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All Smiles Are Positive, But Some Smiles Are More Positive Than Others

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Disagreement as to whether all smiling or specific types of smiling index positive emotion early in life was addressed by examining when infants produced different types of smiling and other facial expressions. Thirteen infants were observed weekly from 1 to 6 months of age. Smiling alone—without cheek raising or mouth opening—was relatively more likely than periods without smiling both when mothers were smiling and when infants were gazing at their mothers' faces. Cheek-raise (Duchenne) smiling was relatively more likely than smiling alone only when mothers were smiling. Open-mouth (play) smiling was relatively more likely than smiling alone only when infants were gazing directly at mothers' faces. Smiling involving both cheek raising and mouth opening was relatively likely both when mothers were smiling and when infants were gazing at mothers' faces and became increasingly likely with age when both conditions co-occurred. The cheek-raise and open-mouth dimensions of smiling appear to be associated with, respectively, the amplification of processes of sharing positive affect and of visual engagement that are present to a lesser degree in smiling alone.

In infancy, positive emotions such as joy are hypothesized to motivate and organize desired actions (Blehar, Lieberman, & Ainsworth, 1977; Cohn, Campbell, & Ross, 1991; Malatesta, Culver, Tesman, & Shepard, 1989) and to help create and maintain pleasurable interactions with caregivers (Barrett, 1993; Campos, Mumme, Kermoian, & Campos, 1994), which, in turn, contribute to optimal outcomes, including secure attachment (Cohn et al., 1991; Malatesta et al., 1989). Yet it is not clear whether all smiling indexes joy in infancy or whether this role is reserved for a single type or several specific types of smiling. To provide information on the social and emotional meaning of different types of smiling, this longitudinal study documented when young infants, unconstrained by social display rules, engaged in these expressions during face-to-face interactions with their mothers.

Research with adults initially indicated that joy was indexed by generic smiling, any smiling involving the raising of the lip corners by the zygomatic major (Ekman & Friesen, 1982; Ekman, Friesen, & Ancoli, 1980). During face-to-face interactions, infants in the first half year of life engage in more generic smiling when gazing directly at their mothers' faces than when gazing away from their mothers' faces (van Beek, Hopkins, & Joeksma, 1994; Weinberg & Tronick, 1994). Independently of gaze direction, infants also engage in more generic smiling when their mothers are smiling than when they are not smiling (Kaye & Fogel, 1980), which suggests that infants perceive maternal smiles even when they are not gazing directly at their mothers' faces. Infants also tend to produce neutral or positive vocalizations when their mothers are smiling and when gazing at their mothers' faces (Kaye & Fogel, 1980; van Beek et al., 1994; Weinberg & Tronick, 1994). These findings suggest that gazing at mother and mother smiling tend to elicit positive emotion or similar states that make infant generic smiling and vocalizations more likely.

More recent research suggests that smiling in which the muscle around the eye contracts, raising the cheeks high (cheek-raise or Duchenne smiling), is uniquely associated with positive emotion. In contrast to smiling without cheek raising, adults engaged in more smiling with cheek raising while watching positive films than while watching negative films, and their cheek-raise smiling was significantly correlated with self-reported positive emotion (Ekman, Davidson, & Friesen, 1990). Ten-month-olds were more likely to produce smiles with cheek raising when their smiling mothers approached and were more likely to produce smiles without cheek raising when an impassive stranger approached. Cheek-raise smiling, but not other smiling, was also associated with

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greater relative activation of the left than the right frontal cerebral hemispheres (Fox & Davidson, 1988), a pattern similar to that found in adults (Ekman et al., 1990).

On the basis of such evidence, Ekman and his colleagues proposed that cheek-raise smiling is uniquely associated with enjoyment. They remained agnostic, however, as to when this association develops (Ekman, 1992, 1994; Frank, Ekman, & Friesen, 1993). In a study of the organization of smiling that used the current sample, Messinger, Fogel, and Dickson (1999) found that half of smiles with cheek raising were immediately preceded by a smile without cheek raising. This pattern suggested that cheek-raise smiles represented the intensification of joyful processes that begin with smiles without cheek raising. Information about the context of smiling is necessary to address this hypothesis. In the present study, we asked whether smiles with cheek raising were relatively more likely than smiles without cheek raising when mothers were smiling and when infants were gazing directly at their mothers' faces during face-to-face interaction.

Ekman (1992, 1994) maintained that adult smiles without cheek raising have social regulatory functions, such as masking displeasure, that are unrelated to joy (Ekman, 1992, 1994). If smiling without cheek raising in infancy is related to producing wary greetings (Fox & Davidson, 1988) and has no positive valence (Dawson, Panagiotides, Klinger, & Spieker, 1997), it should not tend to occur during positive periods of interaction with the mother. If smiling without cheek raising indexes a less intense form of positive emotion, however, it might be more likely than periods of nonsmiling during positive periods of interaction. To address this question, we asked whether smiling without cheek raising was relatively more likely than comparable periods of nonsmiling when infants were gazing directly at their mothers' faces and when their mothers were smiling.

Open-mouth (play) smiling (involving a lowered jaw) and mouth opening in the absence of smiling may also be associated with positive social interaction among older infants and children. Between 10 and 18 months, open-mouth smiling predominates during social games (Dedo, 1991) and tends to elicit laughter from mother (Jones, Raag, & Collins, 1990). Even in the absence of smiling, Kaye and Fogel (1980) found that infant mouth opening was associated with maternal smiling during face-to-face interaction. In a similar vein, among nonhuman infant primates, a wide-open-mouth display in which the upper lips typically cover the teeth (Redican, 1975; van Hooff, 1972) often occurs during play involving physical contact (Plooij, 1979; Redican, 1975; van Hooff, 1972).

To determine if early open-mouth smiling and mouth opening without smiling tended to occur in more positive periods of face-to-face interaction, we made two comparisons. We asked whether open-mouth smiling was relatively more likely than closed-mouth smiling when infants were gazing directly at their mothers' faces and when their mothers were smiling. We also asked whether mouth opening without smiling was relatively more likely than comparable periods without mouth opening in the same interactive conditions. As mouth opening joins with smiling to create open-mouth smiling, so cheek raising joins with smiling to create cheek-raise smiling. For the sake of completeness, we also asked whether cheek raising was relatively more likely than comparable periods without cheek raising in the same interactive conditions used for the other comparisons.

A deficit of the studies reviewed here is that they examined either cheek-raise smiling or open-mouth smiling, but not both. This made it impossible to determine which types of smiling were associated with which positive contexts and whether the different types of smiles might have different functions in social interaction. This deficit was remedied in recent investigations of 6- and 12-month-olds playing games with their mothers (Fogel, Nelson-Goens, Hsu, & Shapiro, 2000) and 12-month-olds playing at home (Dickson, Walker, & Fogel, 1997). In these investigations, smiling was divided into four types: smiling alone involving neither cheek raising nor mouth opening (simple smiling), cheek-raise smiling without mouth opening (Duchenne smiling), open-mouth smiling without cheek raising (play smiling), and open-mouth cheek-raise smiling (duplay smiling). We use descriptive terms for these four types of smiling (e.g., cheek-raise smiling) to efficiently distinguish smiling with and without different characteristics.

Fogel et al. (2000) found that cheek-raise smiling tended to occur during early trials of the climax phase of tickle games (actual tickling), whereas cheek-raise open-mouth smiling tended to occur in the climax phase of the later trials. Dickson et al. (1997) found that cheek-raise open-mouth smiling predominated during physical play. Neither group of investigators found a preponderance of open-mouth smiling without cheek raising in any of the social situations they examined. Though cheek-raise and open-mouth smiling overlapped in our previous study with the current data set, they also showed substantial independence (Messinger et al., 1999). This situation provided us with a unique opportunity to explore the early meaning of these two types of smiling by examining their association with infant gazing at mother and mother smiling. On the basis of the tendency of cheek-raise and open-mouth smiling to co-occur in the current data, Messinger et al. (1999) suggested that the composite smile formed by their overlap might be especially emotionally positive. One possibility is that composite open-mouth cheek-raise smiling might be likely to occur in all of the positive periods of early interaction in which its component smiles are likely to occur.

The current study also addressed developmental changes in the associations between positive periods of interaction and different types of smiling and other facial expressions. Infant overall or generic smiling increases between 1 and 6 months of age (Gewirtz, 1965), particularly during face-to-face interactions (Legerstee, Pomerleau, Malcuit, & Feider, 1987). Cheek-raise and open-mouth smiling also increase during this period (Messinger et al., 1999). Perhaps as a consequence, Messinger et al. found no increase in the *proportions* of all smiling involving cheek raising and of all smiling involving mouth opening (overlaps included in each measure). This meant there was no evidence that certain types of smiling became relatively more likely than others with development. Fogel et al. (2000) also found no age-related changes in the proportions of the four types of smiling defined by the presence and absence of cheek raising and mouth opening in a sample of 6-month-old and a sample of 12-month-old infants playing peek-a-boo and tickle games. Prior studies did not, however, examine developmental changes during specific periods of interaction. The current longitudinal study fills a gap in the existing literature by examining whether different types of smiling and their constituent facial expressions become more likely with age in specific periods of face-to-face interaction. The premise is that if one type of smiling is relatively more likely than another in a specific period

of interaction, it may become increasingly likely in that period of interaction with age.

Method

Participants

The mothers of 15 singletons were contacted through local newspaper ads and asked to participate with their infants in a longitudinal study of infant interaction and communication. Weekly play observations began at 1 month of infant age, and mothers were paid $150 after the completion of their first 6 months of attendance. One mother withdrew after an initial visit, and another withdrew after 2 months because of a death in the family. Of 13 infants whose mothers participated in the study when their infants were between 1 and 6 months of age, 6 were firstborn and 8 were boys. One mother was African American, the rest were European American, and all were part of two-parent families in a small midwestern community. All of the mothers had completed high school, and 11 of them had at least some college experience.

Procedure

When mothers arrived for the first observation session, they were requested to "play and talk to your baby as you would at home." Mothers did not have access to toys. Mothers were seated on chairs, held their infants in their laps, and were free to hold and move their infants as they wished. Infants' bodies were held in the *en face* position 78% of the time (see Figure 1) and within 45° of this position 94% of the time, which suggests that the infants were typically able to see their mothers' smiles whether or not the infants were gazing directly at their mothers' faces. Sessions were terminated after 5 min of interaction, except for nine instances in which infants became too fussy to proceed before the 5 min had elapsed. The average session duration was 287 s (range = 80–300 s). Thirteen mother–infant pairs completed a total of 208 sessions, yielding a mean of 16 sessions per pair (range = 9–20, mode = 18, *Mdn* = 16).

Setting

Mother–infant dyads were videotaped in a 12.5-foot (3.8-m) square carpeted observation playroom with three video cameras mounted on the walls. The movement of each camera was remotely controlled from an observation room located behind a one-way mirror. Two cameras were focused on the infant's face and upper body, and one camera was focused on the mother holding the infant. The camera with the best image of the infant's face provided half of a composite split-screen video image onto which running time, accurate to the video frame, was superimposed. During coding of the mother's or the infant's actions, the half of the video image containing the other partner in the interaction was obscured.

All actions were coded continuously. The infants' hands, the mothers' hands, or the mothers' heads sometimes blocked the coders' view of the infants' or mothers' faces. If facial movement was obscured such that the presence or absence of a facial action could not be distinguished, a not-visible code was used, and this segment of the interaction was eliminated from analyses. In the coding of infant lip-corner raising, mouth opening, and cheek raising and of mother lip-corner raising, not-visible codes accounted for, respectively, 14%, 13%, 4%, and 6% of the total session time. To address concerns about the duration of the not-visible codes, we conducted trial analyses in which we assumed that when a particular facial action was not visible, the prior facial action had continued until the next facial action was observed. Despite some diminution in effect size (three p values rose from below .05 to between .05 and .06), these trial analyses yielded results substantively identical to those reported below, in which not-visible codes were eliminated from the analyses.

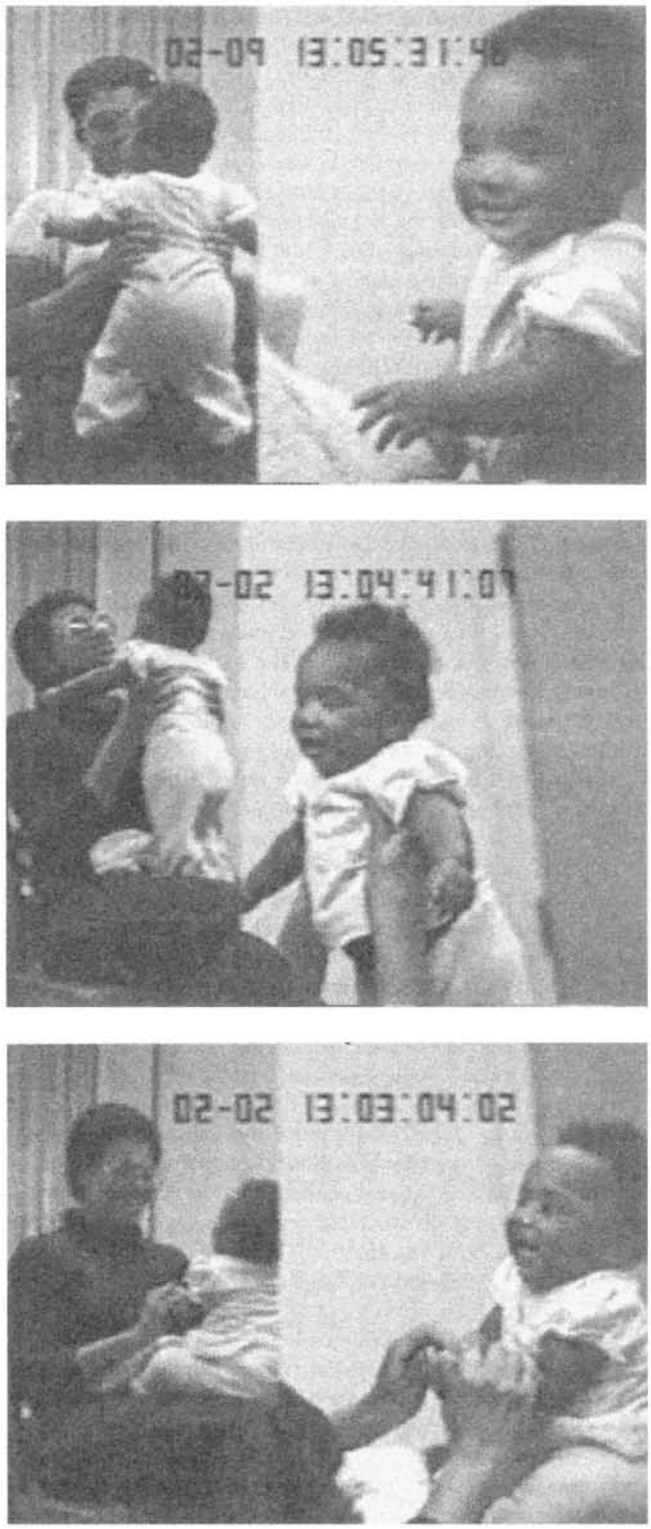

Figure 1. Different smiles in different interactive periods. For illustrative purposes, different types of smiling are presented in periods involving only the interactive period with which they were associated. Top: Cheek-raise smiling while mother is smiling without gazing at mother's face. Middle: Open-mouth smiling while gazing at mother's face without mother smiling. Bottom: Open-mouth cheek-raise smiling while infant is gazing at mother's face and mother is smiling.

Coding

The Facial Action Coding System (FACS; Ekman & Friesen, 1978) is an anatomically based coding system that allows for the identification of muscular contractions that produce unique appearance changes termed facial *action units* (AUs). The coding of infant facial actions and the assessment of their reliability are outlined in Messinger et al. (1999). The presence or absence of infant lip-corner raising (smiling), cheek raising, and mouth opening were coded continuously. The presence of these AUs (see below) was coded if their intensity met or exceeded minimum requirements (the "x" level; Ekman & Friesen, 1978). No other infant facial actions were coded.

Graduate students certified in the FACS (Ekman & Friesen, 1978) and trained in its application to infants (Baby FACS; Oster & Rosenstein, in press) coded infant lip-corner raising and cheek raising. Lip-corner raising (smiling) occurs when the zygomatic major contracts. The minimum criteria for lip-corner raising (AU12) are the raising of the lip corners, the raising of the infraorbital triangle (making the cheeks more prominent), and a deepening of the nasolabial furrow between the nose and cheeks. Coders were instructed to distinguish the zygomatic major action from the dimpling action of the buccinator (AU14) as well as from the rare action of the caninus (AU13) (Oster & Rosenstein, in press).

Cheek raising (AU6) occurs when the muscle orbiting the eye socket (orbicularis oculi, pars lateralis) contracts. The major criterion in infants is prominent cheek raising that deepens and raises the furrow beneath the lower eyelid. Only cheek raising, which primarily affects the cheek and the outer portion of the lower eyelid, was coded. This action was distinguished from the movement of the orbicularis oculi, pars palpebralis (AUs 7 and 44) which raises the lower eyelid itself. The presence of a clearly dropped jaw (AU26c–AU26e/AU27, Oster & Rosenstein, in press), not simply the parting of the lips, defined the open-mouth smile. Jaw drops, a relatively easily identified facial action, were identified by coders trained in the relevant FACS AUs who were not FACS certified.

The periods of interaction in which infants exhibited the different types of smiles were formed by infants gazing directly at or away from mother's face and by mothers smiling or not smiling. The direction of the infant's gaze (at or away from the mother's face) was coded by trained undergraduates. Mothers' smiles (i.e., lip-corner raises, AU12) were identified by non-FACS-certified coders because the identification of adult lip-corner raising (particularly in mothers interacting with their infants) is less complex than the same coding in infants (Ekman & Friesen, 1978; Oster & Rosenstein, in press). Only mother smiling (not mother cheek-raise or open-mouth smiling) was identified, because there was no close-up view of mothers' faces. Two additional factors informed this decision. First, mothers' speech made the segmenting of mouth opening problematic. Second, some mothers wore glasses, which made the detection of cheek raising problematic (in adults, the major criterion for identifying cheek raising is crow's feet wrinkles on the outer corners of the eyes).

Reliability

The order in which sessions were coded was randomized, and weekly coding meetings were held to review difficult coding decisions and disagreements stemming from reliability analyses. Intercoder agreement was calculated for random samples of approximately 15% of the sessions. At least two sessions for each infant, one before and one after 13 weeks of age, were used in these analyses. The total duration of actions formed the basis of the substantive analyses, but accuracy in recording the onsets of these actions played a role in eliminating co-occurrences involving mother smiling (see *Data Aggregation and Analysis* section). Consequently, we conducted separate analyses to ascertain whether coders agreed on the durations of these actions and to ascertain whether coders agreed on the onset of facial actions.

We first calculated the percentage of agreement and Cohen's kappa (κ, which corrects for random agreement) on the total duration of time spent in each coded action. When this stringent and frequently used measure of reliability (see Fogel et al., 2000; Segal et al., 1995; Weinberg, Tronick, Cohn, & Olson, 1999) is used, there is no time window within which two actions that do not exactly coincide are considered to be in agreement (Bakeman & Gottman, 1986). Instead, the duration of all time in which coders disagreed as to the presence or absence of an action constitutes time in disagreement and is entered into the appropriate disagreement cell for calculating percentage of agreement and kappa. The duration of all time in which coders agreed as to the presence or absence of an action constitutes time in agreement and is entered into the appropriate agreement cell for calculating percentage of agreement and kappa. For example, if coders agreed that an infant smile occurred for 3 s but disagreed as to whether it continued for an additional 1 s, 3 s of agreement and 1 s of disagreement would be entered into the respective cells. Time in agreement (expressed as a percentage of total time, followed by kappa) was 89% (κ = .77) for infant lip-corner raising, 87% (κ = .63) for infant cheek raising, and 88% (.72) for infant mouth opening (see Messinger et al., 1999). Agreement was 90% (κ = .77) for direction of infant gazing and 87% (κ = .75) for mother lip-corner raising.

To ascertain agreement on the beginning of facial actions, we established a 2-s time window within which each coder had to code the onset of a facial action, irrespective of its duration, for the codes to be counted as an agreement (see Bakeman & Gottman, 1986). Percentages of agreement were 79% for infant lip-corner raises, 79% for infant cheek raises, and 78% for infant mouth opening. (In ascertaining agreement on action onsets, agreement on nonevents cannot occur, which prevents the calculation of agreement expected by chance and the calculation of kappa.) Once agreement was ascertained, the actual mean lags between coders were determined to be 0.37 s (SD = 0.27) for lip-corner raises, 0.32 s (SD = 0.31) for cheek raises, and 0.50 s (SD = 0.57) for opening the mouth (see Messinger et al., 1999). For actions that defined positive periods of interaction, agreement was 82% for mother smiles and 81% for gazes at mother's face. Mean lags between codes were 0.64 s (SD = 0.55) and 0.33 s (SD = 0.27), respectively.

Data Aggregation and Analysis

To provide clues to the emotional meaning of infant smiles and other facial expressions, we included all infant-initiated co-occurrences of expressions and interactive period in the analyses. Infants could initiate these co-occurrences by beginning an expression or changing expressions (e.g., type of smiling) while mothers were smiling or not smiling and while the infants themselves were gazing at their mothers' faces or elsewhere. Infants could also initiate a co-occurrence in the course of an expression by gazing at or away from their mothers' faces. Co-occurrences produced when mothers smiled or ceased smiling during an infant expression were not included in the analyses. Given infant initiation, no a priori sequencing rules were used to determine the admissibility of different types of infant smiles. An open-mouth smile in a given period of interaction was tabulated, for example, whether the infant first opened his or her mouth and then smiled or first smiled and then opened his or her mouth.

Infants can rapidly transition between different types of smiling. Messinger et al. (1999) found, for example, that cheek-raise smiles in the current sample were frequently preceded by smiles without cheek raising. In a given period of smiling, the duration of each segment of smiling involving a specific type of smiling was tabulated separately without respect to the type of smile that might have immediately preceded or followed it. For example, if an infant, while gazing at the mother, initiated a cheek-raise smile and then transitioned to a cheek-raise smile with mouth opening, the durations of both types of smiles in this interactive period were tabulated separately (see Messinger et al., 1999). Transitions between smile types highlight the importance of using a stable dependent measure. Total duration is often preferred by emotion researchers because longer expressions are given proportionately more weight than briefer expressions (Ekman et al., 1990; Fernandez-Dols & Ruiz-Belda, 1995; Segal et al., 1995). In this study, total duration always refers to the sum of all infant-initiated co-occurrences of different types of smiling in different types of interactions.

Table 1
Distributions of Infant Facial Expressions by Interactive Period

Infant facial expression	Interactive period: No gazing at mother, no mother smiling	Mother smiling, no gazing at mother	Gazing at mother, no mother smiling	Gazing at mother, mother smiling	Marginals
No smiling					
Closed mouth, no cheek raising	.66 (.10)	.48 (.14)	.58 (.14)	.36 (.12)	.56
	607.4 (284.7)	191.3 (108.6)	188.3 (111.5)	131.5 (100.9)	1,118.5
Open mouth, no cheek raising	.12 (.04)	.13 (.07)	.15 (.06)	.14 (.08)	.13
	102.7 (47.7)	49.6 (39.0)	51.8 (40.3)	57.0 (51.0)	261.1
Closed mouth, cheek raising	.07 (.05)	.03 (.01)	.04 (.02)	.04 (.03)	.05
	59.9 (46.2)	12.2 (8.2)	15.1 (12.6)	12.9 (11.4)	100.1
Open mouth, cheek raising	.06 (.06)	.03 (.02)	.04 (.03)	.03 (.14)	.04
	46.8 (40.9)	10.5 (8.1)	14.7 (18.0)	8.5 (5.5)	80.5
Smiling					
Closed mouth, no cheek raising	.05 (.05)	.12 (.06)	.07 (.03)	.12 (.03)	.08
	46.6 (48.4)	47.7 (35.9)	22.6 (12.4)	39.3 (22.1)	156.2
Open mouth, no cheek raising	.02 (.01)	.05 (.03)	.04 (.03)	.08 (.05)	.04
	15.5 (13.7)	19.7 (11.4)	14.1 (10.1)	27.9 (25.6)	77.2
Closed mouth, cheek raising	.02 (.02)	.06 (.04)	.03 (.02)	.09 (.07)	.04
	15.5 (16.3)	23.9 (20.4)	9.2 (7.3)	35.3 (42.0)	83.9
Open mouth, cheek raising	.01 (.01)	.09 (.09)	.05 (.07)	.15 (.10)	.06
	12.9 (15.6)	30.0 (22)	16.9 (20.8)	54.2 (50.6)	114.0
Marginals	.46	.19	.17	.18	1.0
	907.3	384.9	332.7	366.6	1,991.8

Note. The mean proportion of time in interactive periods (columns) occupied by various infant facial expressions (rows) is contained in the top number in each cell; the bottom number in each cell indicates the mean number of seconds of co-occurrence. Standard deviations are in parentheses. Open-mouth cheek-raise smiling, for example, occupied .15 of the time in which infants were gazing at mothers' faces during mother smiling. Marginals derived from the table show total time in each facial expression (last column) and total time in each interactive period (last row) expressed both as a proportion of total time in all interactive periods and in seconds.

Results

The total duration of infant-initiated time in each facial expression is expressed as a proportion of each period of interaction in Table 1. There were four periods of interaction formed by the presence or absence of infant gazing at mother's face and of mother smiling: no infant gazing at mother's face and no mother smiling, mother smiling but no infant gazing at mother's face, infant gazing at mother's face but no mother smiling, and infant gazing at mother's face and mother smiling. The possible variations of the presence and absence of smiling, mouth opening, and cheek raising defined eight facial configurations. No other actions were involved in defining these configurations. Four of the configurations were different types of smiling, and four were nonsmiling configurations (see Table 1).

Marginal sums computed from Table 1 indicate the proportion of total time occupied by each facial configuration and by each type of interaction and provide an informative context in which to address the research questions. Periods in which infants were not gazing at their mothers and their mothers were not smiling were more than twice as long as periods involving either infants gazing at their mothers' faces or mothers smiling or periods involving both. Infant smiling occurred during slightly more than one fifth of the time. Within periods of smiling, smiling with neither cheek raising nor mouth opening occupied the greatest proportion of time, followed by smiling with both cheek raising and mouth opening. These two types of smiling were followed by cheek-raise smiling and by open-mouth smiling, which occupied comparable periods of total time.[1]

To examine whether some types of smiling were relatively more likely in certain conditions than others, we constructed proportions in which the duration of time involved in smiling with a given characteristic was divided by the time involved in comparable smiling with and without that characteristic. Cheek-raise smiling was expressed as a proportion of smiling with and without cheek raising, all in the absence of mouth opening. Open-mouth smiling was expressed as a proportion of open- and closed-mouth smiling, all in the absence of cheek raising. Smiling involving both cheek

[1] Messinger et al. (1999), who used all of the smiling data rather than only those involved in infant-initiated co-occurrences of facial expressions and maternal smiling, found that cheek-raise smiling and open-mouth smiling tended to co-occur in this data set. This pattern is evident in the finding just described in which smiling tended to involve either both cheek raising and mouth opening or neither of these features.

raising and mouth opening was expressed as a proportion of smiling involving both characteristics and smiling involving neither characteristic. That is, each of these types of smiling was expressed as a proportion of itself and of smiling alone, which involves neither cheek raising nor mouth opening.

Each of the three dependent measures—proportions of cheek-raise smiling, open-mouth smiling, and open-mouth cheek-raise smiling—was examined in the presence and absence of gazing at the mother's face and of mother smiling. Specifically, each type of smiling was subjected to a 2 (gazing at mother's face) × 2 (mother smiling) repeated-measures analysis of variance (ANOVA). The contrast between significant and nonsignificant effects is illustrated in the proportions of each smiling type in the different periods of interaction (see Figure 2). Significant effects were reflected in substantial differences between smiling proportions, large effect sizes, and, with one exception, the presence of the effect in question in a significant proportion of individual infants (see Table 2).

Smiling Types

Infants engaged in a higher proportion of cheek-raise smiling when their mothers' were smiling than when their mothers were not smiling ($p < .05$; see Table 2). Infants did not engage in a

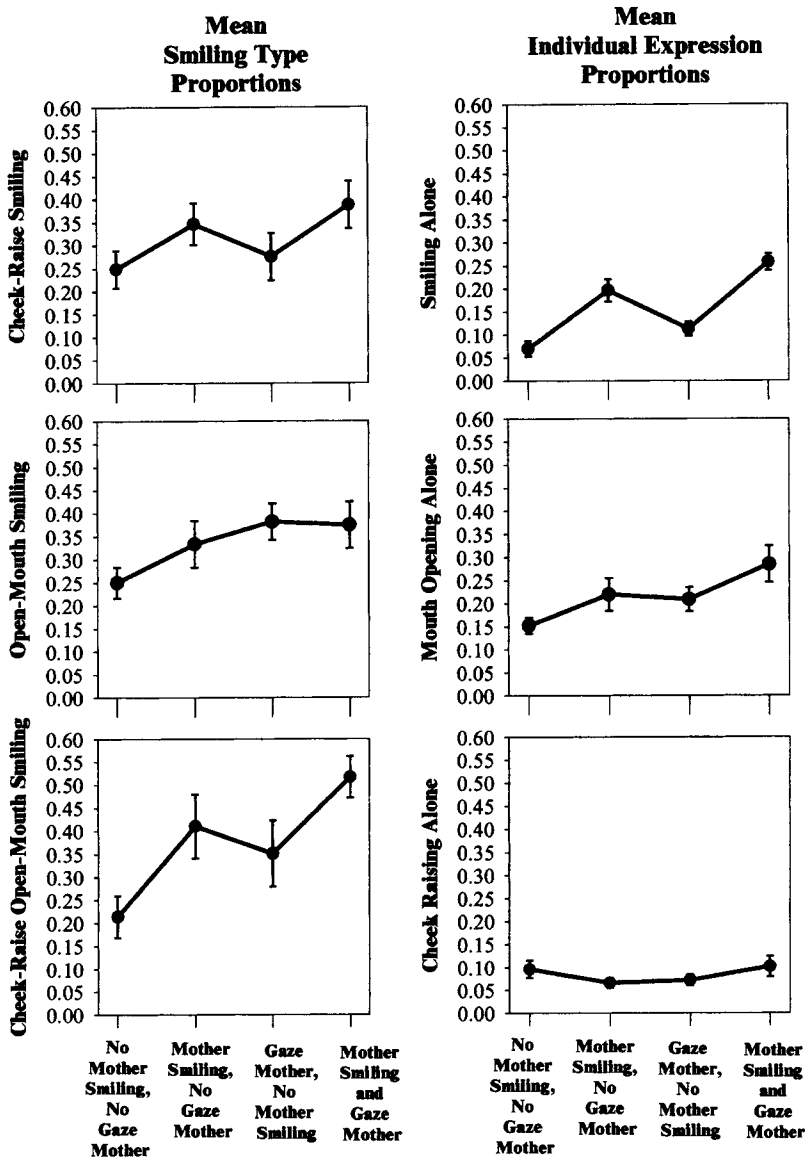

Figure 2. Infant facial expression proportions by interactive period. Within each given period of social interaction, smiling types are expressed as proportions of the given smiling type and smiling alone (left-hand column). Individual facial expressions are expressed as proportions of the given action and periods involving neither smiling, mouth opening, nor cheek raising (right-hand column). Neither set of proportions sums to 1 within a given period of social interaction. Standard error bars surround each mean.

Table 2
Infant Facial Expression Proportions by Mother Smiling and Gazing at Mother

Facial expression	Parameter estimates		Mother-smiling effect			Parameter estimates		Gazing-at-mother effect			Interaction effect	
	Mother smiling	No mother smiling	$F(1, 12)$	η^2	$N^{\#}$	Gazing at mother	No gazing at mother	$F(1, 12)$	η^2	$N^{\#}$	$F(1, 12)$	η^2
Smiling types												
Cheek-raise smiling	.37	.26	5.02*	.30	10*	.33	.30	1.01	.08	8	0.05	.01
Open-mouth smiling	.35	.32	1.38	.10	7	.38	.29	6.30*	.34	13***	5.09*	.30
Open-mouth cheek-raise smiling	.46	.28	26.32***	.69	12***	.43	.31	9.38***	.44	8	0.18	.02
Individual facial actions												
Smiling alone	.23	.09	198.89***	.94	13***	.19	.13	6.03*	.34	11*	0.62	.05
Mouth opening alone	.25	.18	13.07***	.52	12***	.25	.19	10.16***	.46	12***	0.07	.01
Cheek raising alone	.08	.08	0.12	.01	7	.09	.08	.00	.00	6	12.57***	.51

Note. The proportions are parameter estimates from the analyses of variance described in the text. Smiling types are expressed as proportions in which the time involved in the given smiling type is divided by the time involved in the given smiling type and smiling alone. Individual facial actions are expressed as proportions in which the time involved in a given action is divided by the time involved in the given action and periods involving neither smiling, mouth opening, nor cheek raising. η^2 is a measure of effect size equivalent to R^2. $N^{\#}$ = number of infants (out of 13) showing the main effect. Significance was calculated for proportions using binomial tests. Fischer's exact tests indicated that whether or not an infant showed a given association was not associated with whether or not the infant showed any other association.
* $p < .05$. *** $p < .01$.

significantly higher proportion of cheek-raise smiling when gazing directly at their mothers' faces than when gazing away ($p > .25$). The interaction between mother smiling and gazing at mother was not significant ($p > .25$).

Open-mouth smiling showed the opposite pattern of associations. Infants engaged in a higher proportion of open-mouth smiling when gazing directly at their mothers' faces than when gazing elsewhere ($p < .05$). Infants did not engage in higher proportions of open-mouth smiling when their mothers were smiling than when their mothers were not smiling ($p > .25$). A significant interaction ($p < .05$) indicated that the general increase in open-mouth smiling during gazing at the mother was attenuated when the mother was also smiling (see Figure 2).

Open-mouth cheek-raise smiling showed each of the significant patterns that characterized open-mouth smiling and cheek-raise smiling individually. Infants engaged in higher proportions of open-mouth cheek-raise smiling when their mothers were smiling than when their mothers were not smiling ($p < .001$). Proportions were also higher when infants were gazing directly at their mothers' faces than when gazing elsewhere ($p < .01$). The interaction was not significant ($p > .25$).

The effects for each type of smiling involved a comparison with smiling alone, which involves neither cheek raising nor mouth opening. This means that smiling alone was less likely than cheek-raise smiling during mother smiling, less likely than open-mouth smiling while infants were gazing at their mothers' faces, and less likely than open-mouth cheek-raise smiling in both of these conditions. Although smiling alone is less likely than other types of smiling in these conditions, it may nevertheless be more likely than comparable periods without smiling in the same conditions.

Individual Actions

To examine whether smiling alone and the other individual facial actions that composed different types of smiling were relatively more likely in specific periods of interaction, we created proportions in which the time involved in an individual facial action was divided by the time involved in comparable periods with and without that action. Smiling alone, for example, was expressed as a proportion of smiling and nonsmiling, all in the absence of cheek raising and mouth opening. Mouth opening was expressed as a proportion of the presence and absence of mouth opening, all in the absence of smiling and cheek raising. Finally, cheek raising was expressed as a proportion of the presence and absence of cheek raising, all in the absence of smiling and mouth opening.

We compared the proportions of different single facial actions in the presence and absence of gazing directly at the mother's face and of mother smiling using ANOVAs identical to those used for smiling types (see Table 2 and Figure 2). A higher proportion of smiling alone occurred when the infants' mothers were smiling than when they were not smiling ($p < .001$). A higher proportion of smiling alone also occurred when the infants were gazing directly at their mothers' faces than when they were gazing elsewhere ($p < .05$). The interaction effect was not significant ($p > .25$).

A higher proportion of mouth opening alone occurred when mothers were smiling than when they were not smiling ($p < .01$). A higher proportion of mouth opening also occurred when infants were gazing directly at their mothers' faces than when they were gazing elsewhere ($p < .01$). The interaction effect was not significant ($p > .25$). The proportion of cheek raising alone was not higher when mothers were smiling than when mothers were not smiling ($p > .25$). The proportion of cheek raising alone was also not higher while infants were gazing at their mothers' faces rather than elsewhere ($p > .25$). A significant interaction effect indicated that the proportion of cheek raising alone was relatively high both when mothers were smiling while infants were gazing at their mothers' faces and when mothers were not smiling and their infants were gazing elsewhere ($p < .01$; see Figure 2).

Development

The preceding analyses indicated that certain types of infant smiling and other facial expressions were relatively more likely than others during specific periods of interaction. In the developmental analyses, we examined whether those expressions were relatively more or less likely to occur during specific periods of interaction. To examine developmental effects, we calculated the proportions of smiling and other facial expressions that occurred in different periods of social interaction. These proportions were identical to those analyzed earlier except that they were calculated in each of the five monthly periods between 1 and 6 months of age. The developmental analyses of smile type proportions expressed change with respect to smiling alone. The analyses of individual facial expression proportions expressed change with respect to periods without these individual expressions.

For each infant, developmental change in the proportion of each facial expression in each of the four periods of interaction was examined with an individual regression equation. For example, the proportions of open-mouth cheek-raise smiling were examined monthly for each infant in each of the four periods of interaction created by the presence and absence of infant gazing at the mother's face and mother smiling. With age, we expected such expressions to become more likely during periods of interaction involving gazing at the mother and/or mother smiling and less likely in the period involving neither of these actions. One-tailed, single-sample *t* tests were used to determine if the mean level of change in these proportions per month (the mean slope, *b*, of the group) differed significantly from 0 (see Table 3). (When visual inspection suggested curvilinear effects, single-sample *t* tests of the quadratic coefficients obtained from nonlinear regressions were conducted.) One-tailed, paired-sample *t* tests were used to contrast whether facial expression proportions in the period when infants were gazing at their mothers while their mothers were smiling increased significantly more than did proportions in the period when neither of these actions was occurring.

In the period when infants were gazing at their mothers' faces while their mothers were also smiling, proportions of combined open-mouth cheek-raise smiling increased with age (see Table 3). In the period that did not involve gazing at mother or mother smiling, proportions of open-mouth cheek-raise smiling declined. The difference between these linear developmental trajectories was also significant, $t(11) = 3.29$, $p < .005$. Examination of the developmental trajectories shows that proportions of open-mouth cheek-raise smiling overlapped in these different periods of inter-

Table 3
Developmental Changes in Facial Expression Proportions

Infant facial expression and interactive period	Monthly slope change				
	M	*Mdn*	*t*	*df*	$N^{\#}$
Smiling types					
Cheek-raise smiling					
No mother smiling, no gazing at mother	−.02	−.04	−0.93	12	4
Mother smiling, no gazing at mother	−.04	.00	−1.24	12	7
Gazing at mother, no mother smiling	.04	.04	0.98	10	8
Mother smiling, gazing at mother	.10	.05	1.80*	12	10*
Open-mouth cheek-raise smiling					
No mother smiling, no gazing at mother	−.04	−.05	−2.51**	11	3*
Mother smiling, no gazing at mother	−.01	−.01	−0.51	12	6
Gazing at mother, no mother smiling	.05	.02	0.62	11	8
Mother smiling, gazing at mother	.05	.03	1.92*	12	10*
Individual facial actions					
Smiling alone					
No mother smiling, no gazing at mother	.04	.02	2.73	12	12
Mother smiling, no gazing at mother	.04	.04	2.63**	12	10*
Gazing at mother, no mother smiling	.03	.02	2.99**	12	11**
Mother smiling, gazing at mother	.05	.06	1.71	12	11**
Cheek raising alone					
No mother smiling, no gazing at mother	−.04	−.02	−3.37***	12	2**
Mother smiling, no gazing at mother	−.04	−.03	−2.31	12	3
Gazing at mother, no mother smiling	−.03	−.03	−2.75	12	1
Mother smiling, gazing at mother	−.02	−.01	−1.23	12	2

Note. Only facial expressions whose proportions showed a significant mean change in at least one interactive period are listed. One-tailed *t* tests indicate whether the mean slope differed from 0. Increases were expected in all interactive periods involving mother smiling or gazing at mother. Decreases were expected in the period involving neither of these conditions. $N^{\#}$ = the number of infants showing an increase in the proportion of a given facial expression with age. Significance was calculated for changes in proportions using directional binomial tests (Hays, 1988). The denominators of the proportions are equal to one more than the degrees of freedom.

* $p < .05$. ** $p < .025$. *** $p < .01$.

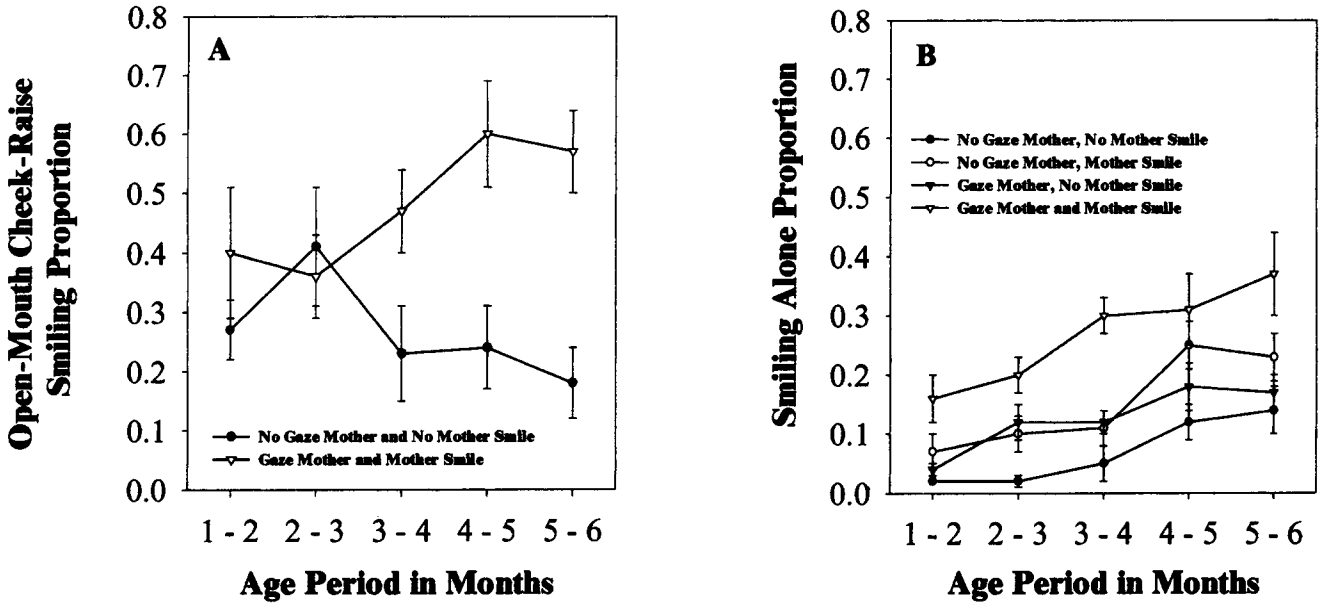

Figure 3. A: Open-mouth cheek-raise smiling proportions increase when infants are gazing at their mothers' faces while their mothers are smiling. They decrease when infants are not gazing at their mothers while their mothers are not smiling. B: By contrast, smiling alone proportions show a tendency to increase in all periods of interaction.

action through 3 months of age (see Figure 3). After 3 months, open-mouth cheek-raise smiling proportions increased while infants were gazing at their smiling mothers and decreased when neither of these conditions obtained. (Quadratic effects were not significant for either proportion.) Proportions of open-mouth cheek-raise smiling did not change significantly in the periods involving only mother smiling and only infant gazing at mother.

Proportions of cheek-raise smiling also increased in periods when infants were gazing at their mothers' faces while their mothers were smiling. The increase in these periods was significantly greater than the (nonsignificant) decrease in proportions of cheek-raise smiling that occurred in the period when infants were not gazing at their mothers and their mothers were not smiling, $t(12) = 2.80$, $p < .01$. There were no other significant developmental changes in the proportions of cheek-raise smiling. There were no significant changes in proportions of open-mouth smiling during specific periods of interaction (see Table 3). The planned contrast between open-mouth smiling proportions occurring in periods with and without the combination of mother smiling and infant gazing at mother was also not significant.

Proportions of smiling alone showed a tendency to rise in all periods of interaction (see Table 3 and Figure 3). Smiling-alone proportions rose both in the period while infants were gazing at their mothers and in the period when their mothers were smiling. There was a tendency for smiling-alone proportions to rise significantly in the period when infants were gazing at their mothers while their mothers were smiling, but this tendency did not reach significance ($p = .06$). The contrast between this proportion and the proportion of smiling alone occurring when infants were not gazing at their mothers and their mothers were not smiling was not significant. These results suggest a general increase in the proportion of smiling alone that was not specific to particular interactive periods.

Proportions of cheek raising alone declined in the period when infants were not gazing at their mothers and their mothers were not smiling (see Table 3). In fact, proportions of cheek raising alone had been expected to rise in periods involving gazing at mother and/or mother smiling, but they were observed to decline in all periods of interaction. As a consequence, the planned contrast between proportions of cheek raising alone in periods with and without the combination of gazing at mother and mother smiling was not significant. There were no significant developmental changes in the proportions of mouth opening alone in any period of interaction, nor was their planned contrast significant.

Discussion

Different types of smiling appear to be associated with a range of positive emotional processes. Smiling was relatively more likely than nonsmiling during periods of interaction selected for their ability to elicit positive emotion, but some types of smiling were relatively more likely than others during these same periods. These results challenge the view—implicit in widely used facial coding systems that do not distinguish between different types of smiling (Izard, 1979, 1983)—that all smiling indexes a single positive emotion. If one accepts the premise that smiling indexes positive emotion because of its predilection to occur in selected periods of interaction, it follows that some types of smiling are more emotionally positive than others because they are more likely to occur in the very same interactive periods. In the following sections, we explore the meaning of the associations of different types of facial expressions with specific interactive periods, examine the devel-

opment of these associations, and review alternative interpretations and supporting evidence.

Smiling Types

The finding that different types of smiling tended to occur in different periods of interaction suggests that these types of smiling may have distinct meanings. Open-mouth smiling tended to occur while infants were gazing at their mothers' faces. Mothers typically gaze at their infants almost continuously during face-to-face interaction (Stern, 1974). Open-mouth smiling may, then, be part of a process of visual connection with an interactive partner. This interpretation is supported by the finding that 17-month-old infants tend to begin open-mouth smiles before gazing at their mothers (Jones et al., 1990).

The tendency for cheek-raise smiling to occur during mother smiling in the first 6 months of life may be early evidence for the association of this expression with positive emotion (Ekman, 1992, 1994). Because infants were held toward their mothers almost 95% of the time, the infants were in a position to see their mothers' smiles even when they were not gazing directly at their mothers' faces. The tendency of infants to engage in cheek-raise smiling during mother smiling indicates that cheek-raise smiles are associated with positive displays in a social partner and may involve the sharing of positive affect. This interpretation is consistent with infants' proclivity to engage in cheek-raise smiling while their mothers smile and approach the infants (Fox & Davidson, 1988).

As cheek-raise smiling was associated with mother smiling and open-mouth smiling was associated with gazing at the mother's face, so open-mouth cheek-raise smiling tended to occur in both of these conditions. This type of smiling appears to be related both to visual engagement and to sharing of positive affect. Open-mouth cheek-raise smiling may occur more generally during peak moments of social interaction, including the culmination of a series of tickling games (Fogel et al., 2000) and other types of physical play (Dickson et al., 1997).

Open-mouth cheek-raise smiling is also prevalent, occurring for at least as much time as either cheek-raise or open-mouth smiling occurred individually in this and other studies (Dickson et al., 1997; Fogel et al., 2000). It is possible, in fact, that associations of cheek-raise smiling with enjoyable situations and with left frontal cerebral activation in earlier research with infants (Fox & Davidson, 1988) and even adults (Ekman et al., 1990) may be due, in part, to unexamined overlaps with open-mouth smiling. Accumulating evidence indicating the prevalence and emotional intensity of open-mouth cheek-raise smiling makes this salient expression an attractive index of infant joy.

Overlaps of open-mouth smiling with a dimension of smiling related to cheek raising, that is, moderate to strong contraction of the muscle that creates smiling (the zygomatic major), have been termed *big smiles* (Oster & Rosenstein, in press). Segal et al. (1995) found that full-term infants displayed more big smiling than did healthy preterm infants during face-to-face interactions, which suggests that big smiling may index full-term infants' enhanced ability to engage in the visual engagement and displays of maternal positive affect that characterize face-to-face interaction as a whole. Smiles involving stronger contraction of the zygomatic major tend to transition more quickly into cheek-raise smiles (Schneider & Uzner, 1992) that involve stronger cheek raising (Messinger et al., in press), which suggests a tight link between these dimensions of smiling (Messinger, Fogel, & Dickson, 1997; Segal et al., 1995). Similarities in when big smiling and open-mouth cheek-raise smiling occur suggest that they may be tapping a common dimension of strong positive affect, a possibility we are investigating by using a full-screen rather than a split-screen image of these infant facial expressions.

Individual Facial Actions

Infants tended to engage in smiling alone both when gazing at their mothers' faces and when their mothers were smiling, which suggests that, compared to periods without smiling, smiling in the absence of cheek raising and mouth opening is associated both with sharing positive affect and with visual engagement. This interpretation is consonant with Fogel et al.'s (2000) argument that smiling alone reflects a readiness to play (it occurred during the early phases of peek-a-boo games) and that it can serve as a precursor to cheek-raise smiling (Messinger et al., 1999). Smiling alone (without cheek raising) appears to represent an intermediate degree of positive emotional engagement between nonsmiling on the one hand and cheek-raise smiling on the other. More qualitatively, smiling alone may involve a readiness to continue pleasant experiences, whereas cheek-raise smiling, open-mouth smiling, and especially their combination involve a more active participation in such experiences.

A striking finding of this research was the tendency of infants to engage in mouth opening (in the absence of smiling) both while gazing at their mothers and while their mothers were smiling (see also Kaye & Fogel, 1980). The possibility that mouth opening alone, like smiling alone, is associated with positive emotional processes is consonant with the tendency of nonhuman primates to engage in open-mouth displays during bouts of exciting play (Plooij, 1979; Redican, 1975; van Hooff, 1972). By contrast, cheek raising alone did not tend to occur either when mothers were smiling or when infants were gazing at their mothers, which suggests that cheek raising in the absence of smiling is not involved with positive emotional processes.

Development

Previous investigations did not find age-related changes in different types of smiling (Fogel et al., 2000; Messinger et al., 1999), but they did not investigate changes in smiling proportions in specific periods of interaction. The current findings indicate that, with age, specific types of smiling become more strongly linked to specific periods of interaction than do other types of smiling. The proportion of open-mouth cheek-raise smiling rose during the period in which infants were gazing at their smiling mothers. It declined in the period when mothers were not smiling and infants were gazing elsewhere. The increasingly specific association between open-mouth cheek-raise smiling and conditions involving the visual sharing of positive affect was most evident after 3 months of age. Between 3 and 6 months, infants become increasingly able to initiate social interaction but increasingly discriminating as to when they do so (Kaye & Fogel, 1980; Messinger & Fogel, 2000). Their comprehension of mother smiling—specifically, its tendency to co-occur with certain types of maternal vocalizations—is also increasing (Walker-Andrews, 1997). In-

fants' increasing tendency to engage their smiling mothers with open-mouth cheek-raise smiling between 3 and 6 months of age may, then, index their emerging capacity to fully participate in intensely joyful interactions.

Proportions of cheek-raise smiling also rose when infants were gazing at their smiling mothers, and this increase was greater than the nonsignificant decrease found when infants were gazing away from their unsmiling mothers. The tendency of cheek-raise smiling with and without mouth opening to be increasingly associated with positive social situations suggests that cheek-raise smiling becomes increasingly tied to positive emotional processes early in development (Ekman, 1992, 1994). The specificity with which cheek-raise smiling with and without mouth opening increased in certain interactive periods stands in contrast to the development of smiling alone and of other individual facial actions.

Proportions of smiling alone showed a general upward developmental trend in all interactive periods (Kaye & Fogel, 1980), including the period in which mothers were not smiling and infants were not gazing at their mothers (see Figure 3). In fact, smiling alone did not increase at a lower rate in this interactive period than in the period in which infants were gazing at their smiling mothers. It appears that increases in infants' abilities to react contingently to interactive changes during the first 6 months of life are not indexed by smiling alone, which became relatively more likely in all of the interactive periods examined. Instead, increasing contingency was seen in infants' propensity to engage in smiles involving cheek raising (with or without mouth opening) rather than in smiling alone.[2]

Alternative Interpretations and Evidence

Positive emotion may be defined in terms of a readiness to continue a pleasant experience (Campos et al., 1994; Messinger, in press). The basis for interpreting different types of smiles as indexes of positive emotion rests in the meaning of the situations in which the smiles occur. The initial inference that gazing at mother and mother smiling elicit positive infant emotion, however, was based on previous research in which infants tended to smile and produce neutral or positive vocalizations during these interactive periods (Kaye & Fogel, 1980; van Beek et al., 1994; Weinberg & Tronick, 1994). Both in previous research and in the current research, however, nonemotional factors might lead infants to smile and vocalize during these interactive periods.

Gazing at mother is a prototypically social act, and mother smiling is an especially salient social signal. Socially elicited arousal and imitation might lead infants to engage in smiling alone when gazing at their mothers and when their mothers are smiling. Open-mouth and cheek-raise smiling may represent the intensification of these processes. Arousal, of course, may also be emotionally positive, and imitation may be part of a process of experiencing positive emotion in social interaction. In future investigations, examination of the infant's own activity level, physiological arousal, and expressive activities such as vocalization may help distinguish between alternative and complementary interpretations of the meaning of different types of infant smiling.

Another relevant source of information is a recent judgment study in which naïve observers were asked to rate the emotional intensity of different types of infant smiles. In that judgment study, 50 participants rated smiling alone as expressing more positive emotion (happiness and joy) than neutral expressions (Messinger, in press). Participants rated cheek-raise, open-mouth, and especially open-mouth cheek-raise smiles as expressing more positive emotion than smiling alone, which did not involve these features. These results do not indicate how infants reacted to the interactive periods we studied. They are consistent, however, with the possibility that the smiling observed in these periods was indicative of positive emotion. In fact, the current study and the judgment study suggest a common conclusion. Infant open-mouth cheek-raise smiling is more emotionally positive than smiling alone, which, in turn, is more positive than nonsmiling.

Conclusions

Frequent observations of 13 infants yielded appreciable and reliable differences between different types of smiling in different periods of interaction that tended to grow stronger with age and that could be observed in a significant proportion of individual infants. The results suggest both how different types of smiling are related and how they differ from one another. Smiling alone appears to have a relatively positive valence, reflected in a tendency to occur during mother smiling and during visual engagement with the mother. Cheek-raise (Duchenne) smiling occurs in situations that suggest that it is relatively specialized for sharing mothers' displays of positive affect. Open-mouth (play) smiling occurs in situations that suggest that it is relatively specialized for visual engagement with the mother. The unification of these expressions in open-mouth cheek-raise (duplay) smiling creates an expression that is sensitive to both visual engagement and displays of positive affect. With age, infants become increasingly likely to engage in open-mouth cheek-raise smiling during periods of interaction that combine infant visual engagement and maternal displays of positive affect. The possibility that certain types of smiling involve the amplification of affective features present to a lesser degree in smiling alone as well as the unification of these features in open-mouth cheek-raise smiling support the view that these expressions constitute a single family of joyful emotions with distinct but related emotional meanings (Barrett, 1993; Campos et al., 1994; Messinger, in press).

[2] The observed decline in proportions of cheek raising alone (including interactive periods in which it was expected to increase) may indicate its association with periods of fussing and other indexes of negative affect (Camras, 1992; Camras, Oster, Campos, Miyake, & Bradshaw, 1992; Messinger et al., 1997) that, although they were not the focus of this study, decline during this age period (Cohn, Campbell, Matias, & Hopkins, 1990).

References

Bakeman, R., & Gottman, J. (1986). *Observing interaction: An introduction to sequential analysis.* New York: Cambridge University Press.

Barrett, K. C. (1993). The development of nonverbal communication of emotion: A functionalist perspective. *Journal of Nonverbal Behavior, 17*(3), 145–169.

Blehar, M. C., Lieberman, A. F., & Ainsworth, M. D. (1977). Early face-to-face interaction and its relation to later infant–mother attachment. *Child Development, 48,* 182–194.

Campos, J. J., Mumme, D. L., Kermoian, R., & Campos, R. G. (1994). A

functionalist perspective on the nature of emotion. *Monographs of the Society for Research in Child Development, 59*(2-3, Serial No. 240).

Camras, L. A. (1992). Expressive development and basic emotion. *Cognition and Emotion, 6,* 269–283.

Camras, L. A., Oster, H., Campos, J. J., Miyake, K., & Bradshaw, D. (1992). Japanese and American infants' responses to arm restraint. *Developmental Psychology, 28,* 578–583.

Cohn, J. F., Campbell, S. B., Matias, R., & Hopkins, J. (1990). Face-to-face interactions of postpartum depressed and nondepressed mother–infant pairs at 2 months. *Developmental Psychology, 26,* 15–23.

Cohn, J. F., Campbell, S. B., & Ross, S. (1991). Infant response in the still-face paradigm at 6 months predicts avoidant and secure attachment at 12 months. *Development and Psychopathology, 3,* 367–376.

Dawson, G., Panagiotides, H., Klinger, L. G., & Spieker, S. (1997). Infants of depressed and nondepressed mothers exhibit differences in frontal brain electrical activity during the expression of negative emotions. *Developmental Psychology, 33,* 650–656.

Dedo, J. Y. (1991). *Smiling during later infancy: Relationships among facial expressions, contexts, and other communicative behaviors.* Unpublished doctoral dissertation, Purdue University.

Dickson, K. L., Walker, H., & Fogel, A. (1997). The relationship between smile-type and play-type during parent–infant play. *Developmental Psychology, 33,* 925–933.

Ekman, P. (1992). An argument for basic emotions. *Cognition and Emotion, 6,* 169–200.

Ekman, P. (1994). All emotions are basic. In P. Ekman & R. J. Davidson (Eds.), *The nature of emotion: Fundamental questions* (pp. 15–19). New York: Oxford University Press.

Ekman, P., Davidson, R. J., & Friesen, W. (1990). The Duchenne smile: Emotional expression and brain physiology II. *Journal of Personality and Social Psychology, 58,* 342–353.

Ekman, P., & Friesen, W. (1978). *The Facial Action Coding System.* Palo Alto, CA: Consulting Psychologists Press.

Ekman, P., & Friesen, W. V. (1982). Felt, false, and miserable smiles. *Journal of Nonverbal Behavior, 6,* 238–252.

Ekman, P., Friesen, W. V., & Ancoli, S. (1980). Facial signs of emotional experience. *Journal of Personality and Social Psychology, 39,* 1125–1134.

Fernandez-Dols, J. M., & Ruiz-Belda, M. A. (1995). Are smiles a sign of happiness? Gold medal winners at the Olympic games. *Journal of Personality and Social Psychology, 69,* 1113–1119.

Fogel, A., Nelson-Goens, G. C., Hsu, H., & Shapiro, A. F. (2000). Do different infant smiles reflect different emotions? *Social Development, 9,* 497–522.

Fox, N., & Davidson, R. J. (1988). Patterns of brain electrical activity during facial signs of emotion in 10-month-old infants. *Developmental Psychology, 24,* 230–236.

Frank, M. G., Ekman, P., & Friesen, W. V. (1993). Behavioral markers and the recognizability of the smile of enjoyment. *Journal of Personality and Social Psychology, 64,* 83–93.

Gewirtz, J. L. (1965). The course of infant smiling in four child-rearing environments in Israel. In B. M. Foss (Ed.), *Determinants of infant behavior* (Vol. 3, pp. 205–248). New York: Wiley.

Hays, W. L. (1988). *Statistics* (4th ed.). New York: Holt.

Izard, C. E. (1979). *The Maximally Discriminative Facial Coding System.* Newark: University of Delaware.

Izard, C. E. (1983). *The Maximally Discriminative Facial Coding System* (rev. ed.). Newark: University of Delaware.

Jones, S. S., Raag, T., & Collins, K. L. (1990). Smiling in older infants: Form and maternal response. *Infant Behavior and Development, 13,* 147–165.

Kaye, K., & Fogel, A. (1980). The temporal structure of face-to-face communication between mothers and infants. *Developmental Psychology, 16,* 454–464.

Legerstee, M., Pomerleau, A., Malcuit, G., & Feider, H. (1987). The development of infants' responses to people and a doll: Implications for research in communication. *Infant Behavior and Development, 10,* 81–95.

Malatesta, C. Z., Culver, C., Tesman, J. R., & Shepard, B. (1989). The development of emotion expression during the first two years of life. *Monographs of the Society for Research in Child Development, 54*(1-2, Serial No. 219).

Messinger, D. S. (in press). Positive and negative: Infant facial expressions and emotions. *Current Directions in Psychological Science.*

Messinger, D., Dondi, M., Nelson-Goens, G. C., Beghi, A., Fogel, A., & Simion, F. (in press). How sleeping neonates smile. *Developmental Science.*

Messinger, D. S., & Fogel, A. (July, 2000). *Does infant attention to and away from mother's face during interaction reflect periods of sustained interest?* Paper presented at the International Conference on Infant Studies, Brighton, United Kingdom.

Messinger, D., Fogel, A., & Dickson, K. L. (1997). A dynamic systems approach to infant facial action. In J. A. Russell & F. M. Dols (Eds.), *The psychology of facial expression* (pp. 205–226). New York: Cambridge University Press.

Messinger, D. S., Fogel, A., & Dickson, K. L. (1999). What's in a smile? *Developmental Psychology, 35,* 701–708.

Oster, H., & Rosenstein, D. (in press). *Baby FACS: Analyzing facial movement in infants and young children.* Palo Alto, CA: Consulting Psychologists Press.

Plooij, F. (1979). How wild chimpanzee babies trigger the onset of mother–infant play—and what the mother makes of it. In M. Bullowa (Ed.), *Before speech: The beginning of interpersonal communication* (pp. 223–243). London: Cambridge University Press.

Redican, W. K. (1975). Facial expressions in nonhuman primates. In L. A. Rosenblum (Ed.), *Primate behavior: Developments in field and laboratory research* (Vol. 4, pp. 103–194). New York: Academic Press.

Schneider, K., & Uzner, L. (1992). Preschoolers' attention and emotion in an achievement and an effect game: A longitudinal study. *Cognition and Emotion, 6,* 37–63.

Segal, L., Oster, H., Cohen, M., Caspi, B., Myers, M., & Brown, D. (1995). Smiling and fussing in seven-month-old preterm and full-term black infants in the still-face situation. *Child Development, 66,* 1829–1843.

Stern, D. N. (1974). Mother and infant at play: The dyadic interaction involving facial, vocal, and gaze behaviors. In M. Lewis & L. A. Rosenblum (Eds.), *The effect of the infant on its caregiver* (pp. 187–213). New York: Wiley.

van Beek, Y., Hopkins, B., & Joeksma, J. B. (1994). Development of communicative behaviors in preterm infants: The effects of birthweight status and gestational age. *Infant Behavior and Development, 17,* 107–118.

van Hooff, M. J. A. R. A. (1972). A comparative approach to the phylogeny of laughter and smiling. In R. A. Hinde (Ed.), *Non-verbal communication* (pp. 209–241). London: Cambridge University Press.

Walker-Andrews, A. S. (1997). Infants' perception of expressive behaviors: Differentiation of multimodal information. *Psychological Bulletin, 121,* 437–456.

Weinberg, M. K., & Tronick, E. Z. (1994). Beyond the face: An empirical study of infant affective configurations of facial, vocal, gestural, and regulatory behaviors. *Child Development, 65,* 1503–1515.

Weinberg, M. K., Tronick, E. Z., Cohn, J. F., & Olson, K. L. (1999). Gender differences in emotional expressivity and self-regulation during early infancy. *Developmental Psychology, 35,* 175–188.

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