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CHAPTER FIVE

Infants' Understanding of Affect

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Consider the following scenario. A 14-month-old infant is playing on the floor in the family living room when an unfamiliar person enters. The infant's mother stands up, smiles, and walks over to the stranger with her hand outstretched. The infant observes this situation, and, losing interest, goes back to her toys. The human infant has shown a skill we call social referencing: an ability to use others' expressions and actions as information about environmental events. Had the mother responded with fear or anger as expressed by her face, voice, gestures, or all three, one would expect a child of this age to react quite differently. In this chapter, we will ask how it is that young children become able to read and understand others' expressions and to use those expressions as information about other separate events. To answer this question, we will explore the development of infants' knowledge of the emotions of others. This skill seems to develop rapidly, progressing from an initial sensitivity to the stimulus information that may characterize emotional expressions to an understanding of the emotions others experience and portray. The perception of others' emotional expressions plays a crucial role in early development, particularly in the realm of communication and in mother–infant interactions. Infants are enthralled by the persons in their environment, and surely it is adaptive for infants to differentiate when their mothers are about to engage in play or merely attend to physical needs. As development proceeds, gaining an understanding of the expressive behaviours of others is a step in acquiring the more

general capability of discerning other persons' thoughts, intentions, desires, and beliefs.

The social referencing illustrated above is itself a sophisticated ability requiring mastery of a host of these interpersonal skills. The infant must both recognize the affective tenor of another's expressions and gestures and relate those behaviours to another environmental event. Although no one would argue that this is the pinnacle of emotional development, when infants show social referencing they are demonstrating that they can use the emotional expressions of another to modify their own behaviour. They must possess the cognitive and social abilities that allow them to interpret others' behaviours with respect to yet another person or event and, in addition, use that information to regulate their own behaviour. During childhood, these abilities will be refined and broadened, but the foundations for the recognition of others' emotional experiences are clearly in place in early infancy.

In this chapter, we will review the data available about infants' perception of others' emotional expressions. In our view, the development of infants' perception of the emotions of others is a continuous process that reflects transitions in an infant's perceptual, cognitive, and social skills. We can speak generally of *levels* of emotional understanding, but pinning definite ages to each level is difficult because some infants may progress faster than others, and because the research data available have been obtained using many different methods and stimulus materials. Furthermore, particular emotional expressions may be less distinctive in specific contexts. For example, fear and surprise are similar in form when they are portrayed facially. Nonetheless, we will provide approximate age ranges where feasible.

In brief, infants' perception of others' emotional expressions progresses rapidly. From birth to about 3–4 months of age, infants detect acoustic, visual, and other sensory information that, to an adult, specifies particular emotions. Beginning at about 4–5 months, infants begin to discriminate among emotional expressions. They seem to discriminate *whole* emotional expressions (facial and vocal expressions in combination) earlier than either vocal expressions alone, or facial expressions alone. Moreover, they may discriminate between some emotions earlier than others; but, in general, they can distinguish two or more expressions from one another. By about 7 months they begin to recognize emotional expressions: they treat others' expressions as meaningful events. Soon after that, beginning at about 9–10 months, they show social referencing. Their social milieu has expanded so that expressions become informative both within an interaction and as data about other events in the environment. In this chapter, we will discuss this progression in more detail, offering research data to support our view.

Before proceeding, we must define what it means for an infant to *detect*, *discriminate*, or *recognize* an expression. Several views, those of primate ethologists, Oster, and our own view, will be offered. The remainder of the chapter will be organized in sections reflecting the transitions (associated with age ranges) in infants' ability to perceive emotional expressions organized by mode of expression (vocal, facial, or both).

WHAT IS MEANT BY THE PERCEPTION OF EMOTION?

As adults, we would say that the perception of others' emotions entails understanding how another person feels internally by attending to his/her external expressions, words, and other actions. A part of that understanding includes being able to discriminate among and within examples of emotional expressions, but we also react differently to others' expressed emotions. We realize that we cannot know *exactly* how another person feels because of idiosyncratic aspects of everyone's experience, but we have a very good idea. When we speak of infants' understanding of another's emotions, we must modify our expectations somewhat given their preverbal status and limited cognitive and social skills. We concentrate, therefore, on whether infants can discriminate others' emotional expressions. We do not presume that the infant will share an adult's emotion or know precisely how someone feels because young infants are limited with respect to the amount and breadth of their experiences, as well as in their cognitive abilities. In addition, it is not clear what behaviours on the part of an infant indicate understanding of emotional expressions.

The obstacles we face are not new ones for researchers who study the perception of emotional expressions in preverbal children, nonhuman primates, and even older children and human adults. There is widespread agreement that expressive behaviours of all kinds have evolved primarily as communicative acts. Research with nonhuman primates (Andrew 1963, Chevalier-Skolnikoff 1973, Sackett 1966, van Hooff 1973) support this assertion. Expressions such as laughing and smiling seem to be homologous in man and nonhuman primates – the "silent bared teeth face" in the macaque and chimpanzee (van Hooff 1973) is similar to the human smile, and the "relaxed open mouth" (van Hooff 1973) to laughter. Ethologists such as van Hooff (1973) and Altmann (1965) have observed and analyzed behaviour sequences as they occur in social groups of chimpanzees and rhesus monkeys in order to determine how primates use and respond to others' expressions and gestures. The results indicate that expressive behaviours reliably evoke

specific responses from other primates, and that a number of particular behaviours regularly occur together in sequence. One interpretation is that "Facial expression has evolved, like other displays, to communicate information about the probable future behaviour of the displaying animal" (Andrew 1963: 1034). This statement captures the communicative function of emotional expressions for nonhuman primates without awarding conscious understanding of emotion to these primates. A similar caution is required before drawing conclusions about what human infants understand about emotional expressions.

Oster (1981) has taken a different approach to the question of what infants understand about emotion. She first proposes different taxonomic categories for facial expressions. These include: (a) stimulus configurations, (b) signs of emotion, and (c) social signals. She is interested in stipulating which category captures infants' perception of emotional expressions. In her view, an expressive behaviour is perceived as a "stimulus configuration" if the particular information that is important for an adult's judgment of emotion is detected by the infant, independent of features or contextual variations not specific to the emotion. As Oster describes it, "A smiling face with flashing teeth would have greater visual contrast than a sad one with closed mouth and downturned lip corners". If, on the other hand, an infant perceives an expression as a "sign of emotion", the infant can glean information from the expression about the underlying emotion. In this instance, the infant responds to the internal state of another person. The infant's reaction to an expression could take the form of a fixed action pattern (an automatic response) to a particular emotional expression, an empathic response such as showing distress to the sounds of crying, or, in older infants, a more cognitively based reaction that includes inferences about another's experience. Finally, closer to the definition of understanding adopted by primate ethologists, the infant might perceive an expression as a "social signal". The infant would, in this case, have expectations about whether particular behaviours will follow or accompany the expression they perceive. Oster asserts that each of these responses is possible and that infants eventually respond to expressions in each of these ways.

Our view reflects identical concerns and incorporates some of the same distinctions. We concentrate on whether infants can discriminate expressions that reflect the primary affects (sadness, anger, fearfulness, happiness/joy, disgust, distress, interest; see Izard 1979) and whether they perceive these emotional expressions as meaningful indicators of another's future behaviour. More specifically, like ethologists asking about the development of communication within primate groups, we ask when infants perceive others' expressions as guides for their own actions.

An adult who perceives someone's emotional state as portrayed by an individual's visible or audible behaviours makes appropriate responses to that perceived state. The response may vary even for the same emotional expressions, depending upon the circumstances, but an observer would see a connection between the initial expressive behaviour and the response. The information for another's emotion is carried by the constellation of visible, audible, and other behaviours emitted by an individual. For example, a person may pull back her lips, thinning them, crinkle up her eyes, toss her head back, speak in a higher pitched, rapid way that is loosely correlated with the head movements, and clap her hands. All of these actions or even a small subset of them may express an internal state (happiness), eliciting a range of possible responses from others.

Infants do not immediately respond to all of these bits and combinations of information, but they progress rapidly in their ability to do so. In general, infants go through several transitions in their understanding of others' emotional expressions: detection, discrimination, and recognition. At birth and for several months after, infants merely *detect* some of the information that potentially specifies an emotional expression. That is, the sensory systems are affected by some information; it is loud enough to be heard, close enough or large enough to be visible to the infant, and so forth. Infants' sensory abilities are maturing as well, so information that is not detected at 1 month may be easily discernible weeks later. Within a few months after birth, infants begin to *discriminate* various emotional expressions. Discrimination refers to the ability to tell the difference among two or more stimulus objects or events using detected information. The objects look different; they don't sound the same.

Finally, at about 7 months, infants begin to *recognize* expressions. The term recognition is reserved for cases in which the emotional expression has meaning for the observer; the infant perceives the expression as a communicative signal of some sort. The precise meaning of the signal will differ, of course, depending upon the experience and maturity of the child.

An analogy may help in keeping the use of these terms distinct. One of us has known identical female twins for 10 years. Whenever one of these women is encountered, this author detects visually her blonde hair and facial features, notices the pitch and timbre of her voice, may catch a whiff of perfume, etc. But I am never sure to which of the twins I am speaking. I cannot discriminate them. When I see them together, I can tell them apart. They have a somewhat different look around the eyes, one's hair is styled in a curlier fashion, one may be slightly heavier than the other. They are discriminable individuals, but again which one is

which? Discrimination is a necessary but not a sufficient basis for recognition. To apply the term *recognition* in this case requires that I view each twin as a unique individual and behave in discriminably different ways to each. Once recognizing the twin, I may talk of school-related events to the one majoring in education and of international news to the other. Others have made similar distinctions with respect to infants' recognition of specific persons.

To summarize, emotional expressions can be viewed in many ways and our perception of them is multifaceted. The development of understanding of emotional expressions probably begins in early infancy as sensitivity to information that can specify an emotional expression. During infancy, the perception of expressive behaviours becomes more differentiated, leading to the ability to recognize expressions as emotional signals and to respond to them appropriately, eventually culminating in a fully mature empathic understanding of another's emotions. (See a further discussion of social cognition in Banerjee, Ch. 7 of this volume.)

THE STUDY OF INFANTS' PERCEPTION OF EMOTION

Researchers have tried to determine what infants understand about emotional expressions by using a number of "converging operations" (Garner 1981, Walker 1981). That is, they test systematically infants' abilities using different methods, stimulus materials, and contexts, allowing them to arrive at a description and, eventually, explanation of the infants' behaviour. Historically, the way in which experimenters tried to determine whether infants recognized emotions was to pose a fixed facial expression and see whether the infant responded in an appropriate fashion. For example, Spitz & Wolf (1946) displayed various expressions to young infants with the idea that the infants would respond fearfully to angry faces, with smiles to happy faces, and so forth. Much to the authors' chagrin, the infants were more apt to laugh out loud, even to the angry expressions. Spitz & Wolf concluded that the appropriate stimulus for an infant's smile was the configuration of elements within the human face, especially if motion was also present, rather than any sensitivity on the part of the infants to the emotional meaning of the expressions. On the other hand, it is not always easy to determine in advance how an infant or anyone else should respond to facial and vocal expressions. We submit a few illustrative examples: Do people always respond with expressions of joy and astonishment to a surprise birthday party? Is it preferable for an infant to respond with a smile or a cry to an adult's angry expression?

Because of these difficulties, more recently, scientists have constructed a number of different methods and combined results from these experiments to arrive at a better understanding of infants' perception of emotional expressions. A general picture has emerged, although specific investigators may argue about the precise age that a particular ability emerges. These data will be reviewed in the remainder of this chapter.

SENSITIVITY TO INFORMATION FOR AFFECT (DETECTION)

At birth the perceptual systems (vision, audition, touch) are sensitive to information available in the world, and they work jointly in an overall system of pre-adapted co-ordinations (Gibson 1983). Exploration by one perceptual system is triggered by exploration by another. For example, infants gaze longer at faces accompanied by a voice (e.g. Haith et al. 1977), and they will turn their heads in the direction of a soft sound (e.g. Butterworth & Castillo 1976, Wertheimer 1961). Moreover, infants attend preferentially to persons and other animate objects in the environment (e.g. Bertenthal et al. 1985, Johnson et al. 1991, 1992, Sherrod 1979). On the other hand, each of an infant's sensory systems has limits as well. For example, both visual acuity and scanning behaviour are restricted at birth. The fovea, the area at the centre of the retina where visual images are focused most sharply, holds visual receptors that are not as developed nor as densely packed as they are in adults. By about 3 months of age, however, the ability to focus at different distances approaches that of an adult (Banks 1980); by the end of the first year, infants' visual acuity approximates that of an adult, and their contrast sensitivity is sufficiently developed to detect most static facial expression contrasts (Slater 1995).

The perception of affective expressions develops from such abilities and through specific experiences. In general, infants in the first few months seem to be sensitive to perceptual information that potentially specifies particular emotions, but infants seem only to respond to this information in rudimentary ways. That is, they may be drawn to a particular voice. That voice may also be characterized as happy by adult listeners, but the infants may not appreciate the emotional content. As stated by Proffitt & Bertenthal (1990:2), "Demonstrating a common sensitivity to stimulus information does not necessarily imply that adults and infants share meanings". The same qualification holds for facial expressions. Infants may look at a smiling face with teeth showing versus a tight-lipped angry grimace, but this visual preference may

result from a tendency to gaze at high contrast patterns or reflect infants' greater familiarity with smiling faces.

Perception of human voices

A large number of studies attest to the perceptual sensitivity of infants for auditory information. For example, infants are sensitive to differences in pitch, loudness, temporal aspects (such as rhythm), and the locations of sounds. Moreover, infants seem to be differentially interested in the human voice (Ecklund-Flores & Turkewitz 1996, Gibson & Spelke 1983, Hutt et al. 1968). Many investigators also have demonstrated that infants detect acoustic characteristics in vocal stimuli.

Incontrovertible evidence that young infants' recognize the emotional content of speech, however, is not available. Infants prefer to listen to infant-directed (ID) speech (speech marked by more exaggerated intonation and higher pitch than adult-directed speech; see, for example, Best et al. 1992, Fernald 1989, Pegg et al. 1992), and infants of about 5 months respond more positively to ID approval compared to prohibitive utterances (Fernald 1990). These findings, however, do not show, by themselves, that infants perceive these voices as carriers of information about emotion. The infants may be responding preferentially to some voices because specific features of those voices are intrinsically attractive to the infants. For example, Aldridge (1994) has reported that newborns prefer happy voices, compared to angry and sad voices, but as will be discussed later, single syllables differing in a variety of ways were used as the stimulus sounds. Infants could have been responding to any of the acoustic differences in the experiment.

Perception of human faces

A huge literature speaks to the visual abilities of young infants. To reiterate, young infants' (newborns to about three months) visual acuity develops rapidly. At birth, infants' ability to discern fine detail is limited (about 20/600 in Snellen units). Within the first few months, however, infants can discriminate differences in the shapes of objects or two-dimensional drawings, perceive spatial relationships between objects, and recognize an object as *the same* when it is viewed from different angles or distances (Bower 1966, Slater et al. 1990). Even newborn infants invariably prefer to look more at a patterned than at an unpatterned visual stimulus, at a moving rather than a static pattern, at a high-contrast rather than low-contrast pattern. Once we begin to look at their perception of faces, more skills become evident. This may be because the stimulus attributes visually preferred by newborns characterize the human face and unite to make the human face one of

the most attention-getting and attention-holding stimulus objects infants encounter. Recent studies of face perception indicate that infants look preferentially to faces within hours after birth (Goren et al. 1975, Johnson et al. 1991, Maurer & Young 1983). For example, Johnson et al. found that infants will track face-like stimulus materials farther with their eyes, in comparison to drawings that contain many of the same features (dots for eyes, a curved line for a mouth, etc.). As the infants get older, however, they seem to require a more realistic representation for the same preference to be demonstrated (Johnson et al. 1992). In part, this may be because of improvements to infants' sensitivity to visual information. As objects such as faces become less blurred, more differentiating features are available to the infants' vision and poorer facsimiles of the human face are not acceptable substitutes.

Not only do neonates look attentively to the human face soon after birth, but they also look preferentially to their mother's face after brief exposures to it. Field et al. (1984) and Bushnell et al. (1989) both report that 4-day-old infants look longer at their mother's face than at a stranger's face, even when other sorts of information (smell, touch) are eliminated. Walton et al. (1992) reported a similar preference when the mother's and stranger's faces were videotaped, rather than live. A closer look at infants' visual preference for the mother's face reveals some interesting patterns. Neonates do not look longer to their mother's face when her hairline is obscured with a head scarf, although infants of about 4 months are not affected by such modifications (Pascalis et al. 1995). Pascalis et al. argue that different perceptual structures are responsible for these changes in ability. Whatever the root cause, it is clear that neonates are attending to specific features such as the hairline rather than configurational information.

In addition, there is a large body of evidence regarding infants' perception of facial expressions. These data will be discussed below, but at this juncture the reader should know that there is little evidence that young infants can readily recognize facial expressions as depicting emotion.

To summarize, ample evidence exists that infants can detect information that may allow for the discrimination and eventual recognition of emotional expressions. Detection itself is important, for without sensitivity to visual, auditory, and other information, infants could not possibly learn to recognize emotional expressions. On the other hand, what is detected is changing rapidly, as the child's perceptual and motor systems develop. With respect to vision, a newborn infant can just discern a blurry face and distinguish the hairline, eyes, nose, and mouth. That a live face is a dynamic, moving object helps provide additional information. Within just a few months, the infant can detect

wrinkles around the eyes, laugh lines marking the sides of the mouth, and other featural and relational information that may be specific to particular facial expressions. Such perceptual development coincides with improvements in other sensory systems and accord with cognitive advances. It is the interplay of these developments that will allow for the recognition of emotional expressions around the middle of the first year. Detection is necessary but not sufficient for discrimination, our next topic.

DISCRIMINATION OF FACIAL AND VOCAL EXPRESSIONS

Discriminating affective displays involves the ability to distinguish between two different displays. As with detection, however, discrimination does not require the perceiver to have an understanding of the meaning of the displays. Many experimenters have investigated the discrimination of facial expression using a number of methods such as visual preference and habituation. Fewer studies have concentrated on infants' discrimination of vocal expressions, although numerous investigators have studied infants' responses to speech sounds and acoustic parameters characterizing emotional expressions. We will discuss research evidence obtained using different methods for infants' discrimination of facial expressions, followed by a discussion of their discrimination of vocal expressions.

Visual preference studies

Early attempts to discover whether infants could discriminate facial expressions of affect typically involved presenting the infants with still, live faces or photographs of faces in different affective poses (e.g. Barrera & Maurer 1981, Field et al. 1982, LaBarbera et al. 1976, Young-Browne et al. 1977). In experiments using the paired-preference technique, the infants were presented with two faces simultaneously for a specified length of time and the amount of time the infants looked at each of the two faces was recorded. If the infants showed a preference for one of the faces by looking longer to it, it was concluded that they could discriminate between the two faces. In one such study, LaBarbera et al. (1976) reported that the 4-month-olds in their experiment discriminated between expressions of joy and anger and between joy and neutral expressions because they looked longer to the joy expression in both of these pairings. Earlier, Wilcox & Clayton (1968) conducted a similar study in which they presented 5-month-olds with 28- and 60-second films of moving or static smiling, neutral, and frowning faces. No preferences emerged for the longer films or for those that portrayed

dynamic expressions, but among the 28-second films, the static smiling face garnered the most visual attention.

Visual habituation

Another method used by researchers is the visual habituation technique in which infants are familiarized to a visual stimulus and then tested on both familiar and novel stimulus materials. Typically the experimenter repeatedly presents one stimulus display over a series of trials until the criterion response (usually visual attention) has declined to some pre-established level. If the criterion response significantly increased on trials involving a new display, it is generally inferred that the two displays are discriminated. Although the intended goal for many using this paradigm is to examine something more than discrimination, "the point to emphasize is that the infant's response provides direct evidence for nothing more than a discrimination" (Proffitt & Bertenthal 1990: 2).

Using this methodology, Barrera & Maurer (1981) reported that 3-month-old infants can discriminate between a frowning face and a smiling face, but they are more likely to do so when the expression is posed by their own mother than by a stranger. Evidence for generalization and discrimination of anger, fear, and surprise in 4- and 6-month olds has been reported by Serrano et al. (1993). Similarly, Young-Browne et al. (1977) found that 3-month-old infants could discriminate between photographed expressions of happy and surprise. Their results are less clear regarding the infants' ability to discriminate between surprise and sad expressions. After visually habituating to sad facial expressions, the infants increased their looking time to the surprise expression. However, the infants did not increase their looking to the sad expression after habituating to surprise.

Order effects such as this one are not uncommon in the literature; it is difficult to determine whether such effects are simply artefactual or whether they reflect something about the infants' abilities to discriminate facial and vocal expressions. Nelson et al. (1979) investigated 7-month-old infants' abilities to *categorize* facial expressions also using a habituation technique, but with several different persons posing each expression. These infants discriminated happy and fearful expressions, but only if the happy facial expressions were shown on the familiarization trials. Nelson & Dolgin (1985) replicated this finding and examined the source of the presentation order effect using a visual preference task. In this study, they found that infants looked much longer to the fearful face.

Overall, habituation data show that infants as young as 3 or 4 months old are able to discriminate between photographs of different

expressions. What is not clear from these experiments, however, is what information the infants are using to discriminate these facial expressions or what the expressions mean to the infants (cf., Nelson 1987). Are they using the affective meaning expressed in the faces to discriminate between them (e.g. *happiness* versus *sadness*), as many have assumed, or are they using some other type of information, for example, differences in the width of the eye opening or the shape of the mouth? Moreover, given that infants only sometimes prefer looking at happy faces (e.g. LaBarbera et al. 1976, Nelson & Dolgin 1985), one cannot conclude that looking time is a sensitive or accurate measure of partiality for a particular emotion.

To test this question directly, Caron et al. (1985) modified the visual habituation method using specially posed facial expressions with infants ranging from about 4 to 7 months of age. In this series of experiments the infants were visually habituated to not one photograph but eight different photographs of different women posing either a *toothy angry*, a *nontoothy angry*, or a *nontoothy smiling* expression. The infants then were presented with two new women posing that same expression and then with those same two women posing a new expression, specifically *toothy smiling*. The authors argued that if the infants were using affective meaning to discriminate the expressions (recognition, in our terminology), then only the infants in the angry conditions would increase their looking time to the apparently novel facial expression. Instead, Caron et al. found that infants at all ages dishabituated to the *toothy smiling* expression only if they had been habituated to one of the nontoothy expressions, regardless of whether that facial expression was angry or smiling. In other words, the infants were responding not to the affective information but to specific featural information (toothy versus nontoothy mouths). When such facial feature information was held constant across expressions, even the 7-month-old infants did not discriminate between the expressions.

More recently, researchers have tested whether, under some conditions, infants can be encouraged to focus on the affective information and ignore featural information. To do so, these researchers have used the modified habituation technique described above in which several different photographs are presented to the infants during the habituation phase of the experiment. In these experiments, however, an attempt is made to ensure that the featural information provided in each of the photographs differs from one photograph to the next. Some have toothy mouths, others do not. Some have wide eyes, others are squinting, and so on. Typically, several different models are used in making the photographs. However, the one variable held constant across the photographs is the affective meaning of the expressions portrayed

in each. After habituation, half of the infants are presented with a new model posing a new version of the old expression. For example, an infant might view several models alternately depicting happy facial expressions on the habituation trials, and be shown a new model depicting a happy expression at test. If these infants notice the common affective meaning in the photographs, they should not increase their looking time to the new photograph because it represents the same old expression. In other words, infants should generalize to the new display of the familiar expression. The other half of the infants are presented with a new expression and are tested for their ability to discriminate it from the earlier expressions. In accordance with the example given above, these infants would see either a familiar or a new model showing anger (for example) at test.

In one such study, Kestenbaum & Nelson (1990) attempted to manipulate their 7-month-old subjects' use of affectively relevant versus feature-specific information by presenting them with either single or multiple, photographed exemplars of an expression during habituation, and by presenting the expressions in either the upright or inverted orientation. Affectively relevant information, Kestenbaum & Nelson argue, is orientation-specific and therefore would not be present in the inverted displays. The results of their first experiment indicated that the infants were able to generalize across different models' happy facial expressions and were able to discriminate these expressions from fear and anger facial expressions but only when the faces were presented in the upright position. That is, only when the affectively relevant information was available. Taken alone, these results would suggest that 7-month-old infants can use affective meaning to discriminate facial expressions.

In a second experiment, 7-month-old infants were visually habituated to a single model with a happy facial expression and tested for discrimination with the same model's expressions of anger or fear. Infants in both the upright and inverted conditions dishabituated to the novel expressions. That inverting the displays did not disrupt the infants' ability to discriminate these facial expressions suggests that they used featural rather than affective information to make the discriminations.

Finally, 7-month-old infants were habituated to three different models expressing toothy smiles and then shown a different model posing nontoothy smiles and nontoothy anger. Infants in both the upright and inverted conditions dishabituated to the nontoothy happy and to the nontoothy anger, again evidence of feature-based discrimination.

Overall, these results suggest that, at least by 7 months of age, infants will base their discrimination of photographs of faces on featural

information (e.g. toothiness) when it is available rather than on affective meaning. However, when featural information is not salient, as in procedures that provide multiple models posing different versions of the same expression, the infants are able to discover the common affect among the different faces and discriminate them from a novel affective expression. This new skill, generalization of emotional expressions, marks the beginning of an ability to recognize emotional expressions that are depicted in photographs.

Despite the methodological advances described above, the use of photographs as stimulus materials for testing infants' perception of facial expressions is not without its critics. Some have argued that the critical invariants that carry affective information in naturally occurring, dynamic and multimodal events are lost in static photographs (Caron et al. 1985). Walker-Andrews (1988: 186) agreed, proposing that "the stimulus information found in these photographs may not be the same as that used for the perception of naturally occurring expressive events", and as such, "may not elicit the same perceptual skills on the part of the infants". In other words, if we would like to discover when infants are able to discriminate between and make sense of the many different emotional expressions they come in contact with in their lives, we would be wise to use stimuli in our experiments that are as close to the *real thing* as possible. As we will see, using such naturalistic displays also allows us to come closer to discovering when infants are able to recognize the meaning of emotional expressions.

RECOGNITION OF FACIAL AND VOCAL EXPRESSIONS

To determine whether infants can recognize emotional expressions has demanded several modifications in the methods typically used to study infant perception. As should be apparent from the work of Kestenbaum & Nelson (1990), 7-month-old infants may be able to use the emotional content of facial and vocal expressions to discriminate them, suggesting that recognition is occurring. One of the difficulties for the researcher, however, is to design a study that *guarantees* that recognition is being measured.

Visual habituation: dynamic stimuli

Several different methodologies have been developed for investigating infants' recognition of the meaning of affective displays. Caron et al. (1988; see also Walker-Andrews 1985), for example, used the standard infant-control habituation procedure, but with films as the stimulus displays. They presented their subjects with several colour-sound films

of different persons facially and vocally portraying either a happy, sad, or angry expression. At 4 months of age, the infants in this experiment were able to discriminate the happy and sad expressions. Only the 7-month-olds were able to discriminate between the happy and angry expressions. The use of dynamic, multimodal displays by these experimenters greatly reduced the salience of specific featural information (e.g. toothiness, specific speech contrasts, etc.) for the infants, because this information was not held constant but varied widely within and across the different displays. Therefore, it is less likely that the infants focused on this information in making the discriminations between expressions and more likely that they focused on the affective meaning of the displays.

Intermodal preference method

The intermodal preference technique (Spelke 1976) is another method used in experiments on the development of the recognition of affect in infancy. Here, infants must detect the correspondence between information presented to two different modalities (for example, vision and audition). By manipulating the displays in certain ways, the experimenters can ensure that the only information that is common across the two modalities is the affective meaning of the displays. Therefore, this is the only information available to the infants with which they can make the *cross-modal* match.

In the first series of experiments using this technique to examine infants' perception of facial and vocal expressions, Walker (1982, Walker-Andrews 1988) tested infants ranging in age from 2 to 7 months. Adults perceive a unified, meaningful expression when they interact with a person speaking, gesturing, and facially expressing an emotion. The major question was whether infants, too, would detect intermodal correspondences in emotional expressions.

In these experiments infants were presented simultaneously with two filmed facial expressions (from the set: happy, sad, neutral, and angry) accompanied by a single vocal expression characteristic of one of the facial expressions. Younger infants (2 months) looked almost exclusively at the happy expressions, regardless of which vocal expression was played. Four-month-olds increased their looking time to a film that was in sound, but only for facial and vocal expressions depicting happiness/joy. Five- and 7-month-old infants increased their looking time to any facial expression (happy, sad, angry, neutral) when it was sound-specified. Even when synchrony relations were disrupted (by delaying the soundtrack by 5 seconds), these infants looked proportionately longer to the film that was sound-specified. Another group of 7-month-olds failed to show looking preferences for the happy and neutral films when these were presented silently.

In one condition, infants viewed the facial expression films accompanied by a single soundtrack either in the upright or inverted orientation. Only those infants viewing the dynamic facial expressions in the upright position looked at the sound-matched facial expression. In another condition, the lower part of the face was occluded so that synchrony between mouth movement and vocalizations was not visible. Again the 7-month-olds looked preferentially to the sound-specified film. We conclude from this that during the first year of life infants develop the ability to detect common affect across bimodal, dynamic presentations of an affective expression. Temporal synchrony between face and voice is not imperative for matching to occur. The mouth and lower part of the face need not be visible, but having an upright face is required.

More recently, Soken & Pick (1992) tested the ability of 7-month-olds to match facial and vocal expressions of emotion and asked what information they used to do so. The infants were presented with two videotapes of the same woman portraying angry and happy facial expressions while the soundtrack that affectively matched one of the videotapes was played. The soundtracks were created separately by a different woman speaking a different text from the woman in the videotapes. In this way, face–voice synchrony information was eliminated while "affect-specific information" was retained. In one condition, the infants saw fully illuminated versions of the woman's face. These infants showed no sign of intermodal matching; they looked for equally long times at the two displays. In the second condition, the infants were presented with *point-light* versions of the same woman's face. These displays were created by blackening the woman's face and then covering it with small luminescent spots. The resulting videotapes reveal only facial motion (through the movement of the spots) and eliminate the presence of facial feature information. The infants in this condition showed a preference for looking at the videotape that affectively matched the presented soundtrack.

In a second experiment, Soken & Pick (1992) created stimulus displays in the same manner as in the previous study except that a single woman was videotaped for both the facial and vocal displays during one session. The videotapes were then edited so that the vocal and facial displays were presented out of synchrony with each other. For this study, then, face–voice synchrony information was again eliminated while both affect-specific and event-specific information were retained. This time, the infants in both the fully illuminated and point-light conditions looked longer to the sound-specified videotapes.

The authors concluded that 7-month-old infants are able to detect the correspondence between facial and vocal expressions based on their

affective meaning (even when produced by different people), but that this ability may be disrupted by artificially produced discrepancies between the facial and vocal displays (these discrepancies were most evident in the fully illuminated condition). Furthermore, 7-month-olds can discriminate happy and angry expressions based solely on motion information (i.e. in the point-light conditions where featural information was removed).

The results of intermodal preference experiments have provided some of the strongest evidence that infants may be able to abstract the meaning of the affective displays of others. By at least 7 months of age infants detect the correspondence between facial and vocal displays of affect even when rhythm, synchrony, and feature-specific information are eliminated. Furthermore, these experiments have used dynamic, bimodal displays, thus reducing the salience of featural information and providing more of the information that carries the affordances of expressive displays.

Preferences for vocal expressions

Research specifically aimed at investigating infants' perception of affordances of vocal expressions of affect is relatively sparse. Most of our recent information has come indirectly from studies of infants' discrimination of and preferences for infant-directed (ID) and adult-directed (AD) speech, which will be included in a later section. However, there have been a few recent experiments specifically aimed at uncovering infants' ability to perceive the affordances of vocal expressions of affect. For example, Aldridge (1994) investigated newborns' preferences for different vocal expressions using the operant-choice sucking procedure. In this procedure, the presentation of a vocal expression is made contingent on an infant's suck on a pacifier nipple. The results indicated that the newborn infants preferred to listen to happy as opposed to angry and sad voices. The infants controlled their sucking in a fashion that permitted them to listen longer to the happy voices, and they paused for longer periods of time before the onset of the angry and sad voices. That newborns *worked harder* to hear the happy voice and *avoided* listening to the sad and angry expressions would imply a preference based on the emotional content of the voice. It is premature, however, for us to conclude that this is the case because infants heard only a single syllable ("hi") during the experiment. A single syllable is easily discriminable using one acoustic parameter, such as pitch, loudness or other acoustic features, and infants may evince a preference based only on these differences. At this time, these results are subject to the same critical interpretation as were the data showing discrimination of toothy smiles from closed-mouth anger expressions.

Visual habituation to vocal expressions

In a series of experiments, Walker-Andrews and her colleagues (Walker-Andrews & Grolnick 1983, Walker-Andrews & Lennon 1991) investigated the ability of young infants to discriminate vocal expressions of affect. The infants in these experiments were habituated to a visual stimulus accompanied by a recording of a vocal expression of affect. The infants' looking time to the visual stimulus was used as an index of their attention to the vocal expression. Upon habituation, the vocal expression was changed while the picture remained the same. An increase in looking to the familiar picture was interpreted as an indication that the infant had discriminated between the two vocal expressions. The vocal expressions were extended speech samples, each lasting about 2 minutes and repeating for as long as the infants continued looking at the visual stimulus. The vocal expression was changed whenever an individual infant reached the criterion for visual habituation. This ensured that every infant heard a different contrast when the vocal expression was changed.

Using this technique, Walker-Andrews & Grolnick (1983) habituated 3- and 5-month-old infants to a soundtrack of either a sad or happy woman's voice along with a picture of a woman's face expressing the same affect. After the infants visually habituated, the voice only was changed either to happy or sad, depending upon the habituated vocal expression. The 3-month-olds dishabituated only in the sad-to-happy condition. The 5-month-olds dishabituated to the change in vocal affect in both conditions. In other words, they were able to discriminate between vocal expressions of sad and happy.

Walker-Andrews & Lennon (1991) extended and refined these findings by investigating what role the presence of the facial expressions has on the infants' ability to discriminate the vocal expressions. For some of the infants in this experiment, the visual stimulus was a face that affectively matched either the voice they heard during habituation (as it had in Walker-Andrews & Grolnick 1983), the voice they heard during the test phase, or neither vocal expression. A final group of infants was shown a black-and-white checkerboard instead of a picture of a face. The 5-month-old infants in this experiment discriminated between happy, angry, and sad vocal expressions when a photograph of a face was present, regardless of whether the face affectively matched the habituated voice, the novel voice, or neither. However, when a checkerboard was used as the visual stimulus, the infants did not dishabituate to the change in voice.

That the 5-month-olds in this experiment did not discriminate the vocal expressions while looking at a checkerboard is surprising given that Horowitz and her colleagues (Horowitz 1974) using a similar

procedure, have shown that much younger infants can discriminate voices differing in pitch and other acoustic features. Walker-Andrews & Lennon (1991: 140) proposed that, for the infants in the face conditions, the presence of the face acts "as a setting for attending to the *affective* quality of the voice", while the infants in the checkerboard condition were not provided with this setting. Younger infants who have been shown to discriminate voices while looking at checkerboards (i.e. without the presence of a face) were probably doing so based on the physical, acoustic properties of the voices rather than on their affective meaning.

Perception of infant-directed speech

Much of our information concerning infants' perception of vocal expressions has come from investigations of their perception of, preferences for, and responses to infant-directed speech. ID speech has been shown to facilitate the communication of affect. Fernald (1989) found that adults were more accurate in categorizing speech segments based on communicative intent (approval, attention-bid, prohibition, comfort, or game/telephone) when the speech was directed toward infants (approximately 12 months old) than when it was directed toward adults. The speech segments were recorded in the home setting and then filtered to eliminate semantic information. Because the semantic information was removed, the observers could only use prosodic contour information to make their judgements. Fernald suggested that although adult–adult and adult–infant speech share many of the same prosodic contours, these contours are more pronounced or exaggerated in adult–infant speech. This exaggeration serves to highlight the relationship between prosodic contours and communicative intent in adults' speech to infants, possibly aiding infants in detecting the meaning of the vocalization.

This conclusion was supported by Fernald (1993) who found that 5-month-old infants responded differentially to infant-directed vocal approvals and prohibitions even when the language was unfamiliar to the infants. The infants smiled more to the approvals and were more likely to show negative affect in response to the prohibitions. Fernald concluded that ID speech is more effective than AD speech in eliciting infant affect and that infants respond to the qualities of ID speech in several languages whatever their typical language environment. Similarly, Papousek et al. (Papousek et al. 1990) found that 4-month-olds looked longer to a photograph of a face when looking caused ID approval vocalizations to be presented than when ID disapprovals were the auditory stimuli. Further support for the universality of the prosodic features of ID speech and its attentional and affect communicating

qualities across languages is provided by Werker et al. (1994, Cantonese) and Grieser & Kuhl (1988, Mandarin).

That infants are sensitive to these characteristics of ID speech and can discriminate ID speech from AD speech has been demonstrated by many researchers as is discussed by Franco in Chapter 4. A finding of particular interest to our discussion of the perception of vocal expressions of affect comes from Werker & McLeod (1989). They emphasize that the ID speakers in their experiments were recorded while speaking to a 6-month-old infant. Four- to 5.5-month-olds responded more to the ID displays than did 7-month-old infants, indicating that there may be a functional match between the style of ID speech adopted by a speaker and an infant's level of development. Although these authors did not speculate on what qualities of the particular ID speech may be relevant to this functional match, results from Bornstein et al. (1992) may be relevant. Bornstein et al. recorded the speech of mothers from four cultures (Argentina, France, Japan, and the United States) as they talked to their 5- and 13-month-old infants and analyzed these speech samples for affective and information content. Although the mothers spoke more to their older infants overall, giving more affective and general information, a greater proportion of their total speech to the younger infants was affectively (as opposed to informationally) salient. Together with Werker & MacLeod's findings, these results indicate that infants may be sensitive to the relative levels of affectivity (as well as other variables) in different styles of ID speech, preferring that style that more closely fits their perceptual, cognitive, and social abilities.

SOCIAL REFERENCING

Once infants can recognize the emotional expressions of others and use that information effectively in an ongoing interaction, they also develop the skill to use others' expressions as information about external events. The development of social referencing requires that infants not only detect and discriminate others' expressions, but that they draw a connection between those expressions and other events in the environment.

In attempts to study social referencing, researchers have staged interesting events with ambiguous consequences and instructed the infants' mothers to respond to the event in predetermined ways. The objects and events selected have ranged widely, including novel toys, strangers, and the visual cliff. For example, Klinnert (1984) presented 12- and 18-month-olds with a set of novel, mobile toys and directed the

infants' mothers to pose either happy, fearful, or neutral expressions in the presence of the toys. At both ages, the infants stuck closer to the mother when she posed fear, stayed at a middle distance when she posed a neutral expression, and moved furthest way from her side when she portrayed a happy expression. In a similar study, Sorce et al. (1985) placed infants on a visual cliff with a 12-inch drop-off. The infants' mothers posed fearful or happy expressions once the infants had been coaxed within 38 cm of the drop-off. Of the infants whose mothers posed a happy expression, 74 per cent crossed over the cliff; no infants whose mother posed a fearful expression crossed the deep side.

Infants as young as 8–10 months provided evidence for social referencing in a stranger-approach study. Feinman & Lewis (1983) found that infants of 10 months responded more positively to a stranger when their mothers directed positive facial, vocal, and gestural messages to the infants, although not when those same behaviours were directed to the stranger. Boccia & Campos (1983) reported similar results to strangers by infants as young as 8½ months. An infant was placed in a high chair and then a female stranger entered the room, approached the infant, picked-up the infant, reseated the child, and left the room. A second stranger repeated the sequence after a short interval. The infant's mother posed a happy facial expression for one sequence and a worried (frowning) expression in the other. Heart-rate changes and behavioural measures (infant smiles to mother, to stranger; infant looks to mother, to stranger) were scored. Infants tended to look at the mother when the stranger entered the room and when she picked them up, whatever expression the mother posed. They tended to smile more when the posed expression was happy. These results suggest that infants discriminated the mother's posed expressions and that the facial expressions influenced the quality of the infants' reaction to the strangers.

SUMMARY

Recent theories about the development of self, of affect, and cognition emphasize the importance of interpersonal interactions in the development of the child (e.g. Franco, Ch. 4 of this volume, Hobson 1989, Hobson et al. 1988, Stern 1985). This chapter describes the course of development for infants' eventual recognition of the emotional expressions of others. In summary, by approximately 7 months of age, infants can match facial and vocal expressions with respect to the portrayed, underlying emotion, and they can categorize and generalize across varied productions of emotional expressions. Shortly thereafter,

they begin to use these expressions as information about other events in the world as well as indicators of another's future behaviour. These are sophisticated abilities that have developed from initial sensitivities to information that potentially specifies emotion. It is these very abilities that allow infants to establish strong attachments and to interact successfully with others. The developmental tasks for the infant are the same as those for the perception of physical objects, although the contingent aspects and pervasive opportunities for social interaction combined with infants' interest in animate objects may hasten their developmental abilities in the social realm.

The pace and form of infants' developing understanding of others' emotional expressions are influenced by a number of factors, including an infant's sensory capacities and characteristics of the expressions themselves. For example, some expressions may be easier to discriminate from one another. Research data from several sources (e.g. Caron et al. 1988) suggest that happy expressions are discriminated from expressions such as sad earlier than they are discriminated from expressions such as angry. Other pairs of expressions, such as surprised and fearful, remain problems even for mature adults to discriminate. The analogous difficulty shown by infants may stem from properties of the expressions themselves (fearful and surprised facial expressions share many features, for example), or from a differential amount of experience with these expressions. Emotional expressions such as pride and shame should be among the last to be discriminated, because it is only through the appreciation of social conventions that these expressions come to be experienced or observed.

In addition, context effects may influence an infant's ability to recognize an emotional expression. Such effects range from the setting, whether the person depicting the expression is familiar, and whether the expression is multimodal and dynamic. Infants appear to discriminate dynamic expressions earlier than static ones: this may be because dynamic stimulus events elicit more attention or because the dynamic information that unfolds during the production of the expression is the very information on which the infant relies. Temporal patterning is a critical aspect in the expression of most emotions, for example.

In conclusion, by the end of the first year, the infant recognizes emotional expressions, an ability important to the development of interpersonal skills and a *theory of mind* (see Hala & Carpendale, Ch. 6 of this volume). The pattern of this developing ability parallels the development of perception of physical objects, although the timing of transitions may differ depending upon an infant's experience, the contexts in which expressions are encountered, and characteristics of the emotional expressions themselves. For infants, as for all humans, the closest attention is paid to "the optical and acoustical information that specifies what the other person is, invites, threatens, and does" (Gibson 1979/1986: 128). With the development of recognition of emotional expressions, the infant is well on the way to developing a more advanced and multifaceted understanding of the self and others.

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