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Effects of Early Experience on Children's Recognition of Facial Displays of Emotion

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The present research examines visual perception of emotion in both typical and atypical development. To examine the processes by which perceptual mechanisms become attuned to the contingencies of affective signals in the environment, the authors measured the sequential, content-based properties of feature detection in emotion recognition processes. To evaluate the role of experience, they compared typically developing children with physically abused children, who were presumed to have experienced high levels of threat and hostility. As predicted, physically abused children accurately identified facial displays of anger on the basis of less sensory input than did controls, which suggests that physically abused children have facilitated access to representations of anger. The findings are discussed in terms of experiential processes in perceptual learning.

Humans rely heavily on facial expressions when communicating emotional states to others. Although considerable attention has been devoted to how the nervous system responds to faces as compared with other objects (McCarthy, Puce, Gore, & Allison, 1997; Moscovitch, Winocur, & Behrmann, 1997), there are still many questions about factors that affect the perception of emotion-specific information communicated by the face. Because emotions are signaled as continuous sequences of changes in facial musculature, rapid, accurate recognition of facial expressions of emotion presents a significant computational processing achievement for the developing child. To correctly identify an emotion, an observer must use early partial information from a dynamic modulation of muscle movements to generate hypotheses about what emotion is being displayed and then map those changing physical features onto categories to label, categorize, and predict the behavior of others.

Visual recognition of emotion requires an observer to relate features of the face to stored representations of facial features in an emotion lexicon. Here we use the term *emotion lexicon* to refer to structured arrays of features, where the observer must determine an abstract concept of a subjective feeling state (such as "anger" or "sadness") based on the detailed configural properties of the surface musculature of the face (such as a clenched jaw or raised eyebrows). Thus, the representation of an emotion begins with the fine-grained details of variation in facial input and results in an emotion labeling choice (for discussions of the processes underlying recognition of facial expressions, see Pollak & Kistler, 2002; Teunisse & de Gelder, 2001; Young et al., 1997). We speculated that if recognition of an emotion requires access to a representation, then early, partial information about the incoming emotional signal must be made available immediately. In ordinary social discourse, an observer would probably not wait until another person's emotional expression had peaked before trying to identify what it was the other person was feeling. More likely, as observers watch a facial expression begin to form, they begin to observe and pick out clues about what emotion is being communicated—long before the final, peak display of the emotional expression.

Therefore, we reasoned that the ability to use partial information in affective signaling would allow an observer to begin to generate hypotheses about what another individual is feeling. Rapid recognition of emotional signals, if accurate, would facilitate adaptive social functioning. However, it is reasonable to expect that the assumptions observers make about the emotional states of others will be guided by the observers' expectations, perceptual sensitivity, and access to mental representations of emotional knowledge. Moreover, an observer's detection of early cues may also restrict consideration of emotion categories as possible choices even when the full identity of the emotion being expressed is uncertain. For these reasons, it is important to better understand what factors influence how individuals learn to recognize and decode emotional information conveyed by the face. Two recent models have been advanced to account for the role of experience in facial recognition. In one model, experience-independent neural structures facilitate attention to facelike objects, and such stimulus preferences lead to increased learning and discrimination based on experience

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(e.g., Morton & Johnson, 1991; Tarr & Gauthier, 2000). In the other model, increasing perceptual experience with faces is hypothesized to result in cortical specialization and hence preferences for faces (Nelson, 2001).

Illustration of Species-Atypical Emotional Experience: Child Maltreatment

Fundamental issues in the development of emotion recognition abilities, such as the relative contributions of experience-independent (i.e., biological programming) versus experience-dependent (i.e., learning) factors, are extremely difficult to investigate.[1] This difficulty arises from the fact that children are virtually always exposed to rich, complex, and perhaps even cross-culturally similar affective experiences from birth. Similarly, it is not possible to experimentally manipulate an individual's prior knowledge or expectations concerning basic affective signals. Therefore, we have attempted to address the difficulties inherent in studying the effects of experience on development by studying children whose experiences with the communication of emotion may deviate in important ways from those of most members of the species. As an example, the emotional environments of children who have experienced various forms of maltreatment by their adult caregivers are different from those of typically developing children; maltreated children experience perturbations in both the frequency and content of their emotional interactions compared with children from nonmaltreating families (U. S. Department of Health and Human Services, 2001). Therefore, studying these children may allow us to parse the effects of social experience on children's perceptual learning about emotion.

Studies of emotional interactions have indicated that maltreating parents show less positive emotion (Bugenthal, Blue, & Lewis, 1990; Burgess & Conger, 1978; Kavanaugh, Youngblade, Reid, & Fagot, 1988) and more negative emotion (Herrenkohl, Herrenkohl, Egolf, & Wu, 1991; Lyons-Ruth, Connell, Zoll, & Stahl, 1987) toward their children than is observed in typical families. Maltreating parents also tend to isolate themselves and their families from others, leaving children exposed to fewer nonparental models of emotional communication (Gaudin & Polansky, 1986; Salzinger, Feldman, Hammer, & Rosario, 1993). Studies contrasting different types of maltreating families suggest that physically abusive parents interact with their children frequently but with high rates of verbal and physical aggression directed at them (Bousha & Twentyman, 1984; Crittenden, 1981). Therefore, physically abusive environments are likely to include high-intensity aggressive outbursts, frequent patterns of aggression, heightened hostility, and increased interpersonal threat.

To further examine the affective input that maltreated children receive, Camras et al. (1988) asked mothers to deliberately produce facial expressions of specific emotions. Despite opportunities to practice in front of a mirror, maltreating mothers produced facial expressions that were less easily identified by observers than were the expressions of nonmaltreating mothers. Moreover, the posing ability of the mothers in both samples was positively correlated with their children's ability to recognize emotions. These findings suggest that mothers' capacity to deliberately produce facial expressions contributes to their children's ability to recognize facial emotion. Camras et al. (1990) also examined spontaneous facial expressions produced during mother–child interactions in both laboratory and naturalistic settings. In the laboratory, children and their mothers were videotaped while playing with toys designed to elicit emotional responses, whereas at the participants' homes, research assistants made observational ratings. Laboratory facial behavior was coded with a facial coding system, and facial behavior during home observations was coded by hand with a simplified system. No differences were found between maltreating and nonmaltreating mothers in terms of spontaneous facial behavior, with the exception of sadness (Camras et al., 1990). Yet regression analyses indicated that the children's emotion recognition skills were associated with their mothers' use of negative lower facial actions (e.g., lip presses) in both the laboratory and home sessions. These findings indicated that mothers who showed more expressive signs of concentration, determination, frustration, or mild anger had children who were better at recognizing emotional expressions. Camras et al. concluded that maternal modeling of low-intensity emotional expressions may enhance the development of children's expression recognition skills. At the same time, mothers who produced more intense negative affect had children who were less able to recognize emotional expressions.

There are a number of additional points to be made about these studies. First, only the facial expressions of mothers were studied—therefore, the effects of the emotional signaling produced by other adults that maltreated children may regularly encounter (such as fathers or the companions of single parents) are left unspecified. It is also possible that although maltreating mothers did not differ from nonmaltreating mothers in their display of spontaneous facial expressions in the Camras et al. (1990) study, maltreating parents may differ from nonmaltreating parents in interactional contexts that were not observed in that study, such as in more highly charged emotional situations. Camras et al. (1990) also noted that observers recorded more frequent displays of sadness among maltreating mothers. However, the higher sadness ratings in maltreating mothers appeared more attributable to lack of facial muscle tone than to production of sadness-relevant facial muscle movements. This finding is particularly interesting in light of a report by Pollak, Cicchetti, Hornung, and Reed (2000) that physically abused children showed poor ability to recognize sad facial expressions. This lower ability suggests that exposure to frequent but poorly posed expressions of emotion may lead to suboptimal learning. These findings are also very similar to those of Denham, Zoller, and Couchoud (1994), who found that mothers who produced more full-face anger in the laboratory had children who scored lower on a test of general emotion knowledge. Thus, maternal displays of intense negative emotion may adversely affect the development of emotion knowledge despite the frequency

[1] Our use of the term *experience-dependent* developmental processes encompasses two different models of experiential effects on development. One model, which refers to "experience-expectant" processes, suggests that certain inputs or experiences must be present at certain times for normal development to occur. Models such as this one include notions such as "sensitive periods." The other model involves individuals learning about things that are unique to their particular environments (learning "depends" on what one encounters in the world) and may not necessarily include temporal constraints on input. Future studies examining the effects of the developmental timing of children's emotional experiences on their behavior should disambiguate these models. For further discussion, see Bruer and Greenough (2001).

of the child's increased exposure to negative emotional expressions.

Experiential Influences on Affect Processing

How might environmental deviation—such as extremely hostile affective experiences—direct (or misdirect) children's learning about facial displays of emotion? Because of the stochastic, extreme, inconsistent, and/or poorly posed nature of the threat signals that physically abused children are exposed to in their family environments, anger may become a particularly salient environmental cue for them. Therefore, one possibility is that physically abused children learn to make decisions about the signaling of anger using minimal visual information. The development of increased perceptual sensitivity for the fine-grained details of variation in affective expressions may provide a behavioral advantage for children living in threatening contexts, allowing earlier identification of emotion. However, early identification of an emotion on the basis of minimal visual information would only be adaptive if it was also accurate. In short, anger-related cues may be especially important to physically abused children because they are a salient cue that harm is imminent, signaling a negative change in context. This view does not suggest that there is anything inherently pathognomonic about anger; the argument is simply that if children learn that anger is a predictive signal that an adult may become violent toward them, minimal affective signals related to anger may begin to attract increased attention.

Consistent with the view that children exposed to high levels of threat allocate attention disproportionately to anger, physically abused children in a study by Pollak et al. (2000) displayed a response bias for anger on a task that required matching facial expressions to emotional contexts. This signal detection paradigm suggested that when physically abused children were uncertain which facial expression to select in these tasks, they showed a bias, or lower threshold, for selecting anger, whereas control children did not display such a response bias. Psychophysiological studies have similarly provided evidence that physically abused children, compared with controls, allocate more processing resources when their attention is directed to anger but perform similarly to controls when attending to happy and fearful faces (Pollak, Cicchetti, Klorman, & Brumaghim, 1997; Pollak, Klorman, Thatcher, & Cicchetti, 2001; Pollak & Tolley-Schell, 2002). These findings suggest that physically abused children do not have global emotional recognition or affective information-processing problems but instead display differential processing of emotion that appears to be specific to anger.

However, it is difficult to explore the hypothesis that children exposed to high levels of threat are especially sensitive to visual cues of anger and can relate visual cues to representations of emotions. The examination of this issue requires both a theoretical model and an experimental technique that are sensitive to the dynamics of emotion recognition—not merely asymptotic performance or response choice probabilities. In the present experiment we sought to acquire data that could inform us about the course of children's affective processing and that would represent more directly the sequential and content-based properties of feature detection involved in emotion recognition processes. The most common approach used to assess the activation of emotional lexica or affective representations involves priming methodologies. Traditionally, priming has been indexed by reductions in response latencies or elevations in some behavioral measure of performance. However, these measures rely on precise temporal measurements (typical priming effects are on the order of tens of milliseconds) and reflect motor response processes in addition to perceptual processes. In the present experiment, we used a "priming" index that measured the minimum amount of information a subject needed to perform an emotion recognition task, independent of response latencies. By presenting affective stimuli to children incrementally as sequences of emotional expressions and asking them to report what emotion they thought they were seeing, we were able to determine very precisely how they were interpreting the visual input up until more visual information was presented.

Our hypotheses for the present study were as follows. First, we expected that physically abused children would accurately identify facial displays of anger on the basis of less sensory input than would nonabused children. Second, we sought to test a more tentative hypothesis that physically abused children would require more perceptual information to recognize displays of sadness. This hypothesis was based on the finding of Camras et al. (1990) that physically abusive mothers displayed more frequent but also more poorly portrayed expressions of sadness and also on the finding of Pollak et al. (2000) that physically abused children had more difficulty matching facial displays of sadness to emotional situations. Both hypotheses allow further exploration of how children are able to use incomplete or partial information to access representations of emotion and may provide a first step toward understanding the processes linking children's experience with their overt behavioral responses. On the basis of our previous psychophysiological studies, we did not predict group differences for the recognition of happiness or fear.

Method

Participants

Twenty-four physically abused and 23 nonmaltreated children participated in this experiment. The physically abused children ranged in age from 8 years 6 months to 10 years 1 month ($M = 9$ years 4 months, $SD = 1$ year 7 months). Seven (30.4%) of the physically abused children were girls. The mothers of the physically abused children described their race as Black/African American (39.1%), White/non-Hispanic (52.2%), or Hispanic (8.7%). These mothers described the race of the children's biological fathers as Black/African American (47.4%), White/non-Hispanic (42.1%), Hispanic (5.3%), or "other" or unknown (5.3%). Physically abusive families were recruited from the Child Protective Services division of the Dane County (Wisconsin) Department of Human Services. Specific hypotheses were not advanced for children who experienced other forms of maltreatment such as sexual abuse, witnessing of violence, neglect, or emotional abuse in the absence of physical abuse; therefore, these groups were not included in this study.

A comparison sample of nonmaltreated children was recruited from publicly funded after-school and day-care programs associated with the Department of Human Services. Children in this sample ranged in age from 8 years 8 months to 10 years 2 months ($M = 9$ years 5 months, $SD = 1$ year 6 months). Nine (39.1%) of the nonmaltreated children were girls. The mothers of the nonmaltreated children described their race as Black/African American (18.2%), White/non-Hispanic (68.2%), White/Hispanic (9.1%), or Asian (4.5%). These mothers described the race of their children's biological fathers as Black/African American (18.2%),

Figure 1. Example of a RISE (random image structure evolution) sequence. The sequence shows a gradual image evolution starting from an unstructured field. The image is from a set of photographs entitled *Japanese and Caucasian Facial Expressions of Emotion (JACFEE)* by D. Matsumoto and P. Ekman, University of California, San Francisco, 1988. Copyright 1988 by D. Matsumoto and P. Ekman. Reprinted by permission.

White/non-Hispanic (59.1%), Black/White (9.1%), Asian (4.5%), or "other" or unknown (9.1%). Permission was obtained from each control family to verify that they did not have existing records with the Department of Human Services child abuse registry. The maltreated and nonmaltreated samples did not differ with respect to age of child, $F(1, 45) < 1$, *ns*; sex of child, $\chi^2(1, N = 47) < 1$, *ns*; race of biological mother, $\chi^2(4, N = 47) = 7.24$, *ns*; or race of biological father, $\chi^2(5, N = 47) = 7.27$, *ns*.

To supplement the maltreatment information obtained from treatment and judicial agencies, all parents completed the Parent–Child Conflict Tactics Scales (CTSPC; Straus, Hamby, Finkelhor, Moore, & Runyan, 1998). The CTSPC measures the extent to which a parent has carried out specific acts of physical aggression toward the child in the past year. A Physical Abuse summary score was calculated by summing the scores of the Minor Physical Assault, Severe Physical Maltreatment, and Very Severe Assault subscales of the CTSPC. Sample items include the presence and frequency of the following acts toward children: "Beat him/her up, that is, you hit him/her over and over as hard as you could"; "Grabbed him/her around the neck and choked him/her"; "Burned or scalded him/her on purpose"; "Threatened him/her with a knife/gun." Parents of children in the comparison group endorsed far fewer aggressive behaviors toward children ($M = 4.30$, $SD = 8.72$) than did physically abusive parents, who reported high frequencies of weekly aggression ($M = 33.91$, $SD = 28.34$), $F(1, 45) = 22.93$, $p < .001$.

Prior to the experiment, parents provided written informed consent for their children to participate, and all children provided verbal assent. Following the experiment, each child was rewarded with a toy, and parents were paid for their time and reimbursed for transportation expenses. Participation of the parents and children was voluntary and not contingent on receipt of services from any of the recruiting agencies.

Stimuli

Four each of angry, happy, sad, and fearful facial images were taken from Matsumoto and Ekman's (1988) color set. Half of the faces were posed by female models. Each series of faces was presented in random order across subjects. Presentation of the facial images was conducted with the use of the random image structure evolution (RISE) paradigm (Sadr & Sinha, 2001). RISE is a continuous image transformation procedure that allows the traversal of continuous trajectories in a multi-dimensional image space. The specific implementation of RISE that we used in the present experiment proceeds by performing pairwise exchanges of image regions. As the exchanges accumulate, the image dissolves into a globally unstructured random field. The RISE software continuously records the coordinates of the exchanged regions so that the sequence can be played backward. When these exchanges are presented to an observer in reverse order, the percept is that of a continuous evolution of image structure—starting with a seemingly random image that gradually gains more organization and is finally transformed into a fully formed pattern. An example sequence is presented in Figure 1. The RISE protocol has the important benefit of precisely maintaining the low-level perceptual attributes of the original stimuli, such as overall luminance and color distributions, and prevents contamination of the experimental results by these factors. The dependent measure in this paradigm is the position along the pattern evolution axis at which an observer first detects the presence of the pattern. This first-detect point also serves as a measure of perceptual sensitivity. Earlier correct identifications will indicate a child's ability to identify a facial expression on the basis of minimal information from the image.

Procedure

Children viewed color image sequences of 16 different models displaying facial expressions of anger, happiness, fear, and sadness on a high-resolution touch-sensitive color monitor (ELO TouchSystems Inc., Fremont, CA). Faces were initially presented in a highly degraded format that made them difficult to discern. However, at 14 regular intervals, the images became more organized and easier to identify. After each of these 3.3-s intervals, the presentation of the image would stop changing, and children were prompted to identify the emotion depicted on the screen by selecting a written label or cartoon image of an emotion. Children had the option of selecting anger, happiness, sadness, disgust, surprise, or fear. Participants were required to make a judgment at each interval, and after selecting an emotion label, they were then asked to rate their confidence in their choice on a 5-point scale that ranged from *certainty* to *a guess*. These confidence ratings were recorded to differentiate correct guesses from hits—only correct responses with confidence ratings of 4 or higher were used. An IBM PC recorded the confidence ratings and the percentage of correct identifications for each emotion for each amount of information available to the child. Children controlled the interval between series of facial displays.

Results

We predicted that physically abused children would detect angry facial expressions on the basis of less perceptual information than would control children. Figures 2 through 5 present the mean recognition accuracy for maltreated and nonmaltreated children as faces became more discernible. Higher scores indicate greater recognition accuracy for each emotion, and earlier images reflect less information about each facial expression. To assess whether the identification rates for each group of children were different, we plotted 95% confidence intervals around each mean.[2]

As shown in Figure 2, physically abused children accurately recognized angry facial expressions on the basis of less informa-

[2] Nonoverlapping confidence intervals are more conservative (by a factor of $\sqrt{2}$) than a two-tailed *t* test with significance $< .05$. The same pattern of results emerged when a more traditional statistical approach was used. Difference scores were calculated between mean scores for the two groups at each point in the sequence for each emotion. Difference scores significantly differed from zero (after Bonferroni correction) at the same points where confidence intervals between the groups did not overlap.

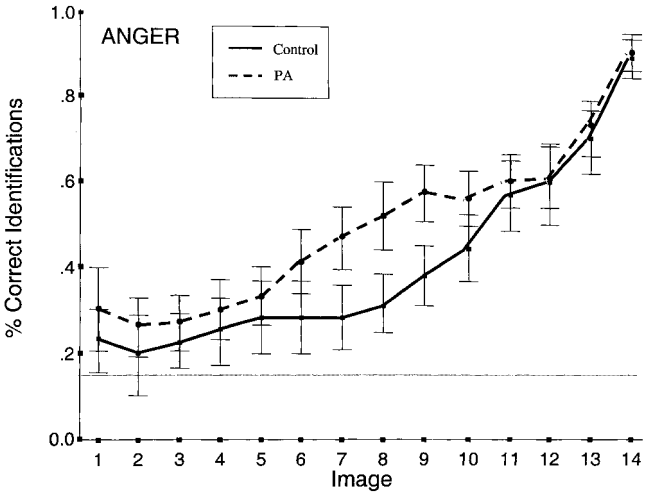

Figure 2. Mean identification rates for angry facial expressions as a function of amount of visual information (95% confidence intervals are plotted around each mean). Results are shown separately for physically abused (PA) and control children. Chance performance (0.16) is indicated by the horizontal line.

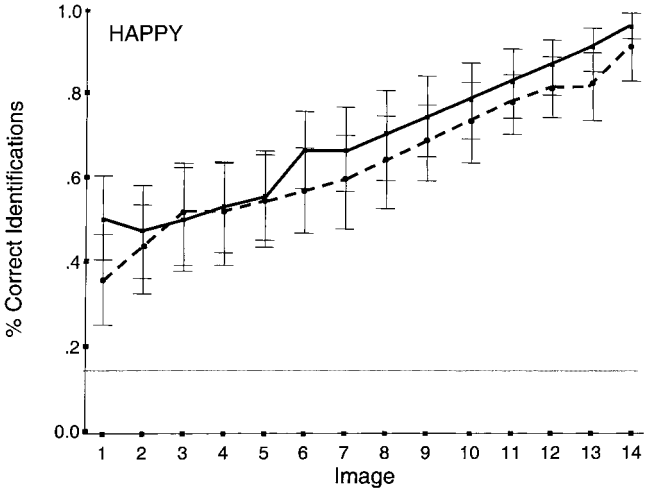

Figure 4. Mean identification rates for happy facial expressions as a function of amount of visual information (95% confidence intervals are plotted around each mean). Results are shown separately for physically abused (dashed line) and control (solid line) children. Chance performance (0.16) is indicated by the horizontal line.

tion about the faces than did controls. There were no differences in the identification rates between samples for the recognition of fear (see Figure 3) or happiness (see Figure 4). There was some suggestion from previous studies of maltreated children's face recognition (Pollak et al., 2000) that they would have more difficulty recognizing sadness. As expected, physically abused children required more information to identify sad faces than did controls (see Figure 5). Previous research has suggested that physically abused children may be biased to select anger in situations of high uncertainty (Pollak et al., 2000). Therefore, we examined children's errors with a multivariate analysis of variance of children's responses for each emotion category, with maltreatment group as a between-subjects variable and responses as within-subject variables; child's age, race, and sex served as covariates. As shown in Figure 6, neither group of children showed a response bias for any particular emotion label, $F(12, 29) = 1.99$, *ns*. Nor did the errors of physically abused and comparison samples differ, $F_{\text{mult}}(4, 37) < 1$, *ns*. Children's errors did not differ on the basis of the child's age, race, or sex (all $ps < 1$).

Figure 7 plots the position along the RISE sequence at which the physically abused children (y-axis) and controls (x-axis) were first able to detect each emotion at a level significantly better than

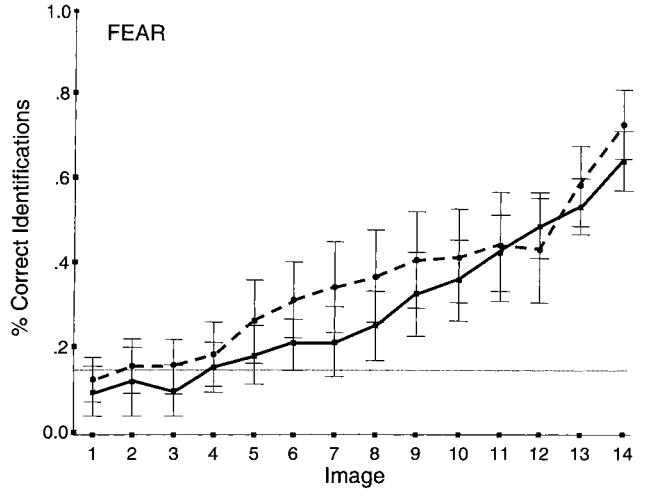

Figure 3. Mean identification rates for fearful facial expressions as a function of amount of visual information (95% confidence intervals are plotted around each mean). Results are shown separately for physically abused (dashed line) and control (solid line) children. Chance performance (0.16) is indicated by the horizontal line.

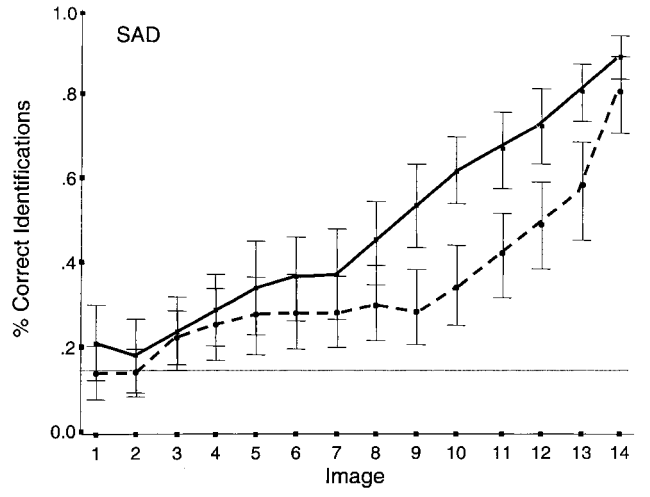

Figure 5. Mean identification rates for sad facial expressions as a function of amount of visual information (95% confidence intervals are plotted around each mean). Results are shown separately for physically abused (dashed line) and control (solid line) children. Chance performance (0.16) is indicated by the horizontal line.

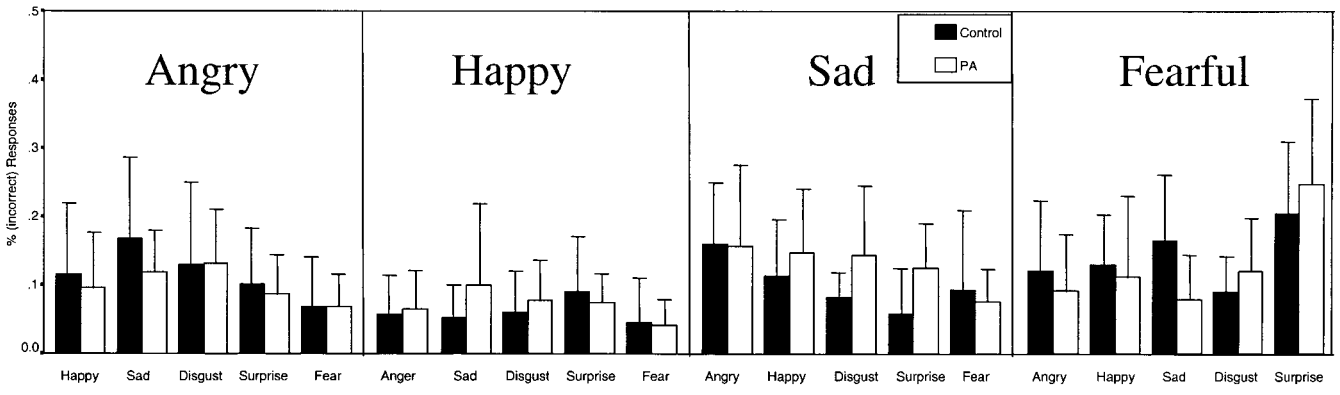

Figure 6. Percentages of incorrect responses to presentations of angry, happy, sad, and fearful faces. Results are shown separately for control and physically abused (PA) children.

chance. Thus, each of the four points on the plot corresponds to one of the four emotions tested. If there was no difference between the two populations, the four points would be expected to lie on the line of unit-slope passing through the origin. Emotions that the physically abused children were able to detect sooner than the controls would lie below the unit-slope line, whereas those for which the controls were better would lie above it. Review of Figure 7 reveals that physically abused children perceived anger on the basis of less information but required more information to identify sadness. Although this figure suggests that physically abused children also required less information to identify fear, this difference was not statistically significant because of the high variability in children's responses (see Figure 3). No significant differences existed for recognition of happiness across the two populations.

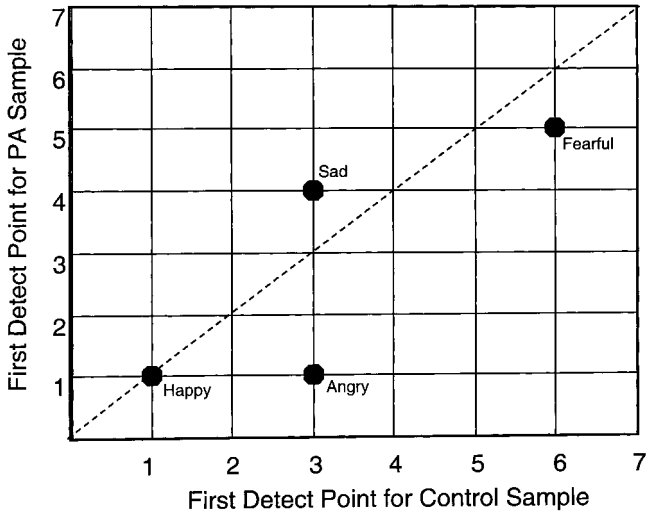

Figure 7. First point of detection for happy, angry, sad, and fearful faces by physically abused (PA; y-axis) and control (x-axis) children. Points that lie on the slope reflect no differences between groups. Emotions that physically abused children detected sooner than controls lie below the slope line, whereas emotions detected sooner by controls lie above the line.

Two post hoc analyses were conducted to explore the possible effects on children's behavioral performance of variables that might co-occur with maltreatment. These variables included parent education (as measured by the Hollingshead [1975] index), race, parent psychopathology (as measured by the Global Severity Index of the Symptom Checklist-90-Revised; Derogatis, 1983), and child psychopathology (as measured by the Total Problem Behavior scale of the Child Behavior Checklist; Achenbach, 1991). The dependent variable in each analysis of variance was the earliest significant detection point at which the maltreated and nonmaltreated groups differed. For the recognition of anger, children's performance was not affected by sex of the child, $F(1, 35) < 1$; parent education, $F(1, 35) = 1.86$; race, $F(1, 35) < 1$; parent psychopathology, $F(1, 35) = 1.51$; or child psychopathology, $F(1, 35) < 1$. Similarly, children's recognition of sadness was not affected by sex of the child, $F(1, 35) = 2.43$; parent education, $F(1, 35) < 1$; race, $F(1, 35) = 1.48$; parent psychopathology, $F(1, 35) = 1.65$; or child psychopathology, $F(1, 35) = 1.39$. All p values for the preceding analyses exceeded .17.

Discussion

This study demonstrated that children whose parents reported high levels of hostility directed toward their offspring required less perceptual information to correctly identify facial expressions of anger. An additional finding to emerge from this study is that physically abused children required more perceptual information than did control children to recognize sad facial expressions. This deficit is consistent with a prior report that maltreating mothers displayed less facial muscle tone, which can appear to observers as poorly displayed sadness (Camras et al., 1990). The present data extend previous reports of maltreated children's emotion recognition abilities by providing information that bears more directly on the sequential and content-based properties of feature detection involved in emotion recognition processes. By presenting affective stimuli to children incrementally as sequences of emotions, we were able to determine very precisely how they were interpreting partial visual input up until the point at which more visual information was presented.

One important aspect of these findings is that analyses of errors did not suggest that the physically abused children's performance

was due to a response bias for anger. This finding is in contrast to previous reports, including those from our own laboratory, that have suggested response biases for anger among physically abused children. It may be the case that tasks requiring children to relate stories or situations to facial expressions allow for more interpretive processes, and hence response biases, whereas the present task, which involves more straightforward visual perception, does not.

Second, identification rates for full, peak facial expressions were equivalent for both samples of children. That is, group differences emerged only for children's recognition of partial information, not for full presentations of facial expressions. Therefore the present results are consistent with the view that physically abused children's recognition of facial expressions is guided by their perceptual sensitivity for, and hence facilitated access to mental representations of, anger. This ability to use partial information about a facial expression of anger early on in affective signaling may confer an adaptive benefit to children living in conditions where the occurrence of threat and the probability of harm are high. The facial images used in the present study were well-validated exemplars of anger, sadness, happiness, and fear. Yet the facial stimuli may also have been more pure expressions of single emotions than might be typical of the facial expressions seen by children in naturalistic settings. Thus, decoding of these exemplars of facial expressions may be considerably easier than the facial decoding that maltreated children may need to undertake in their naturalistic family environments.

Like most children, physically abused children receive a vast amount of information about the environment in the form of emotional signals. However, given the aberrant nature of the physically abused child's affective environment, the emotional signals the child receives may be disproportionately complicated, inconsistent, and/or excessively frightening—all of which may make learning more difficult. Within abusive home environments, anger may become particularly salient to children if it is associated with high-intensity aggressive outbursts or injury. Anger may also be expressed with greater frequency if aggression and hostility are a chronic interpersonal pattern in the home. Thus, the developmental effects observed in maltreated children may result from an experience-dependent process that fine-tunes an experience-independent perceptual mechanism, such as biological preparedness, that allows the developing child to track contingencies of signals in the environment. We view the effects observed in the present study as reflecting an adaptive process for maltreated children. That is, these children may develop the ability to use partial information early in affective signaling. Such an ability might allow them to begin earlier generation of hypotheses about what another individual is feeling. Facilitated access to representations of emotional signals, if accurate, might allow children additional time to prepare for or anticipate hostile interactions. However, premature decisions about facial cues could also restrict consideration of emotion categories as possible choices even when the full identity of the emotion being expressed is uncertain. For these reasons, it is important to better understand what factors influence how individuals learn to recognize and decode emotional information conveyed by the face.

The recognition of social signals, such as facial expressions, is an important developmental ability for children. Even if some biological predisposition for attending to faces or even preexisting knowledge about discrete emotions exists, the decoding of affective signals within social contexts represents an enormously complex learning problem for all children. Learning to recognize and understand the meaning of facial displays of emotion may be a function of salience and/or relative frequency. Yet, as in other domains, relative frequency or perceptual salience alone may not be the most efficient routes to learning how to recognize emotions. Instead, competence may be more readily achieved when the child can effectively pair a signal—in this case, facial expressions—with an outcome (see also, Rescorla, 1966). Even in the most ideal environment, such associations are probably not easy to learn. One possible solution to this learning problem may be general constraints imposed on all children, such as maturational limitations of sensory, attentional, and memory capacities that require young children to filter and select some environmental cues over others. These constraints dictate that all information from the environment cannot be processed equally, and they suggest that what is attended to by the child will be features of the environment that are closely linked with highly positive or highly negative outcomes.

Therefore, the present findings speak to the developmental link between maltreated children's early experiences and their behavioral difficulties in the realm of emotion. More generally, however, these data raise further questions about the range of and ways in which perceptual learning of emotion occurs in typical development and also whether these features of information processing represent a relatively fixed or transient response to environmental stressors. Children who are maltreated by their caretakers are known to be at elevated risk for the development of psychopathology (MacMillan et al., 2001; Malinosky-Rummell & Hansen, 1993). Yet little is known about the specific developmental processes and mechanisms that are affected by children's early emotion experiences that can be empirically linked to cascading negative developmental effects. One candidate mechanism linking early affective experience with the development of psychopathology may be the perceptual and representational systems that children use to recognize social signals, such as facial expressions. Several studies have demonstrated pronounced effects of visual experience on subsequent perceptual performance. These span the range from low-level, retinotopically specific effects such as improvements in hyperacuity (McKee & Westheimer, 1978) to higher level changes in object encoding (Carey & Diamond, 1994). However, the nature and locus of mechanisms underlying these improvements in performance are not well understood (Nelson, 2001). Explaining the mechanisms that link the capacities and processes inherent in the individual organism with the ways in which the organism's experiences become embedded in the individual will require a focus on candidate developmental mechanisms that are responsive to experience. Although we do not yet have answers to these important questions, we believe that the present results suggest that children possess complex learning abilities that, particularly when applied to affective information received from the environment, may provide insight into both behavioral adaptation and maladaptation.

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