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Stress, memory, and emotion: Developmental considerations from the study of child maltreatment

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Abstract
Emotion and memory are examined within a developmental framework. The point of departure for this discussion is the study of maltreated children whose traumatic experiences have been linked to difficulties in emotional development. It is suggested that cognitive processes such as memory and attention serve to link experience with emotion and emotion with psychopathology. Thus, an information processing approach is used to explain the development of maltreated children's adaptive and maladaptive coping responses. It is argued that maltreated children's association of affective stimuli with traumatic experiences and memories selectively alters the meaning of emotions for these children. More generally, the role of experience and learning as a component of emotional development is emphasized.

Introductory Issues: Memory, Emotion, and Child Maltreatment

Extreme emotional experiences are likely to influence an individual's future understanding of and reaction to affective information. This effect of experience suggests that emotion and memory are intimately related. Both emotion and memory are aspects of human information processing that allow one to understand, prepare for, and cope adaptively to salient features of the environment. Consistent patterns of data reveal a strong positive association between how vividly an event is remembered and the emotionality of the event (Linton, 1975). Yet, researchers also have documented many situations in which recall of emotional events is, in fact, vivid, but inaccurate (McClosky, Wible, & Cohen, 1988; Neisser, 1982). It appears that highly emotional events are most likely to be remembered vividly; yet, at the same time, emotionality may undermine memory accuracy. The asynchrony between salience and accuracy raises compelling questions about the relation between traumatic stress and memory.

The empirical evidence discussed later in this paper leaves little doubt that arousing or stressful emotional events recruit substantial cognitive resources. The practical advantages of such distribution of resources are readily apparent. But what would be the adaptive benefit of strong, but inaccurate, emotional memories? Although much research has been directed to understanding the operational features of emotion and memory, relatively little attention has been paid to understanding the emergence and development of the integration

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of these capacities. In this paper, emotion and memory will be examined within a developmental framework. The point of departure for this discussion will be the study of maltreated children, whose traumatic experiences have been linked to difficulties in their emotional development. Although integrations of emotion and memory are not new, there has been renewed interest in these topics as the role of trauma in the development of psychopathology has gained increased recognition and interest (Cicchetti & Toth, 1997).

Memory and emotion in developmental context

Undoubtedly, humans enter the world equipped with some biological predispositions to process, remember, and act upon salient emotional cues. However, fundamental questions about the nature of emotional processes include: How and what does the emotion learner learn?; How do emotion systems remain flexible to experience?; and Through what mechanisms does experience influence the development of emotion systems? These questions hold importance because they may cast light upon how interactions with the environment may predispose the organism towards successful adaptation or psychopathology.

Developmental questions regarding the role of experience in the ontogenesis of emotions are particularly challenging research problems. The literature on emotions indicates both regularly timed changes and individual differences over development. Yet current research supports only the most tentative suggestions concerning the processes that underlie these developmental changes. Many of these research approaches rely upon the assumption that human behavior is rooted partly in biology and partly in experience and that a sound developmental explanation comes from attempts to tease these influences apart. In contrast, the issue most germane to understanding the developmental effects of trauma is not the core systems of emotion knowledge with which children are endowed, but rather the process(es) by which children extend their knowledge beyond its initial state. Thus, a challenge for exploring individual differences in emotional development may be a restriction in the range of emotional experiences. Exploring nature versus nurture issues in emotional development is, then, contingent upon the degree of variance in the emotional environment. If the emotional environments of most humans are relatively similar, then interindividual variation in emotional development could be attenuated. Even cross-cultural data may give the impression of universality of brain functioning rather than reflecting the strength of within-species similarity of experience. One way to explore the relative contributions of experience and learning versus innate propensities to the development of emotional functioning is to examine the effects of markedly species-atypical experiences on cognitive/affective functioning.

Trauma and stress are such aspects of experience (of a negative variety) that deviate from typical experience. The study of atypical or extreme emotional experiences provides a powerful opportunity to explore the mechanisms of emotional development (Cicchetti, 1996). One approach to investigating the associations between emotional development and traumatic experience is to focus upon maltreated children. Examining the cognitive and biological processes associated with child maltreatment may enhance our understanding of the mechanisms through which trauma is associated with pathological emotional development. As an example, the psychophysiological impact of maltreatment is just beginning to receive scholarly attention.

In 1996, 23.1 out of every 1,000 children in the United States met the harm standard of child maltreatment in the United States (U.S. Department of Health and Human Services, 1996). Maltreatment in these cases reflects extreme neglect, physical, and sexual abuse. This phenomenon far surpasses general notions of "poor" parenting. Children younger than 4 years of age accounted for 76% of fatalities secondary to child maltreatment; in 77% of these cases, the perpetrators were the child's parents (U.S. Department of Health and Human Services, 1997). Given the severity of many of these children's experiences, it is not surprising that the sequelae of child

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maltreatment place children at extremely high risk for the development of psychopathology (Cicchetti, 1989; Malinosky–Rummell & Hansen, 1993). One mechanism linking these children's experiences with behavioral maladjustment is their emotional functioning, including impairments in the abilities to recognize, express, and regulate their emotional states (Camras, Sachs-Alter, & Ribordy, 1996; Cicchetti, 1990). Thus, understanding the organization of these children's affective and cognitive processes in response to their stressful and traumatic experiences may shed light on the development of adaptive and maladaptive coping.

Emotional development and maltreated children

The role of negative affects such as anger and fear have played a large role in thinking about the development of emotions in maltreated children. Emotion-regulatory problems are among the best documented of the problems maltreated children display. As an example, for nonmaltreated infants, joyful facial expressions begin to emerge by 3 months of age. Infants begin to smile, show excitement when presented with familiar faces, and display what is considered to be sadness when positive stimulus events are withdrawn. Facial displays of anger have been reported to emerge at around 7–9 months of age (Sroufe, 1979). However, physically abused infants who were evaluated at 3–4 months of age manifested negative emotional expressions (Gaensbauer & Hiatt, 1984). This suggests that physically abused infants display what appears to be anger earlier and more frequently than nonabused children. Furthermore, in a longitudinal study, Erickson, Egeland, and Pianta (1989) found that maltreated toddlers displayed higher levels of anger and noncompliance during experimental tasks than nonmaltreated children. This same study reported that, during the preschool years, maltreated children were rated as more hyperactive and distractible, and more likely to display negative affect than nonmaltreated children. By the end of their first year in school, these same children were rated as more aggressive and overactive by their teachers. Beeghly and Cicchetti (1994) have reported that corpora of speech suggest that maltreated children are less likely to use emotion-related words, specifically those that refer to physiological states and negative affect, than their peers. These findings raise the possibility that behavioral problems may emerge when children are not able to express their feelings.

The developmental progression of emotion regulation problems also has been corroborated by a number of cross-sectional investigations. These studies have generally found maltreated children to show elevated levels of disruptive and aggressive behavior than nonmaltreated children, and to respond to others with inappropriate affects such as anger, fear, and aggression when empathy or concern would be more appropriate (Alessandri, 1991; Haskett & Kistner, 1991; Kaufman & Cicchetti, 1989; Macfie, Toth, Rogosch, Robinson, Emde, & Cicchetti, in press; Main & George, 1985; Troy & Sroufe, 1987).

In an experimental situation, young boys who had been physically abused witnessed a simulated interaction in which an experimental confederate directed anger at their mothers. Based upon observer ratings of behavior, these children evinced greater aggressiveness than did nonabused boys (Cummings, Hennessy, Rabideau, & Cicchetti, 1994). Although it could have been predicted that these children would show decreased responsiveness to inter-adult anger because of habituation effects resulting from their history of familial violence, these abused children appeared more aroused and more angered by the situation. In a related study, Hennessy, Rabideau, Cicchetti, and Cummings (1994) presented videotaped segments of adults in angry and nonangry interactions to physically abused school-aged children. Abused children reported greater distress and fear than nonabused children when questioned about the taped presentations, especially when anger was left unresolved.

Poor organizational control of emotion also is reflected in the finding of Camras et al. (1990) that 3- to 7-year-old maltreated children were less accurate at recognizing

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emotions than their nonmaltreated peers. Yet, Rieder and Cicchetti (1989) found that maltreated children were hypervigilant to aggressive stimuli and recalled a greater number of distracting aggressive stimuli than did nonmaltreated children. Maltreated children may not only assimilate aggressive stimuli more readily, but also may be primed towards interpreting negative affect or attributing hostility as compared to their peers (Weiss, Dodge, Bates, & Pettit, 1992). It is unclear whether hypervigilance to certain forms of affect enhances or impairs these children's overall accuracy in decoding social cues from others.

There also is evidence that maltreated children experience difficulties in relating successfully with peers (Cicchetti, Lynch, Shonk, & Manly, 1992; Mueller & Silverman, 1989; Rogosch, Cicchetti, & Aber, 1995). Physically abused children, in particular, have been reported to exhibit higher levels of aggression (Dodge, Bates, & Pettit, 1990; Salzinger, Feldman, Hammer, & Rosario, 1993), higher levels of avoidance and social withdrawal (Hoffman–Plotkin & Twentyman, 1984; Howes & Espinosa, 1985), or both aggression and withdrawal (Rogosch & Cicchetti, 1994), when interacting with peers than do their nonmaltreated age mates. A number of emotion-related factors have been identified that relate to maltreated children's difficulties forming peer relationships. For example, maltreated children are more likely to respond with aggression when witnessing distress in peers (Klimes–Dougan & Kistner, 1990; Main & George, 1985). These peer difficulties may result from maltreated children's misinterpretation of or selective attention to some emotional cues over others (Weiss, Dodge, Bates, & Pettit, 1992). Such findings are particularly significant in light of the role that peer adjustment plays in children's ability to adjust successfully to life events (Parker, Rubin, Price, & DeRosier, 1995).

Although not all maltreated children have difficulties in each of the emotion domains described above, problems in any one of these areas would increase the likelihood of the development of psychopathology. Several studies have shown that samples of maltreated children have higher prevalence of behavioral problems, including increased incidences of anxiety, depression, aggression, and social withdrawal problems than samples of SES-matched nonmaltreated children (Aber, Allen, Carlson, & Cicchetti, 1989; Erickson, Egeland, & Pianta, 1989; Shields & Cicchetti, in press; Toth, Manly, & Cicchetti, 1992).

Integrating Biology and Psychology in the Study of Emotion

The literature reviewed earlier on maltreated children's emotional development relied exclusively upon children's overt behavior. Yet research is beginning to emphasize that the study of emotions can be successfully decomposed into constituent processes that may not be apparent in overt behavior (Davidson, 1998). For example, animal models of stress have suggested that early adverse life events may trigger hormonal alterations that create vulnerabilities for psychopathology (Heim, Owens, Plotsky, & Nemeroff, 1997; Meany et. al., 1996), but that these peripheral neuroendocrine measures do not necessarily correlate with behavioral measures of stress or anxiety (Engelmann et al., 1996). These models of the effects of early stressful events on brain physiology also have been specifically linked to experiences such as variations in care between rat mothers and their pups (Liu et al., 1997).

Although there is limited knowledge about the neurobiology of stress responses in children, there is some literature suggesting that physiological dysregulation may result from child maltreatment. One relatively new area of inquiry has indicated altered reactivity of the hypothalamic-pituitary-adrenocortical (HPA) system in these children. This physiological system is of theoretical interest because of its sensitivity to stress and hormonal functioning. Initial studies suggest a reduction of cortisol reactivity that is associated with impaired social competence and depression among maltreated children. Perry, Pollard, Blakley, Baker, and Vigilante (1995) reported long-term cortisol elevations in maltreated children. Consistent results were reported by Hart, Gunnar, and Cicchetti (1996), who found that maltreated children had slightly elevated after-

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noon cortisol compared to nonmaltreated children. Further, depressed maltreated children displayed lower morning cortisol concentrations compared to nondepressed maltreated children, and were more likely to show a rise (rather than a decrease) in cortisol concentrations from morning to afternoon. A substantial body of neurobiological evidence related to stress responses (e.g., Gold, 1988) shows that stress enhances memory, with hormones producing intense (even pathologically intense) and long-lasting memories. Thus, both behavioral and neurobiological studies of developmental processes may converge to provide a more complete picture of maltreated children's emotional difficulties.

There exists a large array of particular response systems, sources of individual differences, and levels of analysis that are potential sources of information on the effects of child maltreatment. This paper focuses upon information processing as a developmental mechanism involved in maltreated children's emotional responses. Cognitive psychophysiological techniques, such as the event-related potential (ERP), are particularly well suited for the study of such processes. ERP techniques provide an opportunity to supplement studies of children's behavior with additional information about their electrophysiological brain activity. The ERP is an index of central nervous system (CNS) functioning thought to reflect the underlying neurological processing of discrete stimuli (Hillyard & Picton, 1987). The method is based upon the fact that changing membrane potentials of dendrites and nerve cell bodies generate extracellular current flow. Thus, ERPs represent scalp-derived changes in brain electrical activity over time, obtained by averaging time-locked segments of the EEG that follow or precede the presentation of a stimulus. This method has proven particularly useful in studying the cognitive processes involved in attention, memory, and categorization (Donchin, Karis, Bashore, Coles, & Gratton, 1986). In this manner, ERPs allow for monitoring of neural activity associated with cognitive processing in real cognitive time.

One particular ERP component, called P3b, is related to the delivery and subsequent processing of information deemed relevant by a subject. In particular, P3b may reflect the processes involved in the updating of representations in working memory (Donchin et al., 1986). The process of context updating allows individuals to maintain accurate representations of their environments by highlighting events that are significant. Because the ERP entails processes including memory, monitoring of the environment, and the processing of salient information, it may be particularly informative with regard to understanding the associations between maltreated children's traumatic experiences and their risk for developing emotion regulation problems. In particular, the general notion of context updating and working memory associated with P3b provides a useful link to the theories of emotion proposed by Bower (1981) and Lang (1985). Both of these theories suggest that emotional functioning is a byproduct of allocation of attention and activation of memory.

The link between stimulus and meaning or significance also is indicative of some type of representation in memory. More specifically, it has been suggested that P3b reflects a process of context or memory updating by which the current model of the environment is modified as a function of incoming information (e.g., see Donchin & Coles, 1988). An event may have emotional significance to the extent to which the event is perceived as especially salient or meaningful by an individual. It is the salience, or distinctiveness, of an event that results in more attentional resources being directed to that event. And emotional events may be better remembered because this increased attention serves to enhance encoding in memory. Context updating is linked to emotion in that changes in the environment, or mismatches between expectation and experience, are especially likely to activate emotional systems.

How are emotions then related to memory? A mismatch or updating of context first requires that an individual holds some expectation about the environment. Expectations are reflections of long term memory. The process of comparing expectations and current experience would require a short-term, or working memory. To some extent, both short- and

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long-term aspects of memory may be reflected in P3b. In this view, increased P3b amplitude may reflect enhanced memory functioning. And what enhances memory is information that an individual finds salient, and to which more information processing power is invested.

Psychophysiological processing of emotion and traumatic stress

Although most P3b research has focused heavily upon cognitive processes (for review, see Hillyard & Picton, 1987), this methodology also has been applied to understanding affective processes in both normal and clinical populations. In general, adults show larger P3b responses to emotionally intense, as opposed to emotionally neutral, stimuli. Pictures that subjects deem especially pleasant (e.g., babies, puppies) or unpleasant (e.g., blood, injuries) evoke larger P3b responses than do nonarousing pictures (e.g., furniture; see Johnston, Burleson, & Miller, 1987; Johnston, Miller, & Burleson, 1986; Lang, Nelson, & Collins, 1990; Yee & Miller, 1987). Thus, P3b is responsive to emotional intensity but does not generally distinguish between positive/pleasant and negative/unpleasant stimuli.

Nelson and his colleagues have been among the few investigators to study ERPs to emotional stimuli in children. Nelson and de Haan (1996) observed that ERPs recorded from normal infants could differentiate between expressions of happiness and anger and happiness and fear; no ERP differences emerged between displays of anger and fear. ERPs and cortisol studies of infants also have indicated greater general responsiveness to emotional versus neutral facial expressions (Gunnar & Nelson, 1995). Another study involved asking 4- to 6-year-old children to respond to photographs of either happy or angry faces; P3b amplitude did not distinguish between happy and angry faces (Nelson & Nugent, 1990). Similarly, ERPs of 7-year-olds and adults were compared in response to angry, happy, fearful, and surprised faces (Kestenbaum & Nelson, 1992). Children were asked to press a button in response to either the happy or the angry face, and the fearful and surprised faces served as distractors. Because different measurement schemes yielded different patterns of results, it was unclear whether P3b amplitude differentiated between happy and angry faces (Kestenbaum & Nelson, 1992).

In summary, these studies suggest that stimuli with positive and negative valence increase P3b amplitude. However, P3b amplitude does not differentiate among positive and negative emotional displays. Thus higher P3b amplitudes reflect more intensive processing of emotional versus nonemotional stimuli in general rather than reflecting processes particular to specific emotions. Whether or not there are discrete neural processes associated with specific emotions, these studies confirm that the significance of a stimulus is implicated in the P3b responses of both adults and children to emotional stimuli. Similar ERP methods also have been used to elucidate psychological symptoms and emotional functioning associated with disorders such as depression and anxiety (Fernandes & Miller, 1995; Lang, Bradley, & Cuthbert, 1990; Miller & Yee, 1994).

Scientists have begun to explore the effects of traumatic experience on adult central nervous system functioning. For example, combat veterans with posttraumatic stress disorder (PTSD) who were exposed to simulated combat noise had increased electrodermal arousal, as compared to veterans with combat experience who did not have PTSD (Pitman, Orr, Forgue, deJong & Claiborn, 1987). Paige, Reid, Allen, and Newton (1990) measured subjects' responses using a passive listening task to tones, presented at four different loudnesses. For controls, the amplitude of a positive going ERP wave (P200) increased as the signal loudness increased, but the opposite pattern was observed for PTSD patients (P200 amplitudes decreased as signal intensity increased). The authors suggest that this pattern reflects enhanced general autonomic arousal in PTSD patients. Similarly, McFarlane, Weber, and Clark (1993) used an active listening task in which P3b was recorded when subjects responded to one of three tones. The P3b of PTSD patients was both delayed and attenuated relative to controls, a finding which these

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authors explained as abnormal stimulus processing. Taken together, the results of these investigations suggest that even in individuals with mature CNS systems, prior traumatic experiences may have long-lasting effects on subsequent information processing. It is particularly interesting that both the Paige and McFarlane studies involved stimuli such as pure tones rather than cues actually associated with trauma. Thus, their findings suggest general and pervasive abnormalities in the processing of information following trauma.

These findings also raise questions about how these same individuals would process stimuli that are especially meaningful or significant to them. A study by Attias, Bleich, Furman, and Zinger (1996) examined ERP responses of PTSD patients using both emotionally neutral (pictures of animals and furniture) and combat-related pictures. The combat-related pictures elicited enhanced P3 amplitudes only in the PTSD patients but not in combat veterans without PTSD. In this study, combat veterans suffering from PTSD appeared to display psychophysiological hypervigilance to select stimuli. Thus, the personal significance of certain stimuli, shaped by a history of traumatic experience, modulated the processing of this information. Because cognitive ERP measures reflect aberrations in the information processing of adults who have experienced trauma, this method also may elucidate emotion processing differences in maltreated children.

ERP studies of emotion processing in maltreated children

In previous research (Pollak, Cicchetti, Klorman, & Brumaghim, 1997; Pollak, Klorman, & Cicchetti, 1998) maltreated children's psychophysiological processing of emotional information was examined. This research focused on potential mechanisms through which the psychosocial stress experienced by maltreated children could lead to problems in their processing of emotional information. In theory, such problems could create vulnerabilities to the development of psychopathology.

The experimental task required children to recognize and respond to facial expressions of emotions. In a given condition, children were told to push a handheld button when they recognized one target facial expression (for example, "happy"). This emotional expression, the "target" face, was only one of three faces that were presented to the child. Across various conditions, children were instructed to attend to different emotions, and the probability of occurrence (rare or frequent) and task relevance (target/non-target) were manipulated.

In Experiment 1 (Pollak et al., 1997), a sample of school-aged maltreated children was compared to a group of peers with comparable cognitive maturity and socioeconomic background. Children were asked to respond to either a happy face or an angry face. Because P3b amplitude is influenced by the probability of occurrence, both happy and angry faces were presented infrequently (25%) and the nontarget neutral faces was presented on 50% of the trials. Children generally made few performance errors; no distinctions between emotion conditions or groups of children appeared based upon accuracy or reaction time.

Nonmaltreated children displayed equivalent P3b responses in both happy and angry target conditions. In both cases, P3b amplitude was largest to the target, intermediate to the rare nontarget, and smallest to the frequent nontarget stimuli. In context, maltreated children responded differentially to emotion conditions, with larger P3b amplitudes in the angry as compared to happy target conditions. This difference suggests that, contrary to nonmaltreated children, different patterns of information processing were being evoked depending upon the emotion to which maltreated children were attending.

A second study (Experiment 2; Pollak et al., 1997) examined the P3b responses of a nonclinical young adult sample through the same procedures. Because the ERP findings for children in Experiment 1 were interpreted in terms of the P3b literature, it was necessary to gather further evidence that the ERP component elicited in this stimulus paradigm was consistent with the features of the P3b component. Like the nonmaltreated children in the first study, adults evinced the largest P3b response to the target faces (there were P3bs to

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all stimuli); however, there was no difference in their response to either happy or angry facial expressions. Thus, college students and nonmaltreated children displayed the same general pattern of results. The only difference between the adult and child samples was that the adults' P3b tended to peak about 100 milliseconds earlier than the children's responses. This finding is consistent with the developmental literature. Because faces are relatively complex stimuli, children were expected to process such information more slowly.

One question raised by the Pollak et al. (1997) study was the specificity of the relationship between maltreated children's P3b responses and the eliciting stimuli. For example, were maltreated children's ERPs generalized to positive versus negative emotional valence, or specific to displays of happiness versus anger? Models of emotion and memory (to be discussed below), such as those presented by Bower (1981, 1992) and Lang (1985, 1993) suggest more specific relations between the characteristics of sensory/perceptual input and resultant modifications in cognitive function. As an example, maltreated children may witness anger more frequently, and with more drastic consequences, than do nonmaltreated children; yet, other negative emotions, such as fear, are also frequently associated with episodes of maltreatment. Therefore, it might be expected that maltreated children would process all negative emotions similarly. On the other hand, discrete emotional signals may convey different information and be processed distinctly. In this view, subjective experiences of fear may be an associated feature of maltreatment episodes, but angry displays by others may serve as the most predictive cue, thereby recruiting the most cognitive resources. To explore this idea further, a new experiment was undertaken to compare the responses of maltreated and nonmaltreated children to happy, angry, and fear facial expressions.

In this experiment, each facial expression of happiness, anger, and fear was presented, respectively, as a rare target, rare nontarget, or frequent nontarget. In each of the three conditions, children were asked to press a button when one designated emotional expression (the target face) appeared. As in the previous study, nonmaltreated children displayed equivalent P3b amplitude responses to all of the facial expressions of affect. However, maltreated children's P3b amplitude exceeded that of controls only in response to the angry target but not the fear or happy faces as targets (Pollak, Klorman, & Cicchetti, 1998). Thus, there was specificity in maltreated children's differential processing of emotional information.

Emotion, memory, and risk for psychopathology: Implications for the study of child maltreatment

These psychophysiological data suggest that whatever the initial state of emotions, development entails elaboration by individual experiences, even if those experiences are species atypical. This perspective is consistent with that of many emotion theorists. Ekman has noted that: "Each emotion . . . refers to a different set of organized, integrated processes. They include the antecedent events, the physiological and motor responses, the memories, thoughts, images, and information processing, and the mobilization of efforts to cope with the source of emotion (1989, p. 159)." Thus, a stimulus becomes meaningful to an individual based upon the stored representations that have been associated with that stimulus through experience. The meanings evoked by an emotion are also intimately linked to repertoires of behavioral responses. If there is a function ascribed to emotion, then it is to guide one's actions in accordance with one's circumstances. It is here, perhaps, that the flow of information processing creates risk factors for maltreated children. If certain emotional signals are associated with traumatic, threatening, or even stressful experiences for these children, then part of their behavioral responses to such stimuli is likely to be behavioral responses appropriate to threat. Consequently, maltreated children's regulation of emotional experiences may appear aberrant in other contexts, which could, then,

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create a cascade of interpersonal problems for them.

Mechanisms Linking Trauma, Memory, and Emotion

Cognitive processes such as memory and attention may serve to link experience with emotion and emotion with psychopathology. For example, Bower (1981) has suggested that one attends more to emotionally salient stimuli and that this increased attention enhances memory for the attended to event. This is especially likely when there is a discrepancy between one's expectations and an event. Successful adaptation and learning in this case require that individuals use emotions to mobilize their attentional resources to the features of the stimulus or event. For the young emotion learner, especially, this process will best allow him or her to take appropriate action in the present and predict and plan for such situations in the future. Bower and Cohen (1982) also specifically note that memory enhancement is not indiscriminate or general. Rather, attention acts selectively. Strong emotions will enhance the central or focal component of an event, at the expense of other information. These costs may take the form of hypervigilance to certain cues and hypodetection of other important aspects of information from the environment. Accordingly, when an individual's experience fails to conform to his or her expectation, emotion is elicited. The emotion then serves to mobilize the individual's attention in the service of better learning.

It may be the case that a young learner's attention is directed to the aspects of the situation or environment that he or she judges to be significant or predictive of future violations of expectations. The emotional arousal elicited by the situation may lead to cognitive rehearsal of the event. Accordingly, both the increased attention to the event, and the rehearsal of the event, act in the service of enhanced learning, allowing the learner to form better expectations of future events based upon past experience. This learning process would help the learner to revise and update his/her expectation for what to expect in the future. Thus, emotion helps individuals to adapt. However, this process is not without cost. Whereas attention to and encoding of some aspects of the environment are enhanced, other aspects of an event may not be attended to.

Furthermore, attention to emotionally salient events may occur long after the event occurred, as when an individual rehearses prior emotional events. In this manner, emotion may also serve to distort retrieval of emotional memories. To summarize, traumatic events may enhance memory through attentional arousal and distinctiveness. At the same time, selectivity of attention may limit the features of an event that are encoded in memory, and emotional arousal may lead to distractions that impair an individual's ability to recall aspects of these events. For these reasons, depending on what is to be remembered and how such memories are elicited, emotion may be either an advantage or disadvantage. Of note, the scheme described here does not advance any special memory mechanism for processing traumatic events. Rather, it suggests that the characteristics of the event will affect the encoding and that context will affect retrieval of emotional memories.

A number of aspects of Bower's theory are particularly relevant to understanding the emotional development of maltreated children. First, making emotion-related stimuli privileged relative to other aspects of the environment would certainly enhance learning, but also may mean that some associated features of events are learned less well. Relatedly, if salient emotional information is recruiting a large share of processing capacity (as in rehearsal in working memory), then ruminations about upsetting experiences may leave learners less able to attend to other aspects of the environment. As anxious or depressed persons may be preoccupied by anxiety or depression-related stimuli, so, too, may maltreated children have fewer resources available to learn about nonthreat related emotions. Third, to be adaptive, emotional stimuli are presumed to recruit some sort of priority of information processing. Privileged

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processing would allow emotion systems to make extremely rapid and coherent use of an individual's resources in the service of survival needs. Therefore, the processing of emotions must involve computations of affective significance very rapidly, perhaps by bypassing higher cortical structures (LeDoux 1989, 1995). Such rapid computations are thought to yield basic information about the relation between the stimulus and the individual, resulting in the initiation of behavioral and physiological responses. What may follow these rapid appraisals are cognitive computations that yield information about the stimulus itself and its relations to other stimuli that are secondary to affective computations.

This rapid appraisal of incoming emotional information and the influence of stress and trauma, fit well with Lang's (1985) model of emotion processing. Lang suggests that the emotion learner must link three different kinds of information about him or herself and the environment in memory. These include information about the prompting cues/stimuli and/or context, memories about previous experiences and responses in that context, and information about the meaning or salience of the stimulus. These three pieces of information are combined in an associative network that coherently processes incoming information. Thus, emotion systems have been postulated to function as associative networks wherein input that matches significant mental representations activates memory systems (Lang, 1994). These various nodes of information are then organized into an associative network, the emergent property of which is an emotion or emotional response. Lang's theory may be extended such that P3b amplitude, in this context, may mark the match of facial stimuli with more complex emotional memories. Traumatic stress could influence the development and structure of these associative networks by presenting the network with input that is unusually timed or intense. Another possibility is that the structure of these associative networks remains similar; however, atypical experiences lead to unique patterns or thresholds of activation. That is, the structure of emotion networks remains similar, but the rules of operation (such as resource allocation) are altered. For example, mild displays of anger in isolation may lead to differential patterns of activation in maltreated as compared to nonmaltreated children. Part of these patterns of activation for maltreated children may include memories and initiation of behavioral response patterns that, though adaptive in maltreating situations, are problematic in more normative situations. What makes these networks risk factors for psychopathology in the case of maltreated children is the heightened accessibility of threat responses.

Perhaps most importantly, this view of emotions emphasizes that emotional functioning cannot be understood without reference to the fit between person and environment. Traumatic or stressful experiences encountered by children early in development must factor in to their understanding of emotions, because learning about emotions occurs in the context of adaptational encounters. Whereas learning decreases future discrepancies between expectations and events, the functional significance of this learning is understandable only within environmental context and developmental history.

The embodied cognition perspective

Common to many different theories of emotion is the principle that emotions serve to guide action appropriately in the service of survival (Bower, 1992; Darwin, 1872; Ekman, 1994; Izard, 1994; Lang, 1994). The idea of adaptation is central to contemporary behavioral and biological science. Yet, the marriage between the study of emotion and mainstream cognitive psychology has not flourished despite the advent of emotion as an empirically tractable field of study. At the same time, new approaches to the study of cognition may be particularly suited to be applied to emotion. Recent reconceptualizations of cognition have sought to integrate the abstract tenets of symbol manipulation, as used in classical information processing approaches, with the realization that perceptual and cognitive systems exist to help our bodies cope with the tangible world (Glenberg, 1997; Thelen, 1998). From this perspective, the meaning of an emotional signal is not solely

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sets of propositions or associations linked with that signal, but are highly dependent upon the physical situation available to an individual in a particular situation.

Thus, the representations that individuals form about emotions (and objects and people) reflect the histories of their bodily interactions, and the previous successes and failures of their action-oriented goals (Glenberg, 1997). The idea of action-oriented goals is central to understanding this shift in cognitive theory. From an embodied cognition perspective, how we learn to think about something like a "chair" depends upon the action-oriented goals we have in a given situation. If we need to change a lightbulb, then a chair is a stepladder. But if we need a rest, then our stepladder becomes a seat. And if we are suddenly attacked, then our chair becomes a weapon or source of defense. Mental representations cannot be understood without reference to physical context. Note, however, that the meaning of an object is not without constraints; a chair is unlikely to be thought of as a weapon for a young child who cannot lift it. The point of this analogy is that meaning is not fixed, but dependent upon goals and constrained by biology and circumstance. Our representations also are dependent upon memory. If I regularly see my grandmother sitting in a particular chair, then I may come to think of that chair as "Grandma's chair." Later, though I may need a rest (or a stepladder or a weapon), my actions may be changed because of my memory of grandma sitting in that chair. The particulars of my previous social interactions would lead me to select a piece of furniture other than Grandma's chair to achieve my goals. A history of seeing how a chair is used, or who uses that chair, informs the representation an individual forms of a chair.[1]

A more subtle aspect of the embodied cognition perspective is that bodily experience is central to understanding cognition. The chair example, described above, illustrates that conceptualization of a situation derives from the actions available to an individual in a situation. Thus, actions depend upon the physical situation, the body, and memories of bodily states. A key additional proposal is that emotional experiences can also change bodily states. What emerges from changes in bodily states are changes in conceptualization of a situation. In short, emotional reactions may literally change the functioning and capabilities of the body, and these changes, in turn, affect the individual's interpretations of situations. Although these changes may be crude (increases or decreases in arousal, hormone levels, etc.), the biological literature on stress may reflect these effects. In this manner, a history of traumatic emotional experiences may influence how an individual understands, reacts to, and uses various emotions. In the case of child maltreatment, repeated instances of trauma would produce both physical and conceptual changes. Interestingly, the nature of these changes could reflect individual differences with mediating developmental effects. Thus, different experiences would lead to changes that influence the child's interpretation and available actions (and hence understanding) of an emotional event. Variations in a child's experience and other mediating individual differences would account for why some children respond to emotional cues with fear, while others respond with sadness or aggression.

The change offered by an embodied cognition perspective concerns what memory is. Rather than merely a collection of information, propositions, facts, and images, memories take the form of biases, or expectations. These expectations are based upon past experiences, and prepare us for changes in the world (Glenberg, 1997). This emphasis on the formation of expectations based upon past experiences presents a potential conflict for the development of emotions. On the one hand, it seems adaptive for us to learn about, and to predict, the behavior of others based upon our past experiences. At the same time, for emotions to function most adaptively, they must remain flexible and sensitive to the particulars of a situation. Facile emotional functioning necessitates a balance between refinement through experience and also a freedom from overreliance on inflexible, long-term rules.

1. We thank Arthur Glenberg, who provided this example.

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Thus, there are two types of failures in memory functioning. In one pathway, insufficient or inefficient learning based upon experience would leave an individual unable to predict and respond quickly to emotional cues. Conversely, another pathway marked by lack of flexibility in the regulation of emotion would likely create a mismatch between action and situation, and result in inappropriate behavioral responses. This latter description better characterizes the kinds of problems observed with maltreated children. Interestingly, this view of emotion leads to predictions that are quite similar to those proposed by Bower (1981, 1992) and Lang (1985, 1993). However, whereas these theories emphasize analytical processes (selective attention, associative learning, rehearsal), the current discussion includes consequent environmental/bodily experiences as a developmental mechanism.

Attention, memory, and context-updating

Current empirical research suggests that basic memory and attentional processes operate in traumatic situations. What may differ about traumatic situations are the psychological/biological consequences of these events for an individual (Shobe & Kihlstrom, 1997). Interestingly, cognitive, psychophysiological, and neurobiological evidence converge to support the conclusion that high levels of stress enhance, rather than impair, memory. Certainly, the psychophysiological studies of maltreatment described earlier were not designed to resolve issues about repressed memories. However, in discussing the role of memory, emotion, and trauma, these psychophysiological data suggest increased salience and enhancement rather than attenuation of responsiveness to attended emotional stimuli among maltreated children. From an embodied cognition perspective, this is what would be expected. If developing children hold their own protection or security as an action-oriented goal, then a history of threat would be expected to result in increased vigilance to signals associated with threat, such as anger. In fact, ERPs have been proposed to measure explicit or recognition memory in young children (Thomas & Lykins, 1995).

Neurobiological perspectives on learning

The intent of this paper is not to describe the neurobiological mechanisms through which maltreated children's experiences influence their emotional functioning. It does not follow that all psychological processes must (or can) be explained at a neurobiological level of analysis. However, given the burgeoning array of new techniques and methodologies available to behavioral scientists, it is useful to consider whether developmental theories are at least biologically plausible. Of relevance here is Greenough and Black's (1992) description of a framework through which experience affects brain plasticity. Experience-expectant mechanisms appear to have evolved in cases in which the information to be acquired is common to all young members of a species. Such experiential events play a key role in pruning synapses. Deviations from species-typical patterns of attachment or exposure to threat and stress might interfere with the normal process of synapse pruning in the frontal cortex over the course of maturation. Experience-dependent plasticity refers to events that are idiosyncratic for each individual. Such processes result in localized synaptic overproduction, followed by deletion, and are implicated in learning and memory formation. Experience expectant and dependent processes carry enormous adaptive advantages for the infant. The prolonged immaturity of the human brain allows for relatively large windows of time through which experience may influence the development of neural structures. Such prolonged immaturity of cognitive systems may be evolutionarily advantageous because it allows the child increased opportunities to adapt to the features and demands of her or his current environment (Bjorklund, 1997). However, developmental reliance on the environment also carries some risk. Experience-dependent plasticity allows the individual more developmental versatility. But if the early environmental experiences en-

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countered by the developing individual are atypical, these aberrant experiences are likely to have effects that cascade through future aspects of development as a function of the variations in synaptic structures that emerge developmentally. Thus, the developing child may be particularly vulnerable to traumatic or unusually stressful experiences.

Memory Processes and Traumatic Experience: Implications for Understanding the Effects of Child Maltreatment

There are three important themes that emerge in this discussion of the relation among trauma, emotion, and memory.

Theme 1: The importance of context and prior experience

Current studies on the psychophysiology of emotion are rooted in W. B. Cannon's (1927) critique of the James–Lange theory of emotion. Cannon argued that emotion did not begin with conscious experience of affect and that emotion is a physiological phenomenon. Cannon's model was elaborated by Lacey (1967), who argued that physiological responses to emotions differ depending upon the situational factors that elicited the emotion. In this regard, patterns of reactivity are affected by many factors including the specific task content, environmental demands, and the eliciting stimuli itself (Lacey, 1967). Traces of Lacey's model can be found in nearly all of the current models of emotion. For example, Izard, Lang, Ekman, and Bower, all note the importance of context and prior experience in understanding an individual's emotion responses. Most recently, theories of action-perception (Thelen, 1998) and memory (Glenberg, 1997) have further refined experience to include the individual's history of real, somatic experiences in the development of cognitive functioning. To this end, understanding the effect of maltreated children's traumatic histories on their emotional and memory development will require detailed examination and consideration of these children's actual experiences.

Theme 2: Specificity of effects

A second important theme concerns the importance of specificity of effects based upon experience. It is clear that the effects of maltreatment can influence the developmental organization of children's emotions. But it is not at all clear that these effects are general or random. Rather, specific kinds of experiences are likely to affect specific aspects of emotional development. Therefore, future research may benefit from focusing on specific aspects of emotional functioning, such as recognition, or the approach–withdrawal system. It is not necessary to posit innumerable and separate emotion systems. For example, it is possible that the same factors that account for emotion perception are related to the retrieval of affective memories. Similarly, one memory system or a single emotion system could theoretically hold representations of many different emotions, only some of which could be affected by child maltreatment.

Consistent with the idea of specificity are research findings that various groups of patients selectively process disorder-specific information. For example, McNally, Kaspi, Riemann, and Zeitlin (1990) found that PTSD patients exhibited Stroop interference for trauma-related words, but not for neutral words, positive words, or words related to other forms of anxiety. Moreover, this effect was specific to PTSD patients; combat veterans without the disorder did not exhibit interference for PTSD words. The McNally et al. findings are similar to those of Foa, Feske, Murdock, Kozak, and McCarthy (1991), who found that rape victims exhibited Stroop interference specifically for rape-related words. Indeed, specificity effects are not limited to trauma-related disorders. Data suggest that anxiety or threat in general is associated with attentional biases toward certain kinds of information. Similar effects have been found in spider phobia (Watts, McKenna, Sharrock, & Trezise, 1986), social phobia (Hope, Rapee, Heimberg, & Dombeck, 1990), and panic dis-

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order (Ehlers, Margraf, Davies, & Roth, 1988). These findings suggest that the role of selective attention in these forms of psychopathology is not a function of generally heightened emotionality, but more specifically linked to an individual's concerns and, perhaps, experience.

Theme 3: Adaptation and maladaptation

The information that children learn to attend to is potentially determined by their experiences. For maltreated children, many different affective signals are undoubtedly associated with their threatening and even traumatic experiences. To cope with a maltreating home environment, these children are confronted with an enormously complex learning problem. As a social learner, the child is forming expectations about the world and people in it. To this end, children receive a vast amount of important information about what to expect from others. However, emotional signals are often complicated, context-bound, and, perhaps especially for many maltreated children, inconsistent. Additionally, one constraint imposed on children by development involves limitations on cognitive resources (Bjorklund, 1997). Limitations of sensory, attentional, and memory capacities dictate that for the developing child, all information from the environment cannot be processed equally (Turkewitz & Kenny, 1982). Thus, emotional information from the environment may exceed the developing child's information processing capacity. Therefore, children need to be selective in what they attend to, favoring some information over others. Successful adaptation for maltreated children likely depends upon the selection of emotional cues that provide the best predictive power of others' behavior. It is to these cues that children may learn to direct their available cognitive resources.

The absence of happiness or presence of anger and fear, conveyed through various channels (facial expressions in others, subjective feeling states), can serve as salient predictors of physical threat. However, anger may be especially predictive of impending threat for these children. Early recognition and reaction to anger is likely to provide these children with increased opportunities to seek increased safety, and a child may learn to recognize and respond to angry cues rapidly and efficiently. The benefits to the child, in a maltreating context, are obvious. However, this early form of adaptation and coping is probably not without cost. In other social situations, particularly with nonmaltreating adults and peers, lack of flexibility in responding to perceived threat or anger might lead to the development of interpersonal difficulties and inappropriate social interactions (Cicchetti, 1991).

Future directions

Emotional development almost certainly entails some "directed" learning, wherein the developing child associates emotional signals with interpersonal contingencies in the environment. This predisposition for learning about emotion does not require that the child enter the world with preformed emotional knowledge or understanding. More likely, the child is equipped with some biologically based predispositions to filter and attend to emotional signals, such as facial expressions, verbal prosody, and body position. What those signals come to be associated with and what they will later represent for the child will be a function of the child's experiences in the world. It is these learned associations that intimately link emotion and memory processes.

Much of the research on the sequelae of child maltreatment emphasizes the deficits and problems in socioemotional functioning in these children. The processes underlying maltreated children's emotional recognition reflect adaptive (but costly) responses to their environments. Heightened sensitivity to certain forms of emotional signaling, such as anger, would have clear advantages for these children (Cummings et al., 1994; Hennessy et al., 1994). Understanding the factors influencing these children's emotional development will also need to include the role of their experiences with emotions. It may well be the case that because of their atypical history of

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experiences with particular emotions, these children develop understandings about emotions that differ from those of most other individuals. Part of these differences may include traumatic memories or threat-related representations associated with some emotional signals. These representations would then be reflected in behaviors that appear to observers as hypersensitivity to negative emotions, or aggressive/hostile attributions to other people or situations. Dodge and his colleagues (e.g., Dodge, 1993) have outlined a framework in which such perturbations of social information processing can jeopardize children's socio-emotional development. However, although emotion regulation and information processing problems in maltreated children have been well-documented, many pressing developmental issues remain unanswered. Among those questions is understanding the nature of the relation between the kinds of experience children have and their relative risk for different kinds of disorder. Why is it that some maltreated children develop externalizing problems such as conduct disorder, while others develop internalizing problems such as depression? At what developmental points are children more or less vulnerable to various forms of traumatic stress? And what are the mechanisms that carry experiences of traumatic stress forward into other areas of development?

William James (1890, p. 402) wrote, "My experience is what I agree to attend to." But, really, experiences involve what we attend to, even when we have not actively agreed to attend. As Bower has emphasized in his work with nonclinical populations, emotions affect attention—and vice versa. And what we attend to is likely to be encoded and retrieved as memories associated with particular stimuli or events. In general, when people are fearful—either because of some immediate fear, or because of an extended fearful state—their nervous system responds. When this happens, attention is narrowed and directed to those cues in the environment related to threat and safety. Even more specifically, attention is tuned to those cues most related to the object of the person's anxiety (Foa et al., 1991). Such a mechanism is invaluable for survival. Memory research suggests that the impact of stress upon memory formation may be contingent upon environmental factors (Christianson, 1992). For example, stress may enhance the recall of salient stimuli in the environment (e.g., Brown & Kulik, 1977). The same adaptive principles involving attention, memory, and emotion are presumed to operate for maltreated children. However, the experience of trauma and stress may affect the manner in which maltreated children process emotion information. One possibility is that histories of trauma enhance the relevance of the negative emotional expressions—or diminish the salience of the positive expressions—for these children. Beyond the selectivity of the information encoded by these children, the association of affective stimuli with traumatic experiences or memories could also alter the meaning or content of the representations activated by those emotions. Certainly, the influence of trauma on the development of memory processes must be explored at a variety of levels. Because child maltreatment is a multidetermined problem that likely affects many neurobehavioral systems, a more complete understanding of the role of experience on the development of brain-behavior relations is necessary. Such research not only holds enormous opportunity for understanding maladaptive development of emotion systems but also for expanding our understanding of normal functioning of these processes.

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