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NOTE:
The photographs in Figure 2 and Figure 6 on pages 265 and 270 were switched by the publisher. The caption for Figure 2 refers to the photo in Figure 6 and the caption for Figure 6 refers to the photo in Figure 2.

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6 Facial Behavior in Child Development

Harriet Oster
and
Paul Ekman

University of California, San Francisco

> My first child was born December 27th, 1839, and I at once commenced to make notes on the first dawn of the various expressions which he exhibited, for I felt convinced, even at this early period, that the most complex and fine shades of expression must all have had a gradual and natural origin [Darwin, 1958, p. 131].

The presence of a paper on facial behavior in this forum indicates how developmental psychology (and psychology in general) has changed within the past few years. It reflects a general weakening of old behaviorist taboos and a renewed interest in emotion and the "hidden side" of behavior. Inter-

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est in the face is part of the profound changes in our thinking about human infancy. Infants' faces were long thought to be inexpressive, in part because it was believed a priori that they had nothing to express. Only recently has the infant been viewed as an active, inherently social being with built-in predispositions, sensory and motor adaptations, and precursors of later physical, intellectual, and social skills (e.g., Bower, 1974; Bowlby, 1969; Bruner, 1973; Cohen & Salapatek, 1975). The current interest in facial expression is also consistent with even more recent attempts to study the processes of development in an integrated rather than a piecemeal fashion (cf., Sroufe, in press). Rather than viewing affect as a source of contamination in cognitive and perceptual experiments, researchers are beginning to explore the interrelations among affect, cognition, personality, and social development. Facial behavior accompanies virtually all adaptive behavior and thus can serve as a source of information about nearly all significant facets of development. Finally, the current interest in actual facial *behavior*—as opposed to ratings or judgments based on facial behavior—reveals the growing influence of ethological approaches to developmental problems.

Developmental research involving facial behavior has generally taken two forms, reflecting the dual nature of the phenomenon. From one perspective, facial behavior has been viewed as a "window on the soul," a glimpse into the hidden side of developmental processes. Most interest has focused on emotional development—e.g., recent work on smiling, crying, and fear of strangers (see reviews by Charlesworth & Kreutzer, 1973; Haith & Campos, 1977; Lewis & Rosenblum, 1974b; Sroufe, in press; Sroufe & Mitchell, in press). Affective responses—inferred from smiling, "sobering," a look of "surprise," etc.—have been used as indices of ongoing perceptual and cognitive processes (e.g., Bower, 1974; Haviland, 1975b; Kagan, 1974; McCall, 1972; Zelazo, 1972). Another area of interest has been the interactive, communicative role of facial behavior. The initial communicative capacities of the newborn, the unfolding of those capacities, and the role of newborn behaviors and characteristics in determining the behavior of caretakers have recently been treated by a number of investigators (e.g., Brazelton, Tronick, Adamson, Als, & Wise, 1975; Korner, 1971; Lewis & Rosenblum, 1974a; Osofsky, 1976; Sander, 1969; Vine, 1973).

Our own interests in studying infant facial behavior go beyond what this behavior can tell us about particular aspects of early development. Equally important for us is the fact that developmental data are crucial for resolving basic questions about the face: How did particular movements of the facial muscles come to be associated with particular kinds of stimulus configurations and emotional states? (For example, why do people everywhere pull their lip corners obliquely upward rather than down when happy or greeting a friend?) In what ways are "basic" expressive patterns varied and elaborated by different cultures? How do we learn to control our facial movements and to lie with our faces? How do such efforts at voluntary control affect the subjective experience of emotions? What role do facial movements play in conversation, and how did these movements, quite apart from their role in emotional expression, come to play a role in conversation?

These questions have direct relevance to the long-standing controversy over the existence of universals in facial expressions of emotion. In this paper we will briefly summarize the arguments and evidence on both sides of this issue, and we will suggest how apparently contradictory findings can be reconciled within the broader framework of Ekman and Friesen's (1969; see also, Ekman, 1973) "neurocultural" model of emotional expression. Within this framework we will raise a number of questions about the possible contributions of biology and experience to the development of particular aspects of expressive behavior. We will then discuss a new tool for measuring facial behavior, indicating why such a tool was necessary and how it differs from previous efforts. In the final section of this paper, we will discuss preliminary observations of infant facial behavior, illustrating the usefulness of this new facial measurement tool for developmental research.

The Debate over Universals

The study of human facial behavior has long been dominated by the pseudo-issues of whether expressive movements are universal *or* culturally variable, innate *or* learned. This version of the nature-nurture controversy (not unlike others) has been characterized by oversimplification and false dichotomies. Most often, as we shall see, the findings presented by "opposing" sides have not been mutually exclusive, but merely orthogonal. At one extreme, cultural relativists have argued that expressive movements, like the words of spoken language, are symbolic actions whose patterning, meaning, and use within given social contexts are culturally prescribed and hence variable. Advocates of this position (e.g., Birdwhistell, 1970; Klineberg, 1940; LaBarre, 1947; Leach, 1972; Mead, 1975) point to striking differences from one culture to another in the facial expressions occurring in particular situations: for example, smiling at funerals, crying at weddings, and vice versa. They interpret such observations as proof that culture is the most important, or even the sole, determinant of facial expression. In contrast, extreme universalists have viewed biology as the single most important determinant of facial expression. They have pointed to cross-cultural similarities in the appearance and interpretation of facial expressions, and they have drawn on observations of facial behavior in blind and sighted infants and nonhuman primates (e.g., Darwin, 1872; Eibl-Eibesfeldt, 1972, 1973; van Hooff, 1972; Izard, 1971; Tomkins, 1962). These investigators have concluded that expressive movements are largely innate and that their form, meaning, and elicitors are the products of evolution.

Ekman (1973; 1977a) has examined these opposing views in detail and has indicated many sources of misunderstanding, both conceptual and methodological. We focus here on three underlying sources of ambiguity that can pose problems for developmental research as well as for crosscultural studies.

The most obvious explanation for the apparently contradictory findings of the universalists and relativists is that different investigators may have focused on different types of facial behavior, without recognizing the multiplicity of facial signals. (See Ekman, 1977b, for a description of 18 different kinds of facial signals.) Apart from their role in expressions of emotion, facial movements can function as (1) symbolic gestures (what Ekman & Friesen, 1969, called *emblems*), e.g., a wink; (2) speech *illustrators*, e.g., brow movements accenting a word or phrase; (3) *regulators* that manage the flow of conversation, e.g., the brow raise used as a listener response indicating incredulity. The relativists' claim that there are no universal facial expressions can be explained in part by their failure to distinguish expressions of emotion from the more variable emblems, illustrators, and regulators. Conversely, universalists have focused almost exclusively on the similarities in emotion signals, while disregarding cultural variations in the other categories of facial behavior.

A second problem has been the imprecise description of facial behavior. Confusions would be less likely if different kinds of facial activity involved different facial movements. Instead, some of the same facial movements may appear in each. For example, eyebrow raising (*frontalis* muscle) can function as an emblem symbolizing greeting or negation (Eibl-Eibesfeldt, 1972); as an accenting illustrator; as a question mark, an exclamation point, or an incredulity regulator used by the listener; or as part of the emotional expression of surprise. Avoiding such confusions requires much more careful description of facial movement itself. The facial musculature allows for an extraordinary number of visibly and anatomically different movements which may on first impression seem similar to the untutored eye. Terms like frown, smile, play-face, and even brow raise are much too gross. Each could cover numerous different behaviors which may or may not have the same function. Although the same muscles might sometimes be involved in an emblem, illustrator, regulator, and emotional expression, these might still differ in the timing of the movements (their onset, duration at apex, and fading or offset) or in their location within the flow of ongoing behaviors.

A third fundamental source of disagreement has been the failure to appreciate the complexity of "emotional expression." Even when speaking of behaviors that are clearly "expressions of emotion," universalists and relativists have reached different conclusions, because both have ignored important aspects of the phenomenon. Thus, LaBarre's (1947) observation of smiling at funerals is commonly cited by relativists as evidence that facial expressions are not universal but are purely arbitrary and conventional signs, without any "natural," biologically determined meaning. This conclusion disregards the possibility that funerals are not universal elicitors of grief, or that grief is not openly displayed in some cultures. Thus, while universalists have ignored evidence of cultural variability in certain aspects of emotional expression, relativists have ignored the possible sources of such variability.

The Neurocultural Model

The "neurocultural" model presented by Ekman and Friesen (1969; see also Ekman, 1973) provides a more comprehensive framework for studying both universals and cultural differences in facial expressions of emotion. The model delineates the different components of this complex behavioral system and suggests how biology and experience might differently influence each aspect. The original neurocultural model has been newly expanded (Ekman, 1977a) to make more explicit the necessary assumptions about the nature of emotional responses to account for the observed similarities and differences in facial expressions. The following are the principal components of the model:

1. An "appraisal" mechanism or mechanisms capable of analyzing and evaluating potential elicitors of emotional responses. In some cases this appraisal stage is rapid and automatic, while at other times it may involve more protracted and "ponderous" cognitive processes.

2. A central "affect program" that sets off changes in a number of response systems, only some of which can be directly observed: facial and vocal responses; verbal responses; skeletal motor responses (flinching, turning away, thrusting forward, etc.); more fully elaborated coping behaviors (fleeing, fighting, etc.); autonomic and central nervous system changes; and the subjective experience of emotion, which might include memories, images, expectations, verbal labeling, and an awareness of the changes occurring in some or all of the above response systems. The "affect program" is centrally organized, in the sense that there is likely to be coordinated activity in two or more response systems, and that different emotions are characterized by distinctive patterns of activity within a given response system. (The term "affect program" and much of what we mean by it are taken from Tomkins, 1962.)

3. A mechanism for managing or interfering with emotional responses. Ekman and Friesen (1969) coined the phrase "display rules" to refer to the culturally or individually defined norms and habits governing the outward expression of emotion: "A display rule specifies who can show what emotion to whom, when." Depending on the "time, place, and manner" rules operating in a given situation—and depending on an individual's age, sex, cultural background, and past history—an emotional response may be amplified, modulated, feigned, or masked by the appearance of another emotion. Some emotional responses (e.g., facial expression) are more easily managed than others (autonomic responses); and some individuals are much better than others at controlling the outward appearance of emotion.

Even without a detailed explanation of the proposed model, it should be apparent that the question of whether "expressions of emotion" are universal or culture-specific is too simple, too global for a consistent answer to be found. The answer depends, for any given emotion, on which aspect of emotional expression we are talking about and also on our level of analysis.

If we focus on the specific elicitors of emotion, we are likely to find a great deal of variability, as did the cultural anthropologists. For example, taste in foods is strongly influenced by cultural learning; a delicacy for one group might be an object of disgust for another group. Nevertheless, at a more abstract level potential elicitors of disgust share certain common characteristics: In all cultures, taste and smell stimuli are likely to be among the recognized disgust elicitors; such stimuli are noxious and distasteful rather than painful or threatening. Responses to "bad" tastes no doubt represent the primitive prototype for disgust. In response to sour or bitter taste stimuli, newborn infants show distinctive facial expressions that share many of the components of adult disgust faces; see Peiper (1963), Steiner (1973), and Figure 3(b).* The presence of such responses in an anencephalic infant (Steiner, 1973) indicates that they have a subcortical basis. At the same time, later experience can override these initial biases; sour and bitter are important elements of many national cuisines. Even more striking, whole classes of stimuli having nothing to do with taste or smell but metaphorically sharing the characteristic of being noxious or "distasteful" can become objects of disgust—including social objects, manner of dress, abstract entities like political ideologies. The processes of generalization and analogy by which this occurs have not been further elucidated since Darwin's (1965) treatment of the subject in 1872.

Common elements may also be found among the elicitors

* For this and all other figures referred to in this paper, see pages 264–270.

of other emotions, although these commonalities will not necessarily relate to a prototypical class of objects, as in the case of disgust. Elicitors of surprise, for example, are necessarily defined with respect to the individual's previous experience. Any event that is novel to the individual and unexpected in a given context can elicit surprise—especially if its appearance is sudden rather than gradual.

These examples illustrate the more general point that in most cases emotional responses are not directly, "mechanically" elicited or "released" by simple stimulus configurations. The intervening appraisal mechanisms and (on the output side) display rules contribute to much of the cultural and individual variability that has been found.

The contradictory views of relativists and universalists can easily be integrated within the neurocultural model. The relativists' observations and conclusions reflect the enormous influence of culture in determining the specific elicitors of emotion and the operation of the appraisal mechanism and in controlling the social contexts in which emotions may be overtly expressed. The universalist view reflects certain constancies in the emotion elicitors, when considered on an abstract level; and uniformities in the appearance of facial responses controlled by the affect program, if not interfered with by display rules. The evidence marshaled by each side can also be reconciled within this framework.

Evidence of Universals. Most of the evidence for universals comes from observer judgment studies. In these studies, observers in different cultures are shown photographs of faces and asked to select an emotion term or match the face with a story about an emotion elicitor. In 13 different countries, using 9 different languages, the same emotional interpretation was obtained for the emotional expressions presented. (See reviews of these studies in Ekman, 1973, chap. 4; Ekman, Friesen, & Ellsworth, 1972, chap. 19.) Importantly, the same findings were obtained in two isolated preliterate cultures (Ekman, Friesen, & Ellsworth, 1972; Ekman, 1973).

There has been only one experiment on spontaneous facial behavior in which quantitative measures were used. Japanese and American subjects watched a series of stress films in a laboratory setting. In one part of the study, a hidden camera videotaped the subjects when they were alone. Measurements of their facial behavior showed nearly identical facial movements in individuals from these two very different cultures. (This study is reported in detail in Ekman, 1973.) Qualitative data documenting similar emotional expressions in a variety of cultures have also been reported by Eibl-Eibesfeldt (1972).

Evidence of Cultural Differences. The reports of Birdwhistell (1970), Klineberg (1940), and LaBarre (1947) provide ample examples of cultural differences in facial appearance. Ekman (1973) attributed these differences to variations in elicitors or display rules. This interpretation is strengthened by the one experimental study which showed how culture-specific display rules can override the operation of the affect program, wiping out signs of universal emotional expressions. In the second part of the study involving Japanese and American subjects, a research assistant from the subject's own culture entered the room in a white lab coat and sat facing the subject as he watched another series of stress-inducing films. This social context was expected to favor the operation of display rules for managing facial behavior, particularly in the Japanese subjects. This time the subjects from the two cultures showed dissimilar facial activity. The Japanese no longer showed the signs of negative affect evident when they watched the stress films alone; they were instead more inhibited and smiled more than the Americans. Slow-motion analysis of the actual sequence of their facial movements revealed instances where a smile was superimposed over an upper lip raise or nose wrinkle of disgust. (See Ekman, 1973, and Friesen, 1972, for discussion of this study.)

Biological and Experiential Determinants. Evidence of universality does not necessarily mean that facial expressions are *innate* in the sense that individual experience has little to do with the development of particular movements as expressions of particular emotions. Quite the contrary, the affect program responsible for constancies in facial appearance need not be fixed at birth. (In this respect, Ekman & Friesen's (Ekman, 1973) formulation of an affect program differs substantially from that of Tomkins, 1962.) The neurocultural model outlines a number of alternative paths by which particular muscle actions could come to be associated with particular emotions in people of all cultures. These paths range from the innate to species-constant learning (suggested by Allport, 1924). Different paths may be relevant to different aspects of emotional expression and to different emotions.

For example, take the brow raise as an expression of surprise. Brow raising in response to sudden novel events might have been shaped by evolution as a signal communicating crucial information to conspecifics. Alternatively, biological evolution might only have contributed the simple fact that raising the brow increases the superior portion of the visual field. Complex learning processes might be necessary before this movement comes to be associated with a variety of novel, unexpected stimuli. There are of course many intermediate alternatives, differently combining the possible contributions of biology and experience to the development of facial expressions. Studies of brow raising in blind as compared to sighted infants would shed light on this question. If blind children did not raise their brows in response to unexpected events, this would indicate that the association between brow raising and surprise is based in some way on visual experience. Unfortunately, the existing data are ambiguous (Charlesworth, 1970; Eibl-Eibesfeldt, 1973; Goodenough, 1932).

Observations of congenitally blind infants (e.g., Freedman, 1964, 1965) and infants born blind and deaf (review by Charlesworth & Kreutzer, 1973; Darwin, 1965; Eibl-Eibesfeldt, 1973; Goodenough, 1932) strongly suggest that the "basic" patterns of emotional expression—particularly smiling, laughter, and crying—are not learned in any traditional sense of the word (direct imitation or more subtle forms of shaping and conditioning). However, Fraiberg (1971) has noted a restricted range of facial expressions in blind infants. To date descriptions of facial movements in blind infants and children have been too coarse grained to permit a truly systematic comparison with sighted infants.

Indeed, the really challenging problem is not merely to find recognizable emotional expressions in blind infants, but rather to specify very precisely both the similarities and differences between blind and sighted infants. Differences might be found, for example, in the particular configurations of facial muscle actions; in the timing and sequencing of facial movements; in their social and conversational use; or in the infants' capacity for voluntary control over facial movements. This finer level of analysis can also help us to tease apart the various ways in which visual experience contributes to the development of facial expression. Different aspects of facial behavior might depend to differing degrees on each of the following: the adaptive use of the muscles around the eyes in visual searching, squinting, protective narrowing, etc. (suggested by Allport, 1924; Peiper, 1963); the opportunity for observing and imitating others; and the sensorimotor, intellectual, and social stimulation provided by normal visual experience.

As the above discussion suggests, systematic longitudinal studies involving precise facial measurement can take us far beyond global assessments of what is "innate" and what is "learned." Detailed analysis of facial behavior from the earliest moments of life can reveal which types of actions are random and which configurations of facial movements co-occur with sufficient frequency to show that their activity is organized. Developmental study of facial behavior should not be restricted just to emotional expressions. Symbolic gestures and language-related facial movements—emblems, illustrators, and regulators—are interesting in their own right. Yet virtually nothing is known about the origins and development of these forms of facial activity. Some of these gestures (e.g., brow raising as a conventionalized greeting) are related morphologically and in terms of their signal value to components of emotional expressions. But at present we can only speculate about the ways in which these gestures become part of the child's repertoire. Direct imitation and cultural transmission undoubtedly play an important role. But some symbolic or speech-related facial actions may "naturally" arise from the abbreviation or stylization of expressive movements. Whatever their origin, the role of these gestures in social communication and their relationship to language and other symbolic activities are potentially fruitful areas for investigation.

Having mentioned just some of the reasons why the developmental study of facial behavior is crucial for an understanding of the biological and experiential determinants of expressive movements, let us now turn to the question of facial description and measurement. Many of the questions that we have raised demand an objective, fine-grained, and potentially comprehensive system for measuring facial behavior.

Measuring Facial Behavior

Ekman and Friesen (1976; in press) have recently developed a system for measuring facial movement, the Facial Action Coding System (FACS). It has several unique features: First, it is based on a detailed knowledge of human facial anatomy. The basic units in FACS are discrete, minimally distinguishable, visible actions of the facial muscles. Second, as the above suggests, actions, not static configurations, are coded. Third, each Action Unit is specified in terms of an exhaustive set of cues describing both the movement and the static cues of the "apex" configuration. Finally, FACS uses a completely neutral number code to designate Action Units, rather than the often suggestive descriptive terms used in ethological catalogues (e.g., "angry frown," "sad brow," "scowl").

Let us now look at each of these features more closely.

The Action Units are defined on the basis of *functional* anatomy, as opposed to what Duchenne (1959) called "the anatomy of the dead." That is, where a single, anatomically distinct muscle is capable of more than one independent and distinctive action, two or more Action Units are designated. For example, the inner and outer strands of *frontalis* are capable of contracting independently, raising the inner and outer corners of the brow, respectively. Thus, there are two Action Units based on *frontalis*. Conversely, where two or more anatomically distinct muscles seem to act as a unit, they are grouped together as a single Action Unit. This is the case with the lowering and drawing together actions of the brows.

Because the Action Units are minimally distinguishable actions, FACS is a comprehensive system; i.e., any complex facial movement can be analyzed in terms of its constituent actions. Thus, while the number of basic units remains manageable, the number of distinguishable behaviors is enormous. At present there are 24 discrete, anatomically specified Action Units and 20 "miscellaneous actions," more grossly defined in terms of their anatomical basis (e.g., lip bite, tongue bulge). Ethological catalogues of expressive components (Blurton-Jones, 1971; Brannigan & Humphries, 1972; Grant, 1969; McGrew, 1972) or compound facial gestalts (Young & Decarie, 1977) are based only loosely on functional anatomy. The basic units in these systems are defined phenomenologically—i.e., twist mouth. Such systems cannot be comprehensive since some observed movements may involve only a partial performance of a complex configuration or a combination of actions from two different configurations.

Because FACS is an atomistic and comprehensive system, we do not need to make any assumptions about the "basic" human repertoire of facial expressions. Instead, we can determine empirically which actions or combinations of actions represent the "primary" meaningful expressions. This has an obvious advantage for research on infant facial expressions. Another crucial advantage of a fine-grained anatomically based system like FACS—as opposed to phenomenological systems—is that it permits detailed analysis of the temporal organization of facial behaviors: e.g., the onset, duration at "apex," and offset (fading) time of each constituent Action Unit in a complex facial movement.

FACS is surprisingly easy to use once the coder has learned the mechanics of facial movement. Each Action Unit is specified in terms of a complex pattern of dynamic cues, including movements of the facial features, changes in the appearance of distinctive lines, bulges, pouches, etc. The coding manual also specifies subtle differences in behavior between certain Action Units, and minimum threshold rules to enhance inter-coder reliability. The magnitude (or intensity) of action can also be coded, if necessary. By contrast, ethological catalogues describe expressive units and compound expressions in terms of static apex configurations only: e.g., shape or position of facial landmarks, such as mouth corners down, eyes narrow, etc. Individual differences in facial morphology can make it difficult to match an observed movement to the configuration described, especially when the units are described only in suggestive terms (e.g., kidney-shaped mouth). More generally, with phenomenologically defined units one is never quite sure when a behavior that takes a slightly different form—even in the same individual—is in fact the same unit. By contrast, the dynamic cues specified by FACS can be recognized in individuals of widely differing facial structure and appearance, including, as we shall see, infants and young children.

Because the same set of Action Units can be used for infants and children as well as adults, we can specify changes and continuities in the appearance of discrete Action Units and complex configurations, and we can study changes in the timing and sequencing of facial behaviors. Herein lies the advantage of FACS for analyzing the precursors of adult facial expressions. (A similar system for different nonhuman primate species would be valuable in attempts to establish homologies between human and nonhuman primate expressions.)

Adapting FACS to the Infant's Face

Anatomical Basis. Because of the morphological differences between infant and adult faces, we were cautious about applying FACS to the measurement of infant facial behavior before first obtaining knowledge of prenatal and postnatal changes in the facial musculature and in facial muscle function. Two sources of evidence were important: (1) Embryological studies have shown that all of the muscles of facial expression are formed by 16 weeks of gestation and attain their definitive position between 15 and 18 weeks. Subsequent changes involve increases in the size of muscle fibers and the development of more prominent boundaries between muscles. Bony attachments also become more firmly anchored (Bosma, 1975; Crelin, 1973; Gasser, 1967a). Development of the facial muscles is accompanied by differentiation of the peripheral branches of the facial (seventh cranial) nerve that supply them (Gasser, 1967b). (2) The prenatal functioning of many facial muscles was directly demonstrated in the classic studies of human fetal reflexes conducted by Hooker and Humphrey (Hooker, 1952, 1958; Humphrey, 1970, 1971, 1972). In these studies, the responses of aborted fetuses to cutaneous stimulation were filmed. By roughly 11 weeks of gestation (when the eyelids fuse), stimulation in the facial region elicited mouth opening, reflex jaw closure, and squint- and scowl-like reflexes (*Obicularis oculi* and *corrugator supercilii*, respectively). By 14½ weeks, swallowing, a sneerlike reflex (*levator labii superiorus*), lip compression, and tongue movements could be seen. Upper and lower lip protrusion, including contraction of the chin muscle, could be elicited by 18½ weeks; and between 20 and 29 weeks, brow raising, eyelid opening, and cry faces were present.

Taken together, these studies not only demonstrate the infant's capacity to make particular muscle actions, but they also show a fairly close association between anatomical maturation and functioning of the facial muscles. Thus, although Hooker and Humphrey do not mention roughly half of the discrete actions specified in FACS, we have no reason to doubt that what we see in the infant's face can be anatomically related to what we see in the adult face. In fact, as we point out in the next section, virtually all of the actions in FACS can be seen in the premature and full-term newborn, thus confirming the extremely wide applicability of an anatomically based coding system. However, the appearance change produced by a given facial muscle action is often not precisely the same in infants as in adults. Therefore, some "translation" of the coding criteria was required.

Interpreting Facial Movement and Static Cues. In adapting FACS to the infant's face we took into account the very considerable structural differences between the infant's face and the adult's face. First, there are the obvious differences in the proportions and dimensions of the skeletal parts: the infant's diminutive mandible and underdeveloped chin; the shorter, flatter nose and low, flat nose bridge; the absence of prominent supraorbital ridges; and, of course, the absence of teeth (Enlow, 1968). In addition, there are marked differences in appearance due to the unique *corpus adiposum buccae* (the "sucking pad"), extensive deposits of subcutaneous fat, and thick, highly elastic skin. According to Bosma (1972), these features "constitute essentially an 'exoskeleton' about the face of the newborn [p. 18]".* The lips of the newborn, with their characteristic "cupid's bow" shape, are short

* Bosma (1972, 1976) points out that this "functional exoskeleton" plays an important role in stabilizing the mouth and pharynx, thereby ensuring the integrity of the air passages. However, we disagree with Bosma's (1972) emphasis on the resulting immobilization of the newborn infant's face: "The mobility of the face is limited to the immediate structures of the lips and of the eyelids, with the exception of slight corrugation in the forehead and about the mental eminence. The motions of the lips are limited to their portions medial to the nasolabial folds and above the mental eminence. Note the resulting restriction in potentialities of motion within the infant's physiognomy [p. 18]." This condition may be approached in some infants with extremely full and firm cheeks, but most of the infants we have seen have considerable mobility in their face.

in relation to their skeletal attachments and have a distinctive mucosal adaptation, the "infantile sucking lip" (Bosma, 1972). Differences in the structure of the tongue and oral cavity indirectly affect the appearance of infant facial movements. Finally, the eyebrows of many Caucasian infants are very fair, often making it difficult to see changes in brow position.

In scoring facial behavior, errors both of omission and of commission can occur. Errors of omission can occur if (1) the action is of low frequency or of very low amplitude; (2) the action is never seen in isolation and is masked in combination with other actions; (3) the cues are so different from those seen in adults or so deficient that the action cannot be recognized; or (4) the "background noise" of muscular activity is so high that the discrete actions cannot be identified. Errors of commission can occur if in fact a particular action is not occurring but is coded as having occurred because the appearance of the relaxed face has some of the cues of the muscle action. Thus, the cupid's bow shape of the infant's upper lip, especially when the lips are parted, should not be taken for the action of raising, "squaring," or protruding the upper lip. Errors both of omission and of commission occur when one action is mistaken for another. Finally, a movement may be uncodable if muscular activity is perceived but cannot be related to any particular action, because it is indefinite, incomplete, and ambiguous in articulation—that is, if it is at the level of "background noise."*

* Of course, many of the same kinds of errors can occur in the measurement of adult facial movement. But we have means of verifying the appearance changes seen with specific action units in adults that are generally not available in studying infants; the easiest, of course, is to ask the adult to voluntarily perform the action. Ekman and Friesen have also used surface and depth electrodes on their own faces to verify the appearance changes produced by some muscle actions. To resolve ambiguities in coding infant facial movement, we must rely on extrapolation of the general principles of facial muscle action, guided by knowledge of infant-adult structural differences.

In considering these pitfalls, it is useful to distinguish between possible infant-adult differences in the movement itself and differences in the resulting static cues (e.g., temporary changes in the shape and relative position of facial landmarks such as the lip corners and nasolabial folds). Most difficulties arise from the static cues, though this is not always the case. (In some instances, the static cues may be necessary to distinguish between two actions that have a similar direction of movement.) In general, we found that if we could see the movement, we could identify the action that produced it—given sufficient knowledge of the infant's facial structure and an understanding of the mechanics of facial muscle action. Knowing the kinds of morphological differences described above also made many of the potentially misleading differences in static cues intelligible. We could thus relate particular configurations of static cues to particular actions. Indeed, after watching many infant faces, we found that we had begun to develop an internalized model of the infant's face, and that we could infer how an action that we voluntarily produced on our own face would appear on an infant's face.

The process of adapting FACS to the infant's face can best be illustrated by one of the most common facial actions seen in infants as well as in adults: the action of frowning or "knitting" the brow. In FACS, a single Action Unit (AU 4) designates the combined actions of three anatomically distinct muscles: the *corrugator supercilii*, which draws the corners of the brows together, and the *depressor supercilii* and *depressor glabellae* (*procerus*), both of which lower the brows. These actions nearly always occur together, although it may sometimes be useful to separate the knitting and lowering actions, since one or the other may predominate in a given context.

The *corrugator* action is not difficult to recognize in infants if the movement can be seen. However, the static cues resulting from this action can be quite misleading for the uninitiated. In adults, we can most easily recognize *corrugator* action by the appearance of vertical furrows between the brows; see Figure 1(a).* These are absent in many young infants, perhaps because of the large amount of subcutaneous fat in their forehead and the elasticity of their skin. When the brows are very light, it may also be impossible to judge, from a still photograph, whether the brows have been brought closer together. What we do see in many infants, with even a slight *corrugator* action, are curious "butterfly wing" muscle bulges curling up from the inner corners of the brows, where *corrugator* inserts into the skin; see Figures 1(b) and 5(e). These bulges can be misleading, because they give the impression that the brows have been lifted at their inner corners.† This is a potentially serious confusion, since brows with corners raised and drawn together in the middle ("oblique brows") are usually seen as a component of a sad face. In infants with sufficiently dark eyebrows, one can see that the brows themselves have not lifted. And when the actual movement is closely observed, it is clear that there has been no upward movement, but only a pulling together and slight downward movement of the brows. *Corrugator* action may also produce dimples or pitting over the middle of the brow, a cue that may also be seen in some adults.

We have the opposite situation in identifying the lowering action of Action Unit 4, when little or no *corrugator* action is present. Since *orbicularis oculi* can contribute to brow lowering, this movement by itself may be ambiguous. Here

* The adult photographs presented in this paper do not show spontaneous behavior but are illustrations used to define Action Units in the FACS Manual (Ekman & Friesen, in press). In both the adult and infant photographs actions other than those discussed may be present, and these contribute to the overall appearance of the face (e.g., pouching beneath the lower eyelids produced by contraction of *orbicularis oculi*).

† Young and Decarie (1977) may have made this error in describing their categories "sober frown" and "sober stare," which they described as having brows which were curled up at the inner end. Blurton-Jones (1971) also describes a component of "general frowns" as having just the inner ends of the brows, near the corner of the nose, turned up.

the pattern of static cues can help, because the action of *procerus* produces a marked horizontal crease across the bridge of the nose. While a strong action of *orbicularis oculi* can produce such a crease, it also raises the cheeks and the skin at the outer corners of the eyes—cues not produced by *procerus*.

When both the lowering and knitting actions of Action Unit 4 are strong in infants, the distinctive cues to both may be masked. The bulges, creases, and dimples of the two often combine to produce a generally lumpy appearance, as in Figure 3(c). When *frontalis* action is added, raising the inner and outer corners of the brow (AU 1 + 2)—as often occurs in crying—the whole brow and forehead region may become crumpled; see Figure 1(c). We can distinguish this combined action of raising and drawing the brows together from the action of AU 4 alone, because in the former there are horizontal creases across the forehead and the brows are raised, while in the latter neither of these occurs. The crumpled brow of the infant is quite different from the appearance produced by the same combination of actions (AU 1 + 2 + 4) in the adult; see Figure 1(d). In the adult, we see a raising and straightening of the whole brow and a distinctive pattern of creases in the central portion of the brow. In both the infant and the adult the combined action of these three Action Units produces appearance changes that are not merely a combination of the changes that occur when each acts separately.

The kinds of problems involved in adapting FACS to the infant face and the solutions that we have adopted are discussed more fully elsewhere (Oster, in preparation). But it should be clear from the above illustrations that these problems have several consequences for those who would study infant facial behavior. First, it would be unwise to apply *any* adult measurement system to infant facial movements without some modifications. Second, it is more hazardous to score from still photographs or time-sampled stills than from film or videotapes. This is also true for adults, but the likelihood of error may be even greater with infants, if only because we have less experience with infant than adult faces. Finally, it would be folly to try to do real-time coding of infant or adult facial behavior when using a fine-grained system such as FACS. It is possible to code more grossly defined categories in real time—crying, smiling, "grimacing," frowning—and many researchers have obtained exceptional results using such categories. But if one needs to know what kind of smile, frown, or grimace the infant made, or whether the brows were raised at both ends or only in the middle, or how long the action lasted, then one needs to be able to stop the movement, slow it down, and watch it again—and often again.

Facial Movement in Infants

Our primary aim in adapting FACS to the infant's face was to develop a research tool for ourselves and others. It soon became apparent, however, that in the process of "translating" FACS we would answer some very basic questions about the infant's capacity for facial movement. Can all of the actions of the adult facial musculature be recognized in the infant's facial movements? How well defined are these actions? Are they merely gross approximations that only superficially resemble the adult forms, like the "phonemes" found in young infants' vocalizations? How finely can we discriminate among different facial actions in infants? Can individual actions still be identified when many muscles are active at the same time? As we show below, FACS enabled us to answer these questions definitively for many facial actions and to pinpoint areas where ambiguities and questions still remain. Since we have not completely deserted psychology for functional anatomy, we will then see how FACS can be applied to another set of questions concerning the organization and potential meaningfulness of infant facial behavior.

Our data consist of videotape recordings of full-term and preterm infants ranging from 20 minutes to 3 months of age. The videotapes cover a variety of social and nonsocial situations designed to elicit a broad range of facial behaviors. In all cases the camera focused close up on the infant's face.* In all, there are some 14 hours of videotape from several different sources. (1) Fifty 2-month-olds participating in a visual preference experiment. Although the situation was "nonsocial," it elicited a wide range of expressive behaviors, often "directed" at the stimuli. (2) Neonates (including five within the first 4 hours of life and five 2–5 days old) in the newborn nursery at the University of California, San Francisco's Moffitt Hospital. In the younger group, spontaneous sleeping and waking behaviors were videotaped, as well as the infants' responses to standard nursing procedures: a "heel stick" to draw blood, bathing, diapering, etc. The older newborns were taped during selected portions of the Brazelton exam (responses to a light, bell, and rattle; undressing; and social stimulation). (3) Infants engaging in face-to-face interaction with their mother or another adult. Some of this material was collected by Oster in collaboration with Edward Tronick and Heidi Als at Children's Hospital Medical Center in Boston, as part of a longitudinal project on social responsiveness in full-term and premature infants. Beginning on day 2, infants were videotaped weekly in face-to-face social interaction. Thus far, two infants—one full-term and one healthy, 35-week gestation age preterm—have been videotaped through the first 5 months of life. Oster has videotaped an additional

* In focusing close up on the infant's face we obviously miss a great deal of the infant's other behavior as well as information about the precise contextual determinants of the behavior. In social interaction situations, we have only the partner's voice. At this stage of our research the close-ups were essential for fine-grained coding of facial behavior, and the context was less crucial for analyzing and interpreting the data. When such contextual information does become important, it will be necessary to use two cameras and recorders or a split-screen arrangement.

four 3-to-10 week-old infants—three full-term and one preterm—similarly engaged in social interaction. In all of the above situations, infants were recorded in 10–20-min segments.*

Distinctive Facial Actions

Are there distinctive, well-defined actions in infants' facial movements, and not just a flow of undifferentiated (and undifferentiable) activity? We approached this issue by asking whether the Action Units in FACS, which were developed by study of adult facial action, could be identified in infants' facial movements. Before answering this question, we should explain what we mean by "distinctiveness."

The distinctiveness of a facial action (to the observer) is jointly determined by its magnitude, duration, and the amount of "background noise." Some exceedingly quick and subtle movements (e.g., tiny flicks of the outer corner of one brow) can be recognized in real time if the background is quiet. Conversely, some strong actions can be identified against the noisiest background. Prolonged quiescence is rare in young infants; and there is often much low-level, transitory, indeterminate activity, especially around the mouth region (e.g., chewing and munching movements, compression of the inside of the cheeks against the gums, tongue movements inside and outside the lips, etc.). Such movements may be difficult to identify reliably using the units defined in FACS.

* A visible number code was placed on each field of the videotapes permitting us to determine to within a few sixtieth-of-a-second fields when a movement began, how long it took to reach its apex, and when it was no longer visible. At a finer level of analysis, this can be done for each constituent Action Unit in a complex movement. In coding, we first make a rough pass through a tape in real time to locate events of interest and then go back for a finer analysis, often with repeated, frame-by-frame back and forth passes.

An increase in diffuse, indeterminate movements is characteristic of transitional states, e.g., waking up and mildly fussy presleep states; it is often accompanied by grimaces, motor restlessness, rubbing the eyes and face, etc. (Paradoxically, this increase in randomness can often provide fairly accurate cues about the infant's state, cues that are easily interpreted by parents.) The most distinctive facial movements—the ones most easily and reliably scored with FACS—occur when the infant is alert and nonfussy and also during REM sleep when isolated actions may go on and off against a quiet background. (FACS could be applied to movements that are at the level of "background noise," but this would require repeated slow-motion analysis and probably some sacrifice in reliability.)

Many investigators have noted and described a wide range of facial movements in premature and full-term infants. Gesell (1945) spoke of the "virtuosity of the facial musculature" in the newborn. More recently, Haviland (1975a), using a modification of the Blurton-Jones (1971) coding system, has stated that "almost all the facial movements that we observed were first observed in the first month." But without a fine-grained, anatomically based measurement system, such statements are inherently imprecise. Not only do they not cover all possible simple actions, but they cannot specify whether the actions observed, simple or complex, are actually the same as in adults. The range of infant facial movements can be more precisely specified in terms of FACS: With a single exception, all of the discrete facial actions distinguished by FACS can be clearly identified in both full-term and premature newborns.*

The one AU that we have not yet been able to identify unambiguously in infants is AU 13, the curious action of the *levator anguli oris*, or *caninus*, which raises the corners

* We have not yet determined whether all of these facial actions are present in every infant. This is an interesting question because there do seem to be individual differences in facial mobility in adults, particularly in their ability to produce certain actions voluntarily.

of the lips in a "smirk"; see Figure 2. *Caninus* is a long, broad, and relatively deep facial muscle, which is anatomically present by at least 14.5 weeks of gestation (Gasser, 1967a). We can only speculate about our failure thus far to see any instances of AU 13. It is quite infrequent in most adults, and some cannot do it voluntarily. If it is also infrequent in infants, we may have missed it. Or perhaps the characteristic cues seen in adults are absent in infants because of their firm and heavily padded cheeks.

We now turn to some actions that can be clearly and distinctly seen in both premature and full-term infants within the first days of life. The photographs in this paper, taken from stopped frames of videotape, are for illustrative purposes only. For scoring, as we have said, it is important to see the actual movement. In addition, only the most salient cues to each action are described here. The full range of cues that would be used in actual facial measurement is not presented. In this section we are concerned with the actions themselves and not their determinants or "meaning," if any. Some of the actions illustrated—e.g., Figures 3(e), 5(a), 5(b)—though distinctive in appearance, were brief and isolated events occurring in the transition from sleep to alertness, during postural readjustments, etc.

Two pairs of distinctions nicely illustrate the potential discreteness of infant facial behaviors and the discriminative powers of FACS. The first contrast involves two actions (AU 9 and AU 10) that raise the upper lip, deepen the nasolabial fold, elevate the nostril wings, and—when occurring unilaterally—could both be called "sneers." In adults the expression of disgust usually includes either AU 9 or AU 10, but we do not know whether the two variants of this expression have different distributions or differ subtly in meaning within or between cultures. These actions both occur in other affect expressions, and their signal value varies according to the context of simultaneously occurring facial actions. Though superficially similar, AU 9 and AU 10 are produced by different muscle actions (AU 9 by *levator labii superiorus nasi* and AU 10 by *levator labii superiorus quadratus labii superiorus*), and their appearance does differ both in adults and in infants.

In adults AU 9, the "nose wrinkler," produces oblique wrinkles along the sides of the nose, often extending across the bridge of the nose; see Figure 3(a). Because this action almost invariably involves the contraction of *m. procerus*, the skin between the brows is usually pulled down. In infants we do not usually see wrinkles along the sides of the nose because of the subcutaneous fat extending across the bridge of the nose and into the cheek region. We may see a marked horizontal crease across the bridge of the nose and two cues that are similar to those seen in adults: a deepening of the nasolabial furrow, which forms an acute angle with the upper part of the nostril wing; and a raising of the upper lip just beyond the peak of the *philtrum*—see Figure 3(b). AU 9 can be recognized in infants even when it occurs in combinations that mask some of its cues. For example, Figure 3(c) shows AU 9 as a component of a precry grimace in an 8-day-old premature infant. The shape of the upper lip has been changed by other actions, but some cues to AU 9 are clearly present. Although AU 9 is a common component of defensive responses, its signal value can be quite different in a different context. For example, in 2-month-olds, as in adults, nose wrinkling may occur in smiling.

AU 10, as seen unilaterally in an adult and in a 2-day-old —in Figures 3(d) and 3(e)—differs from AU 9 in three principal ways: there are no nose wrinkles, and there is no horizontal line across the bridge of the nose; the lip is raised farther out toward the lip corner; and the nasolabial fold forms an angular bend rather than an acute angle at the nostril wing.

Although AU 9 and AU 10 differ in appearance, their distributions overlap; and at present it is not possible to say whether the two are functional equivalents in any of the contexts in which they occur in infants: disgust or "distaste," distress and defensive reactions, smiling, waking-up grimaces, and so forth. The important point is that we will never know whether or not they do differ if our measurement system does not distinguish between them but instead lumps them together as "grimaces."

The second set of contrasts involves three different actions that give the appearance of down-turned mouth corners: AU 10, which we have already seen; AU 15 (*triangularis*), which is the only one that actually pulls the corners of the mouth down; and AU 17 (*mentalis*), which raises the chin boss, pushing the upper lip upward and often outward. In all three, the corners of the lips appear depressed relative to the middle part. Otherwise these actions are quite different in appearance, and different combinations of the three yield distinctive configurations. Figure 4(a-g) shows all possible combinations of the three actions in an adult.

These actions and combinations can be as distinctive in infants as in adults. Figure 5(a) shows AU 15 in E., a 3-week-old in the process of waking up. As in the adult—Figure 4(a)—the lip corners are pulled down but the chin is relaxed. The actions of AU 10 and AU 15 are combined in Figure 5(b), showing this same infant at 8 weeks. As in the adult—Figure 4(d)—the cues to both actions are clearly present. AU 17 can be seen in Figure 5(c), again showing E. at 8 weeks. As in the adult—Figure 4(b)—this action raises the chin boss, pushing the lower lip up against the upper lip. E.'s lips are here pressed together (AU 24), whereas they are relaxed in the adult. The lip corners have not been pulled down in either the infant or the adult. (The lines going down from the corners of E.'s mouth are here a misleading cue.) AU 17 produces the "pout" seen in Figure 5(d) when the lips are not pressed together but the lower lip is instead allowed to slide past the upper lip. (A different kind of "pout" is produced by the action of protruding the lips.) When the actions of

AU 15 and AU 17 are combined, we get the classic "horseshoe mouth" seen in the 7-week-old in Figure 5(e) and in the adult in Figure 4(f).

Some of the configurations illustrated above convey strikingly different impressions. But are any of these behaviors meaningful in any way? Before turning to that question, let us answer the more basic question addressed in this section: Are there distinctive, well-defined actions in infants' facial movements? We have seen that infants' facial movements are far from being completely diffuse and undifferentiated as some have assumed. Virtually all of the discrete Action Units specified by FACS are present in infant facial movements. These actions are often distinctive in appearance and can be finely discriminated, even when they occur in combination with other actions. Thus, complex combinations of facial muscle actions can be recognized and analyzed in infants as in adults. These findings show that the potential for patterned facial expression is present at birth and that the infant's facial behaviors are potentially intelligible to its caretakers.

The Structure of Infant Facial Behavior

As noted above, the facial movements of young infants often appear random and uncoordinated. Superimposed against this random background, however, we perceive what seem to be organized and meaningful patterns of facial movement. The difficulty lies in specifying exactly which aspects of the infant's behavior convey this impression and in distinguishing potentially meaningful and "expressive" patterns from purely random concatenations of facial muscle activity. This problem has usually been defined as one of external validation. That is, the investigator has asked whether the *occurrence* of a particular facial response is reliably and differentially related to a particular stimulus situation or to some other response of the infant. Our own approach extends this traditional formulation of the problem by asking whether there is any evidence of "internal structure" or patterning in the facial movements themselves.

Our interest in this question is twofold. First, as we have said, we believe that detailed analysis of infants' facial movements is crucial for an understanding of the origins and possible biological bases of facial expressions of emotion. Second, the presence of organized patterns of facial behavior within the first days or months of life would have important implications for study of the ontogenesis of emotion. Most psychologists have characterized the emotional responses of young infants as global reactions differing only in degree of arousal (cf., Bridges, 1932; Kagan, 1966; Mandler, 1975). This view has been perpetuated in part by the use of global and imprecise categories for describing the infant's actual behavior.* We believe that a more fine-grained analysis of infant facial behavior—one that takes into account regularities in the patterning as well as the occurrence of facial movements—might reveal a greater degree of differentiation and organization than has previously been observed. Evidence of nonrandomness in infants' facial behavior would not prove that the experience of emotion was the *same* in infants and adults. Such evidence would suggest that what we referred to above as the "affect program" is operational at some level even in young infants; and it could provide clues about changes and continuities in emotional responses. (The relevance of facial measurement to the assessment of affect is discussed further in Oster, 1978.)

* There have been exceptions, of course, most notably Wolff's (1963) classic study of ontogenetic changes in the morphology and determinants of smiling. The best evidence for differentiation in negative affect responses has come from studies showing differences in the cry vocalizations elicited by pain, hunger, and "frustration" (Lind, 1965; Stark & Nathanson, 1973; Wasz-Hockert, Lind, Vuorenkoski, Partanen, & Valanne, 1968; Wolff, 1969). Clear-cut evidence for differentiation in facial expressions of negative affect has not been found, however.

In this final section we introduce some of the criteria that we have been developing for studying the "structure" of infant facial behavior. Evidence of patterning can be found both in the simultaneous occurrence of independent muscle actions and in the timing or sequencing of facial movements. We focus here primarily on the question of nonrandomness in the co-occurrence of facial actions, referring only in passing to temporal patterning. Although we have closely analyzed many hours of videotape, data analysis is still incomplete; the following are, therefore, confident impressions which, though tentative, illustrate our approach.

We begin with an examination of smiling, because it is the best example of a universal affect expression whose morphological appearance and determinants are largely independent of learning. There is also clear-cut evidence that early smiling, even in newborns, is not a randomly occurring event or the result of "gas," but is instead a precursor of "true" social smiling (see Emde & Koenig, 1969; Sroufe & Waters, 1976; Wolff, 1963). Smiling, therefore, seemed a good place to look for patterned facial activity.

The term "smiling" covers many different facial actions, which may vary widely in appearance and signal value. The common element of the various smiles is the action of the zygomatic major muscle (AU 12 in FACS), which raises the corners of the mouth obliquely upward.* The simplest smile —such as the typical neonatal sleep smile—is produced by a slight action of this single muscle. The complexity of infant smiling rapidly increases with the earliest social smiles around

* Some investigators may have used the term "smile" to refer to facial movements that do not involve *zygomaticus major* but instead are the result of *risorius* or some strands of *platysma*, which draw the lip corners back laterally but not upward. These actions, though superficially similar to zygomatic action, are associated with human expressions of fear and distress. Failure to distinguish clearly between these actions is a source of ambiguity in theories that trace the origins of human smiling to nonhuman primate defensive grimaces (e.g., van Hooff, 1972).

3–4 weeks. Wolff (1963) and others have noted that these smiles are broader than the earlier REM smiles (resulting from stronger zygomatic action) and involve a "crinkling" of the skin below the eyes (from contraction of *orbicularis oculi*), which contributes to the impression that these are "true" smiles. In addition, various other actions may be present.

Do these more "complex" smiles simply involve random additions of one or another muscle action? Analysis with FACS suggests that this is not the case, but that combinations involving *zygomaticus major* do not include every other muscle action. The most obvious example is that "frowning" (AU 4, lowering and drawing together the brows) rarely occurs simultaneously with zygomatic action. The few exceptions that we have observed seem to prove the general rule: i.e., they occurred when a "frown" preceded a smile, overlapping with it at first but then disappearing as the smile reached its peak. Although raised eyebrows (AU 1 + 2) occur only infrequently with smiles during the first few months, brow raising may be maintained throughout a smile, something that does not happen with a frown. Most often, smiling is accompanied by a smooth brow and—as many have noted—by contraction of the *orbicularis oculi* muscle, which further raises the cheeks and produces pouching below the lower lids.

More interesting, because less obvious, are apparent constraints on the lower-face muscle actions that occur with smiling. *Zygomaticus major* may combine with a wide range of facial actions in 3- to 12-week-old infants: lip narrowing, pursing, and protrusion; raising or pulling down of the upper lip; nose wrinkling; tongue protrusion; and varying degrees of mouth opening. These configurations and the dynamic qualities of the movements often convey the impression of increasing psychological "engagement" and excitement. It remains to be determined empirically whether these variations differ significantly in their affective meaning or signal value.

Several lower-face actions do not seem to occur with smiling within the first few months. Although smiling and fussing may occur in rapid succession, we have not observed AU 12 as a component of mild distress or precry faces. (An intense cry face would be likely to mask any cues of AU 12.) Thus far we have not observed the configuration illustrated in Figure 6, which involves the simultaneous contraction of *triangularis* (AU 15, see above) and *zygomaticus major*. Although these actions are antithetical in terms of their signal value, as well as in the direction of motion, they are not physically antagonistic. (Indeed, the AU 12 plus AU 15 action is not intrinsically more "difficult" than many of the facial contortions seen in infants, especially during crying.) This is actually a fairly common configuration in adults, either as a sad-happy blend reflecting ambivalent feelings (a "brave smile"), as an ironic smile, or as Seaford (1975) has shown, as a regional facial mannerism characteristic of the southern United States. (Seaford reports that he has only rarely observed this smile in preadolescent children.) Two other lower-face actions, in addition to AU 15, have not been observed in infants' smiles: chin raising (AU 17, seen above) and lip pressing (AU 24). Both of these actions do co-occur with smiling in adults, but like AU 15 they may convey ambivalent messages.

It would be tempting to attribute the apparent absence of these configurations in infants to the complexity of their affective meaning or to the influence of culture on their social use. Alternatively, it is possible that they are present but merely infrequent or difficult to recognize in young infants. Although these findings are tentative, they suggest that a finer analysis of the patterning and contextual determinants of smiling in infants and young children would contribute to our understanding of the subtle variants of this behavior in adults.

In addition to studying precursors of the "basic" facial expressions, we have been intrigued by some less familiar but striking configurations that we have observed in young infants. One such example is the "horseshoe mouth" seen in

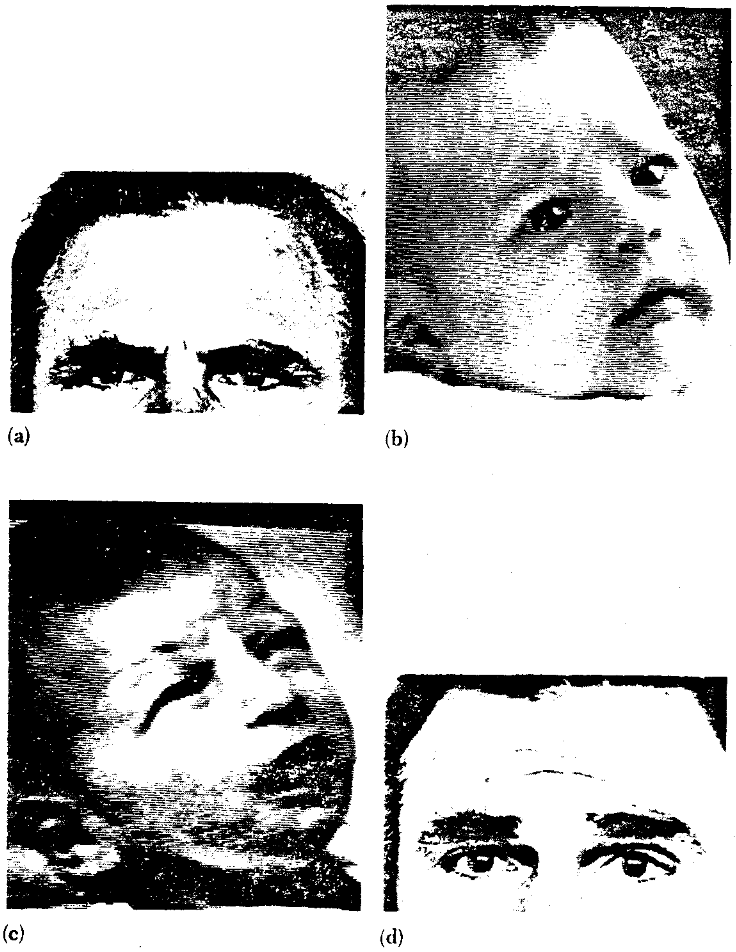


Figure 1. Illustration of brow actions. (See text for descriptions of the Action Units illustrated in this and other figures.) (a) AU 4 as illustrated in the FACS Manual; (b) AU 4 in a 3-week-old; (c) AU 1 + 2 + 4 in a 6-day-old preterm infant; (d) AU 1 + 2 + 4 as illustrated in FACS. (Figures 1[a] and 1[d] © Ekman & Friesen, 1977, illustration from FACS Manual; Figures 1[b] and 1[c] © Oster, 1977.)

Figure 2. The action of AU 13 as illustrated in FACS. This action has not been observed unambiguously in young infants. (© Ekman & Friesen, 1977, illustration from FACS Manual.)

Figure 5(e). This configuration results primarily from the joint action of depressing the lip corners (AU 15) and raising the chin (AU 17). In addition, the lips may be slightly pressed or narrowed, there may be a frown (AU 4), and the muscles around the eyes may contract. Although this configuration is fairly infrequent, especially in infants younger than 2 months of age, the example shown here was not a unique or random occurrence. In the videotapes that we have analyzed so far, we have observed the "horseshoe mouth" unambiguously in three of five infants engaged in social interaction, as well as in a number of infants participating in a visual perception experiment. In each case the same configuration was repeated several different times during the same session.

The actions of AU 15 and AU 17 are synergistic in the sense that the action of raising the chin (AU 17) accentuates the appearance of downturned mouth corners produced by

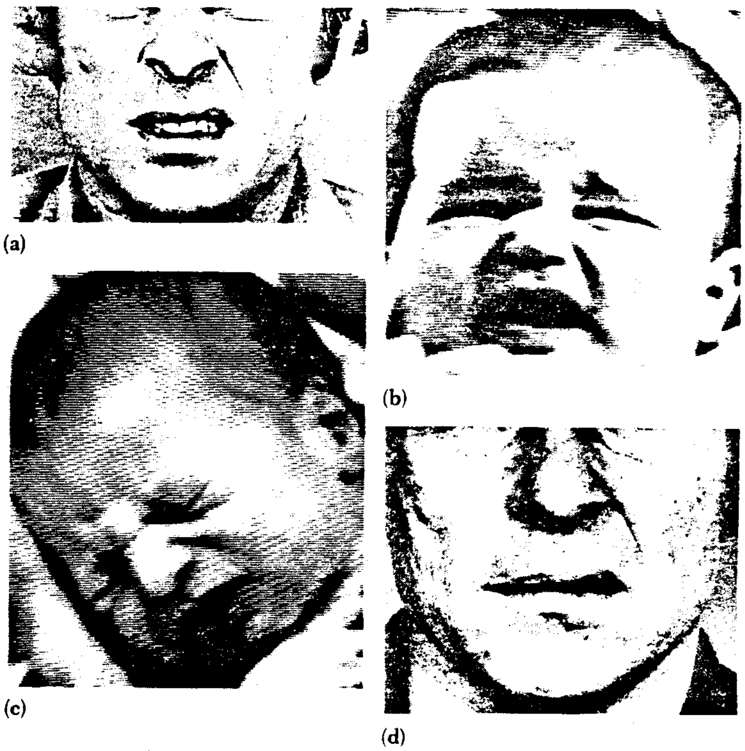


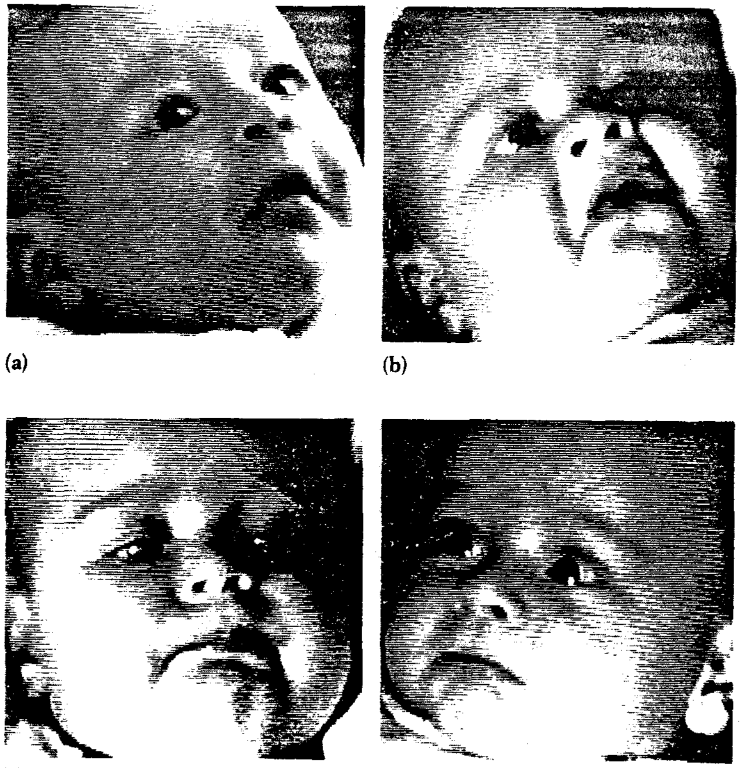
Figure 3. Contrast between two actions that raise the upper lip. (a) AU 9 as illustrated in FACS; (b) AU 9 in a 12-week-old infant who has just tasted a sour lemon-glycerine swab; (c) AU 9 as part of a precry grimace in a week-old preterm infant; (d) unilateral AU 10 as illustrated in FACS; (e) unilateral AU 10 in a 2-day-old. (Figures 3[a] and 3[d] © Eckman & Friesen, 1977, illustration from FACS Manual; Figures 3[b] and 3[c] © Oster, 1977.)

AU 15. This explains the enhanced signal value of the configuration, but its occurrence cannot be explained in purely physical or functional terms. Both AU 15 and AU 17 occur independently and in combination with other actions, as shown in Figures 5(a) through 5(d). The combination seen in Figure 5(c) is clearly more effective in tightly closing the lips than the 15 + 17 configuration. The fact that neither AU 15 nor AU 17 occurs with AU 12 (smiling) also suggests that the distribution of these actions is not random.

Several features of the movement itself further suggest that the horseshoe mouth is not just an accidental combination of muscle actions, like the occasional "winks," "skeptical" brow raises, etc., seen in young infants. The separate actions making up this configuration (which can include five or more AUs) are virtually simultaneous in their onset, which is usually very fast. In their onset, then, the separate AUs behave as a unit. In 2-month-olds the entire configuration may be held for long periods of time—up to 10 sec. (It is usually more fleeting in younger infants.) By comparison, "accidental" configurations, though striking, generally last for only a few frames of videotape. The offset is generally more gradual than the onset, sometimes fading over a period of a minute; some of the individual components may fade more slowly than others. This asymmetry—rapid onset and gradual fading—may be more characteristic of affect expressions than of reflex-like, random discharges.

Thus far we have not found a well-defined elicitor for the horseshoe mouth configuration. The same kinds of social or nonsocial stimuli that produce smiling may on a quite similar occasion evoke a horseshoe mouth. (Some quality of the stimulus—e.g., greater persistence—may turn out to be associated with the configuration, but we must wait to see more examples before speculating further.) The horseshoe mouth is not, however, random with respect to the infant's other behavior. It is accompanied by direct, prolonged, and unbroken visual fixation of the social partner or (in the perception

Figure 4. Three Action Units that give the appearance of downturned lip corners and combinations of these actions, as illustrated in FACS. (a) AU 15; (b) AU 17; (c) AU 10; (d) AU 10 + 15; (e) AU 10 + 17; (f) AU 15 + 17; (g) AU 10 + 15 + 17. (© Ekman & Friesen, 1977, illustration from FACS Manual.)



(a) (b) (c) (d)

(e)

Figure 5. Illustration of the Action Units shown in Figure 4 and some combinations of these in infants. (a) AU 15 in a 3-week-old; (b) AU 10 + 15 in the same infant at 8 weeks; (c) AU 17, plus lip pressing in the same 8-week-old; (d) AU 17 in a 2-week-old; (e) AU 15 + 17, the "horseshoe mouth" configuration, in a 7-week-old. (© Oster, 1977.)

Figure 6. Illustration from FACS of AU 12 + 15, a configuration not yet seen in young infants. (© Ekman & Friesen, 1977, illustration from FACS Manual.)

experiment) the visual target. It is also accompanied by motor quieting. Contrary to what one might expect, it does not precede crying. (In this respect it differs from the "pouting" action produced by raising the chin and protruding the lower lip, which is frequently associated with crying.) Instead, the infant breaks contact or changes expression when there is a change in the stimulus.

We cannot guess at this point the precise meaning of the horseshoe configuration. It is probably safe to say that the specific elicitor is less important as a determinant than the infant's "appraisal" (at least mildly negative) of that elicitor and his or her internal state. (In adults the AU 15 + 17 combination may appear in a sad-angry blend or as a symbolic emblem conveying disbelief or displeasure.)

The horseshoe mouth configuration and the other examples discussed above illustrate the kinds of questions that we are able to address using a fine-grained measurement system. This kind of analysis can be used as a discovery procedure which can then be combined with quantitative analytic techniques—now being developed—and the more conventional methods of functional analysis. We hope that the above examples have illustrated one of the unique advantages of our approach: by observing naturally occurring facial movements in young infants—and by analyzing in detail the precise composition, timing, and sequencing of these movements—one begins to notice behaviors that suggest a richness and complexity of affective and cognitive experience that might not otherwise have been suspected.

References

Allport, F. H. *Social psychology*. Boston: Houghton Mifflin, 1924.

Birdwhistell, R. L. *Kinesics and context*. Philadelphia: University of Pennsylvania Press, 1970.

Blurton-Jones, N. G. Criteria for use in describing facial expressions of children. *Human Biology*, 1971, 43, 365–413.

Bosma, J. F. Form and function in the infant's mouth and pharynx. In J. F. Bosma (Ed.), *Third symposium on oral sensation and perception*. Springfield, Ill.: Charles C Thomas, 1972.

Bosma, J. F. Introduction to the symposium. In J. F. Bosma & J. Showacre (Eds.), *Symposium on development of upper respiratory anatomy and function: Implications for sudden infant death syndrome*. Washington, D. C.: U. S. Government Printing Office, 1975.

Bower, T. G. R. *Development in infancy*. San Francisco: Freeman, 1974.

Bowlby, J. *Attachment and loss*. Vol. 1. *Attachment*. New York: Basic Books, 1969.

Brannigan, C. R., & Humphries, D. A. Human nonverbal behavior, a means of communication. In N. Blurton-Jones (Ed.), *Ethological studies of child behavior*. New York: Cambridge University Press, 1972.

Brazelton, T. B., Tronick, E., Adamson, L., Als, H., & Wise, S. Early mother-infant reciprocity. In *Parent-infant interaction*. Amsterdam: Elsevier Excerpta Medica, 1975.

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

Bruner, J. S. Organization of early skilled action. *Child Development,* 1973, **44**, 1–11.

Charlesworth, W. R. Surprise reactions in congenitally blind and sighted children. National Institute of Mental Health Progress Report, 1970.

Charlesworth, W. R., & Kreutzer, M. A. Facial expressions of infants and children. In P. Ekman (Ed.), *Darwin and facial expression.* New York: Academic Press, 1973.

Cohen, L. B., & Salapatek, P. (Eds.) *Infant perception: From sensation to cognition.* New York: Academic Press, 1975.

Crelin, E. S. *Functional anatomy of the newborn.* New Haven, Conn.: Yale University Press, 1973.

Darwin, C. *Autobiography 1809–1882.* N. Barlow (Ed.). New York: Norton, 1958.

Darwin, C. *The expression of the emotions in man and animals.* Chicago: Phoenix Books, University of Chicago Press, 1965. (Originally published, 1872.)

Duchenne, G. B. [*Physiology of motion.*] E. B. Kaplan (Ed. & Trans.). Philadelphia: Saunders, 1959. (Originally published, 1867.)

Eibl-Eibesfeldt, I. Similarities and differences between cultures in expressive movements. In R. A. Hinde (Ed.), *Non-verbal communication.* New York: Cambridge University Press, 1972.

Eibl-Eibesfeldt, I. The expressive behavior of the deaf-and-blind-born. In M. von Cranach & I. Vine (Eds.), *Social communication and movement.* New York: Academic Press, 1973.

Ekman, P. Cross-cultural studies of facial expression. In P. Ekman (Ed.), *Darwin and facial expression.* New York: Academic Press, 1973.

Ekman, P. Biological and cultural contributions to body and facial movement. In J. Blacking (Ed.), *Anthropology of the body.* New York: Academic Press, 1977. (a)

Ekman, P. Facial signs. In T. Sebeok (Ed.), *New approaches in semiotics.* Bloomington: Indiana University Press, 1977. (b)

Ekman, P., & Friesen, W. V. The repertoire of nonverbal behavior: Categories, origins, usage, and coding. *Semiotica,* 1969, 1, 49–98.

Ekman, P., & Friesen, W. V. Measuring facial movement. *Environmental Psychology and Nonverbal Behavior,* 1976, 1 (1), 56–75.

Ekman, P., & Friesen, W. V. *Manual for the facial action coding system.* Palo Alto, Calif.: Consulting Psychologists Press, in press.

Ekman, P., Friesen, W. V., & Ellsworth, P. *Emotion in the human face*. Elmsford, N. Y.: Pergamon Press, 1972.

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

Enlow, D. H. *The human face: An account of the postnatal growth and development of the craniofacial skeleton*. New York: Harper & Row, 1968.

Fraiberg, S. Intervention in infancy: A program for blind infants. *Journal of the American Academy of Child Psychiatry*, 1971, **10**, 381–405.

Freedman, D. G. Smiling in blind infants and the issue of innate vs. acquired. *Journal of Child Psychology and Psychiatry*, 1964, **5**, 171–184.

Freedman, D. G. Hereditary control of early social behavior. In B. M. Foss (Ed.), *Determinants of infant behavior, III*. London: Methuen, 1965.

Friesen, W. V. Cultural differences in facial expressions in a social situation: An experimental test of the concept of display rules. Unpublished doctoral dissertation, University of California, San Francisco, 1972.

Gasser, R. F. The development of the facial muscles in man. *American Journal of Anatomy*, 1967, **120**, 357–375. (a)

Gasser, R. F. The development of the facial nerve in man. *The Annals of Otology, Rhinology, and Laryngology*, 1967, **76**, 37–56. (b)

Gesell, A. *The embryology of behavior*. New York: Harper & Row, 1945.

Goodenough, F. L. Expression of the emotions in a blind-deaf child. *Journal of Abnormal Social Psychology*, 1932, **27**, 328–333.

Grant, E. C. Human facial expression. *Man*, 1969, 4, 525–536.

Haith, M. M., & Campos, J. J. Human infancy. In *Annual Review of Psychology*. Vol. 28. Palo Alto, Calif.: Annual Reviews, Inc., 1977.

Haviland, J. Individual differences in affect. Paper presented at the biennial meeting of the Society for Research in Child Development, Denver, April 1975. (a)

Haviland, J. Looking smart: The relationship between affect and intelligence in infancy. In M. Lewis (Ed.), *Origins of infant intelligence*. New York: Plenum Press, 1975. (b)

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

Hooker, D. *The prenatal origin of behavior.* Lawrence: University of Kansas Press, 1952.

Hooker, D. *Evidence of prenatal function of the central nervous system in man.* New York: American Museum of Natural History, 1958.

Humphrey, T. Reflex activity in the oral and facial area of the human fetus. In J. F. Bosma (Ed.), *Second symposium on oral sensation and perception.* Springfield, Ill.: Charles C Thomas, 1970.

Humphrey, T. Development of oral and facial motor mechanisms in human fetuses and their relation to craniofacial growth. *Journal of Dental Research Supplement to No. 6,* 1971, **50**, 1428–1441.

Humphrey, T. Central representation of the oral and facial areas of human fetuses. In J. F. Bosma (Ed.), *Third symposium on oral sensation and perception.* Springfield, Ill.: Charles C Thomas, 1972.

Izard, C. E. *The face of emotion.* New York: Appleton-Century-Crofts, 1971.

Kagan, J. Personality, behavior, and temperament. In F. Falkner (Ed.), *Human development.* Philadelphia: Saunders, 1966.

Kagan, J. Discrepancy, temperament, and infant distress. In M. Lewis & L. A. Rosenblum (Eds.), *The origins of fear.* New York: Wiley, 1974.

Klineberg, O. *Social psychology.* New York: Holt, Rinehart & Winston, 1940.

Korner, A. F. Individual differences at birth: Implications for early experience and later development. *American Journal of Orthopsychiatry,* 1971, **41**, 608–619.

LaBarre, W. The cultural basis of emotions and gestures. *Journal of Personality,* 1947, **16**, 49–68.

Leach, E. The influence of cultural context on nonverbal communication in man. In R. A. Hinde (Ed.), *Non-verbal communication.* New York: Cambridge University Press, 1972.

Lewis, M., & Rosenblum, L. A. (Eds.) *The effect of the infant on its caregiver.* New York: Wiley, 1974. (a)

Lewis, M., & Rosenblum, L. A. (Eds.) *The origins of fear.* New York: Wiley, 1974. (b)

Lind, J. (Ed.) *Newborn infant cry.* Uppsala, Sweden: Almqvist & Wiksells, 1965.

Mandler, G. *Mind and emotion.* New York: Wiley, 1975.

McCall, R. Smiling and vocalization in infants as indices of perceptual-cognitive processes. *Merrill-Palmer Quarterly,* 1972, **18**, 341–347.

McGrew, W. C. *An ethological study of children's behavior.* New York: Academic Press, 1972.

Mead, M. Review of *Darwin and facial expression* by P. Ekman. *Journal of Communication*, 1975, **25**, 209–213.

Osofsky, J. Neonatal characteristics and mother-infant interaction in two observational situations. *Child Development*, 1976, **47**, 1138–1147.

Oster, H. Facial expression and affect development. In M. Lewis & L. A. Rosenblum (Eds.), *Affect development*. New York: Plenum, 1978, in press.

Oster, H. Measuring facial movement in infants. In P. Ekman & W. V. Friesen (Eds.), *Analyzing facial action*. New York: Plenum Press, in preparation.

Peiper, A. [*Cerebral function in infancy and childhood*.] B. & H. Nagler (Trans.). New York: Consultants Bureau, 1963. (Originally published, 1961.)

Sander, L. W. Regulation and organization in the early infant-caretaker system. In R. J. Robinson (Ed.), *Brain and early behavior*. New York: Academic Press, 1969.

Seaford, H. W. Facial expression dialect: An example. In A. Kendon, R. M. Harris, & M. Ritchie Key (Eds.), *Organization of behavior in face-to-face interaction*. The Hague: Mouton, 1975.

Sroufe, L. A. The ontogenesis of emotion. In J. Osofsky (Ed.), *Handbook of infancy*, New York: John Wiley, 1978, in press.

Sroufe, L. A., & Mitchell, P. Emotional development. In J. Osofsky (Ed.), *Handbook of infancy*. New York: John Wiley, 1978, in press.

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

Stark, R. E., & Nathanson, S. N. Spontaneous cry in the newborn infant: Sounds and facial gestures. In J. F. Bosma (Ed.), *Fourth symposium on oral sensation and perception*. (DHEW Publication No. [NIH] 73-546) Bethesda, Md.: U. S. Department of Health, Education, and Welfare, 1973.

Steiner, J. E. The gustofacial response: Observation on normal and anencephalic newborn infants. In J. F. Bosma (Ed.), *Fourth symposium on oral sensation and perception*. (DHEW Publication No. [NIH] 73-546) Bethesda, Md.: U. S. Department of Health, Education, and Welfare, 1973.

Tomkins, S. S. *Affect, imagery, consciousness*. Vol. 1. *The positive affects*. New York: Springer, 1962.

Vine, I. The role of facial-visual signalling in early social development. In M. von Cranach & I. Vine (Eds.), *Social communication and movement*. New York: Academic Press, 1973.

Wasz-Hockert, O., Lind, J., Vuorenkoski, V., Partanen, T., & Valanne, E. *The infant cry: A spectrographic and auditory analysis*. Clinics in Developmental Medicine No. 29, Spastics International Medical Publications. London: Heinemann, 1968.

Wolff, P. H. Observations on the early development of smiling. In B. M. Foss (Ed.), *Determinants of infant behavior II*. New York: Wiley, 1963.

Wolff, P. H. The natural history of crying and other vocalizations in early infancy. In B. M. Foss (Ed.), *Determinants of infant behavior IV*. London: Methuen, 1969.

Young, G., & Decarie, T. G. An ethology-based catalogue of facial-vocal behaviour in infancy. *Animal Behaviour*, 1977, 25(1), 95–107.

Zelazo, P. Smiling and vocalizing: A cognitive emphasis. *Merrill-Palmer Quarterly*, 1972, 18, 349–365.