are maltreated frequently experience more than one type of abuse (Vachon, Krueger, Rogosch, & Cicchetti, 2015). Though there is some preliminary evidence that these subtypes of maltreatment may be associated with different emotional problems, current scientific understanding of these differential pathways is limited. Consequently, in this chapter, we discuss maltreatment as a broad construct composed of these subtypes (acts of

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commission/harmful input and acts of omission/inadequate input), and we review research that focuses on one or more of these different components of maltreatment.

Childhood maltreatment is associated with a number of problems related to emotional development, defined as the development of emotion perception, communication, interpretation, and regulation of emotion (Halberstadt, Denham, & Dunsmore, 2002). Abnormal development of these processes can lead to behavioral problems and psychopathology, such as post-traumatic stress disorder (PTSD), conduct disorder, drug addiction, delinquency, incarceration, and depression (Humphreys & Zeanah, 2015; Cicchetti & Ng, 2014). Critically, many of these outcomes do not become apparent until long after maltreatment has ended. This pattern suggests that childhood maltreatment might initially alter certain developmental mechanisms, such as emotion processing or response to reward and punishment, which then lead to cascading effects as development progresses. This chapter will focus on alterations in potential mechanisms of emotional development stemming from childhood maltreatment that may lead to a broad spectrum of health and behavioral problems.

Emotional Problems Related to Child Maltreatment

Childhood maltreatment is reliably associated with a broad range of negative outcomes that may stem from problems with emotion processing. For example, maltreatment is equally likely to be associated with internalizing problems like depression and anxiety symptoms, and with externalizing problems such as anger and aggressive behavior (Springer, Sheridan, Kuo, & Carnes, 2007). Children who were maltreated also experience poorer peer relationships (Kim & Cicchetti, 2010). This broad range of outcomes linked to maltreatment exemplifies the concept of multifinality, that similar childhood experiences can facilitate different developmental pathways due to bidirectional interactions between a child and his/her environment (Cicchetti & Doyle, 2016). However, these diverse outcomes may share common underlying mechanisms related to emotion processing. For example, maltreated children tend to show an atypical trajectory of facial emotion recognition development, which is most apparent for expressions of anger. Relative to non-maltreated children, these children have heightened perceptual and physiological sensitivity to angry facial expressions (Pollak & Sinha, 2002; Shackman & Pollak, 2014), and are more likely to perceive emotional situations as demonstrating anger as early as preschool age (Pollak et al., 2000). Studies of maltreated children also show less accurate identification of facial emotions in general (da Silva Ferreira, Crippa, & de Lima Osório, 2014; Pollak et al., 2000) and particular difficulty identifying positive emotions (Koizumi & Takagish, 2014). In addition, these children show abnormalities in the expression and regulation of emotions (Kim-Spoon, Cicchetti, & Rogosch, 2013). For example, physically abused children show difficulty in interpreting emotional cues, greater tendencies to respond aggressively to conflict (Teisl & Cicchetti, 2007), and they more commonly show contextually inappropriate expressions of emotion (Shields & Cichetti, 1998). Another study found that 7–10-year-old physically abused boys show more aggressive behavior and negative affect than non-abused boys, and these behaviors appear to be mediated by heightened allocation of attention to angry faces (Shackman & Pollak, 2014). Maltreated children also show higher levels of rumination (repeatedly dwelling on past negative experiences), which has been associated with an attention bias to sad faces (Romens & Pollak, 2011) and may contribute to risk for depressive symptomatology. The combination of difficulties with emotional recognition, expression, and regulation may increase children's risk for a broad range of maladaptive outcomes. For example, misreading others' facial emotion might impair peer interactions, while problematic emotion regulation and expression may contribute to rumination and/or aggressive behavior.

There are several characteristics of maltreating families that distinguish them from typical family environments and create an atypical

emotional environment for children. First, children in maltreating families that are physically abusive experience physical harm and threat from their caregivers (Bick & Nelson, 2016; Pollak, 2015). This is in contrast to a supportive family environment, in which caregivers provide protection from physical harm. In neglectful families, caregivers fail to meet children's basic physical needs with respect to clothing, hygiene, food, and/or safety (Leeb et al., 2008). As a result, both neglect and abuse result in a high degree of environmental uncertainty for children: in abusive families it is difficult for a child to predict how a caregiver will react to his/her behavior, and in neglecting families, a child may not know when s/he will have food to eat or when a caregiver will be in the home. Children in maltreating families may also experience a non-normative emotional learning environment. Parents in these families often provide poor emotional signaling to their children, producing unclear facial and vocal expressions of emotion. For example, Shackman et al. (2010) found that abusive mothers produced less prototypical facial expressions of anger (i.e., less pronounced brow lowering and contracting) relative to non-abusive mothers. In addition, abusive mothers produced less prototypical vocal expressions of anger, happiness, and sadness, showing less affect and less variability between emotions than non-abusive mothers. These findings suggest that, while these parents may often be experiencing high levels of emotion, they do not convey their feelings in ways that are readily discernable or reliably predictive for their children.

These characteristics of maltreating families create pathways that lead to disturbances in children's perception, expression, and regulation of emotions. The physical harm and threat that maltreated children are exposed to results in chronic stress, which may lead to heightened anxiety, vigilance for threat, and stress dysregulation (Norman, Byambaa, Butchart, & Vos, 2012). Unclear emotional signaling from caregivers may impair children's developing abilities to recognize and respond appropriately to the emotions of others (Kim & Cicchetti, 2010). Finally, adverse childhood experiences such as maltreatment appear to be a form of "toxic stress" (McEwen & Seeman, 1999) that derails healthy brain development, impacting the structural and functional development of brain regions associated with attention, emotional control, and reward learning (Hart & Rubia, 2012; Heleniak, Jenness, Vander Stoep, McCauley, & McLaughlin, 2015). Altered development of these regions is likely to impact many aspects of emotional development including (1) emotion perception, recognition, and attention, (2) emotion expression, (3) regulation of negative emotions and stress, and (4) reward processing. Although most research to date has focused on the processing of negative emotions in the context of maltreatment, more recent research indicates that maltreatment may also alter reward processing and positive emotions. We focus on alterations in the four processes listed above and their associated neurobiology as potential mechanisms that link maltreatment to mental health and behavior problems. We also discuss the potential for interventions and therapies that target these mechanisms.

Emotion Perception, Recognition, and Attentional Processes

When identifying emotional expressions in others, children who have experienced maltreatment tend to differ from children raised in typical family environments. These atypical patterns of emotion recognition have implications for maltreated children's social development: emotion understanding and recognition in young children has been associated with quality of friendships, prosocial behavior, peer acceptance, and social skills later in childhood (Cutting & Dunn, 1999; Izard et al., 2016; Mostow, Izard, Fine, & Trentacosta, 2008). Therefore, maltreated children's atypical emotion perception and recognition patterns may partially explain their difficulties with peer relationships.

Different types of maltreatment have been associated with specific abnormalities in emotion perception and recognition. For example, children who were neglected, but not physically abused, show more difficulty in recognizing

emotional expressions, perceiving fewer distinctions between emotions than either physically abused children or non-maltreated children (Pollak et al., 2000). This evidence suggests that neglected children show generalized emotion recognition deficits, possibly because parents in these families tend to express a more restricted range of emotions to their children, providing fewer opportunities for children to learn to associate emotional expressions with environmental events. If caregivers' emotional expressions do not reliably predict subsequent events, neglected children might begin to attend to others' emotional expressions less than typically developing children, hindering their ability to accurately recognize emotions. Physically abused children, in contrast, do not show generalized difficulties in emotion recognition. Rather, they identify anger more readily than neglected or non-maltreated children (Ardizzi et al., 2015; Briggs-Gowan et al., 2015; Cicchetti & Curtis, 2005; Curtis & Cicchetti, 2011; da Silva Ferreira et al., 2014; Gibb, McGeary, & Beevers, 2015; Pollak, Vardi, Putzer Bechner, & Curtin, 2005; Shackman & Pollak, 2014; Shackman, Shackman, & Pollak, 2007). This tendency to readily and quickly recognize cues of anger and hostility is likely due to emotional attention processes that have been shaped by living in a threatening family environment.

Emotional Attention Processes

Children are exposed to an array of emotional cues and learn to direct their attention to salient and meaningful information in their environment. In an abusive family, it becomes particularly important for a child to attend to cues of anger that may indicate a threat to their well-being. This type of attention to threat cues in the environment subsequently affects the way children come to construe their social worlds. As an illustration, one study found that 5-year-old abused children tended to believe that almost any kind of interpersonal situation could result in an adult becoming angry. In contrast, most non-abused children saw anger as likely to result only from particular interpersonal circumstances (Perlman, Kalish, & Pollak, 2008). Children who suffered physical abuse are also more likely to view others as hostile and the world as generally unsafe (Gibb, 2002; Keil & Price, 2009). These biases influence information processing, with physically abused children incorrectly encoding social cues and exhibiting hostile attributional biases (Teisl & Cicchetti, 2007). Although these attentional processes reflect short-term adaptation to hostile environments, they carry long-term risk for health and behavior, contributing to problems such as aggressive behavior, depression, and anxiety.

One aspect of abused children's sensitivity to cues of anger and hostility is that they more readily identify emotional facial expressions as angry than non-maltreated children, a bias which may contribute to aggressive behavior. A series of studies demonstrate attentional biases toward angry expressions among abused children between preschool and middle childhood. For example, physically abused children more readily categorize faces that are morphed between two different emotions as angry (Pollak & Kistler, 2002) and require less perceptual information to identify faces as angry than non-maltreated children (Pollak & Sinha, 2002). Physically abused children also show biases to angry faces during cognitive tasks. They respond more quickly to angry faces during a Go/No-go paradigm (Pollak et al., 2000) and seem to require greater cognitive resources to disengage their attention from angry faces, showing delayed disengagement when angry faces served as invalid cues in a selective attention paradigm (Pollak & Tolley-Schell, 2003).

Shackman and Pollak (2014) examined individual differences in maltreated and non-maltreated children's attention to angry faces, along with negative affect and aggression after experiencing an acute, laboratory stressor. Physically abused children showed greater negative affect after the stressor, and these negative emotions were associated with greater aggressive behavior toward children's peers. However, this association was only present among children who exhibited greater attention to angry faces.

These findings demonstrate the impact of child maltreatment on emotional attention that influences children's regulation of emotion and aggression.

Heightened attention to angry faces in abused children likely reflects vigilance for threat in the environment, and therefore may also be related to the development of anxiety disorders. Heightened vigilance to threat has been associated with anxiety disorders in children and adolescents (Krain Roy et al., 2008), suggesting that such vigilance may be a mediating factor between maltreatment and anxiety-related psychopathology. Curiously though, PTSD, one type of anxiety disorder resulting from maltreatment, has been linked to attentional biases *away* from angry faces during a dot probe task (Pine et al., 2005). In this case, the different task format (quickly identifying the location of a dot versus explicitly identifying an emotion) may explain the difference in findings from studies that found heightened attention toward angry faces during emotion identification. Another possibility is that maltreatment initially heightens vigilance to angry faces, but over time severely maltreated children might develop automatic tendencies to avoid angry faces, resulting in an attention bias away from threat (Krain Roy et al., 2008). What does seem clear is that individuals who experienced child maltreatment show abnormal attentional processes associated with angry expressions, which may contribute to anxiety problems.

Maltreatment-related emotional attention biases may also contribute to the development of internalizing problems such as depression. One study reported that maltreated children showed attentional biases to sad faces under certain conditions: Children who experienced high levels of maltreatment showed biased attention toward sad faces following the initiation of a sad emotional state, while maltreated children with high levels of trait rumination exhibited biased attention toward sad faces during both sad and neutral states (Romens & Pollak, 2011). The phenomenon of rumination—a maladaptive emotion regulation strategy that involves passively and repetitively dwelling on and questioning negative feelings in response to distress—is a known risk factor for the development of psychopathology, particularly depression (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). These cognitive patterns may identify which maltreated children are most likely to exhibit biased attention for sad cues and be at heightened risk for depression. In addition, this study illustrates how two aspects of emotion processing—emotion regulation and emotional attention biases—can interact to increase maltreated children's risk for mental health problems.

Neural Bases of Emotional Attention

There is also support for alterations in regions of the brain associated with both attentional processes and emotional regulation as a result of maltreatment. The amygdala is involved in the rapid detection and response to emotionally salient events, particularly those that signal threat (Tamietto & deGelder, 2010). While the amygdala likely plays an important role in the vigilance toward anger and hostility observed in maltreated children, this is not the amygdala's only role. In addition to modulation by the frontal cortex (e.g., during emotion regulation), there is strong evidence that the amygdala coordinates the function of cortical networks when an organism evaluates the biological significance of affective information (for review, see Pessoa & Adolphs, 2010). In this way, the amygdala may influence higher-level cortical processing of emotional events, indicating that it can influence attention and appraisal of information both early and late in the processing stream.

In some, but not all, maltreated samples, the amygdala region shows abnormal development. For example, Heleniak et al. (2015) completed rigorous hand tracing of the amygdala in samples of children who experienced different forms of early stress including physical abuse, early neglect, or extreme family poverty. They found smaller amygdala volumes for children exposed to these different forms of stress. Furthermore, amygdala volumes were associated with both greater cumulative stress exposure and a higher prevalence of

child behavioral problems (Heleniak et al. 2015). These data suggest that early and severe life stress may be associated with increased excitation and cell death, reflected in reductions in gray matter volume. Although smaller, the amygdala may become overactive in maltreated children, who tend to show a heightened response in the amygdala during emotion processing tasks (Dannlowski et al., 2012; McCrory et al., 2010, 2012; McLaughlin, Peverill, Gold, Alves, & Sheridan, 2015; van Harmelen et al., 2013). Structural and functional alterations in the amygdala may help us understand individual differences in risk and resilience to behavioral problems as related to early life stress.

Interventions Targeting Emotional Attention

These emotional attention disturbances in maltreated children may also hold promise as targets for intervention. One example is the proliferation of attention bias modification paradigms that have been used to alter emotional attention biases associated with psychopathology (Shechner et al., 2011). Effective behavioral methods have been developed to ameliorate symptoms in a range of mental health problems including anxiety (Amir, Beard, Burns, & Bomyea, 2009), depression (Beevers, Clasen, Enoch, & Schnyer, 2015), phobias (Amir, Taylor, & Donohue, 2011), disordered eating (Renwick, Campbell, & Schmidt, 2013), and substance abuse (Field, Duka, Tyler, & Schoenmakers, 2009). Existing interventions that target attentional processes have most commonly been designed to reduce or modify maladaptive attention toward disorder-relevant stimuli (e.g., threat; Mogg, Waters, & Bradley, 2017). A number of training programs have been developed, with the most common being a modified version of the visual probe, or "Dot Probe" task (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002), which promotes threat avoidance (e.g., Amir et al., 2009).

The modified visual probe task is based on research implicating preferential attention toward certain stimuli as a contributing factor in the development and maintenance of behavioral and mental health difficulties (Shechner & Bar-Haim, 2016). This task was designed to promote avoidance of threat-related cues by requiring participants to respond to a probe that appears behind a neutral stimulus a greater proportion of time than a targeted, threat-related stimulus. This training paradigm allows participants to learn the probable location of the probe and thus where to attend to improve their performance. In this way, participants learn to preferentially attend away from target cues in favor of the reinforced neutral cues (Bar-Haim, 2010). Such training programs have demonstrated alterations in attentional biases as well as reductions in various psychological symptoms (Beevers et al., 2015; Linetzky, Pergamin-Hight, Pine, & Bar-Haim, 2015; Mogoaşe, David, & Koster, 2014; Pergamin-Hight, Naim, Bakermans-Kranenburg, Van Ijzendoorn, & Bar-Haim, 2015; Shechner & Bar-Haim, 2016).

An alternative training program, interpretation bias training, was designed to improve the ability to discriminate between different emotions (Penton-Voak, Bate, Lewis, & Munafo, 2012). In this task, participants view single facial expressions of emotion morphed from one high intensity emotion to another (e.g., anger to happiness) and then attempt to identify what emotion is being expressed. To improve discriminability, participants receive corrective feedback during the training portion of the task. Such training is designed to alter individuals' interpretation of ambiguous faces to be more positive and less threatening (Penton-Voak et al., 2012; Penton-Voak et al., 2013; Stoddard et al., 2016). This paradigm has yielded shifts in maladaptive attentional tendencies as well as improvements in problematic symptomatology, including aggression and irritability in adolescent samples (Penton-Voak et al., 2012; Stoddard et al., 2016).

While not geared toward the specific deficits associated with a history of maltreatment, these advances suggest that similar types of approaches—if appropriately tailored—may also help address the threat biases and concomitant behavioral problems among maltreated children.

Promoting avoidance of threat, such as in the modified visual probe task, may in fact prove maladaptive for maltreated children, as the ability to quickly identify threat in a potentially dangerous situation allows for a possible escape from harm. However, improving children's ability to more accurately recognize certain emotional cues, such as anger, may prove adaptive if generalized to more social, non-threatening environments. A training program that improved accuracy in recognizing emotional cues may have the added benefit of maintaining the ability to recognize threat in settings where such cues are indicative of probable harm. Furthermore, interventions that successfully reduce maltreated children's hypervigilance to threat and hostility in others may reduce these children's own experience and expression of negative emotions.

Emotional Expression

The unpredictable and disorganized qualities that are associated with maltreating families—including unclear emotional signaling and inconsistent reactions to children's behavior—are likely to alter children's experience and expression of emotions, in addition to their emotion recognition and perception. In contrast to emotion perception and recognition, little is known about the extent to which abuse versus neglect exerts differential influences on children's emotional expression; most research to date on this topic involves children who were physically abused or who experienced a combination of abuse and neglect. Children living in these environments are likely to experience frequent negative emotions, including anger, frustration, and irritability (Shields & Cicchetti, 1998). Indeed, maltreated children show higher levels of negative emotionality than non-maltreated children particularly in terms of anger reactivity (Gunnar & Donzella, 2002). In addition to a preponderance of negative emotions, these children may be vulnerable to overwhelming emotional arousal. Such chronically heightened arousal may lead to difficulties managing and regulating intense emotions such as anger (Cummings, Hennessy, Rabideau, & Cicchetti, 1994). The proclivity to experience intense negative emotions combined with high emotional arousal may explain the tendencies of maltreated children to experience anger and behave aggressively in challenging social situations.

One aspect of emotional expression that has been studied in the context of child maltreatment is emotion lability/negativity, described as children's speed in reacting to affective stimuli and difficulty in recovering from negative emotional reactions (Dunsmore, Booker, & Ollendick, 2013). As an illustration, a child with high emotion lability/negativity may be prone to angry outbursts or exhibit dramatic mood swings. A longitudinal study of maltreated and non-maltreated children (Kim-Spoon et al., 2013) showed that maltreatment predicted higher emotion lability/negativity. Furthermore, lower levels of emotion regulation and higher levels of emotion lability/negativity were independently associated with increases in internalizing symptomatology between eight and nine years of age. In addition, emotion regulation mediated the longitudinal link between emotion lability/negativity and change in internalizing symptomatology among both groups of children: those with high emotion lability/negativity showed poor emotion regulation in the following year, which in turn predicted an increase in internalizing symptomatology. This study suggests that high emotion lability/negativity might interfere with the development of effective emotion regulatory strategies.

In a maltreating environment, children's heightened frequency and intensity of negative emotions likely requires greater emotion regulation capacity to manage. At the same time, Kim-Spoon et al. (2013) report that maltreatment appears to derail children's development of emotion regulation skills. Thus, a maltreated child is likely to experience intense negative emotions *and* to lack the skills and strategies need to regulate them in the service of goal-directed behavior. Insufficient regulation and management of emotions may lead to circumstances in which children are frequently overwhelmed by negative emotions, and in turn

contribute to the development of internalizing symptomatology (Calkins & Fox, 2002; Cicchetti & Toth, 1998). These interactions between emotional reactivity/expression and emotion regulation are an important potential mechanism underlying the development of internalizing disorders in maltreated children.

Emotion Regulation

Problems with emotion regulation are some of the most commonly noted sequelae of childhood maltreatment. Emotion regulation refers to an individual's ability to modify his/her own emotional arousal in order to maintain an optimal level of engagement with the environment (Thompson, 1994). Thus, emotion regulation is intertwined with emotional reactivity, and these two constructs are often difficult to disentangle. Emotion regulation allows children to respond in flexible and socially appropriate ways to changing demands in the environment (e.g., it may be acceptable to express dismay with a disappointing gift in some circumstances, but typically not when in the presence of the gift giver). Poor emotion regulation abilities are reflected in a broad range of negative outcomes, including internalizing problems (Kim & Cicchetti, 2010), externalizing problems (Herts, McLaughlin, & Hatzenbuehler, 2012), and peer rejection (Hanish et al., 2004). All of these problems are more prevalent in maltreated children relative to the general population, and are associated with psychopathological problems including depression, anxiety, and conduct disorder.

There is strong evidence that emotion regulation mediates links between maltreatment and later mental health and behavior problems. For example, one study found that young adults who experienced maltreatment as children showed higher levels of ADHD symptoms than non-maltreated individuals. However, this relation was mediated by individual differences in coping self-efficacy, an aspect of emotion regulation defined as the belief that one can effectively utilize coping behaviors in stressful situations. Maltreated individuals with high coping self-efficacy showed lower ADHD symptoms than those with low coping self-efficacy (Singer, Humphreys, & Lee, 2016). In addition, in a longitudinal study of over 400 children 6–12 years of age, Kim and Cicchetti (2010) found that neglect, physical abuse, and sexual abuse all predicted emotion dysregulation in early childhood, which in turn predicted peer rejection and externalizing symptoms in later childhood. These studies raise the possibility that diminished emotion regulation resulting from childhood maltreatment may lead to a cascade of social problems that ultimately result in increased risk for psychopathology and behavioral problems.

There is also evidence that the timing of maltreatment influences relationships between emotion regulation and subsequent mental health problems. Emotion regulation may be a stronger predictor of subsequent internalizing symptomatology in early childhood than in later childhood because younger children have not yet developed the cognitive and social skills that help older children cope with stress (Cole, Luby, & Sullivan, 2008). For the same reason, younger children, who are just beginning to develop abilities to regulate their emotions, may be more vulnerable to environmental stress such as maltreatment. Maltreatment in early childhood may both hinder the emergence of emotion regulation skills (Kim-Spoon et al., 2013), and in turn prevent the development of higher-level executive function capacities that build upon this initial regulatory capacity. This notion may explain why maltreatment occurring in early childhood appears to exert more deleterious effects on mental health and social adjustment than maltreatment that is confined to later childhood or adolescence (Pechtel & Pizzagalli, 2011).

Neural Bases for Emotion Regulation

Emotion regulation is dependent on the prefrontal cortex (PFC) and its connections with limbic brain regions involved in emotional reactivity. During emotional events, an optimally functioning PFC can modulate the activity of limbic brain regions to keep emotional reactivity at an appro-

priate level. For example, when individuals are instructed to regulate negative emotions using cognitive reappraisal, PFC activity reduces negative emotion by increasing activity in limbic regions involved in the generation of positive emotions (i.e., ventral striatum/nucleus accumbens) and decreasing activity in regions involved in generating negative emotions (i.e., amygdala). The modulation of these systems implicated in affective appraisal and learning processes in turn impacts individuals' emotional experience (Wager et al., 2008). The PFC is significantly impacted by childhood maltreatment and other forms of early adversity (Hart & Rubia, 2012), likely because it contains a high density of glucocorticoid receptors; therefore, chronically high levels of stress hormones disproportionately interfere with the growth and development of the PFC (Joëls et al., 2007; Dias-Ferreira et al., 2009). Smaller PFC gray matter volumes are commonly observed in individuals exposed to childhood maltreatment (Gorka, Hanson, Radtke, & Hariri, 2014; Hanson et al., 2010). Although links between brain structure and function are not always straightforward, a reduction in the number of PFC neurons and/or dendrites might impair the PFC's ability to regulate the activity of limbic brain regions. Supporting this notion, childhood maltreatment is also associated with weakened functional connectivity between the ventral PFC and subcortical regions such as the amygdala and hippocampus. This reduced connectivity may play a role in fear regulation and contribute to the development of PTSD (Birn, Patriat, Phillips, Germain, & Herringa, 2014). Another recent study found that childhood maltreatment was associated with reduced structural integrity of the uncinate fasciculus (UF) in young adults, a major white matter tract that links the ventromedial PFC to the amygdala (Heleniak et al., 2015). Structural integrity of the UF also mediated the relationship between childhood maltreatment and internalizing symptoms assessed at a later time point, with lower UF integrity predicting higher internalizing symptoms. This relation suggests a potential causal link between a neural pathway involved in emotion regulation and mental health.

Abnormal growth and development of brain regions that regulate stress and negative emotions may influence subsequent mental health by hindering the ability to regulate stress responses to later events. If an individual cannot efficiently regulate their emotions during stressful situations, those stressors are more likely to adversely affect their psychological functioning. Supporting this idea, Hanson et al. (2015) found that the link between UF integrity and internalizing problems was most pronounced in individuals who experienced additional stressful events between their initial scan and later psychological assessment. Individuals who had greater stress exposure over the course of the study showed a stronger negative correlation between UF integrity and internalizing symptoms. Another study (Gorka et al., 2014) found that reduced gray matter volume in the hippocampus and medial prefrontal cortex regions mediated the association between self-reported childhood maltreatment and trait anxiety in adulthood and predicted the association between anxiety symptoms and stressful life events in the subsequent year. These results suggest that reduced volume in these regions is associated with higher susceptibility to future stressful events.

Hormonal Regulation of Emotions and Stress

Additional evidence that increased biological and psychological reactivity to later life stressors could mediate links between childhood maltreatment and mental health outcomes comes from studies examining the regulation of stress by the hypothalamic-pituitary-adrenal (HPA) axis. This system also plays an important role in emotion regulation. When an individual encounters a stressor, corticotropin-releasing hormone (CRH) is secreted from the hypothalamus. This hormone acts on the pituitary gland, causing it to release adrenocorticotropic hormone (ACTH). ACTH then acts upon the adrenal gland, resulting in the production of cortisol. Cortisol binds with glucocorticoid (GR) receptors in the hippocampus to regulate the HPA axis and inhibit further release

of CRH. Similarly, cortisol released in response to stress binds with GR receptors at the cellular level to regulate the immune system (Lupien, McEwen, Gunnar, & Heim, 2009).

The HPA axis promotes adaptation in response to normative stressors. However, extreme levels of early life stress exposure, such as severe maltreatment, may impair biological regulation of stress hormones, as well as general health and immune functioning (Koss, Hostinar, Donzella, & Gunnar, 2014). For example, in typically developing individuals, cortisol release follows a diurnal rhythm with higher levels in the morning and lower levels in the evening. However, this diurnal pattern may be altered in children exposed to severe early life stress. A recent meta-analysis showed that maltreatment was strongly associated with lower awakening cortisol levels (Bernard, Frost, Bennet, & Lindhiem, 2017). In addition, a review of 20 studies examining stress and adult immune function found that child maltreatment was reliably associated with higher levels of circulating inflammatory proteins in adulthood (Coelho et al., 2014) pointing to long-term health effects of this type of chronic stress.

Altered functioning of HPA systems may help to explain relationships between child maltreatment and behavior problems. For example, one study found that children who had been abused and exhibited abnormal, flat diurnal cortisol rhythms tended to exhibit high levels of aggressive behaviors (Bernard, Zwerling, & Dozier, 2015). However, children with normal diurnal cortisol rhythms did not show increased aggressive behavior. These findings suggest a relation between maltreatment and dysregulated stress reactivity that may have implications for the development of emotion regulation. Along these lines, dysregulation in stress reactivity was found to mediate the relation between child maltreatment and the later emergence of externalizing behaviors in a longitudinal study spanning from middle to high school, with greater stress dysregulation predicting more externalizing problems (Heleniak et al., 2015). Causal influences between cortisol reactivity and emotion regulation may operate in both directions. Abnormal diurnal cortisol patterns may diminish children's ability to regulate their emotions, but emotion regulation can also influence the appraisal of stressful situations and halt or modulate the stress response (Stansbury & Gunnar, 1994).

Prevention and Intervention for Emotion Regulation Difficulties

In sum, maltreatment appears to disrupt the development of neurobiology that facilitates emotion regulation, which can contribute to both internalizing and externalizing problems later in development. However, emotion regulation is a promising target for therapy-based approaches to aid emotional development in victims of maltreatment. For example, trauma-focused cognitive behavior therapy is a treatment for traumatized children that provides individual and family therapy and includes parental or caregiver participation as a critical component (Cohen & Mannarino, 2015). Trauma-focused cognitive behavior therapy provides psychoeducation, targets emotion regulation and cognitive processing, and has strong empirical support for improving symptoms of anxiety, depression, and PTSD in addition to behavioral, cognitive, and relationship problems for both children and parents. Despite these promising developments, to fully address emotion-processing sequelae of maltreatment and prevent psychopathology, interventions that target positive emotions and reward, in addition to management of negative emotions, may be needed in light of recent evidence that maltreatment appears to disrupt reward processing.

Reward Processing

Most research to date has focused on how maltreated children perceive, recognize, and respond to negative emotions, given the preponderance of negative emotions to which these children are exposed. However, there is a growing scientific interest and awareness in the effects of early stressful environments on children's processing of positive emotional information in the form of

rewards. Rewards consist of positively valenced events or information that tend to elicit approach and/or consummatory behavior. As shown by animal and human research, rewards also facilitate learning, i.e. associating events or behaviors with rewarding or non-rewarding information (Schoenbaum & Roesch, 2005). After repeated associations involving reward, individuals learn to repeat actions that result in reward and cease actions that result in non-reward or punishment. In addition, rewards tend to induce positive emotions such as excitement and satisfaction (Berridge, Robinson, & Aldridge, 2009). Reward processing thus provides a useful window into understanding the multiple levels of impact that child maltreatment may have on emotional development.

Abnormal responsivity to rewarding information might help to explain several difficulties that have been noted in maltreated individuals. One commonly observed phenomenon is anhedonia, a lack of positive emotion that is thought to be an endophenotype of depression (Pizzagalli, 2014). Individuals with anhedonia may not take pleasure in stimuli or activities that are typically experienced as rewarding, such as food or social activities. Another problem that has been observed in maltreated adolescents and adults is difficulty learning from positive and negative feedback (Hanson et al., 2017: Harms, Shannon Bowen, Hanson, & Pollak, 2017; Pechtel & Pizzagalli, 2013). In probabilistic or instrumental learning tasks, abused individuals are slower to associate images with positive or negative feedback than non-maltreated children, as reflected in their accuracy in selecting the image that is associated with reward. Attention to and engagement with rewarding information is necessary both to take pleasure in rewards and to use rewards to guide future behavior. Hypo-responsivity to rewarding information might therefore explain why maltreatment is associated with both anhedonia and associative learning difficulties.

In contrast to *heightened* attention toward negative or threatening information exhibited by maltreated children, a growing body of evidence shows a relation between maltreatment and *reduced* reactivity to the anticipation and/or consumption of reward. Because reward processing in the context of maltreatment is a relatively new area of research, little is known about whether different forms of maltreatment are associated with different reward-related processes. Nevertheless, there is evidence that children exposed to various forms of maltreatment prioritize negative cues at the expense of positive cues. For example, when viewing emotional facial expressions, abused children identified as having attachment anxiety exhibit an attentional bias away from facial expressions depicting happiness (Davis et al., 2014). Consistent with this view, on a probabilistic reward task, maltreated children fail to show sensitivity to important environmental cues, such as changing rewards (Guyer et al., 2006; Mueller et al., 2012; Weller & Fisher, 2013). In contrast, non-maltreated children respond more quickly as their chances of winning a reward increase. Reports of primate behavior also suggest that maltreated monkeys display less interest in rewards relative to control monkeys (Pryce, Dettling, Spengler, Schnell, & Feldon, 2004). While these findings emphasize the importance of early experience in shaping responses to rewards, a greater understanding of the brain regions associated with learning reward or punishment is likely to help account for the effects of the environment on maltreated children's interpersonal behavior. Indeed, a few candidate brain systems have emerged as potentially underlying these phenomena and provide clues about the development of psychopathology.

Neural Mechanisms of Reward Processing

Rodent studies provided the first pieces of information regarding links between abnormal parenting behaviors and offspring's reward processing. For example, experimental disruption of reward circuitry in the brain prevents mice pups from emitting vocalizations when removed from their mothers; such a disturbance interferes with brain reward systems and also prevents mice from showing a preference for their own mothers (Moles, Kieffer, & D'Amato,

2004). This association also works in the opposite direction: when attachment to the parent is disrupted, other aspects of the animals' reward systems are affected. Animals with disrupted attachments to their parents also show abnormal responses to novelty, altered appetitive conditioning, and unusually high sensitivity to dopamine antagonists and reactivity to other drug administrations. This cluster of symptoms resembles anhedonia, which is a symptom of depression in humans (for review, see Bakermans-Kranenburg & Van Ijzendoorn, 2011; Matthews & Robbins, 2003).

The brain region most often associated with reward processing is the ventral striatum (VS), which is part of the basal ganglia, a diverse network of subcortical structures that work in concert to orchestrate and execute planned, motivated behaviors that require integration of movement, thinking, and feeling (Haber, 2003). Adolescents and adults exposed to childhood family adversity and maltreatment tend to show decreased VS response during reward anticipation (Boecker et al., 2014; Dillon et al., 2009; Hanson et al., 2016; Holz et al., 2017). Interestingly, these populations do not show blunted VS activity when they actually receive a reward, suggesting that these types of early adversity might particularly influence the ability to *learn* rewarding-predicting cues. Blunted VS activity during reward anticipation might also reflect deficits in approach behavior toward biologically relevant goals, which may result in less effort and motivation to obtain rewards (Holz et al., 2017). This pattern would have adverse effects for social functioning, which is dependent on the desire to obtain rewards such as social approval.

The anterior cingulate cortex (ACC) is another area of the frontal cortex implicated in reward learning. Computational models, single-unit recording in non-human animals, studies of human patients with brain damage, and basic cognitive neuroscience studies in typically developing humans all cohere in suggesting that the ACC plays a central role in how organisms make predictions and improve those predictions by processing prediction errors (Botvinick, Cohen, & Carter, 2004; Ridderinkhof, 2004; Schultz & Dickinson, 2000). Prediction errors are engines of learning because detecting differences in outcomes guides subsequent actions.

Neuronal loss and smaller volumes in the ACC have been reported in children who have suffered physical abuse compared to non-maltreated children (Carrion et al., 2009; De Bellis, Keshavan, Spencer, & Hall, 2000; Teicher, Anderson, Ohashi, & Polcari, 2014; Thomaes, Dorrepaal, & Draijer, 2010). Hanson and colleagues (Hanson et al., 2012) found that children who experienced high levels of early life stress had smaller volumes in the ACC and also more errors during an executive functioning task. In that study, individual differences in ACC volumes accounted for the association between levels of early life stress and the number of errors children made during the task. Research in non-human animals has also noted structural differences in the ACC, with lower dendritic branching in this area in rodents exposed to early stress (Gos, Bock, Poeggel, & Braun, 2008).

Functional brain imaging has also revealed that abused adolescents who showed lower ACC activation to reward trials during reversal learning performed more poorly on the task. This finding could reflect reduced cognitive engagement during rewarded trials in adolescents who had difficulty switching associations (Harms, Shannon-Bowen, Hanson, & Pollak, 2017). Similarly, resting-state functional connectivity points to effects of child maltreatment in the circuit level dynamics of the ACC related to abuse (Herringa, Birn, & Ruttle, 2013). Taken together, these findings are consistent with the possibility that children who have suffered from maltreatment experience problems related to associative learning processes. Reduced engagement and attention to reward as reflected in ACC activity may lead to reduced learning from reward. Such processes may lead to a cascade of developmental challenges because they are a major component of adaptive social learning. In this manner, learning difficulties may undermine children's attempts

to develop effective strategies to cope with changing environmental contingencies.

The orbitofrontal cortex (OFC) is another region that plays an important role in reward processing. The OFC is crucial for signaling and updating outcome expectancies such as reward/punishment to facilitate associative learning (Kringelbach & Rolls, 2004). This region also contributes to an organism's ability to flexibly adapt behavior in response to changing contingencies (Murray, O'Doherty, & Schoenbaum, 2007), in coordination with the basal ganglia (Frank & Claus, 2006). Interestingly, OFC neurons do not stop firing in response to a reward after learning, suggesting that these neurons support predictions on the basis of afferent input and anticipation prior to other emotion-processing regions such as the amygdala (Schoenbaum, Roesch, Stalnaker, & Takahashi, 2009). As expected, impairments in these systems are associated with poor learning from environmental cues.

Supporting the role of the OFC in reward learning, damage to the OFC causes deficits in reversal learning, reduces the speed of reward learning, and is activated in humans during processes such as regret and counterfactual reasoning (Honey, Kötter, & Breakspear, 2007; Passingham, Stephan, & Kötter, 2002). Common to these examples is the need to signal, in real-time, information about outcomes predicted by circumstances in the environment. Some emerging evidence also suggests functional changes in the OFC and BG during reward processing in adolescents (Galvan et al., 2006). This further suggests that these systems are a source of developmental changes in social behavior.

There is some inconsistency in the literature regarding the effects of maltreatment on the structure and function of the orbitofrontal cortex (OFC). There have been reports of both smaller volumes (Hanson et al., 2010; Holz et al., 2015; McCrory, De Brito, & Viding, 2012) and larger volumes (Carrion et al., 2009) in the OFC for children and adolescents who have suffered physical abuse. Inconsistencies have also been found in non-human animals, with both dendritic expansion (Liston et al., 2006) and retraction (Helmeke et al., 2009) reported in the OFC after chronic stress exposure. Functional brain imaging may help in clarifying the role of frontal lobe circuitry in developmental problems associated with maltreatment. However, functional abnormalities in the OFC have not consistently been identified among maltreated individuals. Although abnormal structure and function of the VS and ACC have been associated with maltreatment, links between maltreatment and abnormal reward processing might be a function of network-level and connectivity disturbances, rather than abnormal size or function of individual regions. This would not be surprising, given that reward pathways involve the complex coordination of many brain regions (Haber & Knutson, 2010).

There is evidence that functioning of these reward systems may account, in part, for how child maltreatment confers pervasive lifetime risks for children, but also confers the potential for resilience. As an illustration, hypoactive reward processing has repeatedly been demonstrated in depression (Pizzagalli, 2014; Russo & Nestler, 2013), and a substantial portion of depressed individuals have a history of maltreatment (Norman et al., 2012). This suggests that maltreatment may confer risk for depression via hypoactive reward processing. However, behavioral and neural reward reactivity during a monetary-incentive delay task has been shown to moderate the association of maltreatment with depression. Both faster reaction times to cues that predicted monetary reward and greater activation of the left pallidum, a region of the basal ganglia, were linked to lower symptoms of depression in maltreated adolescents (Dennison et al., 2016). Furthermore, higher levels of reward response predicted lower increases in depression over the next two years. This study suggests that higher reactivity to monetary reward is a potential marker of resilience to depression among adolescents exposed to maltreatment. Future interventions could capitalize on findings such as this one to develop treatments that increase attention to

and processing of reward cues in children exposed to maltreatment.

Conclusions and Future Directions

Although it has been clear for a number of years that maltreatment tends to result in disturbances in children's emotional development, the mechanisms that explain these processes are not fully understood. Here, we focused on emotion and stress regulation, the perception and expression of emotion, and reward processing as critical components linking child maltreatment to difficulties in emotion processing and development. Each of these mechanisms has been empirically shown to link child maltreatment to later mental health problems. However, there are undoubtedly additional mechanisms that will be uncovered by future research.

There are some outstanding limitations in the current literature that, if addressed, will greatly improve our understanding of the specific impacts of child maltreatment on emotional development. First, many studies still rely on self-report by adult subjects of past maltreatment. This approach may not accurately capture specific aspects of timing and chronicity of maltreatment, which are important factors in emotional development. For example, some studies indicate that children who were abused earlier and more chronically show more maladaptive emotional and cognitive processes (Cowell, Cicchetti, Rogosch, & Toth, 2015; Pechtel & Pizzagalli, 2011), and higher rates of anxiety and depression (Kaplow & Widom, 2007).

Studying the sequelae of child maltreatment is also complicated by the fact that many of the emotional manifestations of this early stress do not appear until much later in development, often adolescence or even adulthood. For example, adolescents in substance abuse treatment who were maltreated in early childhood are more likely to relapse than adolescents who were not maltreated, and relapse appears to be linked to maltreatment-related changes in limbic brain regions (Van Dam et al., 2014). Long-term alterations in limbic brain regions (Dannlowski et al., 2012) and HPA system function (Gunnar & Quevedo, 2008) due to maltreatment may also contribute to other problems that tend to emerge during adolescence, such as depression and PTSD. Adolescence may represent an especially vulnerable time for maltreated individuals due to changes in fronto-limbic connectivity patterns that occur during the pubertal transition (Ladouceur et al. 2012). Despite evidence of these sleeper effects, there are few longitudinal studies that identify maltreatment in childhood and observe emotional development in these individuals until adulthood. These types of studies are essential to understanding how maltreatment impacts emotion processing and how certain developmental mechanisms confer mental health risks over time. The few longitudinal studies that do exist suggest that maltreatment in infancy and/or early childhood may be associated with the most significant emotional and neurocognitive problems across development (Cowell et al., 2015; Kim-Spoon et al., 2013). Yet, psychopathologies such as depression, conduct disorder, and drug abuse are often not apparent until adolescence. Long-term longitudinal studies are thus essential to improve our understanding of links between maltreatment, emotional development, and mental health.

A final limitation in understanding the effects of child maltreatment on the development of emotion systems is that maltreatment history is likely to reflect the potential for broader stress and conflict in family relationships (Kim-Spoon et al., 2013). Factors in the family environment such as parenting behaviors, marital relationships, and communication of positive and negative emotion among family members also impact children's emotional development (Morris, Silk, Steinberg, Myers, & Robinson, 2007), and their effects may be difficult to tease apart from those of maltreatment. Thus, future research that examines the unique effects of these other aspects of the emotional climate within maltreating and non-maltreating families will benefit the field.

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