27 Infant Emotional Development

Samantha Mitsven, Daniel S. Messinger,
Jacquelyn Moffitt, and Yeojin Amy Ahn*

Infants are emotional. From peals of laughter to disconsolate crying, infants are notorious for both the intensity and lability of their emotional displays. From the 1-year-old's distress in pursuing a retreating parent to the 2-year-old's joyful pursuit of a favorite pet, emotion appears to be a central motivator of infant action. Infancy is also characterized by rapid emotional development. Neonates exhibit high rates of crying, but by 6 months broad-mouthed smiles are a common feature of social play. Infants develop sadness expressions in the first year, demonstrate empathy by 2 years, and pride by 3.

Despite the clarity of some features of infant emotional life, multiple theories of emotional development exist and the chapter begins by summarizing competing and complementary theoretical perspectives. In light of unresolved theoretical questions, we review what is known about the development of negative and positive emotions in the first years of life, and report similarities in the expression of positive and negative emotion. This is followed by a discussion of the neural underpinnings of emotion perception where we note the relative lack of research on the neural concomitants of emotion expression. We next illustrate the complexities of emotional development by reviewing behavioral, cognitive, and caregiving dimensions involved in the emergence of empathy. The penultimate section of the chapter provides perspective by investigating cross-cultural differences in emotional development. Finally, we discuss policies that may support optimal emotional functioning, and conclude with suggestions for future research.

27.1 Theoretical Orientations

Theories of emotional development differ as to the defining features of infant emotion and how emotions develop (Camras, Fatani, Fraumeni, & Shuster, 2018). They offer competing perspectives on how behaviors such as crying are associated with emotional states such as distress. Most important,

* Work on this chapter was supported, in part, by grants to the second author from the National Science Foundation (1620294) and the Institute of Education Sciences (R324A180203).

however, is the degree to which these theories have generated productive research on infant emotional development.

27.1.1 Cognitive Differentiation

Developmentalists have long posited that emotional development involves the emergence of more differentiated emotional states from more diffuse states (Bridges, 1932). More undifferentiated distress expressions manifested in crying and accompanying facial expressions, for example, are characteristic of the first months of life while facial expressions of anger, sadness, and fear emerge over the first year (Sroufe, 1979; Sroufe & Waters, 1976; Tomkins, 1962). This differentiation perspective is typically aligned with a theoretical emphasis on the role of cognitive understanding as a defining characteristic of emotion (L. F. Barrett, 2006; Bridges, 1932; Sroufe, 1996).

A cognitive differentiation perspective holds that infants must be aware of their own affective reaction for emotion to be present (Lewis, 2018). In the first 2 to 3 months of life, for example, smiles are thought to be a pre-emotional signal of sensory pleasure – and to index a relaxation in cognitive tension related to recognition of a visual stimulus. Only when the infant, sometime after 6 months, is at least implicitly aware of their own emotional response – seeking and finding the parent's face during peek-a-boo, for example – is joy said to be present (Sroufe, 1996). Likewise, toward the end of the second year of life, the cognitive ability to recognize another's pain heralds the emergence of emotions such as empathy (Lewis, 2018). The emphasis on cognitive awareness of feelings as a defining characteristic of emotion contrasts with discrete emotion perspectives.

27.1.2 Discrete Emotion Theory

Discrete emotion theories regard core affective feelings as the defining feature of infant emotions (Ackerman, Abe, & Izard, 1998; Bridges, 1932; Izard & Ackerman, 2000; Sroufe, 1996; Tomkins, 1962). The elation of joy or the dejection of sadness are thought to be developmentally invariant characteristics of emotion states. These feeling states are hypothesized to be the product of discrete affect programs that also output specific patterns of expressive action such as facial expressions (Ackerman et al., 1998; Izard & Ackerman, 2000). As neurophysiologically based affect programs give rise to both expressive actions and feelings, the expressive actions are thought to typically index feeling states during infancy (though exceptions are allowed in early infancy; (Izard & Abe, 2004). Through its emphasis on facial expressions as markers of feeling states, discrete emotion theory can be thought of as the implicit theoretical basis for the vast quantities of research that use facial expressions as dependent variables to examine individual and group differences in expressivity. Discrete emotion theory, however, has also motivated a body of research that challenges its own account of the correspondence between expression and emotion in infancy.

27.1.3 Functionalist Theory

While discrete theories hold that emotion exists within the individual, functionalist theory holds that emotions are defined by maintaining and altering relationships with the social environment (K. C. Barrett, 1993; Campos, Mumme, Kermoian, & Campos, 1994; Witherington, Campos, & Hertenstein, 2001). Emotion, then, resides in the infant's relationships. Sadness, for example, functions to elicit succor and tenderness from caregivers. Oster (2005) proposes an ontogenetic variant of functionalist theory, which asks what expressive behaviors are available to the infant at a given age and how they allow the infant to function in his or her environment. More broadly, the functionalist perspective has served to direct attention to vocal, gestural, and whole-body expressions of emotion in context.

27.1.4 Sociocultural Theory

Sociocultural theory considers the proximal cultural rules and scripts that guide interactions as the rubric in which emotional development occurs (Holodynski, 2009; Holodynski & Friedlmeier, 2006). Holodynski and colleagues argue that in educated Western families, when infants make initial signals of an emotional experience such as pleasure and distress, parents respond with more discrete models of the initial signal such as smiles or an exaggerated sadness display, and frequently label the infant's presumed emotional experience. In this way, preverbal expressions of infant emotions develop more culturally meaningful forms. Depending on cultural values, expressions of infant emotions are differentially imitated and imbued with linguistic meaning.

27.1.5 Dynamic Systems

A dynamic systems approach focuses on emotional process as the transaction of multiple interfacing constituents including expressive actions, physiological arousal, and the social surround (Camras et al., 2018; Messinger, Fogel, & Dickson, 1997; Thelen & Smith, 1994). Emotion is thought to be the emergent outcome of the bottom-up inter-relationship of neural, expressive, social, and physiological constituents. In this chapter, we employ a dynamic systems approach as a meta-theoretical orientation with which to integrate insights from other perspectives in part to emphasize their areas of overlap and agreement. The differentiation perspective, for example, highlights the development of self-referential cognition as critical to the emergence of emotions such as empathy. This perspective is consonant with a dynamic systems emphasis on the bottom-up interplay of nonobvious constituents in emotional development.

27.2 Negative Emotional Development

Below we review the development of negative emotions, noting the overwhelming evidence for the prevalence of the cry-face expression from before birth through at least 6 months of postnatal age. In that context, we discuss the appearance of facial expressions of negative emotion including distress, anger, sadness, and fear in the first year of life. The evidence suggests that expressions of these discrete emotions are rare, difficult to recognize, and do not consistently occur in the contexts hypothesized to elicit the emotions in question. However, we also note that facial expressions of anger and sadness are associated with different patterns of physiological responsivity and patterns of motor (in)activity, which suggest different functional roles for these emotions.

27.2.1 Early Cry-Face Expressions

27.2.1.1 Distress Expressions in Fetuses

Recent advances in the use of three- and four-dimensional ultrasonography have allowed researchers to explore the fetal origins of emotional expression. Fetuses were observed displaying cry-face pain/distress expressions in which brow knotting was combined with stretching of the lower lip and/or mouth opening as early as 20 weeks of gestational age (Dondi et al., 2012). To chart this prenatal development, Reissland, Francis, and Mason (2013) reliably coded components of the cry-face configuration including brow lowering, upper-lip raising, and mouth opening. Between 24 and 36 weeks gestation, there was an increase in the likelihood of such facial components co-occurring to produce increasingly complex cry-face configurations. In sum, facial movements involved in cry faces appear to be part of an early developing muscular synergy such as those proposed by dynamic systems theorists (Messinger et al., 1997).

27.2.1.2 *Postnatal Cry Faces*

Undifferentiated distress manifested in cry faces and accompanying cry/fuss vocal expressions are the most salient and common expressions of negative emotions in the first months of life. Although postnatal cry faces may occur (as in the fetuses) without known cause, they frequently reflect a continuum of negative response from discomfort to pain. Infant pain accompanying immunization, for example, is signaled by a cry-face expression involving deepening of the nasolabial furrow, raising of the upper lip, tightening of the lower eyelids, cheek raising, jaw dropping, and horizontal mouth stretching (Kohut, Riddell, Flora, & Oster, 2012). Different combinations of these core facial actions, including the presence or absence of eye constriction and the intensity of mouth stretching, reflect the intensity of the pain as well as infants' ability to regulate their own distress (Kohut et al., 2012).

27.2.2 The Development of Discrete Negative Emotions

Given the predominance of distress, a preeminent question in the first years of life is when (and if) discrete negative emotional states of anger, fear, and sadness emerge. Four overlapping areas of evidence are relevant here: (1) Do the expressions of negative emotion specified by differential emotions theory tend to occur as discrete entities? (2) Do adults perceive the target facial expressions as presentations of the emotion in question (face validity)? (3) Are the emotion displays reliably elicited by contexts and situations designed to elicit them (situational specificity)? (4) Do these displays co-occur with behaviors or physiological patterns consonant with the emotional meaning represented by the facial expression (withdrawal with sadness, for example)?

27.2.2.1 *The Occurrence of Discrete Negative Expressions*

The first question is whether the full-face expressions specified by discrete emotion theory (e.g., anger) occur more frequently than blended expressions. Matias and Cohn (1993) compared the longitudinal occurrence of full-face expressions of discrete emotion and blended expressions (e.g., an anger brow together with a mouth configured in pouting sadness configuration) at 2, 4, and 6 months. Proportions of full-face and blended expressions did not differ or change with age, indicating that discrete expressions of negative emotion are not more common than blends.

The morphology of the discrete emotion anger expression itself overlaps with the distress/pain cry-face expression. In the discrete emotion description of the early anger expression, the brow is lowered, the upper lip is lifted, the corners of the mouth are drawn to the side, and the mouth is opened to produce a squarish configuration (Izard, Dougherty, & Hembree, 1983; Izard, Hembree, Dougherty, & Spizzirri, 1983). If the muscle surrounding the eyes (orbicularis oculi) now contracts, raising the cheeks (pars lateralis) and squinting the eyes (pars palpebralis), the anger configuration becomes a cry-face or distress-pain expression. It is possible, then, that anger expressions may occur as infants move in and out of cry-face expressions. More radically, the anger constellation may be an attenuated version, and perhaps the developmental outgrowth, of the cry-face (distress) expression (Camras et al., 2018).

27.2.2.2 *Adult Perception of Infants' Discrete Negative Expressions*

When young infants do exhibit expressions of discrete emotion, it is reasonable to expect that adults can accurately identify these facial expressions. When viewing prototypical exemplars of discrete joy, interest, and surprise (Izard, 1979; Izard, Dougherty et al., 1983), adults were accurate (83%) in identifying the exemplar emotions (Oster, Hegley, & Nagel, 1992). However, adults identified infant facial expressions reflecting discrete negative emotions of disgust, fear, anger, and sadness with very low (6%) accuracy. Camras, Sullivan, and Michel (1993) also found low levels of adult recognition using dynamic (video) displays where infant facial expressions of negative emotion were accompanied by corresponding body movements and vocalizations. Adults rated each negative emotion higher on distress than on the discrete emotion being depicted. In sum, adult judgment studies suggest that through 2 years of age infants display a generalized distress-linked emotion expression rather than discrete facial expressions of anger, fear, and sadness (Oster et al., 1992).

27.2.2.3 *Negative Emotion Expression in Emotion-Eliciting Situations*

Research on infants' facial expressions in response to situations hypothesized to differentially elicit discrete emotion expressions has failed to find evidence of specificity for negative emotion expressions of anger, disgust, sadness, and fear. Bennett, Bendersky, and Lewis (2002) found that, contrary to hypotheses, surprise and joy expressions were 4-month-olds' most common response to both arm restraint and being approached by a masked stranger, and that sadness expressions were the most common reaction to a sour taste. Camras et al. (2007) reported a similar lack of differentiation of facial expressions. Anger expressions were the most common reaction to both anger- and fear-eliciting conditions. Likewise, Bennett, Bendersky, and Lewis (2005) reported increases in full-face anger expressions in response to arm restraint (9% to 22%) from 4 to 12 months of age, but also observed that anger expressions were elevated at both ages in response to the fear-eliciting condition. These results suggest increasing specificity of discrete facial expressions to targeted emotion elicitors in the first year of life, although, few infants produced the target expressions overall.

27.2.2.4 *Actions and Vocalizations Distinguishing Anger and Sadness Expression*

Although concordance between emotion-eliciting contexts and specific facial expressions is rare, early anger and sadness may be linked to specific action patterns. Four-month-olds who are suddenly unable to make a display appear, display anger expressions and persistent arm pulling. When the display was removed from same-age infants who never learned to control it, sadness and decreased arm pulling was observed. Likewise, Weinberg and Tronick (1994) found moderate evidence for the behavioral specificity of anger and sadness behavioral configurations in the face-to-face/still-face (FFSF) protocol at 6 months. Sad facial expressions were associated with fussy vocalizations and spitting up. Angry expressions were associated not only with fussy vocalizations but also with crying, pick-me-up gestures, and avoidance (turning away from the partner) movements. There was no evidence of situational specificity as both anger and sadness behavior constellations increased during the maternal still-face and remained high when mother reinitiated play. These results suggest overlapping but distinguishable anger and sadness states as early as 4 months of age.

27.2.2.5 *Physiological Specificity of Negative Emotion Expressions*

In conjunction with reports of distinguishable motor activity patterns, differential associations between physiological and emotional responses to a blocked goal have been observed. At 4 months, increases in sadness following the extinction of a learned arm-pulling response were associated with higher cortisol levels (Lewis & Ramsay, 2005) as were 6-month-olds' increases in sadness in the still-face episode of the FFSF protocol (Lewis & Ramsay, 2005; Lewis, Ramsay, & Sullivan, 2006). These results suggest that, at least in response to loss of control, infant sadness and anger facial expressions coincide with specific physiologically mediated responses. However, infants who exhibited higher increases in anger also exhibited higher increases in sadness, suggesting these were not entirely disparate emotional reactions.

27.2.2.6 *Body Movement and Negative Emotion Expressions*

Toward 1 year of age, there is evidence that infant body movements reflect different emotional states (Camras et al., 2007). Eleven-month-old infants withdrew, struggled, and turned toward their caregiver more frequently in response to arm restraint but tended to increase respiration and stilling in response to a growling gorilla (Camras et al., 2007). Likewise, adults tended to rate infant discomfort and anger expressions as being accompanied by flexed, jerky, and active body movements while sadness displays were described by depressed body activity (Camras et al., 1993). These results seem consistent with a motivational model where anger and sadness/fear are differentially related to approach and withdrawal tendencies. (Buss & Kiel, 2004).

27.2.3 Negative Emotion Conclusions

In summary, cry faces develop *in utero* as increasing numbers of facial components of the expression co-occur in the apparent absence of negative emotion elicitors. After birth, the cry-face expression is a prepotent response to pain and is used to index distress. In fact, an attenuated version of the cry face in which the eyes are constricted but not squeezed shut is the basis of discrete anger expressions, which suggests variations of distress are infants' most common negative emotion expression through 1 year of life. Relatedly, discrete expressions of negative emotion including anger, fear, and sadness occur in the first 6 months of life but not more frequently than blends of these expressions. Moreover, they tend to be perceived by adults as expressions of distress more so than that of the specific target emotion. There is evidence that facial expressions of anger and disgust (but not fear) become more likely in contexts designed to elicit these emotions over the first year of life, but the overall number of infants who display the expressions is low. When anger and sadness expressions do occur after 4 months of age, they appear to reflect different developing emotional orientations to the environment. Anger is associated with increased heart rate and instrumental bodily movements while sadness expressions are associated with bodily stilling and cortisol reactivity, suggesting that distinct functions for these two emotions emerge over the first years of life.

Oster argues that infant emotions should be understood not in terms of adult emotion categories but from a functionalist ontogenetic perspective (Camras et al., 2018; Oster, 2005). From this perspective, one might suggest that through the first year of life, cry-face expressions and associated crying and fussing are reliable tools for soliciting caregiving from parents and others (Bell & Mary, 1972). The emergence of anger expressions from distress expressions involves a decoupling of intense eye squinting from the squared mouth of the anger configuration in the service of active visual engagement with the object of the emotion. As infant motor coordination improves, instrumental actions such as arm batting and body twisting (supported by increased heart rate) are incorporated into angry responses. Distress, which is perhaps prototypically *about* the self (I am overwhelmed by negative affect), yields anger, which is *about* the environment (that situation must change). Meanwhile, beginning in the first year and becoming more evident in the second year, a more passive withdrawal associated with sadness becomes an increasingly effective medium for indicating that a situation is displeasing to the infant.

27.3 Positive Emotional Development

Infants express happiness and joy most clearly through facial expressions and laughter and, with less specificity, through vocalizations, touch, and physical movement. Adults perceive infant smiles to be direct expressions of joyful feelings (Abe, Beetham, & Izard, 2002; Darwin, [1872] 1998). Infant laughter is a rhythmic vocalization that indexes especially intense joy (Sroufe & Waters, 1976) and is frequently elicited by tickling and other physically stimulating games (Cohn & Tronick, 1987; Davila-Ross, Jesus, Osborne, & Barad, 2015; Lewis & Granic, 2000; Owren & Amoss, 2014). Scientific observers posit that children clap their hands and jump with joy (Darwin, [1872] 1998). However, like nonlaughter vocalizations, these actions appear to accentuate smiles and laughter but may not be independently associated with positive affect (Hsu, Fogel, & Messinger, 2001; Weinberg & Tronick, 1994; Yale, Messinger, & Cobo-Lewis, 2003).

Taken as a whole, infant facial expressions of happiness and joy are differentially elicited by situations posited to elicit positive emotion, and are easily discernible as such to adult observers. Next, we review behavioral expressions of happiness and joy and their heterogeneity, discuss the emergence of positive emotional interaction in the first 6 months of life, and describe how smiles are embedded in referential communicative gesturing between 8 and 18 months. We conclude by asking whether different types of infant smiling reflect different types of positive affect, and suggest that infant positive affect expression is inherently social.

27.3.1 Varieties of Positive Emotion Expression

Although levels of infant smiling as a whole rise between 2 and 6 months, infants exhibit different types of smiling with different developmental trajectories.

27.3.1.1 *Strong Smiles*

Infant smiles vary continuously. Degree of zygomaticus major contraction (the muscle controlling lip-corner retraction) determines a smile's strength. Parent tickling produces stronger smiling than not tickling (Fogel, Hsu, Shapiro, Nelson-Goens, & Secrist, 2006), and stronger smiles are perceived as more positive than weaker smiles. As infant smiles become stronger and weaker, the strength of co-occurring eye constriction and the extent of co-occurring mouth opening increase as well (Messinger, Mattson, Mahoor, & Cohon, 2012). All of these features index the intensity of early joy (see Figure 27.1).

27.3.1.2 *Duchenne Smiles and Open-Mouth Smiles*

Duchenne smiles are a well-known signal of joy, which may index reciprocated positive affect in infants. Duchenne smiles involve eye constriction produced by orbicularis oculi (pars lateralis), the Duchenne marker (Duchenne, [1862] 1990). Through 6 months, Duchenne smiles are most common when gazing at mother, and, at 12 months, when infants are approached by their smiling mothers (Fox & Davidson, 1988). Heart rate, however, does not appear to vary between smiles with and without the Duchenne marker (Mattson, Ekas et al., 2013). Frequently elicited by excited social engagement, infant smiles involving mouth opening (jaw dropping) are most likely to occur while infants look at their mothers' faces (Messinger et al., 2012) and are a frequent context for laughter (Davila-Ross et al., 2015; Nwokah, Hsu, Davies, & Fogel, 1999; Sroufe & Waters, 1976).

27.3.1.3 *Combined Open-Mouth Duchenne Smiles*

Infant smiles that involve the Duchenne marker also tend to involve mouth opening (see Figure 27.1) (Messinger, Fogel, & Dickson, 1999), and tend to occur during particularly positive epochs of interaction such as when infants gaze at their smiling mothers (Messinger, Fogel, & Dickson, 2001). Moreover, open-mouth Duchenne smiles exhibit developmental specificity (Mendes & Seidl-de-Moura, 2014). Through the first 6 months, these smiles became relatively more likely than other smiles when infants were gazing at their smiling mothers (the most positive eliciting context) but showed relative declines when mothers were not smiling and infants were gazing away from mother (Messinger et al., 2001). By 1 year, open-mouth Duchenne smiles are most likely to occur in contexts that elicit intense joy such as tickling (Fogel et al.,

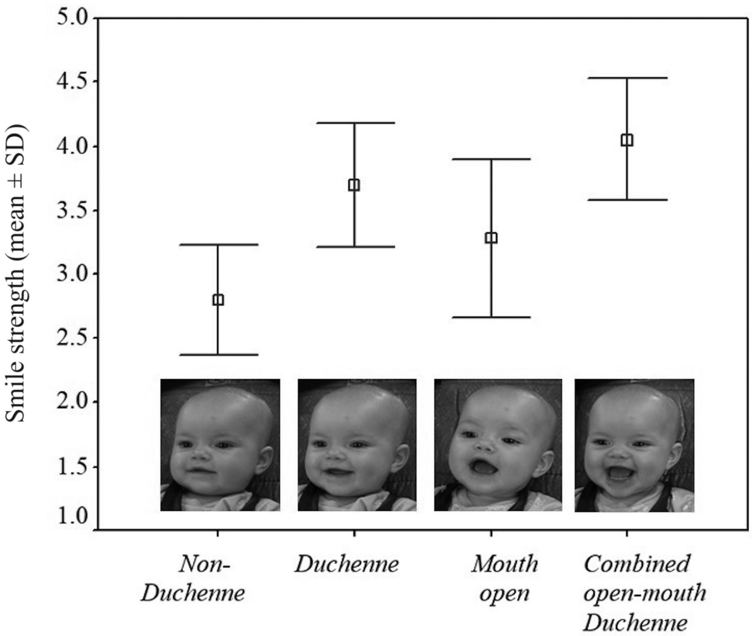

Figure 27.1. *Mean smile strength from 1–5 of different smile types.*
Source: Fogel et al. (2006).

2006) and physical play with parents (Dickson, Walker, & Fogel, 1997). Overall, stronger smiles and smiles that involve both mouth opening and the Duchenne marker (eye constriction) are the most joyful, while smiles without these features are more likely to index less intense happiness (Messinger et al., 2012).

27.3.1.4 *Laughter*

Laughter emerges developmentally between 2 and 5 months (Nwokah, Hsu Dobrowolska, & Fogel, 1994; Washburn, 1929), and between 6 and 12 months of age, infants become more likely to laugh during active social games such as peek-a-boo (Sroufe & Waters, 1976). Between 1 and 2 years, infant and mother laugh onsets and offsets come to follow one and another more closely in time, indicating increasing interactive coordination of joyful expressions (Nwokah et al., 1994). The form of laughter also appears to change developmentally (Sauter, Evans, Venneker, & Kret, 2018). At 3 months, infants tend to laugh both while inhaling and exhaling, a pattern shared with chimpanzees; older infants, however, tend to laugh only while exhaling, a pattern seen in older children and adults.

27.3.2 The Development of Happiness and Joy

27.3.2.1 Prenatal and Neonatal Smiling

Reissland, Francis, Mason, and Lincoln (2011) observed smiling, eye constriction (the Duchenne marker), and lip parting at 32.5 weeks gestation, and found that these smiling configurations become increasingly complex between

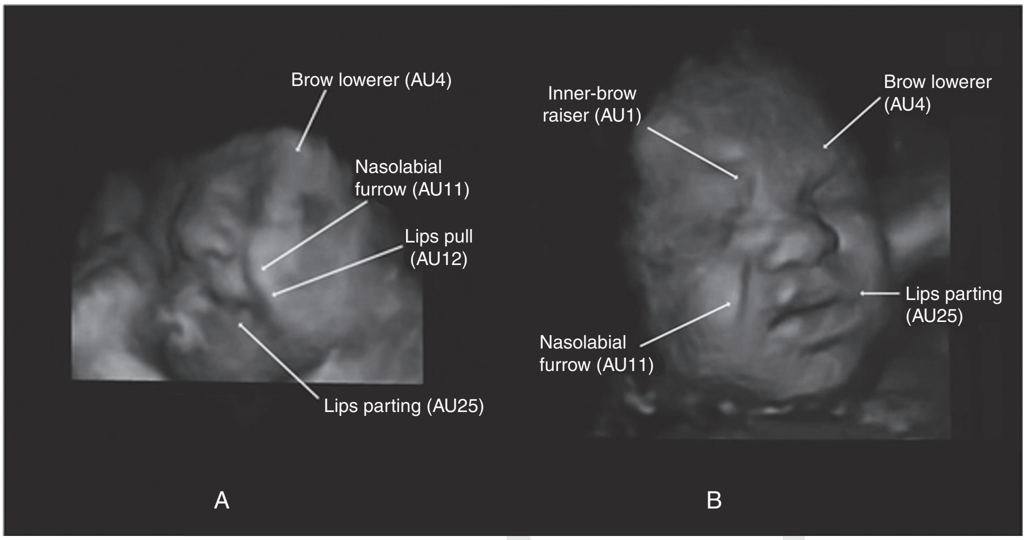

Figure 27.2. *In utero smile and cry-face configurations at 32 weeks gestation. Action units (AUs) are defined by the Facial Action Coding System (Ekman & Friesen, 1992). (A) Facial AUs associated with a prenatal smile configuration. (B) Facial AUs associated with cry-face configurations.*
Source: Reprinted from Reissland et al. (2011).

24 and 34 weeks gestation (see Figure 27.2). An intriguing feature of these prenatal results was the occurrence of brow lowering that, postnatally, does not overlap with smiling (Oster, 1978). Smiling is present from birth in both full-term and preterm neonates (Emde & Koenig, 1969; Emde, McCartney, & Harmon, 1971) but occurs predominantly in sleeping/drowsy states involving rapid eye movement (Dondi et al., 2007). In full-term neonates, smiles with strong zygomaticus major contraction and the Duchenne marker occur in roughly equal proportion to weaker smiles without eye constriction (Dondi et al., 2007; Messinger et al., 2002). Although stronger Duchenne smiles in the neonate suggest positive emotion, these smiles rarely occur outside of sleep and are not integrated into social interaction.

27.3.2.2 *The Transition to Social Smiling Between 1 and 2 Months*

Smiles during sleep states decrease in frequency and stronger smiles increase during alert states toward 1 month of age (Harmon & Emde, 1972; Mizuno, Takeshita, & Matsuzawa, 2006; Wolff, 1987). In the second month, infants spend more time in alert states, which facilitates gazing at caregivers' faces and interaction (Lavelli & Fogel, 2005). This sets the stage for the emergence of social smiles. A 3–20-second epoch of brow knitting and gazing at the mother's face, is typically followed by relaxation of the brows and smiling (Anisfeld, 1982; Lavelli & Fogel, 2005; Oster, 1978). Thus, a period of effort, perhaps linked to recognition of the parent's face, appears to precede the first social expressions of happiness. Physiological arousal is hypothesized to drive neonatal smiles, while a relaxation of cognitive tension occurring when infants recognize the parental face as meaningful, is hypothesized to drive social smiles (Sroufe, 1996).

27.3.3 Developments in Interactive Smiling Between 2 and 6 Months

As infant social smiles become more frequent in interaction around 2 months of age, maternal positive expressions also increase (Lavelli & Fogel, 2002). Turn-taking in which mothers and infants alternate initiating and terminating smiles increases (Messinger, Ruvolo, Ekas, & Fogel, 2010) and smiling interactions become faster paced between 2 and 6 months (Malatesta, Culver, Tesman, & Shepard, 1989). At the same time, individual infant's smiling levels from 1 week to the next become more similar to each other over successive weeks of interaction – and the same pattern is evident for mother smiling (Messinger et al., 2010). That is, infants (and mothers) develop increasingly stable levels of positive affect expression. Infants also become accustomed to specific levels of partner responsivity. Two-month-olds smile less to an interactive partner who is either more or less responsive to the infant's smiles than the infant's mother (Bigelow & Rochat, 2006). Thus, infant expressions of positive affect become increasingly tied to their partner's levels of smiling and responsivity.

27.3.3.1 *Temporal Patterning of Smiles*

Infant expressions of joy develop in tandem with changes in the patterning of infant attention to the partner's face. Between 2 and 6 months, infants devote less time to gazing at their mothers' faces, but become more likely to smile when they are doing so (Kaye & Fogel, 1980). The temporal patterning of smiling and attending to the parent's face also changes (Yale et al., 2003). Three-month-olds' smiles occur within a gaze at the parent's face. By 6 months, infants continue to initiate smiles while gazing at the parent's face but then gaze away from the parent before they end the smile. In fact, when 5-month-olds play peek-a-boo, they are more likely to gaze away from the mother's face for longer periods of time during stronger, longer-lasting smiles (Stifter & Moyer, 1991). This suggests that as infants increasingly participate in arousing social exchanges with intensely joyful smiles, they become more likely to regulate their own involvement in interchanges by gazing away from their interactive partners.

27.3.3.2 *Infant and Mother Responsivity to Smiling*

The FFSF protocol is well suited to examining dynamic changes in infant positive and negative affect. In the FFSF, an episode of face-to-face play is followed by the still-face episode (in which the parent maintains a still face and does not respond to the infant's bids) and then a reunion episode in which the parent resumes playing with the infant (Adamson & Frick, 2003; Mesman, van Ijzendoorn, & Bakermans-Kranenburg, 2009). As a whole, smiling declines precipitously over the course of the still face (Ekas, Haltigan, & Messinger, 2013) and rises again when the parent reengages with the infant, although not quite to initial face-to-face play levels.

27.3.3.3 *Contingent Responsiveness*

Parents' expressive responses to infant smiling during face-to-face interactions allow infants to experience themselves as instigators of positive interactions with others. Infants aged 2 to 3 months, for example, whose mothers exhibit higher vocal contingent responsiveness display more smiles when their mother adopts a still face (as a way to reengage their mothers) than do infants of less responsive mothers (Bigelow & Power, 2016). Descriptive data suggest that infant and mother continuously affect one another's joyful expressions such that stronger infant smiling is mirrored by stronger mother smiling (Messinger, Mahoor, Chow, & Cohen, 2009).

Although infants and parents respond to one another in play, this responsiveness is asymmetric. Infant smiles reliably elicit mother smiles, typically within a 2-second window (Malatesta & Haviland, 1982; van Egeren, Barratt, & Roach, 2001). However, mother smiles are less reliable elicitors of infant smiles than the reverse (Cohn & Tronick, 1987; Kaye & Fogel, 1980) and mothers frequently smile when infants are not smiling (Messinger et al., 2010). Parent smiles in the absence of infant smiles reduce the degree to which the parent smiles and are contingent on those of the infant (Symons & Moran, 1994). In fact, infant smiles are most likely in response to multimodal parental displays involving some combination of smiling, laughter, touching the infant, and high-pitched infant-directed speech (Cohn & Tronick, 1987; Feldman, 2003; Feldman, Greenbaum, & Yirmiya, 1999; Fogel, 1988).

27.3.3.4 *Increases in Smiling Intensity During Interaction*

When caregivers respond to their infants' smiles with increasingly intense smiles, infants are likely to perceive the increase in the parental positive emotion and simultaneously perceive an increase in their own joy. Processes implicated in infants' positive responses to their parent's positive expressivity may include a hypothesized mirror neuron system (Marshall & Meltzoff, 2014) or automatic facial mimicry (de Klerk, Lamy-Yang, & Southgate, 2018; Isomura & Nakano, 2016). Interactions in which infants simultaneously experience their own positive emotions, and the role of their own joyful expression in augmenting the expressions of others, suggest that one path to the development of joy involves interactively experiencing another's joy (Holodynski, 2009).

27.3.3.5 *Why Infants Smile*

Inverse optimal reinforcement modeling allows one to infer infant and mother probable goals during interactions (Ruvolo, Messinger, & Movellan, 2015). Goals are inferred from the likely consequences of beginning and ending smiles on the durations of ensuing dyadic states such as mutual smiling. This modeling indicates that mothers act to increase time in mutual smiling. Infants, on the other hand, act to increase time in states when mother is smiling but the infant is not smiling. Infants enact this goal, for example, by smiling briefly until the mother smiles and then ending their own smile. These findings are challenging because they suggest that infants do not act to increase the time they are expressing happiness. Instead, infant smiles may be part of a dyadic process that involves creating and then disengaging from moments of mutual positive emotion expression (Stifter & Moyer, 1991).

27.3.4 Smiling Between 6 and 18 Months

In the first 6 months of life, smiles and laughter appear to represent nonreflective expressions of ongoing emotional experience (Kaye & Fogel, 1980). Between 6 and 12 months, infants become increasingly intentional communicators, and are more likely to coordinate smiling with gestures and gazes that reference objects and events (Striano & Bertin, 2005). The coordination of positive affect expressions with referential communication represents the type of cognitive awareness that differentiation theorists argue heralds the emergence of joy and other emotions (Adamson & Bakeman, 1985; Messinger & Fogel, 1998).

27.3.4.1 *Anticipatory Smiling*

Anticipatory smiling is a pattern of referential communication, which emerges around 8 months of age and increases in frequency through 12 months. Anticipatory smiling occurs when infants gaze at an object or event, smile, and then continue to smile as they shift their attention to a social partner who is also attending to the object or event (Venezia, Messinger, Thorp, & Mundy, 2004). Anticipatory smiles often appear to communicate something like, "That was funny, wasn't it?" (Mundy, Thorpe, Hogan, & Doehring, 1996; Seibert, Hogan, & Mundy, 1982). Anticipatory smiling is associated with the comprehension of means–end relationships (Jones & Hong, 2001), suggesting that anticipatory smiling indexes infants' emerging understanding that positive affect can be shared with another (Venezia et al., 2004).

27.3.4.2 *Happiness and Pretense*

Incongruous (unexpected and unthreatening) events such as placing a ball on one's head elicit joyful reactions early in development. Five-month-old infants are more likely to smile and laugh in response to a confederate engaging in absurd actions (e.g., poking a clown nose and saying "beep") than ordinary actions (Mireault et al., 2018). Between 5 and 7 months, infants are faster to initiate smiles and laughs when their parents provide positive affective cues following an absurd event (Mireault et al., 2015), a pattern also observed in 18-month-olds (Lillard et al., 2007; Nishida & Lillard, 2007). Incongruous events appear to elicit happiness and joy between 5 and 18 months, although the importance of smiles displayed by those around the infant requires continued investigation.

27.3.5 Positive Emotion Conclusions

27.3.5.1 Positive Affect Multiplicity?

Overall, smiling develops from an endogenous neonatal expression to a signal of intense positive social engagement at 6 months, which becomes embedded in referential communications by 12 months. The discrete perspective holds that there is a single happiness/joy emotion in infancy, which is accompanied by specific feeling states. However, the infancy literature suggests that Duchenne smiles involve reciprocated positive affect, smiles involving mouth opening are associated with arousing sociality, and strong smiles with both features mark the climax of mutually positive states. The possibility that different types of smiling (and laughter) index different types of positive emotion is antithetical to a discrete perspective, which holds that there is one form of positive emotion. An alternate (and parsimonious) possibility holds that different types of smiling and laughter reflect a continuum of positive emotion. Relatedly, Duchenne smiles are often regarded as unique signals of joy (Ekman, Davidson, & Friesen, 1990). In early infancy, however, non-Duchenne and Duchenne smiles appear to reflect a range of positive emotion and frequently follow one another in time (Messinger et al., 1999).

27.3.5.2 *Is Early Positive Affect Expression Exclusively Social?*

Smiling faces – typically the smiles of playful social partners – are a potent elicitor of smiling and laughter in the first year of life. In fact, with the decline of smiling to audio stimuli during the first 2 months of life, it is unclear whether smiles and laughter can be reliably elicited by nonsocial stimuli. There is some evidence that infants between 9 and 11 months are more likely to smile and laugh when engaging in difficult motor actions (e.g., pulling to stand) than less difficult actions (e.g., pulling to sit) (Mayes & Zigler, 2006; but see Yarrow, Morgan, Jennings, Harmon, & Gaiter, 1982). However, these actions were observed in naturalistic settings where social contact was uncontrolled. Likewise, Watson (1972) found that after 3–5 days of daily exposure to a contingently controlled visual mobile, 8-week-old infants were reported by their mothers to engage in vigorous smiling and cooing. However, the sociality of the conditions in which mothers reported smiling could not be determined. It remains unknown, then, whether early positive affect expression – by far the most reliable index of happiness and joy – are linked to positive social interaction. If so, this would suggest that infants' prototypical expression of positive affect has an inherently social function.

27.4 Positive *and* Negative Emotion

Having discussed the development of negative and positive emotion separately, we now discuss the generalized Duchenne intensification hypothesis,

Figure 27.3. *Dynamic expressions of infant emotions showing increasing intensity of both smiling (top) and cry face (bottom). This 6-month-old infant's Duchenne marker (eye constriction) and mouth opening provide a parsimonious means for indexing the intensity of both positive (top) and negative (bottom) infant emotions. Notably, the Duchenne marker intensifies from left to right in both smiles and cry faces, accompanied by stronger pulling of the lip corners and mouth opening in smiles and horizontal mouth stretching in cry faces.*
Source: Messinger et al. (2012).

which posits similarities between smile and cry-face expressions. A dynamic systems perspective suggests that specific facial actions may have similar functions across positive and negative expressive configurations. Both smiles and cry face can involve the Duchenne marker – eye constriction produced by the muscle orbiting the eyes (orbicularis oculi, pars lateralis). As indexed by neurophysiological activity, eliciting situations, and signal value, the Duchenne marker appears to index both greater positive valence in smile expressions and greater negative valence of cry-face expressions (see Figure 27.3).

Electrophysiological evidence suggests greater left than right cerebral activation during Duchenne smiles than non-Duchenne smiles in 10-month-olds (Fox & Davidson, 1988), a pattern associated with approach motivation in adults (L. F. Barrett & Wager, 2006; Murphy, Nimmo-Smith, & Lawrence, 2003). The opposite pattern of electroencephalograph (EEG) asymmetries was observed during sadness and anger expressions with strong eye constriction

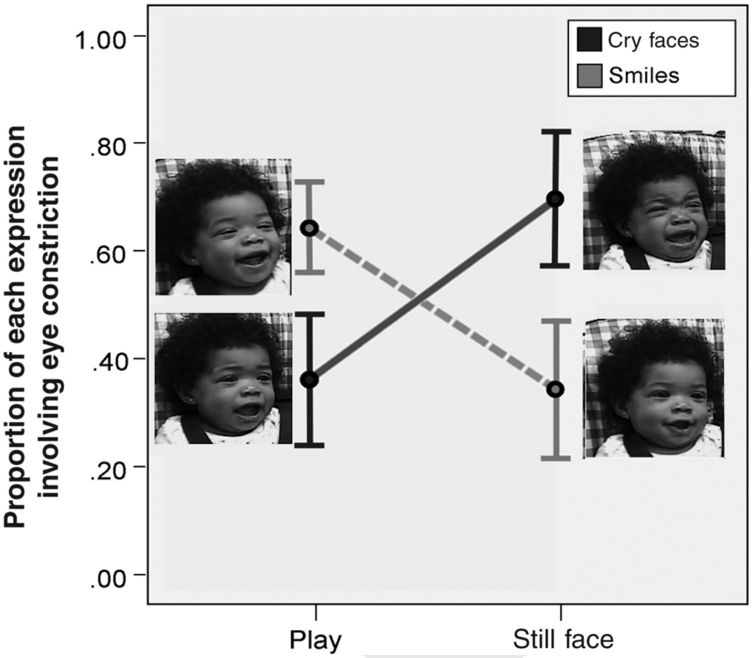

Figure 27.4. *Eye constriction (the Duchenne marker) indexes positive and negative affective intensity in the face-to-face/ still face (FFSF). Smiling during the face-to-face play with the parent involved a higher proportion of smiling with eye constriction than smiling during the still face. The still face involved a higher proportion of cry faces with eye constriction than face-to-face play.*
Source: Mattson, Cohn et al. (2013).

(as indexed by crying) (Fox & Davidson, 1988). The results support the general Duchenne intensification hypothesis, which was recently tested using the FFSF protocol (Mattson, Cohn, Mahoor, Gangi, & Messinger, 2013; but see Mattson, Ekas et al., 2013). Smiles during the positive-emotion-eliciting face-to-face play episode were more likely to involve eye constriction than smiles occurring during the negative-emotion-eliciting still face. In a cross-over effect, the proportion of cry faces involving eye constriction was higher during the still face than during face-to-face play (see Figure 27.4).

The general Duchenne intensification hypothesis was also tested using objective measurements (computer vision) of the intensity of facial actions (Messinger et al., 2012). Just as smiling actions were stronger in Duchenne smiles, the lateral mouth pulling of the cry face was stronger in the presence of the Duchenne marker. Even when controlling for the strength of smiling and mouth-pulling cry-face actions, eye constriction was a unique predictor of continuous ratings of positive emotional valence during smiles and negative emotional valence during cry faces. The results suggest that specific facial actions such as eye constriction can have a generalized intensifying effect. The possibility that specific facial actions have general functional roles in multiple types of facial expressions is an exciting area of future investigation (Susskind et al., 2008).

27.4.1 The Heritability of Positive and Negative Expressivity

Behavioral genetic analyses have shed light on the sources of early positive and negative emotional variability. Parent reports of infant smiling and laughter (temperament-linked indices of happiness and joy) typically reveal roughly similar levels of genetic and environmental influence (Goldsmith, Buss, & Lemery, 1997; Goldsmith, Lemery, Buss, & Campos, 1999). By contrast, parent reports of infant negative emotion expression yield higher genetic and lower environmental effects. However, a recent investigation of observed and parent-reported affect in a large sample of mono- and dizygotic twins produced striking results (Planalp, van Hulle, Lemery-Chalfant, & Goldsmith, 2017). Genetic (inherited) variability in negative emotion was not detectable, while shared environmental variance was evident in both observed and reported positive affect at both 6 and 12 months. These findings underscore the role of familial processes in the socialization of happiness and joy, and raise questions about the role of genetic variance in observed negative expressivity.

27.5 The Neural Context of Infant Emotional Development

Caregivers' facial expressions provide infants with information regarding the caregiver's emotional state and – in the case of fear expressions, for example – threats in the surrounding environment. Research on the neural underpinnings of emotional processing uses both event-related potentials (ERPs) – time-locked EEG – and near-infrared spectroscopy (NIRS) to examine the infant's processing of positive and negative emotional stimuli. In the ERP domain, infant N290 and P400 ERP components – negative and positive deviations of the EEG signal at 290 and 400ms – show specificity to upright human faces (de Haan & Nelson, 1999; de Haan, Pascalis, & Johnson, 2002). Affective cues modulate activation in the negative central (Nc) component, which reflects attentional allocation to salient stimuli (Nelson & Monk, 2001).

The responsivity of infant face-sensitive (N290 and P400) and attention-associated Nc components suggest that a neural network for facial emotion processing emerges in the first year of life. The amplitude of the N290 and P400 response tends to distinguish between different combinations of happy, fearful, and angry expressions, although the direction of effects associated with the contrast between expressions is not consistent (Hoehl & Striano, 2008; Jessen & Grossmann, 2015; Kobiella, Grossman, Reid, & Striano, 2008; Leppänen, Moulson, Vogel-Farley, & Nelson, 2007; van den Boomen, Munsters, &

Kemner, 2019; Xie, McCormick, Westerlund, Bowman, & Nelson, 2018). As with the N290 and P400, investigations of the Nc component have yielded variable results. In 7-month-old infants, heightened Nc component amplitudes have been observed in response to fearful faces relative to happy expressions (Leppänen et al., 2007; Nelson & de Haan, 1996), angry relative to fearful faces (Kobiella et al., 2008), angry faces relative to happy and fearful faces (Xie et al., 2018), and happy relative to angry faces (Grossmann, Striano, & Friederici, 2005). Differences in results may be due to differences in the psychophysics of stimulus presentation and the intensity of the emotion displayed (Sprengelmeyer & Jentzsch, 2006). The use of source analysis and increased attention to developmental changes within the first year of life may ultimately contribute to greater understanding of the functional meaning of cortical responses to facial expressions (Xie et al., 2018). Finally, as discussed above, infants do not reliably produce fear faces in response to relevant experimental stimuli. Increased attention to individual differences in infant fearfulness would help integrate research on infants' perception of emotional stimuli and their production of emotional behavior.

27.5.1 Neural Bases of Affective Prosody Processing

At the same age at which infants exhibit differential responses to emotional facial expressions, they also exhibit differential responses to affective prosody. Words spoken with angry prosody are more attention-capturing – as indexed by the heightened amplitude of the Nc component in frontal and central scalp regions – to 7-month-old infants than those spoken with happy or neutral prosody (Grossmann et al., 2005). Likewise, sad vocalizations elicit significantly greater neural activation in brain regions that support processing of affective stimuli, including the insula and orbitofrontal cortex, than happy (i.e., laughing) and neutral vocalizations (i.e., coughing, sneezing; Blasi et al., 2011). Infants' amplified response to negative stimuli such as a fearful face or an angry tone of voice suggests increased allocation of attentional resources to negative affective information that may be associated with negative consequences for the infant.

27.5.2 Perception of Smiles

Research using NIRS suggest that brain regions involved in encoding reward value become functional toward 1 year of age (Mingawa-Kawai et al., 2009). Between 9 and 13 months of age, infants exhibited increased activation in the anterior orbitofrontal cortex, a region implicated in processing rewarding social information, in response to video clips of their mother's smile relative to mother's neutral expression. The infants exhibited more attenuated activation of the orbitofrontal cortex in response to an unfamiliar mother's smile. These findings suggest that orbitofrontal activation is especially responsive to positive emotional expressions from known and, arguably, rewarding individuals.

27.5.3 Neural Bases and Correlates of Emotional Expressivity

Spontaneous facial expressions involve an extrapyramidal pathway involving subcortical structures, such as the basal ganglia, and deep cortical structures, such as the amygdala, which communicate with the facial motor nucleus (Elliot, 1969; Williams, Warwick, Dyson, & Bannister, 1989). Relative to the substantial body of work examining the neural correlates of emotion processing, however, the literature examining the neural correlates of emotional expressivity is limited. Following Fox and Davidson's seminal research (1988), there have been few EEG-based studies of the neural correlates of infants *production* of emotional expressions and, to our knowledge, no relevant neuroimaging studies. Portable methods for the acquisition of cortical hemodynamics through NIRS represent one method for addressing the urgent need to investigate the neural basis of infant emotional functioning *in situ* (Perlman, Luna, Hein, & Huppert, 2014). An understanding of the neural correlates of emotion expression, and the association between neural responsivity to emotional stimuli and the infant's production of emotional behavior, will require a new generation of research activity.

27.6 Empathy Development

Empathy, sharing another's emotional experience, is not a discrete emotion such as happiness, sadness, or fear. Instead, the development of empathy reflects the confluence of behavioral, cognitive, and expressive factors that characterize the emergence of emotional functioning more broadly. We review the development of empathy to illustrate emotional development as an evolving interface of perception, motoric responses, and actions that are influenced both by inherited and relational factors.

27.6.1 Responses to Other Infants' Cries

Precursors of empathy appear to be present in neonates (Sagi & Hoffman, 1976; Simner, 1971). Within 3 to 4 days of birth, infants produce more intense distress reactions when exposed to a newborn cry than when exposed to a computer-generated synthetic cry, white noise, silence (Sagi & Hoffman, 1976; Simner, 1971), or their own cry (Dondi, Simion, & Caltran, 1999). This contagious cry phenomenon continues without evident developmental change between 1 and 9 months of age (Geangu, Benga, Stahl, & Striano, 2010), although evidence of increased autonomic emotional arousal in the form of pupil dilation in response to another infant's cry has not been documented before 6 months (Geangu, Hauf, Bhardwaj, & Bentz, 2011). With respect to individual differences, however, it is not clear whether distress or autonomic arousal in response to another infant's crying in the first year of life is related to later responsiveness to adult distress.

27.6.2 Responsiveness to Adult Distress

The development of empathic concern is typically assessed by recording infants' responses to a caregiver or stranger who feigns a distressing event such as stubbing a toe (Zahn-Waxler, Radke-Yarrow, Wagner, & Chapman, 1992). Infants' potential empathy-related behaviors include attempts to alleviate distress or prosocial behavior (e.g., kisses), empathic concern for the distressed victim (e.g., "I'm sorry"), attempts to understand the cause of distress or hypothesis testing (e.g., "What happened?"), and attempts to replicate another's experience or self-referential behaviors (e.g., rubbing one own toe). Exploratory work indicates that empathic concern and hypothesis testing are observable by 8 months of age (Roth-Hanania, Davidov, & Zahn-Waxler, 2011). More generally, the frequency of prosocial behaviors, empathic concern, and hypothesis testing increases significantly from 13 to 25 months, and the entire repertoire of prosocial behaviors is observable by 2 years (Zahn-Waxler, Radke-Yarrow et al., 1992).

27.6.3 Genetic Influence on Empathy Development

By 14 months, there is a higher concordance of prosocial behavior, empathic concern, and hypothesis testing behaviors among monozygotic (MZ) than and dizygotic (DZ) twins, suggesting these empathy related behaviors are influenced by genetic factors (Zahn-Waxler, Robinson, & Emde, 1992). Moreover, genetic concordance for individual differences in empathy emerged at 20 months and increased through 36 months in a separate study, while shared environmental effects that were evident at 14 months gradually declined with age (Knafo, Zahn-Waxler, van Hulle, Robinson, & Rhee, 2008). These findings highlight increases in hereditary influence on emerging empathy-related behaviors.

27.6.4 Contributions of Early Interactions to Empathy Development

In addition to the genetic influences indicated by twin studies, maternal responsiveness during mother–infant interactions is associated with individual differences in empathy development. Infants whose mothers were more responsive at 9 months – which encompassed the quality of mothers' responses to infants' bids, distress, need for help, or physiological signals – were more empathic when their mothers feigned distress at 22 months of age (Kochanska, Forman, & Coy, 1999). Along with maternal responsiveness, infants whose mothers were rated as exhibiting greater warmth were more empathic at 14 and 20 months than those whose mothers were rated lower on maternal warmth (Robinson, Zahn-Waxler, & Emde, 1994). These findings point to the importance of early warmth and responsivity in fostering empathic responding.

27.6.5 Summary and Future Directions

The development of empathy illustrates the importance of longitudinal studies integrating early potential behavioral substrates – negative affect and pupil dilation in response to a conspecific's cry – with later empathic action. Finally, understanding the intersecting roles of hereditary and caregiver responsiveness on empathy development will require increased attention to genetic correlates of parental behavior, parental warmth, and gene by environment interactions in the first years of life.

27.7 Cultural Differences in Infant Emotional Development

The majority of research on infant emotional development has been conducted in Western societies with highly educated samples (Henrich, Heine, & Norenzayan, 2010). There are, however, multiple pathways to infant emotional development. Of particular note are cultural emphases on collectivism versus individualism, and the valuing of emotional experience and expression (Halberstadt & Lozada, 2011). Here we explore cultural differences and similarities in parental expectations of infant emotion, parent responses to emotion, and differences in infant emotion expressions (Kärtner, Holodynski, & Wörman, 2013).

27.7.1 Culturally Divergent Parental Emotional Expectations

In broad strokes, Western and more educated mothers value expressions of positive emotion in their infants, and tend to try to elicit these expressions during dyadic interactions (Kärtner et al., 2013). Mothers from subsistence cultures, on the other hand, tend to value quiet contentment in their infants, and focus on soothing them. Keller and Otto (2009), for example, investigated infant emotional development in urban, independent German families, and rural, interdependent Nso (Cameroonian) families. While Nso mothers report expecting and valuing calm behavior in their children, and frequently use corrective language to suppress negative emotional displays in their infants, German mothers report valuing expressivity in their infants and expect their infants to display both positive and negative emotions earlier than Nso mothers. Likewise, German mothers expect expressions of joy in their infants starting around 2 months, while Nso mothers expect these expressions around 7 months of age. A notable exception involved self-referential emotions (shame and guilt), which Nso mothers expect to see about 10 months earlier than German mothers, reflecting a cultural valuing of group cohesion (Keller & Otto, 2009). Such differences in parent expectations appear to be associated with differences in behavioral responses to infant emotional displays.

27.7.2 Cultural Differences in Emotional Displays and Parental Responses

Wörmann, Holodynski, Kärtner, and Keller (2012) found that levels of infant smiling and maternal imitative smiles did not differ between Nso and German groups at 6 weeks. By 12 weeks, however, German mothers and their infants engaged in more social smiles and imitation than Nso mother–infant dyads. A developmental divergence was also evident in the infant's behavior responses to maternal imitation (Wörmann, Holodynski, Kärtner, & Keller, 2014). Maternal imitation of infant smiles was associated with increases in the duration of infant smiles in the German sample at 8 weeks, but was not evident in the Nso sample until 12 weeks. This careful documentation of developmental differences in parental (and infant) responsivity suggests how culturally mediated differences in emotional expressions arise.

Differences between the more interdependent (Nso) and more independent (German) cultures were also evident at a molar behavioral level. Over the first 3 months of life, Nso mothers engaged in more body contact and fewer face-to-face interactions. By contrast, German mothers increasingly engaged in face-to-face interactions and exhibited increases in vocal contingent responsiveness (Kärtner, Heller, & Yovsi, 2010; Keller, Borke, Lamm, Lohaus, & Dzeaye Yovsi, 2011). Nso mothers report breastfeeding to help their infants regulate negative emotions, while German mothers report breastfeeding primarily to satisfy hunger (Keller & Otto, 2009). Likewise, Richman, Miller, and LeVine (1992) found that Gusii mothers in an interdependent Kenyan culture focused on soothing and calming responses to 4- and 10-month-old infant emotional displays, while American mothers attempted to engage the infants in emotionally arousing conversation-style interaction. Moreover, an early investigation found that !Kung San infants in Botswana initiated more frequent cries of briefer duration than Dutch or American infants (Barr, Konner, Bakeman, & Adamson, 1991). However, the differences apparent in targeted contrasts of more and less developed societies are not always apparent in multinational studies. Specifically, a large (N = 684) observational study in Argentina, Belgium, Brazil, Cameroon, France, Kenya, Israel, Italy, Japan, South Korea, and the United States did not reveal differences in the likelihood a mother would pick up and hold her distressed infant (Bornstein et al., 2008). This suggests the need for in-depth observational research of infant–parent emotional interaction across multiple cultural contexts.

27.8 Policy Implications

Cross-cultural comparisons suggest a diversity of normative caregiving styles and trajectories of infant emotional development. Moreover, beliefs, practices, and infant emotionality are part of larger cultural and societal systems. They reflect implicit and explicit beliefs about what is necessary and ideal in a developing child (are toddler temper tantrums, for example, mortifying or unavoidable?).

Cultural diversity has policy implications because of the multi-ethnic nature of most Western societies, and the degree to which American society is host to diverse parenting cultures associated with differences in ethnicity and income

(Sperry, Sperry, & Miller, 2018). Overall, however, the importance of direct social interaction with parents, other caregivers, and peers to infant emotional development cannot be overstated. Thus, generous parental leave policies are imperative in allowing both mothers and fathers adequate time to build relationships with their infants. Moreover, infant care, preschool, and prekindergarten programs – including Head Start – are important contexts for emotional development (Santos, Daniel, Fernandes, & Vaughn, 2015). Adequate funding of such programs has both immediate and long-term consequences for positive social development and sound fiscal policy (van Huizen, Dumhs, & Plantenga, 2017).

27.8.1 Specific Policy Issues

The recognition of expressions of pain in the young infant remains an important policy issue in neonatal medicine (Cruz, Fernandes, & Oliveira, 2016). In this vein, it is important to recognize the importance of both the cry face and cry vocalizations as prima facie indices of distress. Cry faces and crying are robustly elicited by pain (Izard, Hembree et al., 1983) – and neonatal pain appears to be associated with long-term pain sensitivity (Valeri et al., 2016). With respect to positive emotion, it is noteworthy that modern, educated cultures place a larger emphasis on visually mediated positive engagement than do many more traditional cultures. Thus, we suggest that for parents, the development and occurrence of positive emotion (e.g., social smiling) should be seen as an opportunity for relaxed positive engagement rather than a goal to be achieved (Beebe et al., 2016).

Finally, the increase in electronic media exposure and active digital use by infants is concerning (Chang, Park, Yoo, Lee, & Shin, 2018). Parents of infants with reported social-emotional difficulties indicate greater use of mobile technology to regulate their children' negative affect (Radesky, Peacock-Chambers, Zuckerman, & Silverstein, 2016), and greater use of such technologies is associated with parental ratings of risk for social-emotional delay (Raman et al., 2017). Limitations on infant exposure to electronics (with the exception of video chatting with family) has been recommended by the American Academy of Pediatrics (McClure, Chentsova-Dutto, Barr, Holochwost, & Parrott, 2015). Nevertheless, not only are infants increasingly engaged with digital interfaces, but parents increasingly monitor their infants using digital equipment (Messinger et al., 2015). High-quality research exploring the impact of these factors on infant social and emotional development is necessary to better understand their long-term consequences.

27.9 Future Directions

This chapter's review of infant emotional development suggests three salient directions for future research: (1) integration of multiple indices of emotional process, (2) increased attention to the temporality of emotional processes and emotional regulation, and (3) use of naturally occurring elicitors of strong emotion.

First, reports on infant facial expressions would be enhanced by documenting their correspondence with related expressive vocal and bodily actions. Pointedly, research on infant facial expressions rarely employs a thorough analysis of infant vocalization (and vice versa). There is a clear need for careful multimodal analysis of facial, bodily, and vocal behavior – ideally integrated with measures of heart rate and skin conductance – to identify emerging infant emotional states such as sadness and anger. Such research would be further strengthened by the integration of neurophysiological measures of cerebral activity provided by EEG and functional near-infrared spectroscopy (fNIRS) into studies of emotion production. Inclusion of neural and physiological measures of emotion would provide the opportunity to address unanswered questions such as the extent to which positive emotional expressions reflect a decrease in cognitive tension and physiological arousal, a supposition that has been posited for decades but for which evidence is limited (Sroufe & Waters, 1976).

Second, by incorporating potential behavioral attenuators of expressive actions, research on temporal associations would, in turn, elucidate the development of infant mechanisms for regulating emotion (Ekas, Braungart-Rieker, & Messinger, 2018). Here, we have suggested that anger expressions are an attenuated version of the cry face. In a similar vein, observations by both Camras and Oster suggest that the raised chin and pouting (protruding) lower lip characteristic of the sadness expression may occur prior to cry-face expressions and help regulate negative affect – but these temporal patterns require rigorous study. Research on the degree to which these different expressive configurations in fact co-occur and follow one another in time would shed new light on the behavioral and developmental emergence of anger and sadness expressions and their components. However, fine-grained coding of facial and vocal expression is frequently a rate-limiting factor in research on infant emotional production and emotion regulation. Future research in emotion regulation and emotional development more broadly is likely to involve increased integration of advances in the use of computer vision and signal processing to reliably measure infant and caregiver emotional expressions, vocalizations, and body movements (Hammal et al., 2019; Messinger et al., 2009; Rao et al., 2017).

Third, low levels of concordance between emotion-eliciting contexts and facial expressions of discrete negative emotion might lead investigators to pursue such investigations at later ages in the hopes of detecting clear evidence for expressions of discrete emotion states. These expressions would have to be interpreted as such by adult raters. A difficulty with this strategy, however, is a lack of clear evidence for the consistency with which even adults display discrete negative emotions (Aviezer, Trope, & Todorov, 2012; Yik & Russell, 1999). An alternate possibility is that ethical, appropriate constraints on research limit understanding of infants' reactions to especially potent negative stimuli. In this regard, researchers may consider the use of publicly posted videos on sites such as YouTube.com as well as initiatives to have citizen scientist parents record and submit emotional behaviors such as temper tantrums for analysis (Camras et al., 2018). These resources – as well as recording of events such as vaccinations – may provide access to potent emotion-eliciting situations that will expand our understanding of infant emotion (Backer, Quigley, & Stifter, 2018).

References

Abe, J., Beetham, M., & Izard, C. E. (2002). What do smiles mean? An analysis in terms of differential emotions theory. In M. H. Abel (Ed.), *Mellen studies in psychology* (Vol. 4, pp. 83–109). Lewiston, NY: Edwin Mellen Press.

Ackerman, B. P., Abe, J. A. A., & Izard, C. E. (1998). Differential emotions theory and emotional development: Mindful of modularity. In M. F. Mascolo & S. Griffin (Eds.), *What develops in emotional development?* (pp. 85–106). New York, NY: Plenum Press.

Adamson, L. B., & Bakeman, R. (1985). Affect and attention: Infants observed with mothers and peers. *Child Development*, 56, 582–593.

Adamson, L. B., & Frick, J. E. (2003). The still face: A history of a shared experimental paradigm. *Infancy*, *4*, 451–473.

Anisfeld, E. (1982). The onset of social smiling in preterm and full-term infants from two ethnic backgrounds. *Infant Behavior and Development*, *5*, 387–395.

Aviezer, H., Trope, Y., & Todorov, A. (2012). Body cues, not facial expressions, discriminate between intense positive and negative emotions. *Science*, 338(6111), 1225–1229.

Backer, P. M., Quigley, K. M., & Stifter, C. A. (2018). Typologies of dyadic mother–infant emotion regulation following immunization. *Infant Behavior and Development*, *53*, 5–17.

Barr, R. G., Konner, M., Bakeman, R., & Adamson, L. (1991). Crying in !Kung San infants: A test of the cultural specificity hypothesis. *Developmental Medicine and Child Neurology*, *33*, 601–610.

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

Barrett, L. F. (2006). Solving the emotion paradox: Categorization and the experience of emotion. *Personality and Social Psychology Review*, *10*, 20–46.

Barrett, L. F., & Wager, T. D. (2006). The structure of emotion: Evidence from neuroimaging studies. *Current Directions in Psychological Science*, *15*(2), 79–83.

Beebe, B., Messinger, D., Bahrick, L. E., Margolis, A., Buck, K. A., & Chen, H. (2016). A systems view of mother–infant face-to-face communication. *Developmental Psychology*, *52*(4), 556–571.

Bell, S. M., & Mary, D. S. A. (1972). Infant crying and maternal responsiveness. *Child Development*, *43*(4), 1171–1190.

Bennett, D. S., Bendersky, M., & Lewis, M. (2002). Facial expressivity at 4 months: A context by expression analysis. *Infancy*, *3*(1), 97–113.

Bennett, D. S., Bendersky, M., & Lewis, M. (2005). Does the organization of emotional expression change over time? Facial expressivity from 4 to 12 months. *Infancy*, *8*(2), 167–187.

Bigelow, A. E., & Power, M. (2016). Effect of maternal responsiveness on young infants' social bidding-like behavior during the still face task. *Infant Child Development*, *25*(3), 256–276.

Bigelow, A. E., & Rochat, P. (2006). Two-month-old infants' sensitivity to social contingency in mother–infant and stranger–infant interaction. *Infancy*, *9*, 313–325.

Blasi, A., Mercure, E., Lloyd-Fox, S., Thomson, A., Brammer, M., Sauter, D., … Murphy , G. M. (2011). Early specialization for voice and emotion processing in the infant brain. *Current Biology*, *21*(14), 1220–1224.

Bornstein, M. H., Putnick, D. L., Rigo, P., Esposito, G., Swain, J. E., Suwalsky, J. T. D., … Venuti, P. (2008). Neurobiology of culturally common maternal responses to infant cry. *Proceedings of the National Academy of Sciences of the United States of America*, *114*(45), E9465–E9473.

Bridges, K. M. B. (1932). Emotional development in early infancy. *Child Development*, *3*, 324–341.

Buss, K. A., & Kiel, E. J. (2004). Comparison of sadness, anger, and fear facial expressions when toddlers look at their mothers. *Child Development*, *75*(6), 1761–1773.

Campos, J. J., Mumme, D. L., Kermoian, R., & Campos, R. G. (1994). A functionalist perspective on the nature of emotion. In N. A. Fox (Ed.), *Monographs of the Society for Research in Child Development* (Vol. 59, pp. 282–303, Serial No. 240). Chicago, IL: University of Chicago Press.

Camras, L. A., Fatani, S. S., Fraumeni, B. R., & Shuster, M. M. (2018). The development of facial expressions: Current perspectives on infant emotions. In L. F. Barrett, M. Lewis, & J. M. Haviland-Jones (Eds.), *Handbook of emotions* (4th ed., pp. 255–271). New York, NY: Guilford Press.

Camras, L. A., Oster, H., Bakeman, R., Meng, Z., Ujiie, T., & Campos, J. J. (2007). Do infants show distinct negative facial expressions for fear and anger? Emotional expression in 11-month-old European American, Chinese, and Japanese infants. *Infancy*, *11*(2), 131–155.

Camras, L. A., Sullivan, J., & Michel, G. (1993). Do infants express discrete emotions? Adult judgments of facial, vocal, and body actions. *Journal of Nonverbal Behavior*, *17*(3), 171–186.

Chang, H. Y., Park, E. -J., Yoo, H. -J., Lee, J. W., & Shin, Y. (2018). Electronic media exposure and use among toddlers. *Psychiatry Investigation*, *15*(6), 568–573.

Cohn, J., & Tronick, E. (1987). Mother–infant face-to-face interaction: The sequence of dyadic states at 3, 6, and 9 months. *Developmental Psychology*, *23*(1), 68–77.

Cruz, M. D., Fernandes, A. M., & Oliveira, C. R. (2016). Epidemiology of painful procedures performed in neonates: A systematic review of observational studies. *European Journal of Pain*, *20*(4), 489–498.

Darwin, C. [1872] (1998). *The expression of the emotions in man and animals* (3rd ed.). New York, NY: Oxford University.

Davila-Ross, M., Jesus, G., Osborne, J., & Bard, K. A. (2015). Chimpanzees (pan troglodytes) produce the same types of "laugh faces" when they emit laughter and when they are silent. *PLoS One*, *10*(6), e0127337.

de Haan, M., & Nelson, C. A. (1999). Brain activity differentiates face and object processing in 6-month-old infants. *Developmental Psychology*, *35*(4), 1113.

de Haan, M., Pascalis, O., & Johnson, M. H. (2002). Specialization of neural mechanisms underlying face recognition in human infants. *Journal of Cognitive Neuroscience*, *14*(2), 199–209.

de Klerk, C. C. J. M., Lamy-Yang, I., & Southgate, V. (2018). The role of sensorimotor experience in the development of mimicry in infancy. *Developmental Science*, *22*(3), e12771.

Dickson, K. L., Walker, H., & Fogel, A. (1997). The relationship between smile-type and play-type during parent–infant play. *Developmental Psychology*, *33*(6), 925–933.

Dondi, M., Gervasi, M. T., Valente, A., Vacca, T., Bogana, G., de Bellis, I., … Oster, H. (2012). Spontaneous facial expressions of distress in fetuses. Paper presented at the 14th European Conference on Facial Expression, Lisboa-Almada, Portugal.

Dondi, M., Messinger, D., Colle, M., Tabasso, A., Simion, F., Barba, B. D., & Fogel, A. (2007). A new perspective on neonatal smiling: differences between the judgments of expert coders and naive observers. *Infancy*, *12*(3), 235–255.

Dondi, M., Simion, F., & Caltran, G. (1999). Can newborns discriminate between their own cry and the cry of another newborn infant? *Developmental Psychology*, *1999*(35), 2.

Duchenne, G. B. [1862] (1990). *The mechanism of human facial expression* (R. A. Cuthbertson, Trans.). New York, NY: Cambridge University Press.

Ekas, N. V., Braungart-Rieker, J. M., & Messinger, D. S. (2018). The development of infant emotion regulation: Time is of the essence. In P. M. Cole & T. Hollenstein (Eds.), *Emotion regulation: A matter of time* (pp. 49–69). New York, NY: Routledge.

Ekas, N. V., Haltigan, J. D., & Messinger, D. S. (2013). The dynamic still-face effect: do infants decrease bidding over time when parents are not responsive? *Developmental Psychology*, 49(6), 1027–1035.

Ekman, P., Davidson, R.J., Friesen, W. (1990). The Duchenne smile: Emotional expression and brain physiology: II. *Journal of Personality and Social Psychology*, *58*(2), 343–353.

Ekman, P., & Friesen, W. (1992). *Changes in FACS scoring (instruction manual)*. San Francisco, CA: Human Interaction Lab.

Elliot, H. C. (1969). *Textbook of neuroanatomy* (2nd ed.). Philadelphia: J. B. Lippincott.

Emde, R. N., & Koenig, K. (1969). Neonatal smiling and rapid eye movement states. *Journal of the American Academy of Child Psychiatry*, *8*, 57–67.

Emde, R. N., McCartney, R. D., & Harmon, R. J. (1971). Neonatal smiling in REM states, IV: Premature study. *Child Development*, *42*, 1657–1661.

Feldman, R. (2003). Infant–mother and infant–father synchrony: The coregulation of positive arousal. *Infant Mental Health Journal*, *24*(1), 1–23.

Feldman, R., Greenbaum, C. W., & Yirmiya, N. (1999). Mother–infant affect synchrony as an antecedent of the emergence of self-control. *Developmental Psychology*, *35*(1), 223–231.

Fogel, A. (1988). Cyclicity and stability in mother–infant face-to-face interaction: A comment on Cohn and Tronick. *Developmental Psychology*, *24*(3), 393–395.

Fogel, A., Hsu, H. -C., Shapiro, A. F., Nelson-Goens, G. C., & Secrist, C. (2006). Effects of normal and perturbed social play on the duration and amplitude of different types of infant smiles. *Developmental Psychology*, *42*, 459–473.

Fox, N., & Davidson, R. J. (1988). Patterns of brain electrical activity during facial signs of emotion in 10 month old infants. *Developmental Psychology*, *24*(2), 230–236.

Geangu, E., Benga, O., Stahl, D., & Striano, T. (2010). Contagious crying beyond the first days of life. *Infant Behavior and Development*, *33*(3), 279–288.

Geangu, E., Hauf, P., Bhardwaj, R., & Bentz, W. (2011). Infant pupil diameter changes in response to others' positive and negative emotions. *PLoS ONE*, *6*(11), e27132.

Goldsmith, H. H., Buss, K. A., & Lemery, K. S. (1997). Toddler and childhood temperament: Expanded content, stronger genetic evidence, new evidence for the importance of environment. *Developmental Psychology*, *33*(6), 891–905.

Goldsmith, H. H., Lemery, K. S., Buss, K. A., & Campos, J. J. (1999). Genetic analyses of focal aspects of infant temperament. *Developmental Psychology*, *35*(4), 972–985.

Grossmann, T., Striano, T., & Friederici, A. D. (2005). Infants' electric brain responses to emotional prosody. *NeuroReport*, *16*(16), 1825–1828.

Halberstadt, A. G., & Lozada, F. T. (2011). Emotion development in infancy through the lens of culture. *Emotion Review*, *3*(2), 158–168.

Hammal, Z., Wallace, E. R., Speltz, M. L., Heike, C. L., Birgfeld, C. B., & Cohn, J. F. (2019). Dynamics of face and head movement in infants with and without craniofacial microsomia: An automatic approach. *Plastic and Reconstructive Surgery – Global Open*, *7*(1), e2081.

Harmon, R. J., & Emde, R. N. (1972). Endogenous and exogenous smiling systems in early infancy. *Journal of the American Academy of Child Psychiatry*, *11*, 77–100.

Henrich, J., Heine, S. J., Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences*, *33*, 61–135.

Hoehl, S., & Striano, T. (2008). Neural processing of eye gaze and threat-related emotional facial expressions in infancy. *Child Development*, *79*(6), 1752–1760.

Holodynski, M. (2009). Milestones and mechanisms of emotional development. In H. J. Markowitsch & B. Röttger-Rössler (Eds.), *Emotions as bio-cultural processes* (pp. 1–25). New York, NY: Springer.

Holodynski, M., & Friedlmeier, W. (2006). *Development of emotions and emotion regulation*. New York, NY: Springer.

Hsu, H. -C., Fogel, A., & Messinger, D. S. (2001). Infant non-distress vocalization during mother–infant face-to-face interaction: Factors associated with quantitative and qualitative differences. *Infant Behavior & Development*, *24*(1), 107–128.

Isomura, T., & Nakano, T. (2016). Automatic facial mimicry in response to dynamic emotional stimuli in five-month-old infants. *Proceedings of the Royal Society B: Biological Sciences*, *283*(1844). https://doi.org/10.1098/rspb.2016.1948

Izard, C. E. (1979). *The maximally discriminative facial coding system*. Newark: University of Delaware.

Izard, C. E., & Abe, J. A. A. (2004). Developmental changes in facial expressions of emotions in the strange situation during the second year of life. *Emotion*, *4*(3), 251–265.

Izard, C. E., & Ackerman, B. P. (2000). Motivational, organizational, and regulatory functions of discrete emotions. In M. Lewis & J. M. Haviland-Jones (Eds.), *Handbook of emotions* (2nd ed., pp. 253–264). New York, NY: Guilford Press.

Izard, C. E., Dougherty, L. M., & Hembree, E. A. (1983). *A system for identifying affect expressions by holistic judgements*. Newark: Instructional Resource Center, University of Deleware.

Izard, C. E., Hembree, E. A., Dougherty, L. M., & Spizzirri, C. L. (1983). Changes in facial expressions of 2- to 19-month-old infants following acute pain. *Developmental Psychology*, *19*, 418–426.

Jessen, S., & Grossmann, T. (2015). Neural signatures of conscious and unconscious emotional face processing in human infants. *Cortex*, *64*, 260–270.

Jones, S. S., & Hong, H.-W. (2001). Onset of voluntary communication: Smiling looks to mother. *Infancy*, *2*(3), 353–370.

Kärtner, J., Holodynski, M., & Wörmann, V. (2013). Parental ethnotheories, social practice and the culture-specific development of social smiling in infants. *Mind, Culture, and Activity*, *20*(1), 79–95.

Kärtner, J., Keller, H., & Yovsi, R. D. (2010). Mother–infant interaction during the first 3 months: The emergence of culture-specific contingency patterns. *Child Development, 81*(2), 540–554.

Kaye, K., & Fogel, A. (1980). The temporal structure of face-to-face communication between mothers and infants. *Developmental Psychology*, *16*(5), 454–464.

Keller, H., Borke, J., Lamm, B., Lohaus, A., & Dzeaye Yovsi, R. (2011). Developing patterns of parenting in two cultural communities. *International Journal of Behavioral Development*, *35*(3), 233–245.

Keller, H., & Otto, H. (2009). The cultural socialization of emotion regulation during infancy. *Journal of Cross-Cultural Psychology*, *40*(6), 996–1011.

Knafo, A., Zahn-Waxler, C., van Hulle, C., Robinson, J. L., & Rhee, S. H. (2008). The developmental origins of a disposition toward empathy: Genetic and environmental contributions. *Emotion*, *8*(6), 737–752.

Kobiella, A., Grossmann, T., Reid, V. M., & Striano, T. (2008). The discrimination of angry and fearful facial expressions in 7-month-old infants: An event-related potential study. *Cognition and Emotion*, *22*(1), 134–146.

Kochanska, G., Forman, D. R., & Coy, K. C. (1999). Implications of the mother–child relationship in infancy socialization in the second year of life. *Infant Behavior & Development*, *22*(2), 249–265.

Kohut, A. S., Riddell, P., Flora, D., & Oster, H. (2012). A longitudinal analysis of the development of infant facial expressions in response to acute pain: immediate and regulatory expressions. *Pain*, *153*(12), 2458–2465.

Lavelli, M., & Fogel, A. (2002). Developmental changes in mother–infant face-to-face communication: Birth to 3 months. *Developmental Psychology*, *38*(2), 288–305.

(2005). Developmental changes in the relationship between the infant's attention and emotion during early face-to-face communication: The 2-month transition. *Developmental Psychology*, *41*(1), 265–280.

Leppänen, J. M., Moulson, M. C., Vogel-Farley, V. K., & Nelson, C. A. (2007). An ERP study of emotional face processing in the adult and infant brain. *Child Development*, *78*(1), 232–245.

Lewis, M. D. (2018). The emergence of human emotions. In L. F. Barrett, M. Lewis, & J. M. Haviland-Jones (Eds.), *Handbook of emotions* (4th ed., pp. 272–292). New York, NY: Guilford Press.

Lewis, M. D., & Granic, I. (2000). *Emotion, development, and self-organization: Dynamic systems approaches to emotional development* (Vol. 8). Cambridge, UK: Cambridge University Press.

Lewis, M. D., & Ramsay, D. S. (2005). Infant emotional and cortisol responses to goal blockage. *Child Development*, *76*(2), 518–530.

Lewis, M. D., Ramsay, D. S., & Sullivan, M. (2006). The relation of ANS and HPA activation to infant anger and sadness response to goal blockage. *Developmental Psychobiology*, *48*(5), 397–405.

Lillard, A., Nishida, T., Massaro, D., Vaish, A., Ma, L., & McRoberts, G. (2007). Signs of pretense across age and scenario. *Infancy*, *11*(1), 1–30.

Malatesta, C. Z., Culver, C., Tesman, J. R., & Shepard, B. (1989). Engaging the commentaries: When is an infant affective expression an emotion? *Monographs of the Society for Research in Child Development*, *54*(1–2, Serial No. 219), 125–136.

Malatesta, C. Z., & Haviland, J. M. (1982). Learning display rules: The socialization of emotion expression in infancy. *Child Development*, *53*(4), 991–1003.

Marshall, P. J., & Meltzoff, A. N. (2014). Neural mirroring mechanisms and imitation in human infants. *Philosophical Transactions of the Royal Society B Biological Sciences*, *369*(1644), 20130620.

Matias, R., & Cohn, J. F. (1993). Are MAX-specified infant facial expressions during face-to-face interaction consistent with differential emotions theory? *Developmental Psychology*, *29*(3), 524–531.

Mattson, W. I., Cohn, J. F., Mahoor, M. H., Gangi, D. N., & Messinger, D. S. (2013). Darwin's Duchenne: Eye constriction during infant joy and distress. *PLoS ONE*, *8*(11), e80161.

Mattson, W. I., Ekas, N. V., Lambert, B., Tronick, E., Lester, B. M., & Messinger, D. S. (2013). Emotional expression and heart rate in high-risk infants during the face-to-face/still-face. *Infant Behavior & Development*, *36*(4), 776–785.

Mayes, L., C., & Zigler, E. (2006). An observational study of the affective concomitants of mastery in infants. *Journal of Child Psychology and Psychiatry*, *33*(4), 659–667.

McClure, E. R., Chentsova-Dutton, Y. E., Barr, R. F., Holochwost, S. J., & Parrott, W. G. (2015). "Facetime doesn't count": Video chat as an exception to media restrictions for infants and toddlers. *International Journal of Child–Computer Interaction*, *6*, 1–6.

Mendes, D. M. L. F., & Seidl-de-Moura, M. L. (2014). Different kinds of infants' smiles in the first six months and contingency to maternal affective behavior. *Spanish Journal of Psychology*, *17*, e80. https://doi.org/10.1017/sjp.2014.86

Mesman, J., van IJzendoorn, M. H., & Bakermans-Kranenburg, M. J. (2009). The many faces of the still-face paradigm: A review and meta-analysis. *Developmental Review*, *29*(2), 120–162.

Messinger, D., Dondi, M., Nelson-Goens, G. C., Beghi, A., Fogel, A., & Simion, F. (2002). How sleeping neonates smile. *Developmental Science*, *5*(1), 48–54.

Messinger, D. S., Duvivier, L. L., Warren, Z. E., Mahoor, M., Baker, J., Warlaumont, A., & Ruvolo, P. (2015). *Affective computing, emotional development, and autism* New York, NY: Oxford University Press.

Messinger, D. S., & Fogel, A. (1998). Give and take: The development of conventional infant gestures. *Merrill-Palmer Quarterly*, *44*(4), 566–590.

Messinger, D. S., 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, NY: Cambridge University Press.

Messinger, D. S., Fogel, A., & Dickson, K. (1999). What's in a smile? *Developmental Psychology*, *35*(3), 701–708.

(2001). All smiles are positive, but some smiles are more positive than others. *Developmental Psychology*, *37*(5), 642–653.

Messinger, D. S., Mahoor, M. H., Chow, S.-M., & Cohn, J. F. (2009). Automated measurement of facial expression in infant–mother interaction: A pilot study. *Infancy*, *14*(3), 285–305.

Messinger, D. S., Mattson, W. I., Mahoor, M. H., & Cohn, J. F. (2012). The eyes have it: Making positive expressions more positive and negative expressions more negative. *Emotion*, *12*(3), 430–436.

Messinger, D. S., Ruvolo, P., Ekas, N., & Fogel, A. (2010). Applying machine learning to infant interaction: The development is in the details. *Neural Networks*, *23*(10), 1004–1016.

Mingawa-Kawai, Y., Matsuoka, S., Dan, I., Naoi, N., Nakamura, K., & Kojima, S. (2009). Prefrontal activation associated with social attachment: Facial-emotion recognition in mothers and infants. *Cerebral Cortex*, *19*(2), 284–292.

Mireault, G. C., Crockenberg, S. C., Heilman, K., Sparrow, J. E., Cousineau, K., & Rainville, B. (2018). Social, cognitive, and physiological aspects of humour perception from 4 to 8 months: Two longitudinal studies. *British Journal of Developmental Psychology*, *36*(1), 98–109.

Mireault, G. C., Crockenberg, S. C., Sparrow, J. E., Cousineau, K., Pettinato, C., & Woodard, K. (2015). Laughing matters: Infant humor in the context of parental affect. *Journal of Experimental Child Psychology*, *136*, 30–41.

Mizuno, Y., Takeshita, H., & Matsuzawa, T. (2006). Behavior of infant chimpanzees during the night in the first 4 months of life: Smiling and suckling in relation to behavioral state. *Infancy*, *9*(2), 221–240.

Mundy, P., Hogan, A., & Doehring, P. (1996). *A preliminary manual for the abridged Early Social-Communication Scales*. Retrieved from www.psy.miami.edu/faculty/pmundy.

Murphy, F. C., Nimmo-Smith, I., & Lawrence, A. D. (2003). Functional neuroanatomy of emotions: A meta-analysis. *Cognitive, Affective & Behavioral Neuroscience*, *3*(3), 207–233.

Nelson, C. A., & de Haan, M. (1996). Neural correlates of infants' visual responsiveness to facial expressions of emotion. *Developmental Psychobiology*, *29*(7), 577–595.

Nelson, C. A., & Monk, C. S. (2001). The use of event-related potentials in the study of cognitive development. In C. A. Nelson & M. Luciana (Eds.), *Handbook of developmental cognitive neuroscience* (pp. 125–136). Cambridge, MA: MIT Press.

Nishida, T. K., & Lillard, A. S. (2007). The informative value of emotional expressions: "social referencing" in mother–child pretense. *Developmental Science*, *10*(2), 205–212.

Nwokah, E. E., Hsu, H. -C., Davies, P., & Fogel, A. (1999). The integration of laughter and speech in vocal communication: A dynamic systems perspective. *Journal of Speech*, *Language*, *and Hearing Research*, *42*(4), 880–894.

Nwokah, E. E., Hsu, H. -C., Dobrowolska, O., & Fogel, A. (1994). The development of laughter in mother–infant communication: Timing parameters and temporal sequences. *Infant Behavior & Development*, *17*(1), 23–35.

Oster, H. (1978). Facial expression and affect development. In M. Lewis & L. A. Rosenblum (Eds.), *The development of affect* (pp. 43–74). New York, NY: Plenum Press.

(2005). The repertoire of infant facial expressions: An ontogenetic perspective. In J. Nadel & D. Muir (Eds.), *Emotional development* (pp. 261–292). New York, NY: Oxford University Press.

Oster, H., Hegley, D., & Nagel, L. (1992). Adult judgments and fine-grained analysis of infant facial expressions: Testing the validity of a priori coding formulas. *Developmental Psychology*, *28*(6), 1115–1131.

Owren, M., & Amoss, R. (2014). Spontaneous human laughter. In M. M. Tugdale, M. N. Shiota, & L. D. Kirby (Eds.), *Handbook of positive emotions* (pp. 159–178). New York, NY: Guilford Press.

Perlman, S. B., Luna, B., Hein, T. C., & Huppert, T. J. (2014). fNIRS evidence of prefrontal regulation of frustration in early childhood. *Neuroimage*, *85*(Pt. 1), 326–334.

Planalp, E. M., van Hulle, C., Lemery-Chalfant, K., & Goldsmith, H. H. (2017). Genetic and environmental contributions to the development of positive affect in infancy. *Emotion*, *17*(3), 412–420.

Radesky, J. S., Peacock-Chambers, E., Zuckerman, B., & Silverstein, M. (2016). Use of mobile technology to calm upset children: Associations with social-emotional development. *JAMA Pediatrics*, *170*(4), 397–399.

Raman, S., Guerrero-Duby, S., McCullough, J. L., Brown, M., Ostrowski-Delehanty, S., Langkamp, D., & Duby, J. C. (2017). Screen exposure during daily routines and a young child's risk for having social-emotional delay. *Clinical Pediatrics*, *56*(13), 1244–1253.

Rao, H., Clements, M. A., Li, Y., Swanson, M. R., Piven, J., & Messinger, D. S. (2017). Paralinguistic analysis of children's speech in natural environments. In J. M. Rehg, S. A. Murphy, & S. Kumar (Eds.), *Mobile health: Sensors, analytic methods, and applications* (pp. 219–238). Cham, Switzerland: Springer International Publishing.

Reissland, N., Francis, B., & Mason, J. (2013). Can healthy fetuses show facial expressions of "pain" or "distress"? *PLOS ONE*, *8*(6), e65530.

Reissland, N., Francis, B., Mason, J., & Lincoln, K. (2011). Do facial expressions develop before birth? *PLOS ONE*, *6*(8), e24081.

Richman, A. L., Miller, P. M., & LeVine, R. A. (1992). Cultural and educational variations in maternal responsiveness. *Developmental Psychology*, 28(4), 614–621. doi:610.1037/0012-1649.1028.1034.1614.

Robinson, J. L., Zahn-Waxler, C., & Emde, R. N. (1994). Patterns of development in early empathic behavior: Environmental and child constitutional influences. *Social Development*, *3*(2), 125–145.

Roth-Hanania, R., Davidov, M., & Zahn-Waxler, C. (2011). Empathy development from 8 to 16 months: Early signs of concern for others. *Infant Behavior and Development*, *34*(3), 447–458.

Ruvolo, P., Messinger, D., & Movellan, J. (2015). Infants time their smiles to make their moms smile. *PLoS ONE*, *10*(9), e0136492.

Sagi, A., & Hoffman, M. L. (1976). Empathic distress in the newborn. *Developmental Psychology*, *12*(2), 175–176.

Santos, A. J., Daniel, J. R., Fernandes, C., & Vaughn, B. E. (2015). Affiliative subgroups in preschool classrooms: Integrating constructs and methods from social ethology and sociometric traditions. *PLOS ONE*, *10*(7), e0130932.

Sauter, D., Evans, B., Venneker, D., & Kret, M. (2018). How do babies laugh? *Journal of the Acoustical Society of America*, *144*(3), 1840–1840.

Seibert, J. M., Hogan, A. E., & Mundy, P. C. (1982). Assessing interactional competencies: The Early Social-Communication Scales. *Infant Mental Health Journal*, *3*(4), 244–258.

Simner, M. L. (1971). Newborns' response to the cry of another infant. *Developmental Psychology*, *5*(1), 136–150.

Sperry, D. E., Sperry, L. L., & Miller, P. (2018). Reexamining the verbal environments of children from different socioeconomic backgrounds. *Child Development*, *90*(1). doi: 10.1111/cdev.13072

Sprengelmeyer, R., & Jentzsch, I. (2006). Event related potentials and the perception of intensity in facial expressions. *Neuropsychologia*, *44*(14), 2899–2906.

Sroufe, L. A. (1979). Socioemotional development. In J. Osofsky (Ed.), *Handbook of infant development* (pp. 462–516). New York, NY: Wiley.

(1996). *Emotional development: The organization of emotional life in the early years*. New York, NY: Cambridge University Press.

Sroufe, L. A., & Waters, E. (1976). The ontogenesis of smiling and laughter: A perspective on the organization of development in infancy. *Psychological Review*, *83*(3), 173–189.

Stifter, C. A., & Moyer, D. (1991). The regulation of positive affect: Gaze aversion activity during mother–infant interaction. *Infant Behavior and Development*, *14*, 111–123.

Striano, T., & Bertin, E. (2005). Coordinated affect with mothers and strangers: A longitudinal analysis of joint engagement between 5 and 9 months of age. *Cognition & Emotion*, *19*(5), 781–790.

Susskind, J. M., Lee, D. H., Cusi, A., Feiman, R., Grabski, W., & Anderson, A. K. (2008). Expressing fear enhances sensory acquisition. *Nature Neuroscience*, *11*, 843–850.

Symons, D., & Moran, G. (1994). Responsiveness and dependency are different aspects of social contingencies: An example from mother and infant smiles. *Infant Behavior and Development*, *17*(2), 209–214.

Thelen, E., & Smith, L. B. (1994). *A dynamic systems approach to the development of cognition and action*. Cambridge, MA: MIT Press.

Tomkins, S. S. (1962). *Affect, imagery, consciousness: The positive affects* (Vol. 1). New York, NY: Springer-Verlag.

Valeri, B. O., Ranger, M., Chau, C. M. Y., Cepeda, I. L., Synnes, A., Linhares, M. B. M., & Grunau, R. E. (2016). Neonatal invasive procedures predict pain intensity at school age in children born very preterm. *Clinical Journal of Pain*, *32*(12), 1086–1093.

van den Boomen, C., Munsters, N. M., & Kemner, C. (2019). Emotion processing in the infant brain: The importance of local information. *Neuropsychologia*, *126*, 62–68.

van Egeren, L. A., Barratt, M. S., & Roach, M. A. (2001). Mother–infant responsiveness: Timing, mutual regulation, and interactional context. *Developmental Psychology*, *37*(5), 684–697.

van Huizen, T., Dumhs, L., & Plantenga, J. (2017). The costs and benefits of investing in universal preschool: Evidence from a Spanish reform. *Child Development*, *90*(3), e386–e406.

Venezia, M., Messinger, D. S., Thorp, D., & Mundy, P. (2004). The development of anticipatory smiling. *Infancy*, *6*(3), 397–406.

Washburn, R. W. (1929). A study of the smiling and laughing of infants in the first year of life. *Genetic Psychology Monographs*, *5*(5–6), 397–537.

Watson, J. S. (1972). Smiling, cooing, and "the game." *Merrill-Palmer Quarterly, 18*(4), 323–339.

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*(5), 1503–1515.

Williams, P. L., Warick, R., Dyson, M., & Bannister, L. H. (1989). *Gray's anatomy*. Edinburgh: Churchill Livingstone.

Witherington, D. C., Campos, J. J., & Hertenstein, M. J. (2001). Principles of emotion and its development in infancy. In G. Bremner & A. Fogel (Eds.), *Blackwell handbook of infant development* (pp. 427–464). Malden, MA: Blackwell.

Wolff, P. H. (1987). *The development of behavioral states and the expression of emotions in early infancy: New proposals for investigation*. Chicago, IL: University of Chicago Press.

Wörmann, V., Holodynski, M., Kärtner, J., & Keller, H. (2012). A cross-cultural comparison of the development of the social smile: A longitudinal study of maternal and infant imitation in 6- and 12-week-old infants. *Infant Behavior and Development*, *35*(3), 335–347.

(2014). The emergence of social smiling: The interplay of maternal and infant imitation during the first three months in cross-cultural comparison. *Journal of Cross-Cultural Psychology*, *45*(3), 339–361.

Xie, W., McCormick, S. A., Westerlund, A., Bowman, L. C., & Nelson, C. A. (2018). Neural correlates of facial emotion processing in infancy. *Developmental Science*, *22*(3), e12758.

Yale, M. E., Messinger, D. S., & Cobo-Lewis, A. B. (2003). The temporal coordination of early infant communication. *Developmental Psychology*, *39*(5), 815–824.

Yarrow, L. J., Morgan, G. A., Jennings, K. D., Harmon, R. J., & Gaiter, J. L. (1982). Infants' persistence at tasks: Relationships to cognitive functioning and early experience. *Infant Behavior and Development*, *5*(2), 131–141.

Yik, M. S. M., & Russell, J. A. (1999). Interpretation of faces: A cross-cultural study of a prediction from Fridlund's theory. *Cognition and Emotion*, *13*(1), 93–104.

Zahn-Waxler, C., Radke-Yarrow, M., Wagner, E., & Chapman, M. (1992). Development of concern for others. *Developmental Psychology*, *28*(1), 126–136.

Zahn-Waxler, C., Robinson, J. L., & Emde, R. N. (1992). The development of empathy in twins. *Developmental Psychology*, *28*(6), 1038–1047.