Hemispheric Asymmetries in Adults' Perception of Infant Emotional Expressions

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Accounts of emotion lateralization propose either overall right hemisphere (RH) advantage or differential RH versus left hemisphere (LH) involvement depending on the negative–positive valence of emotions. Perceptual studies generally show RH specialization. Yet viewer emotional responses may enhance valence effects. Because infant faces elicit heightened emotion in viewers, perceptual asymmetries with chimeric infant faces were assessed. First, it was determined that chimeras must be paired with their counterparts, not their mirror images, to tap viewers' sensitivity to adult facial asymmetries. Results showed an RH perceptual bias for infant cries but bihemispheric sensitivity to asymmetries in infant smiles. This effect was not due to LH featural versus RH holistic processing and held for additional, intensity-matched, spontaneous expressions. Specialized RH sensitivity to infant cries may reflect an evolutionary advantage for rapid response to infant distress.

Although findings with both unilateral brain-damaged patients and normal adults have led to a general consensus that the human cerebral hemispheres are differentially involved in emotional and cognitive processes, the exact pattern of hemispheric involvement in emotions remains controversial. According to the most widely held view, the right hemisphere (RH) dominates overall in perception and expression of emotion, across both negative and positive valence (e.g., Campbell, 1978; Chaurasia & Goswami, 1975; Gainotti, 1972, 1987; Hirschman & Safer, 1982; Ladavas, Umiltà, & Ricci-Bitti, 1980; Ley & Bryden, 1979, 1981; Safer, 1981; Strauss & Moscovitch, 1981). For convenience, we refer to that view as the RH hypothesis. The major counterproposal has been that the RH predominates

in negative emotions and the left hemisphere (LH) in positive emotions, a view we will call the valence hypothesis (e.g., Ahern & Schwartz, 1979; Dimond & Farrington, 1977; Natale, Gur, & Gur, 1983; Reuter-Lorenz & Davidson, 1981; Reuter-Lorenz, Givis, & Moscovitch, 1983; Rossi & Rosadini, 1967; Sackeim et al., 1982; Silberman & Weingartner, 1986; Terzian, 1964). Several variations on the valence hypothesis have also been offered. Some evidence suggests that whereas negative emotions show differential RH involvement, there may be less hemispheric asymmetry for positive emotions (e.g., Dimond, Farrington, & Johnson, 1976; Ehrlichman, 1987; Sackeim & Gur, 1978, 1980); we call this the negative-valence hypothesis. Another possibility is that differential hemispheric involvement in emotions may depend on the motivational qualities of approach versus avoidance, rather than valence per se (e.g., Kinsbourne, 1978). According to Davidson and colleagues, the hemispheric approach–avoidance distinction pertains only to the subject's internal feeling-state and expressions (both mediated by frontal lobes), but not to perception of emotions (parietal lobes), which show an overall RH superiority (Davidson, 1984, 1992; Davidson & Fox, 1982; Davidson, Schwartz, Saron, Bennett, & Goleman, 1979; Fox & Davidson, 1986, 1987, 1988). We call the latter proposal the motivational hypothesis.

This article focuses on normal adults' perceptual asymmetries for infant facial expressions. Findings on perception of adult facial expressions by neurologically intact subjects generally favor the RH hypothesis (e.g., Brody, Goodman, Halm, Krinzman, & Sebrechts, 1987; Bryden, 1982; Bryden & Ley, 1983; Campbell, 1978; Carlson & Harris, 1985; Gage & Safer, 1985; Heller & Levy, 1981; Hirschman & Safer, 1982; Ley & Bryden, 1979, 1981; Moscovitch, 1983; Safer, 1981; Segalowitz, 1985; Strauss & Moscovitch, 1981). They have typically found a left visual field (LVF) advantage (RH superiority) for both positive and negative expressions.

A few perceptual studies have supported the other hypotheses. Favoring the valence hypothesis, adults rate tachistoscopically presented facial expressions more negatively in the LVF–RH, more positively in the right visual field (RVF)–LH, although the RH is better overall at differentiating emotions (Natale et al., 1983). Similarly, subjects detect which visual field contains a negative expression (vs. a contralateral neutral expression) more rapidly in the LVF–RH, but they detect positive expressions more rapidly in the RVF–LH (Reuter-Lorenz & Davidson, 1981; Reuter-Lorenz et al., 1983). Supporting the motivational hypothesis is the finding that both adults (Davidson et al., 1979) and infants (Davidson & Fox, 1982) show greater electroencephalographic (EEG) activation in frontal RH when they view emotionally negative films but greater LH frontal activation during positive films; parietal activation is greater in RH in both groups for both film types. Consistent with the negative-valence hypothesis, subjects rate RH stimuli as more intensely negative when emotionally negative films (Dimond et al., 1976) or odorants (Ehrlichman, 1987) are lateralized to a single hemisphere, but they fail to show asymmetries for rating positive stimuli.

Why the inconsistencies? One possibility is that studies favoring the RH hypothesis have often, though not always, assessed recognition or discrimination of facial expressions, whereas studies showing valence effects have called for judgments about stimulus emotionality. Recognition and discrimination can be carried out by so-called "cold" cognitive abilities, but emotionality judgments may encourage the viewer to tap into emotional processes. Perceptual asymmetries may be enhanced by the viewer's emotional response to the stimuli (e.g., Safer, 1981), perhaps especially to their valence properties (see Davidson, 1984; Ehrlichman, 1987). Emotional response may, in turn, be influenced by whether the expressions are spontaneous or posed. Spontaneous emotional expression is disrupted by temporal or extrapyramidal damage, posed expression by frontal or pyramidal damage (e.g., Monrad-Krohn, 1924; Remillard, Anderman, Rhi-Sausi, & Robbins, 1977; Rinn, 1984). Spontaneous versus posed expressions likely carry information about the emitter's emotional state. Viewers should be more likely to respond emotionally to genuine rather than simulated expressions. Notably, most perceptual asymmetry studies have used posed rather than spontaneous stimuli.

Therefore, we conducted a series of studies involving emotionality judgments about stimuli that are highly likely to elicit emotional responses: smiling and crying infants. Infants' expressions are more spontaneous than those of adults, which are influenced by social conditioning and cultural display rules (Buck, 1986; Ekman, 1972). Those factors have little or no influence on young infants, who are thought not to simulate or mask emotional expressions until the second year (e.g., Campos, Barrett, Lamb, Goldsmith, & Stenberg, 1983; Oster & Ekman, 1978; Rothbart & Posner, 1985; Sroufe, 1979; but see Fox & Davidson, 1988, and our Experiment 5). Moreover, adult expressions are said often to show complex emotion mixtures, making them more difficult to "read" than infant expressions, which are

thought to display simple, basic emotions (Campos et al., 1983; Izard, 1979; Izard, Huebner, Risser, McGinnes, & Dougherty, 1980; but see Oster, Hegley, & Nagel, 1992). Most important, ethological research indicates that infant faces elicit stronger emotional responses in viewers than do those of (unknown) adults (e.g., Bowlby, 1969; Eibl-Eibesfeldt, 1975; Lorenz, 1935, 1981; Lorenz & Leyhausen, 1973). The emotional responses of adults to infant expressions are part of a mutually adapted behavior system that shapes communicative interactions and that presumably evolved to promote nurturance and survival of the relatively helpless human infant. These responses are particularly strong in infants' caregivers but are present in all humans.

What role might perceptual asymmetries play in face-to-face interactions between adult and infant? Infant crying and smiling are of particular interest here. Both promote physical proximity between infant and caregiver, though for different reasons (e.g., Bowlby, 1969; Campos et al., 1983; Emde, Gaensbauer, & Harmon, 1976). Infant smiling indicates a positive affective state and emotional approach toward the adult partner and typically elicits corresponding positive feelings and approach from the adult. Infant crying, however, indicates negative feelings toward a noxious stimulus and thus a withdrawal tendency. Infant crying typically evokes negative feelings of concern in adults, who usually want to approach in order to mitigate the infant's distress. This analysis leads to different predictions by the four hypotheses regarding cerebral organization for emotional processes. The RH hypothesis predicts an overall RH bias unaffected by valence. The valence hypothesis predicts an RH advantage for infant crying expressions, but an LH advantage for smiles. The negative-valence hypothesis predicts an RH advantage for cries only. The motivational hypothesis should predict an LH advantage for cries and smiles, both of which motivate approach responses in adults.

To investigate these possibilities, we tested perception of photographs of smiling and crying infants. A free-viewing procedure (Levy, Heller, Banich, & Burton, 1983a) was deemed best suited to the ecological condition of interest—adults' perception of infants in natural face-to-face situations—and to future studies with infant and child viewers (see Levine & Levy, 1986). For each page of the test booklet, subjects chose between two half-neutral/half-emotional chimeras of a given infant to indicate which one appeared happier (or sadder); the emotional expression was on the left in one chimera, on the right in the other, with top versus bottom position on the page counterbalanced across items. Because binary forced-choice data avoid floor and ceiling effects, performance level corrections such as the Phi coefficient (Kuhn, 1973) or λ (Bryden & Sprott, 1981) are neither necessary nor applicable; unbiased asymmetry scores on this task are obtained through simple laterality ratios (Levine & Levy, 1986).

Visual asymmetries have often been assessed through tachistoscopic lateralization of stimulus input to a single hemisphere, under the assumption that tasks involving lateralized input provide a more precise and controlled index of hemispheric processing differences than do free-field

tasks. However, this assumption is not supported by theory and recent findings. Over two decades ago, Kinsbourne (e.g., 1970, 1978) argued that task requirements and subject expectancies increase the activation of the hemisphere that the subject uses preferentially for the perceptual or cognitive functions involved. This biases attention to the spatial hemifield contralateral to the more active hemisphere, which heightens sensitivity to, and perceived intensity of, stimuli in that hemifield and results in the lateral asymmetries observed in both free-field and lateralized-input tasks. Although there were some failures to replicate certain of Kinsbourne's specific results, recent findings with brain-damaged and intact adults support the claim that activational asymmetries cause perceptual biases in tachistoscopic tasks (e.g., De Renzi, Gentillini, Faglioni, & Barbieri, 1989; Reuter-Lorenz, Kinsbourne, & Moscovitch, 1990). In fact, tasks in which input is restricted to one hemisphere are subject to individual differences in attentional biases or hemispheric arousal asymmetries (Levy, Wagner, & Luh, 1990; Mondor & Bryden, 1992). Moreover, several free-field tasks reliably elicit the expected left spatial field (LSF) bias in tests of RH functions (e.g., Levy et al., 1983a; Luh, Rueckert, & Levy, 1991) and a right spatial field (RSF) bias for LH functions (Levy & Kueck, 1986; Wirsen, Klinteberg, Levander, & Schalling, 1990). Indeed, subjects' free-field perceptual biases are predicted by their asymmetries on tachistoscopic tasks (Burton & Levy, 1991; Hellige, Bloch, & Taylor, 1988; Kim, Levine, & Kertesz, 1990; Wirsen et al., 1990). The correlation reflects individual variations in characteristic arousal differences between the hemispheres (e.g., Levy, Heller, Banich, & Burton, 1983b), which are corroborated by individual differences in EEG alpha asymmetry in the parietal and temporal regions (Green, Morris, Epstein, West, & Engler, 1992), which include the cortical projection area of the posterior, visuospatial attention system (Posner & Petersen, 1990).

On the chimeric free-field task, an LSF-RH bias for negative infant expressions would be expected according to the RH, valence, and negative-valence hypotheses; however, the motivational hypothesis predicts an RSF-LH bias. The four theoretical models differ as to whether infant smiles should yield an LSF-RH bias (RH hypothesis), an RSF-LH bias (valence and motivational hypotheses), or no asymmetry (negative-valence hypothesis).

Moreover, the heightened perceptual sensitivity to infant expressions that is predicted by ethological theory suggests that viewers' perceptual asymmetries should also be influenced by hemiface differences in infant emotional expressiveness. Infants, like adults, show greater emotional intensity on one hemiface, a manifestation of hemispheric differences in expression of emotions. Unlike adults, however, who show a left hemiface expressive bias, infants show a right hemiface bias (Best & Queen, 1989; Rothbart, Taylor, & Tucker, 1989). Therefore, we wanted our task to detect interactions between infant hemiface biases and adult perceptual asymmetries. In their original tachistoscopic study with chimeras of smiling adults, Heller and Levy (1981) found just such an interaction between emitters' hemiface biases and viewers' perceptual asymmetries.

However, they failed to find a hemiface effect on perception when they used their free-field test with the same faces (Levy et al., 1983a). Whereas the tachistoscopic measure might be more sensitive than the free-field one, differences in the construction of the chimeric choice pairs in the two studies provide another potentially important methodological factor. In the tachistoscopic study, each chimera was paired with one generated from the other halves of the same photographs. The free-field task paired each chimera with its mirror-reversed print. Thus, the pairs in the tachistoscopic task retained information about emitter hemiface asymmetries, whereas those in the free-field task did not. To determine whether the free-field task can detect emitter hemiface effects on perceptual asymmetries, we first tested two versions of the Levy et al. free-field adult face task, which differed only in how the chimeric choices were paired.

As indicated earlier, the expressive asymmetries of the smiling emitters in the Levy et al. (1983a) test booklet had been previously determined tachistoscopically in Heller and Levy (1981) through viewers' paired-comparison emotionality judgments of mixed-expression chimeras of each emitter. Because our interest was in perceived emotionality, perceptual evidence about the expressive asymmetries of the stimulus faces was deemed most appropriate for our purposes (as opposed to, e.g., taking some physical measurement of each hemiface, which may not necessarily map straightforwardly to perceived emotionality of the two hemifaces; see also Footnote 1). Although not all of the emitters in the Levy et al. test booklet had shown a left hemiface bias in smiling, we used their full set of stimuli because we needed to replicate their findings for comparison against the results from free-field presentations of the pairings used in the Heller and Levy (1981) tachistoscopic study.

Experiment 1

Method

Subjects. The subjects were familial right-handers, who show stronger, more consistent cerebral asymmetries than nonright-handers, including emotion perception asymmetries (Chaurasia & Goswami, 1975; Heller & Levy, 1981). The handedness checklist assessed degree of hand preference on 10 unimanual activities, as well as writing hand of immediate family members. Right-handedness was defined as a "strong" to "moderate" right-hand preference for all items, with no switch during childhood, and both parents being right-handed. Four subjects failed to meet these criteria. Subjects were university students with normal or corrected vision, who received $4 for participation. Forty-six subjects (23 men, 23 women) completed Test A (see the Procedure section), and 58 (29 men, 29 women) completed Test B. All had participated in a related study of asymmetries in infants' facial expressions (Best & Queen, 1989).

Stimuli. We used the chimeras of half-smiling, half-neutral adult faces constructed by Heller and Levy (1981) from frontal photographs of nine young men, including both right- and left-handers, whose smiles had been elicited by the photographer's own smiling and joking. Given that the photographer was unfa-

miliar to the men, their smiles were most likely the socially conditioned sort rather than the truly spontaneous, genuine smiles that occur in interactions among good friends. All nine emitters displayed strong evidence of orbicularis oculi muscle activity, which causes cheek-raising, eye narrowing, and crinkling at the outer corners of the eyes (AU6-7 muscle involvement) and results in the appearance of "happy eyes." AU6-7 activity has been posited to occur only with smiles that are "felt," that is, spontaneous and genuine expressions of heartfelt positive emotion; such "felt" smiles are claimed by some to show symmetry rather than asymmetry (Ekman & Friesen, 1982). Nevertheless, Heller and Levy (1981) found that all but one emitter had asymmetrical smiles; six were perceived to be more expressive on the left hemiface, two on the right.[1] The right-handed viewers in that study showed an LVF (RH) perceptual bias across this set of emitters.

The two normal orientation chimeras of each emitter had been made by joining the left half of the smiling photo with the right half of the neutral photo, and conversely, the right half of the smile with the left half of the neutral. Mirror-reversed chimeras were constructed from reverse prints of the photos.

Procedure. The Test A booklets were those developed by Levy et al. (1983a). Each normal orientation chimera (9 emitters × 2 chimeras) was paired with its mirror-reversed counterpart. Each pair was presented one below the other on 18.9 cm × 27.5 cm (8½ in. × 11 in.) pages and appeared twice in the randomized 36-page test booklet, once with the normal orientation chimera at the top and once at the bottom. For the 36-page Test B booklets we re-paired the chimeras as in Heller and Levy (1981), such that each normal orientation chimera was presented with its normal orientation counterpart, and each mirror-reversed chimera was likewise presented with its mirror-reversed counterpart. Thus, each choice pair in Test B retained evidence of hemiface differences between each emitter's two half-smiles, but those hemiface biases were missing from each Test A pair.

Subjects were run in small groups in a quiet windowless room, with Test A and Test B conducted as separate experiments. Each subject had a separate copy of the booklet. The task was to write on an answer sheet which of the two items appeared happier for each page of the booklet. Test completion was self-paced, but subjects were told to follow their initial reaction rather than deliberating over their choices. They were told there were no correct answers, and that they should do the pages in order without comparing or changing answers.

Results

The data were converted to laterality ratios through the formula $(R - L)/(R + L)$, in which R = percentage of choices with the emotional expression on the right side of the chimera (i.e., RSF preference), L = percentage of choices with it on the left side (LSF preference), and R + L = 100%. The laterality ratios thus range from -1.0 (LSF bias) to $+1.0$ (RSF bias). The Test A data were entered into a 2 × 2 analysis of variance (ANOVA) for the factors of subject gender and emitter hemiface (i.e., whether the half-smile of the mirror-imaged chimera pairs was from the right or left hemiface of the emitter). Test B data were entered into a separate 2 × 2 ANOVA, for the factors of subject gender and chimera orientation (i.e., normal or mirror-reversed pairs). To determine whether specific laterality ratios showed significant asymmetry (i.e., deviation from 0), two-tailed t tests were conducted, with alpha level correction for multiple t tests set at $p < .0125$ for Test A and $p < .007$ for Test B.

In the Test A analysis, only the grand mean was significant, $F(1, 44) = 15.62$, $p < .0003$, indicating a significant LSF bias (M lat

ratio $= -.302$) in perceived intensity of the chimeric half-smiles. Neither gender nor hemiface nor their interaction was significant. The LSF effect was significant both when the emitter's left hemiface provided the smile (M lat ratio $= -.294$), $t(45) = -3.73$, $p < .0005$, and when the right hemiface did (M lat ratio $= -.309$), $t(45) = -3.75$, $p < .0005$, and for both male viewers (M lat ratio $= -.23$), $t(22) = -2.84$, $p < .01$, and female viewers (M lat ratio $= -.374$), $t(22) = -4.53$, $p < .0005$.

In the Test B analysis the grand mean effect, $F(1, 56) = 19.19$, $p < .0001$, was also LSF biased (M lat ratio $= -.155$). Note, however, that it was only half the magnitude of that for Test A. Moreover, both the orientation effect, $F(1, 56) = 248.94$, $p < .0001$, and the gender effect, $F(1, 56) = 18.72$, $p < .0001$, were significant. The orientation effect indicated that the LSF bias occurred only for the mirror-reversed chimera pairs (M lat ratio $= -.529$), $t(57) = 12.51$, $p < .0001$; normal-oriented chimeras showed a significant RSF bias (M lat ratio $= +.218$), $t(57) = -4.25$, $p < .0001$. Males showed an overall LSF bias (M lat ratio $= -.308$), $t(28) = -8.19$, $p < .0001$, whereas females showed no overall asymmetry (M lat ratio $= -.002$). Although the Gender × Orientation interaction was not significant, male viewers' striking LSF bias for mirror-reversed chimeras (M lat ratio $= -.651$), $t(28) = -19.06$, $p < .0001$, was met by a lack of significant asymmetry for normal-oriented chimeras (M lat ratio $= +.034$), but females' LSF bias for mirror-reversed chimeras (M lat ratio $= -.406$), $t(28) = -9.23$, $p < .0001$ was opposed by an equally large RSF bias for normal-oriented chimeras (M lat ratio $= +.402$), $t(28) = 8.09$, $p < .0001$ (see Figure 1). That is, whereas both genders were sensitive to emitter expressive asymmetries, the orientation factor interacted with spatial hemifield asymmetries in male viewers, but instead it overpowered hemifield asymmetries in females. Emitter asymmetries enhanced or attenuated male viewers' perceptual bias, dependent on whether the more intense half-smile appeared in the more attentionally biased hemifield, but stimulus asymmetry was apparently the sole determinant of female performance on Test B.

Discussion

The overall LSF bias found with the mirror-image pairings of Test A replicates the Levy et al. (1983a) findings with the same booklet and supports the RH hypothesis for perception of adult smiling faces. This result runs counter to the other three theoretical hypotheses, except possibly the motivational hypothesis, which assumes RH parietal involvement in simple perception of both negative and positive expressions.

However, the Test B results complicate this interpretation. When the chimera choices retain emitter hemiface differences, those expressive asymmetries significantly affect the viewers' perceptual asymmetries in this free-field task, just as in a tachistoscopic test (Heller & Levy, 1981). For normal orientation chimera pairs, the emitter's left-

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[1] Thus, these observations call into question the assumptions that AU6-7 activity is an unequivocal marker of spontaneous or genuine smiles, and that felt smiles are symmetrical in expressiveness. Eye crinkling apparently can also occur with socially conditioned, elicited smiles, and these smiles do show perceived expressive asymmetries. This illustrates some of the difficulties inherent in relying solely on physical measures to assess the emotionality of expressions and the motivations behind them.
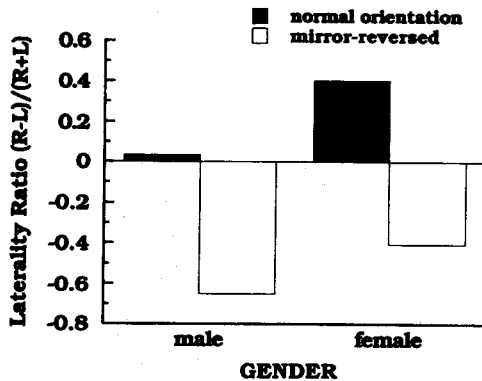
Figure 1. Effect of chimera orientation on male versus female viewers in Test B of Experiment 1 (smiling adult chimeras). In normal orientation chimera pairs, the left (L) hemiface of the emitter's smile appears on the right (R); in mirror-reversed pairs, the left hemiface smile appears on the left. Negative laterality ratios indicate a left spatial hemifield bias; positive scores indicate a right hemifield bias.

hemiface (LF) smile (the more expressive hemiface, on average) falls in the viewer's less sensitive RSF, but for mirror-reversed chimeras the more expressive LF smile falls in the viewer's more sensitive LSF. Male viewers showed a trading relation between their basic LSF attentional asymmetry (tapped in Test A) and the emitter's LF expressive asymmetries. Cooperation between the two asymmetries in the case of mirror-reversed chimera pairs enhanced the magnitude of LSF bias in viewers' choices. However, the two asymmetries were in conflict in the case of normal orientation pairs and thus cancelled each other's effects.

Female viewers did not show this trading relation. Instead, their choices for normal versus mirror-reversed chimera pairs showed equal-magnitude but directionally opposite biases (i.e., they depended exclusively on emitter expressive asymmetries). That their laterality ratios were not at the extremes of the possible range (−1.0 and +1.0) may reflect individual differences in the direction and degree of expressive asymmetry in the emitters, two of whom were reported to have RF expressive biases, another a complete lack of expressive asymmetry (Heller & Levy, 1981). The crucial point is that when expressive asymmetries were evident in the paired choices of Test B, for female viewers those expressive asymmetries apparently overpowered the effect of the basic attentional asymmetry that was evident in females on Test A. Thus, the two asymmetry factors interact in male judgments about stimulus emotionality, but stimulus asymmetry takes primacy over spatial hemifield biases in female judgments. Another possibility, though not mutually exclusive, is that the differential impact of emitter asymmetries may reflect gender differences in perceiving the smiles of young men.

In any event, the Test B approach is better suited to assessing how adult attentional asymmetries when viewing infant faces may interact with the infants' expressive asymmetries. Would infant expressions, like those of adults, elicit an overall LSF bias even for smiles, supporting the RH

hypothesis? Or would the increased emotional response to infant faces result in a valence effect on attentional asymmetry? These questions were examined with emotional–neutral chimeras of smiling and crying infants, presented in a free-field task. To assess any interaction between infant expressive asymmetries and attentional asymmetries, we retained information about hemiface asymmetries in each chimeric choice pair as in Test B. Recall that our previous study of infant expressive asymmetries had found a right hemiface (RF) bias in infant cries and smiles (Best & Queen, 1989; also Rothbart et al., 1989), contrary to the LF bias found in adult expressions. Thus, whereas in normal face-to-face interactions the more expressive LH of most adults appears in the viewer's less sensitive RSF, most infants' more expressive RF appears in the viewer's more sensitive LSF. That is, the RH hypothesis predicts that for normal orientation chimeras the infant's expressive asymmetry and the viewer's attentional asymmetry will usually coincide, enhancing the LSF perceptual bias regardless of the emotional valence depicted. According to variants of the valence hypothesis, however, the pattern of asymmetries may differ for crying versus smiling expressions, due to heightened emotional responses toward infants. Specifically, the valence and negative-valence hypotheses predict the same LSF pattern for cries as the RH hypothesis. For smiles, however, the valence hypothesis predicts an RSF bias that is stronger for mirror-reversed than normal orientation, whereas the negative-valence hypothesis predicts an orientation-dependent shift in perceptual asymmetry concordant with the spatial position of the more expressive RF. Finally, the motivational hypothesis should predict an RSF bias for both the smiles and cries of infants, stronger for mirror-reversed than normal orientation chimeras; as argued earlier, both expressions should elicit an approach tendency from the viewer.

Experiment 2

Method

Subjects. The 46 subjects who took Test A in Experiment 1 also participated in this study.

Stimuli. The stimulus materials were generated from photographs of facial expressions by 10 normal, full-term 7- to 13-month-old infants, originally taken by a portrait photographer for a series of infant attractiveness studies (Hildebrandt & Fitzgerald, 1978, 1979, 1981). The same original photographs were used in Best and Queen (1989). In that study, viewers made paired-comparison judgments of mirror-image composites of each infant's left versus right hemiface. Their data indicated that the infants showed more intense emotional expressions on the right hemiface than on the left; this was true for both smiling and crying expressions.

For the present study, each of the infants provided a neutral expression and either a clearcut negative (crying) or a clearcut positive (smiling) expression, according to ratings obtained in an independent study (Hildebrandt, 1983). Four infants had crying expressions; 6 had smiling expressions. Only 2 of the smiling infants displayed AU6-7 eye "crinkling" activity; these were the two youngest infants photographed. All photographs were full-frontal facial views.

Chimeras were constructed as in Experiment 1 (see Heller & Levy, 1981). Each print was cut exactly down facial midline, defined by a line extending through the point midway between the internal canthi of the eyes and the point in the center of the philtrum just above the upper lip. For each chimera, the hemifaces were aligned at the eyes and nose (mouths often could not be exactly aligned because of differing degrees of opening; see also Heller & Levy, 1981).

Each chimera was then centered behind an oval-shaped matt-board opening the size of the average photographed face, to screen out variations among infants in hair and facial outline. Copies were made with a high-quality Kodak photocopier, using a gray-scale photograph correction template. Each infant was represented on four pages, as in Test B of Experiment 1. Thus, there were 40 pages of paired chimeras. The pages were ordered pseudorandomly, with no more than three consecutive smiling or crying infants, and no consecutive presentations of the same emitter. The question "Which infant looks happier?" (for smiling chimeras) or "Which infant looks sadder?" (for crying chimeras) was printed at the top of each page.

Procedure. Testing was the same as in Experiment 1, except for the question valence difference.

Results

Laterality ratios were entered into a 2 × 2 × 2 ANOVA for the factors of emotion (cry, smile), orientation (normal, mirror-reversed), and gender. As before, t tests were used to test significance of laterality ratios; the alpha adjustment was set to $p < .0065$.

There was a significant (though modest) LSF bias overall (M lat ratio = $-.13$), $t(45) = -4.78, p < .0001$. However, a significant emotion effect, $F(1, 45) = 10.09, p < .003$, indicated that valence influenced the asymmetry of the adults' judgments about the intensity of infant expressions. Specifically, the LSF bias was significant for crying infants (M lat ratio = $-.19$), $t(45) = -4.84, p < .0001$, but not for smiling infants (M lat ratio = $-.07$). In addition, the orientation effect, $F(1, 45) = 366.68, p < .0001$, revealed perceptual biases in adult viewers as well as sensitivity to asymmetries in the infants' expression. Normal orientation chimeras, in which the infants' more expressive RH (Best & Queen, 1989) appeared in the LSF, yielded a significant LSF bias (M lat ratio = $-.57$), $t(45) = -17.84, p < .0001$, whereas mirror-reversed chimeras, in which the infant RH appeared in the RSF, yielded a smaller but significant RSF bias (M lat ratio = $+.31$), $t(45) = 8.02, p < .0001$. Finally, the significant Emotion × Orientation interaction, $F(1, 45) = 66.80, p < .0001$, indicated that laterality ratios for smiles reversed from a strong LSF bias for normal orientation chimeras (M lat ratio = $-.72$), $t(45) = -22.07, p < .0001$, to a strong RSF bias for mirror-reversed chimeras (M lat ratio = $+.59$), $t(45) = 15.22, p < .0001$ (see Figure 2). Perceptual asymmetries were less strongly influenced by orientation of the crying chimeras, with a moderate LSF bias for normal orientation chimeras (M lat ratio = $-.42$), $t(45) = -7.84, p < .0001$, but nonsignificant asymmetry for mirror-reversed chimeras (M lat ratio = $+.03$). Simple effects tests found that the orientation effect was nonetheless significant for both crying and smiling chimeras, $F(1,$
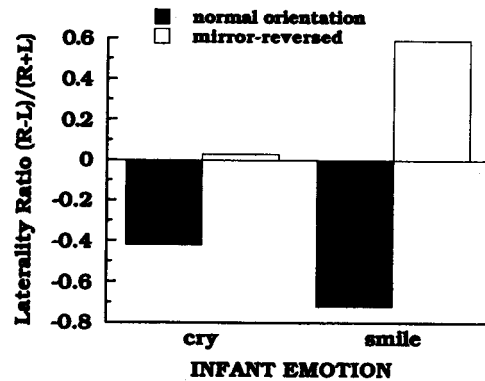

Figure 2. Interaction of Infant Emotion × Chimera Orientation (Experiment 2). R = right; L = left.

$45) = 28.25, p < .0001$, and $F(1, 45) = 703.32, p < .0001$, respectively. Furthermore, the emotion effect was significant for both normal and mirror-reversed chimeras, $F(1, 45) = 24.14, p < .0001$, and $F(1, 45) = 63.29, p < .0001$, respectively. There were no significant gender effects or interactions.

Discussion

The main effect of emotion is consistent with our suggestion that valence effects may be optimized in perception of infant faces, perhaps due to increased emotional responsiveness to infants of the sort posited by ethological theory. Indeed, many subjects smiled or showed other positive emotional responses to the smiling infant faces, but none did so while judging adult smiles in Experiment 1; conversely, crying infant faces often evoked sympathetic frowns or other emotional responses. Viewers showed a significant LSF bias in perception of negative infant expressions but no asymmetry for positive expressions. This pattern is most compatible with the negative-valence hypothesis of cerebral organization for emotional processes (e.g., Ehrlichman, 1987). We found no support for the prediction of the valence hypothesis (e.g., Silberman & Weingartner, 1986; Tucker, 1981) that there should be an RSF-LH bias for positive expressions, or for the prediction of the motivational hypothesis (e.g., Davidson, 1984) that infant cries and smiles should yield an RSF-LH advantage because both infant expressions should elicit approach responses from adult viewers. The results also stand in contrast to the RH hypothesis prediction that smiles should trigger the same overall LSF bias as cries.

In addition, the orientation effect shows a significant influence of infants' expressive asymmetries on adult perceptual field biases. Viewers showed a strong LSF bias for normal orientation chimeras, when infants' more expressive RF appeared on the left. This shifted to a smaller yet significant RSF bias for mirror-reversed pairs, when infants' RF fell on the right.

It is important to note, however, that the significant interaction between emotion and orientation reveals that the

relation between viewers' attentional biases and infant expressive asymmetries differed between judgments of negative and positive expressions. Although orientation (right–left position of infants' more expressive RF) influenced perception of both expressions, it did so differently for smiles and cries. The interaction pattern is reminiscent of the gender differences found for Test B in Experiment 1 and meets the negative-valence hypothesis' predictions of strong LSF bias for normal orientation cries, little or no bias for mirror-reversed cries, and an orientation-dependent shift in perceptual asymmetry for smiles concordant with the spatial hemifield containing the more expressive RF. The obtained pattern was inconsistent with the predictions of each of the other three hypotheses.

Specifically, there was a trading relation between viewer attentional asymmetries and emitter expressive asymmetries in judgments of infant crying expressions, analogous to that for male responses to smiling young men in Test B. Because the adult emitters' mean hemiface asymmetry was LF-biased whereas the infants' was RF-biased, however, viewer left hemifield attentional bias and emitter hemiface bias were concordant for normal orientation infant chimeras (as in face-to-face interactions) and discordant for mirror-reversed adult chimeras. Thus, the LSF bias was significant for normal-oriented infant cries, where attentional asymmetry and emitter asymmetry cooperate, but the two biases conflicted for mirror-reversed chimeras, resulting in a lack of perceptual asymmetry. In contrast, infant smile asymmetries essentially overshadowed the impact of viewer attentional biases, analogous to the findings for females viewing smiling men in Test B. That is, judgments about intensity of infant smiles depended on which spatial hemifield contained the more expressive infant RH; they were influenced very little by viewers' attentional asymmetry. We found a strong LSF bias for normal-oriented infant smiles, but a strong RSF bias for mirror-reversed smiles. Recall that there were no gender effects in Experiment 2. Both male and female viewers showed this Orientation × Emotion interaction with infant faces, unlike the gender effect for adult faces in Test B.

Thus, Experiment 2 indicated a negative-valence effect on adult perceptual asymmetries for infant emotional expressions. However, it did not elucidate the perceptual processes underlying the phenomenon. One possibility is that negative expressions may be perceived as a configuration of the whole face (i.e., a gestalt of the combined features within the "frame" of face outline and hair), whereas perception of positive expressions may instead focus on the mouth as a singular distinguishing feature (Moscovitch, 1983). The holistic approach should call more heavily on RH skills, whereas the feature-oriented approach should be better suited to LH analytic abilities (e.g., Bradshaw & Nettleton, 1981; Bryden, 1982; Levy, 1974; but see Trope, Rozin, Kemler Nelson, & Gur, 1992). If the valence effect is attributable to such differences in perceptual approach to crying and smiling expressions, then the negative-valence effect—indeed, the overall LSF bias—should become attenuated as the viewers' attention is progressively restricted to specific features of emotional information, such as the pat-

tern of the central facial features taken out of their contextual "frame." This manipulation may lead subjects to use a more feature-oriented, analytic approach and thus to rely more heavily on LH information processing strategies. Alternatively, the viewers' actual emotional responses to crying and smiling infants, rather than the information processing strategy, may be responsible for the valence effect. If so, the negative-valence effect should appear even when the viewer's attention is focused on facial-expression subcomponents or specific features. The next two experiments were designed to examine these possibilities systematically.

Experiment 3

If the holistic, gestaltlike perceptual specialization attributed to the RH accounts for the LSF for crying but not smiling infants, then removal of the peripheral context such as facial outline, cheeks, and hair should attenuate or eliminate the negative-valence effect in perception of the remaining central facial features. To restrict the viewers' attention to the details of the central features of eyes/brows, mouth, and nose, we deleted the unwanted peripheral "frame" information (i.e., face outline, chin, ears, hair, cheeks) by image-editing of optically digitized versions of the original photographs, leaving only the facial features against a uniform white background. A new group of subjects made choices between pairs of the mixed-expression chimeras generated from these computer-edited expressions.

Method

Subjects. Ninety-six right-handed university and high school students (50 women, 45 men) participated.

Stimuli. High-quality photocopies of the original photographs from Experiment 2 were computer-digitized and edited, using an Apple Macintosh™ computer (see Best & Queen, 1989, for details). The cheeks, ears, chin, hair, and face outline were digitally erased from the digitized pictures, and the resulting images of the decontextualized facial features were printed in normal and mirror-reversed orientation on white paper. Obtaining judgments of mirror-image composites of each emitter's hemifaces, Best and Queen had found that these digitally edited faces showed a strong right hemiface bias in expressiveness. These digitally edited faces were used to generate mixed-expression chimeras (Figure 3),[2] which were assembled into a 40-page test booklet as before.

Procedure. Subjects completed the test booklet as in Experiment 2.

Results

Laterality ratios were analyzed as before. Significance for *t* tests was again set at $p < .007$. There was a significant overall LSF bias (*M* lat ratio = $-.11$), $t(95) = -5.33$ $p < .0001$, the magnitude of which did not differ significantly

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[2] The smiling infant in the figure is one of the two posers who showed AU6-7 activity around the eyes. The other four smiling infants showed none of the AU6-7 activity that is thought to reflect "felt" smiles even in infants (e.g., Fox & Davidson, 1988).
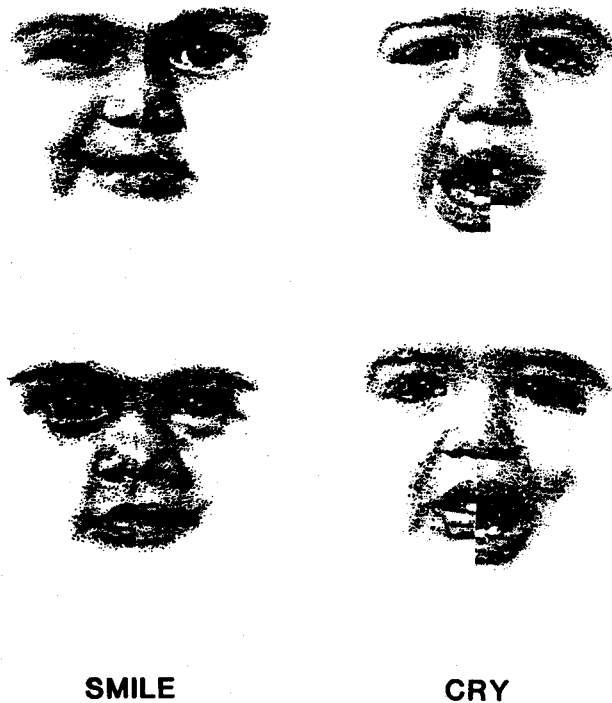
SMILE   CRY

Figure 3. Examples of digitized mixed-expression chimeras of a smiling and a crying infant, with the emotional expressions on the left versus right side of the chimera (Experiment 3).

from that in Experiment 2 according to t test. The emotion effect was significant, $F(1, 95) = 7.76$, $p < .007$, again indicating a stronger LSF bias for crying (M lat ratio = $-.15$), $t(95) = -5.62$, $p < .0001$, than smiling expressions (M lat ratio = $-.07$), $t(95) = -3.10$, $p < .003$. The magnitude of the emotion difference in hemifield biases did not differ significantly from those in Experiment 2.

The orientation effect was significant, $F(1, 95) = 432.01$, $p < .0001$, indicating that infant expressive asymmetries affected viewers' judgments. There was a significant LSF bias when the infants' more expressive RF was on the left in the normal orientation chimeras (M lat ratio = $-.49$), $t(95) = -19.13, p < .0001$, but an RSF bias when it was on the right in mirror-reversed chimeras (M lat ratio = $+.26$), $t(95) = 8.83, p < .0001$. The Emotion × Orientation interaction was also significant, $F(1, 95) < 63.64$, $p < .0001$, repeating the pattern found in Experiment 2 (see Figure 4). For smiling infants, normal orientation chimeras showed a strong LSF bias (M lat ratio = $-.56$), $t(95) = -19.66, p < .0001$, and mirror-reversed chimeras showed an equivalent, strong RSF bias (M lat ratio = $+.42$), $t(95) = 12.34$, $p < .0001$. The crying infants yielded a strong LSF bias for normal orientation chimeras (M lat ratio = $-.41$), $t(95) = -11.08$, $p < .0001$, but a smaller RSF bias for mirror-reversed chimeras (M lat ratio = $+.11$), $t(95) = 2.94$, $p < .005$. Simple effect tests found the orientation effect to be significant for both crying, $F(1, 95) = 13.23$, $p < .0005$, and smiling, $F(1, 95) = 65.76, p < .0001$, and the emotion effect to be significant for both normal and

mirror-reversed chimeras, $F(1, 95) = 559.26$, $p < .0001$, and $F(1, 95) = 104.62, p < .0001$, respectively.

Discussion

The results of this experiment replicated those of Experiment 2, even though the gestalt of the whole faces had been modified by removing the facial outline and other peripheral details, leaving only the central facial features. In fact, the magnitude of the effects did not differ significantly from Experiment 2, suggesting that viewers' perception of the full-face chimeric photographs in the previous study had focused on the central facial features rather than their holistic relation to the contextual "frame" of facial outline. It also suggests that the negative-valence effect may be due to some factor other than differential involvement of RH holistic and LH feature-analytic approaches to negative versus positive expressions, respectively.

Perhaps, however, the stimulus manipulations of Experiment 3 failed to disrupt the facial gestalt sufficiently to interfere with a holistic RH response to crying expressions. In the next experiment we investigated this possibility by narrowing viewers' focus to specific facial features.

Experiment 4

Restricting the view of infant faces to the mouth or eye/brow region alone should bias viewers' perceptual ap-
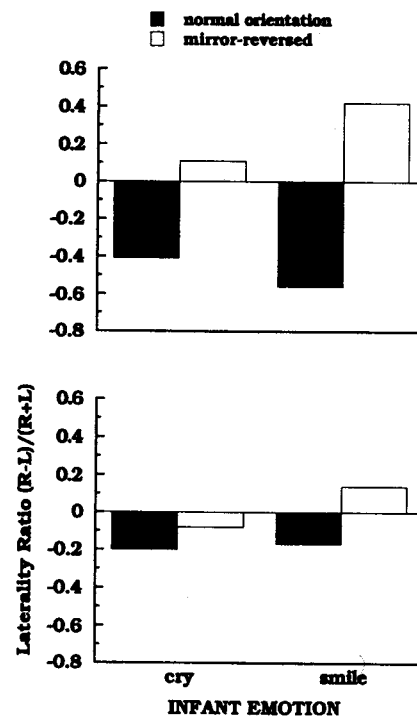

Figure 4. Interaction of Infant Emotion × Chimera Orientation in Experiment 3 (top) and Experiment 4 (bottom). R = right; L = left.

proach toward the analytic, feature-oriented abilities ascribed to the LH. If information processing differences between smiles and cries were responsible for the negative-valence effect as reasoned in Experiment 3, then this manipulation should either eliminate the valence effect or shift it to a strong RSF bias for smiles but a weak or nonexistent LSF bias for cries. However, if the negative-valence effect arises from emotional rather than cognitive factors, it should be impervious to this manipulation.

We focused on the expressive patterning of the mouth versus the eyes because our previous report (Best & Queen, 1989) had found that the infants' RF expressive bias was specific to the mouth and was not present in the eye region; this eye/mouth asymmetry held for both smiles and cries. Nonetheless, viewers were able to judge reliably relative happiness–sadness for either facial region. Each of these regions carries distinctive information in smiles and cries due to differential actions of the zygomaticus, mentalis, levator palpebralis, orbicularis oculi, and other facial muscles (Ekman, 1979; Oster & Ekman, 1978). Given that cortical input to the mouth region is contralateral, whereas input to the eye region is bilateral, our earlier results had suggested that lateralized cortical specializations rather than more peripheral factors are responsible for the RF bias in infant expressions. Thus, a second purpose of the present experiment was to test whether adults' perceptual asymmetries are influenced by the difference in asymmetrical patterning between the eye and the mouth regions of the infants' expressions. For Experiment 4, a new group of judges was presented with an "upper face" test and a "lower face" test using further modifications of the digitized, edited infant expressions.

Method

Subjects. Participants were 54 right-handed university students (27 women, 27 men).

Stimuli. The digitized, edited faces from Experiment 3 were revised to produce an "upper face" test, for which all facial features other than the eyes, brows, and bridge of the nose were removed, and a "lower face" test, for which all features other than the mouth and the tip of the nose were eliminated. Mixed-expression chimeras were generated separately for the eyes/brows and for the mouth (see examples in Figure 5, which uses the same infant emitters as in Figure 3). The eye and mouth regions were not separated from one another until after the midline had been traced, as in Experiment 2. Two 40-page booklets were constructed as before, one for the "lower face" test and one for the "upper face" test.

Procedure. The subjects were tested as before. Each completed the "lower face" test first and the "upper face" test second. Pilot testing had suggested that judgments about the eyes/brows might be more difficult than judgments about the mouth; this test order thus allowed practice before the more difficult test.

Results

The data were handled as before, except that the ANOVA included a fourth factor: face part (mouth vs. eyes). Significance for multiple t tests was set at p < .002.
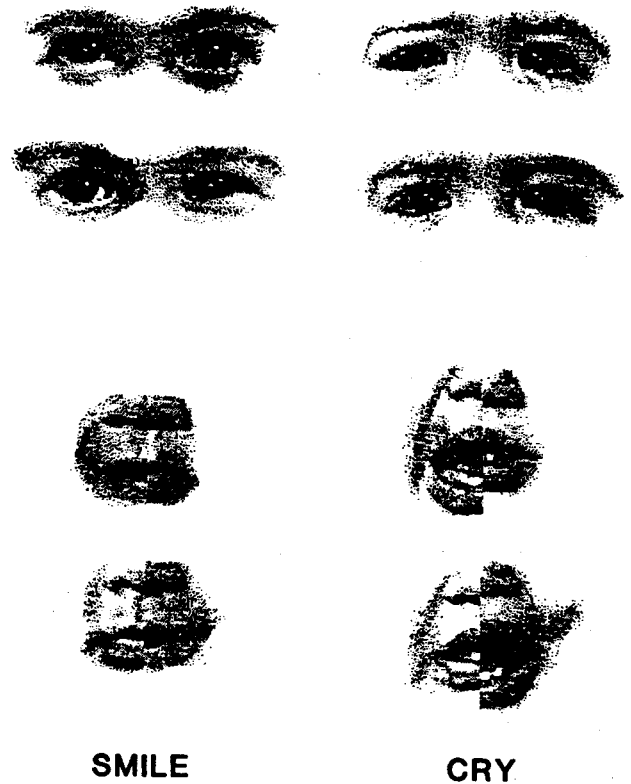

SMILE   CRY

Figure 5. Examples of digitized mixed-expression chimeras of the eye and mouth regions of a smiling and crying infant, with the emotional expressions on the left versus the right side of the chimera (Experiment 4).

Once again, there was an overall LSF bias (M lat ratio = −.08), t(53) = −4.44, p < .0001, which did not differ significantly from the two preceding experiments. The emotion effect was again significant, F(1, 53) = 13.96, p < .0005. The facial regions from cries elicited a significant LSF bias (M lat ratio = −.14, t(53) = −5.14, p < .0001, but those from smiles yielded no significant bias (M lat ratio = −.02). The magnitude of this valence effect again failed to differ significantly from the earlier experiments. As before, there was also a significant orientation effect, F(1, 53) = 39.70, p < .0001. The LSF bias held only for normal orientation, when the infants' RF was on the left side of the chimeras (M lat ratio = −.19), t(53) = −8.47, p < .0001. The mirror-reversed chimeras elicited no significant bias (M lat ratio = +.03). The Emotion × Orientation interaction was significant as well, F(1, 53) = 8.97, p < .004 (see Figure 4, bottom panel). As before, orientation had a smaller effect on perception of crying than smiling expressions. There was an LSF bias for normal orientation cries (M lat ratio = −.20), t(53) = −5.62, p < .0001, but not for mirror-reversed cries (M lat ratio = −.08). In contrast, normal orientation smiles evoked an LSF bias (M lat ratio = −.17), t(53) = −6.99, p < .0001, but mirror-reversed smiles produced a significant RSF bias (M lat ratio = +.14), t(53) = 4.79, p < .0001. Simple effects tests found the orientation

effect to be significant for both crying, $F(1, 53) = 5.13, p = .02$, and smiling, $F(1, 53) = 76.97, p < .0001$. However, the emotion difference was significant only for mirror-reversed chimeras, $F(1, 53) = 21.28, p < .0001$.

The face part factor also entered into two significant interactions. The Face Part × Orientation interaction, $F(1, 53) = 101.86, p < .0001$, showed that infant expressive asymmetries had a greater influence on perception of the mouth than the eyes. Normal orientation mouth chimeras yielded an LSF perceptual bias (M lat ratio = $-.35$), $t(53) = -10.31, p < .0001$, whereas mirror-reversed mouths yielded an RSF bias (M lat ratio = $+.20$), $t(53) = 4.93, p < .0001$. In contrast, the eyes produced a smaller but significant LSF bias in mirror-reversed orientation (M lat ratio = $-.14$), $t(53) = -3.98, p < .0002$, which became nonsignificant for normal orientation (M lat ratio = $-.03$). In simple effects tests, the face part difference was significant for both normal orientation, $F(1, 53) = 62.39, p < .0001$, and mirror-reversed items, $F(1, 53) = 44.88, p < .0001$. Moreover, the orientation effect was significant both for the mouth and for the eyes, $F(1, 35) = 119.58, p < .0001$, and $F(1, 53) = 6.68, p < .01$.

The Face Part × Orientation × Emotion interaction was also significant, $F(1, 53) = 165.97, p < .0001$. As with the full-face studies, smiling mouths produced a large LSF bias for normal orientation (M lat ratio = $-.57$), $t(53) = -17.31, p < .0001$, and a large RSF bias for mirror-reversed items (M lat ratio = $+.52$), $t(53) = 11.92, p < .0001$. Crying mouths showed nonsignificant LSF biases for normal orientation (M lat ratio = $-.13$), and mirror-reversed chimeras (M lat ratio = $-.11$). Crying eyes yielded a significant LSF bias for normal orientation chimeras (M lat ratio = $-.28$), $t(53) = -6.23, p < .0001$, but no bias for mirror-reversed ones (M lat ratio = $-.05$), consistent with previous full-face results. Smiling eyes, however, elicited a modest RSF bias for normal orientation (M lat ratio = $+.23$), $t(53) = 5.67, p < .0001$, and an equal LSF bias for mirror-reversed chimeras (M lat ratio = $-.24$), $t(53) = -4.95, p < .0001$. The direction of this orientation effect for smiling eyes was opposite that of the Emotion × Orientation interactions found in Experiments 2 and 3, where the normal orientation was associated with LSF bias and the mirror-reversed with RSF bias.

Overall, then, orientation again had a greater effect on perceptual responses toward the smiling expressions than toward the crying expressions. According to simple effects tests, the orientation effect was significant for crying eyes, $F(1, 53) = 53.48, p < .0006$, for smiling mouths, $F(1, 53) = 457.26, p < .0001$, and for smiling eyes, $F(1, 53) = 11.06, p < .002$, but not for crying mouths. The emotion effect was significant for eyes in both normal, $F(1, 53) = 56.96, p < .0001$, and mirror-reversed orientation, $F(1, 53) = 9.72, p < .003$, as well as for mouths in both normal and mirror-reversed orientation, $F(1, 53) = 58.74, p < .0001$, and $F(1, 53) = 90.83, p < .0001$, respectively.

Discussion

The emotion main effect was not diminished relative to the two other infant face tests, despite restricting the view-

ers' attention to isolated facial features. This finding suggests that the negative-valence effect on perceptual asymmetries for infant emotional expressions derives from emotional processes rather than information processing factors. The Emotion × Orientation interaction again indicated that, overall, there was a weaker hemiface effect, or greater effect of attentional asymmetry, on perception of crying than smiling expressions. Moreover, differences in perception of the eye and mouth regions suggest that the viewers were sensitive to differences in the expressive asymmetries displayed by those facial regions. Consistent with the Best and Queen (1989) finding of a significant overall RF bias only for the mouth region, the viewers in the present study were more affected overall by orientation of the mouth than of the eyes. We should note, however, that this face part interaction differed for smiles versus cries. For smiles, both face regions showed dominance of the orientation factor, as before, but the direction of this influence was reversed for the eyes relative to the mouth and to the previous studies. That is, viewers apparently detected greater intensity of expression on the left hemiface for smiling eyes, but on the right for the mouth. For crying expressions, there was a greater perceptual effect of orientation on eyes than mouth. The pattern of higher order face part effects is curious, given the Best and Queen finding that only mouths showed significant RF expressive asymmetry. Although a complete explanation cannot be offered at this time, this interaction nonetheless indicates that adults are quite sensitive to emotional information in the eye region of infant expressions.

To summarize, the perceptual findings with infant smiles and cries in Experiments 2–4 provided fairly strong support for the negative-valence hypothesis over the other three hypotheses. However, those results were based on the same set of six smiling and four crying infants. Therefore, it was important to extend our investigation to a new set of infant photographs.

Experiment 5

In the three preceding studies the smiling and crying expressions had come from different infants. Although the mean rated intensities (Hildebrandt, 1983) of the two types of expression were roughly equivalent, they were not absolutely matched. These factors left open the (unlikely, we thought) possibility that individual differences in infant expressiveness and in the mean intensity of the two expression types might account for the main effects of emotion found in Experiments 2 and 3, or for the pattern of the Emotion × Orientation interactions.

We wished to insure that the infants' expressions of happiness and distress were spontaneous and genuine. Although the laboratory photographs of infants from Hildebrandt and Fitzgerald (1978, 1979, 1981) seemed appropriate for our purposes, on the basis of reports that infants do not mask or simulate emotions until their second year (Campos et al., 1983; Oster & Ekman, 1978; Rothbart & Posner, 1985; Sroufe, 1979), a recent study suggests that infants do produce smiles like those of adults simulating happiness they don't feel or covering up negative emotions. Ekman

and Friesen (1982) termed such adult expressions "unfelt smiles" and claimed that felt smiles are virtually symmetrical, but that unfelt smiles tend to show asymmetries favoring the LF. (Recall, however, the difficulties presented to this position by the asymmetrical adult smiles in the Levy et al., 1983a, stimuli used in Experiment 1.) Fox and Davidson (1988) videotaped infants responding to mother versus a stranger in an unfamiliar laboratory setting and found evidence of unfelt smiles (i.e., lacking orbicularis oculi activity) toward strangers but not toward mother. Moreover, EEG asymmetry patterns over the infants' frontal lobes differed between felt (LH activation) and unfelt smiles (RH activation). The facial expressions we used in Experiments 2–4 had been obtained by a portrait photographer (i.e., a stranger) in a university laboratory (i.e., unfamiliar setting). Both factors raise the likelihood of unfelt smiles and the possibility that the RF bias we found in those smiles might not occur in genuine, felt smiles. Indeed, as mentioned earlier, only two of those six smiling expressions showed evidence of orbicularis oculi activity.

For these reasons, one of us (J.S.W.) photographed infants enrolled in high-quality daycare, a familiar and comfortable setting to the infants. During a two-month period J.S.W. visited the daycare centers 2–3 days per week to interact with the infants. Before she began to photograph the infants at a given center, she spent at least three weeks there, playing with the infants, interacting with their caregivers, and participating in daily caregiving (e.g., feeding, diaper-changing). Thus, she was not a stranger but had become a familiar caregiver. After she had become familiar to the infants, she took multiple photographs of each infants' expressions, taking care to "catch them in the act" of spontaneous social smiles and distress cries, as well as of neutral expressions. We selected for this study only those emitters for whom a smile and a cry photo were matched in emotional intensity, according to a preliminary rating study. These photographs were then used to assess infants' expressive asymmetries for spontaneous smiles and cries, as well as to extend the investigation of perceptual asymmetry. This study was modeled after Experiment 2, using photographs rather than digitally edited images. There had been remarkable consistency in the major findings of the preceding studies, indicating that the primary effects had not been influenced substantially by the progressive restriction of facial features available for judgments. Therefore, we used the full facial configurations of the actual photographs in the present study.

Method

Subjects. Forty-nine subjects were recruited for this study; 3 failed the handedness criteria and 2 filled out their answer sheets incorrectly, leaving 44 right-handed university students (22 men, 22 women) who participated.

Stimuli. The spontaneous neutral, crying, and smiling expressions of 17 infants (range = 5–14 mo.) were photographed at their daycare, using black-and-white print film in a Minolta XG-1 camera fitted with a zoom lens. All were printed, placed behind an oval template as in Experiment 2 to screen out peripheral and background details, and photocopied using a Xerox 1012 machine

with a grayscale setting. The first 12 infants provided 68 photos, which were compiled randomly into a pretest intensity rating booklet. Twelve university students rated each expression between −3 (very sad) to +3 (very happy), with 0 as neutral. Nine infants had at least one smile and one cry that were rated equally intense (e.g., +2 and −2, respectively), along with one clearly neutral expression (rated 0). Therefore, five additional infants were photographed and their expressions submitted to 12 new raters; the latter infants all met the equal-intensity criterion. Of the final 14 infants, 12 showed clear orbicularis oculi activity (AU6–7), suggesting "felt" smiles.

Mixed-expression chimeras were constructed for the 14 infants with matched intensity and paired as before, for the first 56 pages of a new test booklet. Mirror-image composites of each hemiface for each infant's smile and cry were also constructed, as in Best and Queen (1989), to test for expressive asymmetries in the booklet's last 28 pages. Top–bottom position of right versus left composites was counterbalanced over infants and expressions.

Procedure. For the first part of the test, subjects judged mixed-expression chimeras. For the second part, they judged left versus right mirror-composites of each expression for each infant.

Results

Mirror-image composites. Because the interpretation of orientation effects on judgments of mixed-expression chimeras depends on the expressive asymmetries observed in the emitters, we begin by reporting on the test for hemiface biases in infant smiles and cries. Laterality ratios were computed on choices of the left versus right hemiface mirror-composites and analyzed in a 2 × 2 ANOVA (Gender of Viewers × Infant Emotion). Alpha level for t tests was set at $p < .025$.

Only the main effect of emotion was significant, $F(1, 42) = 34.931, p < .0001$, reflecting a right hemiface bias in intensity of crying expressions (M lat ratio = +.263), $t(43) = 8.736, p < .0001$, but a nonsignificant left-side bias in smiles (M lat ratio = −.013). That is, these spontaneous smiles failed to show the rightward bias found in previous reports (Best & Queen, 1989; Rothbart et al., 1989) and in the smiling expressions used in Experiments 2–4, although crying expressions replicated the earlier found right hemiface bias. Thus, the new set of mixed-expression chimeras were expected to yield the same orientation effect for crying chimeras as found before, but there should be no orientation difference for smiling chimeras, unlike Experiments 2–4.

Mixed-expression chimeras. Laterality ratios were entered into a 2 × 2 × 2 ANOVA (Gender × Emotion × Orientation). The alpha criterion for multiple t tests was set at $p < .00625$.

There was a significant LSF bias overall (M lat ratio = −.312), $t(43) = 6.92, p < .0001$. However, the significant effect of emotion, $F(1, 42) = 32.16, p < .0009$, indicates that the LSF bias for smiles (M lat rat = −.44), $t(43) = −7.78, p < .0001$, was larger than that for cries (M lat rat = −.18), although cries were significantly LSF-biased, $t(43) = −3.84, p < .0004$. The Emotion × Orientation interaction was also significant, $F(1, 42) = 6.754, p < .0129$ (see Figure 6). Simple effect tests found significant orientation effects for both cries and smiles, $F(1,$
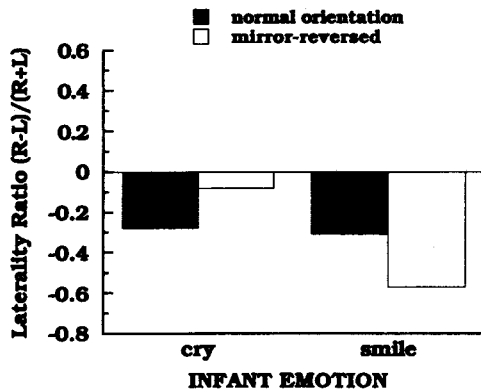
Figure 6. Interaction of Infant Emotion × Chimera Orientation on the mixed-expression chimera trials (Experiment 5). R = right; L = left.

42) = 17.188, p < .001, and $F(1, 42)$ = 23.347, p < .001, respectively. The difference between expressions was significant for normal, $F(1, 42)$ = 80.152, p < .0001, but not mirror-reversed orientation. An LSF bias appeared for smiles in normal (M lat rat = −.31), $t(43)$ = −4.69, p < .0001, and mirror-reversed orientation (M lat rat = −.57), $t(43)$ = −9.61, p < .0001, and for cries in normal orientation (M lat rat = −.28), $t(43)$ = −7.78, p < .0001. As in Experiments 2–4, perceptual asymmetry was lacking for mirror-reversed cries (M lat rat = −.08).

Discussion

The mirror-image composites revealed a significant RF expressive bias for infant crying, consistent with previous reports (Best & Queen, 1989; Rothbart et al., 1989). However, these spontaneous smiles showed no asymmetry. Thus, spontaneous infant smiles and cries show expressive asymmetries that, like the perceptual results of Experiments 2–4, support the negative-valence hypothesis. That these smiles were symmetrical, whereas RF bias is reported for smiles obtained under conditions that may foster "unfelt" or socially conditioned expressions (see Fox & Davidson, 1988), is also compatible with claims (Ekman & Friesen, 1978) that truly spontaneous, genuine smiles fail to show significant asymmetry.

Given the replicated RF bias for cries, the same interaction of emitter hemiface bias and viewer attentional bias on perception of mixed-expression crying chimeras should occur as in Experiments 2–4. This was exactly the result obtained. As before, an LSF bias in perception occurred for normal-orientation cries, where the more expressive infant RF fell in the viewer's left spatial hemifield but disappeared for mirror-reversed cries, where the RF fell in the less sensitive hemifield. However, the near-symmetry of spontaneous smiles in this experiment substantially changed the perceptual pattern found for smiles in Experiments 2–4, which was essentially determined by which hemifield contained the infants' more expressive RF. Specifically, this time both chimera orientations yielded an LSF bias for

infant smiles. That is, when the hemiface bias of the smiles is extremely weak, it no longer dominates the viewer's perceptual asymmetry. Instead, an underlying leftward attentional bias appears, as was found for adult smiles in Test A of Experiment 1, where hemiface biases were eliminated by the pairing of chimeras. Nonetheless, the present finding for spontaneous infant smiles still differed in an important way from the Test A pattern. Remarkably, these very weakly asymmetrical infant smiles still produced a significant orientation effect on degree of LSF bias. The tiny, nonsignificant LF bias in spontaneous infant smiles produced a significantly larger viewer LSF bias when the infant LF appeared in the more sensitive left hemifield for mirror-reversed pairs than when it appeared in the less sensitive right hemifield for normal orientation pairs.

General Discussion

Taken together, the results indicate that the relative contributions of viewer attentional bias and emitter expressive bias on adult judgments of infant emotional expressions differ for crying and smiling. The perceptual asymmetries as well as hemiface biases in infants' spontaneous expressions (Experiment 5) both support the negative-valence model of emotional asymmetries (e.g., Dimond et al., 1976; Ehrlichman, 1987; Sackeim & Gur, 1978, 1980). When viewing static infant faces, adults show an RH bias for negative emotion, which interacts with asymmetries in the infants' faces. Adults' perception of positive emotion in infants is dominated by asymmetry in the expressions, which overpowers adults' attentional bias toward the LSF unless the expressive asymmetry is very weak, as in spontaneous smiles.

The other three models of emotional asymmetry did not fare as well. The RH model predicts the same perceptual pattern for negative and positive emotions, yet there were significant differences. The valence hypothesis posits RH specialization for negative emotion and LH specialization for positive emotion; however, perception of infant smiles failed to show an overall RSF-LH bias, and their spontaneous smiles showed no expressive asymmetry. As for the motivational hypothesis, an RSF-LH bias should result from approach responses to infant smiles, as we argued for cries also, yet neither showed that perceptual bias. It should be noted, however, that a more stringent test of the motivational hypothesis would require direct assessment of viewers' motivational tendencies toward the infant emitters.

Given that the majority of findings on perceptual asymmetries for adult facial expressions have supported the RH hypothesis, the present infant face findings suggest that valence effects on perceptual asymmetries may depend on viewers' emotional responses. Although this and other tasks supporting valence effects have called for emotionality judgments, that alone may not suffice to produce a negative-valence effect on perception. Levy et al. (1983a) and Experiment 1 required emotionality judgments about adult chimeras, yet those studies found a significant LSF-RH bias for smiles. Infant smiles, which should increase viewers'

emotional responses, instead yielded no overall perceptual asymmetry (Experiments 2, 4, and 5) or at best a small LSF bias (Experiment 3). A separate study from our laboratory provided additional corroboration of perceptual differences for infant versus adult expressions. Chaiken (1988) used two chimeric choice tasks involving both adult and infant expressions with 7–15-year-old children and adults and found a valence effect only for infant expressions. However, in future studies viewer emotional responses will need to be assessed directly to test whether this factor is indeed crucial to valence effects on perception. Such information may be especially critical for a more comprehensive test of the motivational model than provided in the studies reported here.

Experiments 3 and 4 suggest that the negative-valence effect on perception was not due to basic information processing differences between the hemispheres for negative versus positive expressions. Manipulations designed to restrict viewers' attention to progressively narrower features of the infant expressions should have shifted perception toward the analytical, feature-oriented approach of the LH, yet did not influence overall perceptual asymmetry. More important, they did not change the valence effect. Thus, the negative-valence effect for infant expressions seems to reflect an aspect of hemispheric specialization that is largely independent of information-processing asymmetries.

As noted earlier, adult LSF-RH bias in perception of infants' crying expressions is compatible with the greater intensity of expressions on the infant's RF (Best & Queen, 1989; Rothbart, Taylor, & Tucker, 1989). In face-to-face interactions, the infant's more expressive hemiface appears in the adult's more sensitive LSF, presumably enhancing the adult's emotional response. This compatibility does not hold in the case of adult face-to-face interactions, given that adults show an LF expressive bias, which falls in the viewer's less sensitive RSF. Generally enhanced sensitivity and responsiveness to infant expressions is consistent with ethological theory. Why should the interaction between infant expressive asymmetry and adult attentional bias differ between crying and smiling expressions? Perhaps it can be related to differences in the imperativeness of adult responses to infant distress and pleasure states. Presumably, infant distress indicates a possible danger to the infant, or some health or survival need, which would impel caregivers or other adults to take action on the infant's behalf. In contrast, an infant's smile does not signal this sort of urgency. Therefore, the evolutionary pressure for specialized responsiveness toward infant crying expressions may have been greater than, or at least qualitatively different from, that toward infant smiles. Specialized responsiveness to infant cries may be optimized by the interaction between infant expressive asymmetries and the viewer's LSF attentional bias, which may provide for the most direct, immediate activation of the RH motivational and action systems that are specialized for rapid responses to potentially threatening situations. The notion that the right hemisphere is specialized for response to affectively negative situations that mobilize fleeing behavior (rapid withdrawal) was proposed by Kinsbourne (1978) and further developed by

Davidson (1984). Supporting evidence has been found in infants' EEG asymmetries during facial expressions of distress in response to stranger approach and maternal separation, as well as during newborns' facial disgust responses to noxious gustatory stimuli (Fox & Davidson, 1986, 1987, 1988). Moreover, an evolutionary foundation for this bias is suggested by two recent studies of monkeys. In one, rhesus monkeys displayed earlier appearing and more intense negative emotional expressions on the left (RH) than the right hemiface (Hauser, 1993). In the other report, rhesus mothers consistently picked up their infants with the left hand when frightened by the approach of a human (Haida & Koichi, 1991); however, the latter finding is difficult to interpret because no baseline or control condition was provided to assess hand use in nondistress situations.

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