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WHY FACES ARE SPECIAL TO INFANTS - ON CONNECTING THE ATTRACTION OF FACES AND INFANTS' ABILITY FOR IMITATION AND CROSS-MODAL PROCESSING

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ABSTRACT. There is more to faces than meets the eye. Infants can see the faces of others, but can also feel their own faces move. We propose a *cross-modal* hypothesis about why faces are attractive and meaningful to infants. According to this view, faces are attention-getting in part because they look like infants' own felt experiences. This cross-modal correspondence drives not only visual attention but also action. Infants produce facial acts they see others perform. We here report an experiment on the efficacy of mothers versus strangers in eliciting facial imitation. The development of imitation is also investigated. The results show that there is no disappearance or "drop out" of imitation in early infancy; however, infants develop social expectations about face-to-face interaction that sometimes supersede imitation. Special procedures are required to motivate imitative responding in the 2- to 3-month age range. A theory is proposed about the motivation and functional significance of early facial imitation. According to this theory early imitation subserves a social identity function. Infants treat the facial behaviors of people as identifiers of who they are and use imitative reenactments as a means of verifying the identity of people. Facial imitation and the neural bases of the multimodal representation of faces provide interesting problems in developmental cognitive neuroscience.

1. An Hypothesis

The idea developed in this chapter is that faces are special and meaningful to infants in part because infants experience their own faces through proprioception. The visual pattern provided by a face can be assimilated to infants' own felt experiences. On this view, the human newborn, fresh from the womb, has already had months of experience with faces. Young infants may prefer to look at faces, in part, because faces are familiar; infants may accord privileged status to faces because they are seen to be "like me." It is the psychological resonance between the face that is seen and the face that is felt that makes human faces so meaningful to infants.

This idea has not been given serious consideration in the past 30 years of research on the development of face perception. Virtually all previous research has analyzed the face as a visual pattern and has inquired as to what makes this optical input so attention-getting (for excellent reviews see: Flin & Dziurawiec, 1989; Maurer, 1985; Johnson & Morton, 1991; Ellis & Young, 1989). When considered as purely an optical pattern, faces are, of course, completely novel to

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the newborn. Infants will not have seen faces in the womb. What is a newborn to make of this novel visual pattern? This intriguing question has motivated dozens of studies. However, this may miss an essential ingredient of what makes faces meaningful to infants. Faces are not just optical patterns. What really makes faces special and meaningful to infants is that they look like what the infants feel themselves to be. For faces, but not for inanimate objects such as rattles, checkerboards, or swaying trees, there is a cross-modal equivalence between the visual pattern of the adult and the proprioceptive pattern of the self. From everything that is known about infants, this cross-modal match would be a very visually and cognitively engaging stimulus. Seeing a real, 3-d moving human face is the infants first "Aha" experience.

This does not exclude the possibility that there is an innate face detector based on visual specifications. Such an innate device has been discussed by Johnson and Morton, who claim that the innate visual template consists of "three-blobs" in a rough triangle, which they call Conspec (Johnson & Morton, 1991; Morton & Johnson, 1991; Johnson, Dziurawiec, Ellis, Morton, 1991). Nor does it exclude the possibility that for the youngest infants, facial patterns provide particularly salient visual signals for psychophysical reasons (e.g., their stimulus energy as measured by amplitude spectra), as championed by Kleiner (1987) and Kleiner and Banks (1987) and others. We here introduce a third reason why faces are special, which we call the "cross-modal" hypothesis. This hypothesis supplements rather than replaces the Johnson-Morton "Conspec" and Kleiner-Banks "sensory" hypotheses. The thesis is that infants' self-produced movements provide a framework for interpreting the facial movements they see. Feeling one's own face movements infuses the seen face with special meaning.

When one begins to think about faces as cross-modal stimuli and contemplate their meaning and social significance to infants, one becomes interested not only in visual discrimination but the control of actions and interpersonal communication based on these perceptions. Our approach has been to examine infant imitation of facial gestures. To imitate, infants must visually resolve this facial gesture and transduce the visual input into motor terms. If the imitation is delayed, then the memory and representation of facial actions comes into play. One can investigate developmental changes in facial imitation as well as differences in imitation of mothers versus strangers, with implications for the social significance of the behavior. We here integrate several new experiments of early facial imitation and situate the phenomenon within a broader psychological framework than has traditionally been offered. We show how early facial imitation can inform our theories of face and person perception and provide a glimpse of early social-cognition.

2. Early Facial Imitation: Existence and Mechanism

Over the past 15 years there has been a radical revision in our understanding of infant facial imitation. Standard developmental theories had considered the imitation of facial actions to be a milestone in social-cognitive development that was first passed at about 1 year of age (Piaget, 1962). Although other types of imitation, notably hand movements and vocal imitation, was said to occur earlier, facial imitation was classically viewed as a late achievement because infants cannot see their own faces. If infants are young enough they will never have seen their own face in a mirror. How can infants possibly match a gesture they see with an action of their own that they cannot see? How could they connect seen faces with their own unseen face? Because this question is so baffling for developmental theory, researchers for many years were content with the analysis that facial imitation first became possible at about 1 year and depended on learning experiences such as visual exploration of the self in a mirror and exploration of one's own and another's face by hand. These learning experiences were thought to be necessary to bring the faces of self and others into the same framework.

2.1. INFANTS IMITATE WITH SPECIFICITY AND TEMPORAL FLEXIBILITY

Meltzoff and Moore's (1977) report that 12- to 21-day-old infants imitated tongue protrusion, mouth opening, and lip protrusion came as a surprise to the developmental scientists (Figure 1). It was not just the existence of facial matching, but the specificity of the response and our proposal that cross-modal matching was involved that drew attention.

Figure 1. Sample photographs showing 12- to 21-day-old infants imitating facial acts. (Reprinted with permission from Meltzoff & Moore, 1977, Science, 198, 75-78.)

The experiment was designed to assess the specificity of the imitative effect and distinguish it from a global arousal response. We reasoned that if infants were simply being aroused by a human facial pattern (but could not imitate), they might make more oral movements when they saw a human face than when they saw no face at all. This certainly would not support the inference of imitation. In our work, the specificity of the imitative behavior was demonstrated because infants responded differentially to two types of lip movements (mouth opening vs. lip protrusion) and two types of protrusion actions (lip protrusion vs. tongue protrusion). The results showed that when the body part was controlled - when lips were used to perform two subtly different movements - infants responded differentially. Likewise, when the same general movement pattern was demonstrated (protrusion) but with two different body parts (lip vs. tongue protrusion), they also responded differentially. The response was not a global arousal reaction to a human face, because the same face at the same distance moving at the same rate was used in all of these conditions. Yet the infants responded differentially.

Another issue concerned the level of "automaticity" of the imitative reaction. If imitation were a simple reflex, it might fall to chance if a delay was inserted between stimulus and response. To address this point, a pacifier was put in infants' mouths as they watched the display so that they could observe the adult demonstration but not duplicate the gestures on-line. The pacifier was effective in disrupting imitation while the adult was demonstrating; the neonatal sucking reflex was activated and infants did not tend to push the pacifier out with their tongues or open their mouths and let it fall out. However, when the pacifier was removed, and the *E* presented only a passive face, the infants initiated imitation of the now-absent displays. The finding suggested that even this very early imitation could be mediated by memory for facial acts (Meltzoff & Moore, 1977; Meltzoff & Moore, 1989).

2.2. NEWBORN IMITATION AND INDEPENDENT REPLICATIONS

The subjects in the 1977 experiments were 12 to 21 days old. Perhaps they had been trained to imitate during the first weeks of life. Meltzoff and Moore (1983) next tested 40 newborns (M = 32 hr). The youngest infant was 42 minutes old. The results showed that the newborns imitated both mouth opening and tongue protrusion. This result was replicated and extended in a second study (M = 41 hr) using a non-oral gesture (Meltzoff & Moore, 1989). We can infer that a primitive capacity to imitate is part of the normal child's birthright.

Early facial imitation has now been replicated and broadened in well over 20 different studies. It has been demonstrated cross-culturally: positive results have been reported in the U.S., Canada, France, Switzerland, Sweden, Israel, and even rural Nepal (e.g., Abravanel & Sigafoos, 1984; Field, Woodson, Greenberg, & Cohen, 1982; Fontaine, 1984; Heimann, Nelson, & Schaller, 1989; Kaitz, Meschulach-Sarfaty, Auerbach, & Eidelman, 1988; Legerstee, 1991; Reissland, 1988; Vinter, 1986). In short, the phenomenon reported by Meltzoff and Moore has been documented by numerous independent investigators, in different settings, using a variety of procedures. At a purely behavioral level, the effect is secure: Infants do duplicate certain adult gestures. The behavior is visible, but the underlying mechanism is not. How shall we characterize this reaction?

2.3. CROSS-MODAL MECHANISM

The hypothesis suggested by Meltzoff and Moore was that imitation is based on infants' capacity to register equivalences between the body transformations they see and the body transformations they only feel themselves make. In this view, although the infant's own facial gestures are invisible to them, they are not unperceived, for even unseen body movements can be monitored by proprioception. We proposed that information about facial acts is fed into the same representational code regardless of whether those body transformations are seen or felt. There is a "supramodal" network that unites body acts within a common framework. The development and neural bases for such a cross-modal representation of the face is a pressing issue for developmental neuroscience (Damasio, Tranel, & Damasio, 1990; de Schonen, 1989; de Schonen & Mathivet, 1989; Desimone, Albright, Gross, & Bruce, 1984; Gross & Rodman, this volume; Perrett, Mistlin, & Chitty, 1987; Stein & Meredith, in press). Our hypothesis is that neonatal imitation is mediated by an active intermodal mapping (AIM) process in which the equivalence between the facial acts seen and done is taken into account.

In 1977, the notion that neonates could detect and utilize cross-modal equivalences was considered even more surprising than the fact that infants duplicated facial gestures (but see Bower, 1974). Over the past 15 years this notion has garnered considerable empirical support. Several lines of work indicate that cross-modal processing is available to young infants (see Meltzoff, Kuhl, & Moore, 1991 for a review). For example, we have shown that 1-month-olds can detect tactual-visual equivalences (Meltzoff & Borton, 1979). That is, they can recognize the equivalence between objects that are felt in their mouths and the subsequent visual presentations of those objects - a finding replicated and broadened by Gibson and Walker (1984). We have also shown that young infants recognize the correspondence between facial movements and speech sounds (Kuhl & Meltzoff, 1982, 1984, 1988),which was replicated and nicely extended by both MacKain, Studdert-Kennedy, Spieker, and Stern (1983) and Walton and Bower (in press). Young infants do not relate facial articulatory movements to *non*speech sounds (Kuhl, Williams, & Meltzoff, 1991), indicating a privileged link between face and speech in early infancy.

3. Exploring the Function and Development of Facial Imitation

3.1. MOTHERS, STRANGERS, AND MOVEMENT PATTERNS

The question immediately arose as to whether young infants would differentially imitate mothers versus strangers. It has been demonstrated that infants only a few days old can discriminate their own mothers from a stranger (Bushnell, Sai, & Mullin, 1989; Field, Cohen, Garcia, & Greenberg, 1984; Pascalis, Deruelle, Fabre-Grenet, de Schonen, Morton, & Johnson, 1992; Walton, Bower, & Bower, 1992). Does facial recognition relate to facial imitation? On purely a priori grounds it might be predicted that infants would imitate the familiar face, the affectively-laden mother, with greater facility than a complete stranger. The opposite view could also be developed: Infants might be more interested in exploring the behavioral properties of the unfamiliar face. We also wanted to know about the role of kinetic facial patterns in imitation. Is there any evidence that 6-week-old infants can mimic static facial *forms* in addition to the dynamic gestures that are usually presented?

To address both these issues Meltzoff and Moore (1992) tested 32 6-week-old infants. Each infant was exposed to two facial gestures, mouth opening (MO) and tongue protrusion (TP). Each infant was exposed to two actors, mother and stranger. For any given infant, one of the actors (mother or stranger) demonstrated one type of gesture, and the other actor demonstrated the other gesture, so there would be no confusion about which gesture went with which person. Each actor presented the specified gesture in both movement formats - as a dynamic gesture (e.g., the mouth was opened and closed at a prescribed rate) and as a static gesture (e.g., the mouth was simply held open).

The overall repeated-measures results provided strong evidence for imitation. It is also of interest to consider the first trial data in which the infants saw the stranger (n = 16) or mother (n = 16) demonstrating these facial displays for the first time. The procedure had ensured that a research assistant had handled the child up to this point, and so the stranger (a male) was genuinely a novel person for the infant. Somewhat surprisingly, the results showed that there was no difference in imitation according to who was the model. The frequency of tongue protrusion was greater to the TP demonstration than to the MO demonstration in the case that the mother served as model (M = 6.50 vs. 3.75); this was also true in the case that the stranger served as the model (M = 7.00 vs. 4.00). Parallel analyses were also conducted using the measures of mouth-opening, and again no difference as a function of who served as model emerged.

Evidently, for infants in this young age group, imitating requires no special relationship or attachment to the person or even perceptual familiarity with the person's face. This is true despite the fact that infants by this age can discriminate their own mother from a stranger (Bushnell et al., 1989; Field et al., 1984; Pascalis, et al., 1992; Walton, et al., 1992). The basis of early imitation lies in stimulus attributes that are shared by both familiar maternal faces and a novel male face. However, familiarity and especially the shared interactive experience with a familiar person will influence how imitation is deployed at some point in infancy. An experiment with 2- to 3-month olds provided data illuminating the role of social experience on imitation, as described later.

Analyses were also performed to examine the effects of facial movement. The results showed that infants imitated the moving gestures, as expected, but also provided evidence that infants at this age could imitate static postures. Moreover, the results showed that infants mimicked the temporal aspects of the display. They responded to the MOstatic display with extraordinarily long mouth-opening durations. On average, the duration of infant mouth opening to MOstatic was 14.66 s, which was more than twice that to the MOdynamic display (M = 5.24 s) and almost four times that to either the TPstatic or TPdynamic demonstrations (3.75 and 3.86 s, respectively). The findings document that infants are sensitive to both the structural and temporal aspects of facial gestures. (a) The finding that MOstatic elicited longer infant mouth opening than TPstatic demonstrates that different facial postures can specify different actions. (b) Conversely, temporal parameters are not wholly ignored by the young infant. When the class of gestural acts is controlled, infants produced significantly longer mouth opening to one kind of adult MO (MOstatic) than the other kind (MOdynamic). A differentiation between such closely related displays, two different types of mouth openings, is neither predicted by nor compatible with the notion of early imitation as a simple, global reflex (Meltzoff & Moore, 1992).

3.2. DOES EARLY IMITATION DROP OUT OR DISAPPEAR? NEW FINDINGS

It is sometimes reported that neonatal imitation exists, but then disappears or declines at approximately 2 to 3 months of age (Abravanel & Sigafoos, 1984; Fontaine, 1984; Maratos, 1982). The most common interpretation of these data is that newborn imitation is based on simple reflexes that are inhibited with a cortical take over of motor actions, and therefore imitation "drops out." To address the drop out issue, we tested 16 infants between 2 to 3 months of age using the same design as described in the previous section (Meltzoff & Moore, 1992). The overall results yielded strong evidence for imitation at this age; however, these infants gave no sign of imitating the adult gestures in the first trials alone. This pattern of results does not comport with the traditional

interpretation of imitative drop out, because the same children who did not imitate on first encounter, successfully imitated when measured across all four trials. What is going on?

We think the previously reported decline in imitation is attributable to *social* reasons, infants growing expectations about people in face-to-face interactions. When these older infants first encountered the adult, they initiated social overtures as if to engage in a nonverbal interchange. This behavior supplanted any first-trial imitation effects. After the initial social gestures failed to get a response (by experimental design), infants settled down and engaged in imitation. A prime difference from past studies reporting drop out is that we presented the gestures in a time-locked manner, rather than having them be contingent on infants' behavior. This format probably helped to shift the older infants away from interpreting the situation as a routinized interactive game (e.g., smiling, cooing, greeting), which typically have a "give and take" contingent aspect. In addition, the design helped specify for the infant the category of adult behavior that was being demonstrated. Exemplar variation can aid infants' extraction of the stimulus invariant (Cohen & Strauss, 1979; Kuhl, 1983). All the studies reporting imitative drop out used repetitions of a single type of act with no variation. The current design provided within-category variation (both static and dynamic exemplars). Simultaneously, it highlighted intercategory differences (person-1 performed one type of gesture and the second person performed the other gesture). One person was connected with one of the gestural games and a second person with a different game, which should lessen confusion in a repeated-measures approach.

We are thus suggesting that for older infants social games are higher on the older infant's response hierarchy than is simple imitation. Hence the apparent drop out. It is not that the older infants are not capable of imitation; rather, it is that they have expectations about a human encounter that are different from the newborn's. If we modify the typical designs, we can find imitation among older infants. The previously-reported drop out is not due to a fundamental loss of imitative competence but to social and motivational factors that mask competence.

4. Using Facial Imitation to Investigate Early Cognition

4.1. MEMORY FOR FACIAL ACTS

The principal rationale for the next experiment was to test whether young infants could imitate from memory over a 24-hr delay interval. Deferred imitation would indicate a long-term memory of the facial actions of people. Such memory is a factor in interpersonal communication and to developing attachments to specific people, but has not been investigated at this age in any previous work. A test of memory-based imitation also influences how we think about the "sensorimotor" period and brings infant cognition into the picture. Facial imitation from memory would mean that infants could use a part of their body that they had never seen to match a target that was no longer visible. Such behavior would be far removed from the kind of sensory-based, stimulus-driven behavior often associated with early infancy.

Meltzoff & Moore (in press) tested 6-week-old infants on three consecutive days. Each infant was randomly assigned to one of four groups, in which the E

demonstrated either: no oral movement (NOM), mouth opening (MO), tongue protrusion at midline (TPmid), or tongue-protrusion-to-the-side (TPside). The NOM group served as a control for the repeated exposure to the same adult face. In this group, the *E* simply presented the neutral facial expression on each of the three visits. In the other three experimental groups the *E* demonstrated the target gesture on day 1 (a 90-s trial). Day 2 began with a 90-s memory trial in which the adult simply exhibited a neutral face pose for 90 s. This provided infants with a kind of "projective test" to see if they recalled what the adult had done the day before. This was followed by the 90-s demonstration period, in which infants were once again shown the specific facial target gestures. Day 3 was identical to Day 2.

As might be expected, the results for the immediate imitation trials provided evidence for facial imitation. The memory trials provide new information about the ability of infants to retain and mimic facial acts. In the memory trials the face that was perceptually present was the same for all infants regardless of group. Infants differed only according to what they had seen the stranger's face do on the previous day. The results showed a significant effect of memory of facial actions. Infants who were viewing the *E*'s neutral face but who had seen that adult showing tongue protrusions the day before (TPmid and TPside), produced significantly more tongue protrusions than infants who had not seen the tongue protrusions (NOM, MO), $t(38) = 3.35, p < .005$. Similarly, infants who had seen the adult showing mouth openings (MO) the day before produced more mouth opening than those who had not seen the mouth openings (NOM, TPmid TPside), $t(38) = 2.06, p < .05$. This is the first experimental demonstration in infants of this age of a *recall* for facial acts after a significant delay. The reflexive model cannot explain these data. The information on which such imitation is based is not in the stimulus; it is represented in the infant's mind.

4.2. MOTOR CONTROL AND CORRECTING IMITATION: TO ERR IS HUMAN

The results also provided information about the temporal organization and morphology of the imitative response. The types of infant tongue protrusions were subdivided into four different levels that bore an ordinal relationship according to their fidelity to the TPside display. Statistical analyses showed that over the 3-day study there was an orderly progression from level-1 to level-4 behavior for those infants who had seen the TPside display. This was not the result of a general arousal because infants in the other three groups, including the TPmid group, did not show any such progression. A similar convergence towards the MO target was found for the mouth opening response.

These findings of infants homing-in on the target fit with the mechanism of early imitation suggested by Meltzoff and Moore's AIM proposal. The core notion is that early imitation is a matching-to-target process. The gradual correction in the infants' response supports the idea of active matching to target. While the AIM hypothesis highlights error detection and correction in the motor control of early imitation, it does not rule out visual-motor mapping of elementary acts on "first try," without the need for feedback. There may be a delimited set of primitive acts (midline tongue protrusion?) that are achieved with little need of feedback, while other more complex acts involve the computation of transformations on these primitives (e.g., TPside) and proportionately more proprioceptive monitoring. Infants cannot have templates for each of the numerous transformations that different body parts may be put through. In fact, the results demonstrated that infants did not immediately trigger accurate imitations of the novel TPside behavior; they needed to correct their behavior to achieve it.

5. Why Do Infants Imitate ? On Linking Face, Imitation, and the Identity of Persons

We can now offer some ideas about the meaning, motivation, and social significance of early facial imitation. Imitation has multiple determinates (Meltzoff & Moore, 1983, 1985, 1989, 1992), but here we will focus on one motivation to imitate that we call the *social identity function*. It has special bearing on how imitation and face perception are embedded within infant cognition. According to the identity function notion, imitation is a procedure infants use in re-identifying particular people after a break in perceptual contact. To get a better idea about how imitation fulfills such an identity function, recall the experiment in which two people, the stranger and the mother, appeared and disappeared in front of the infant as they presented gestures in the course of the study.

We found that the way that these people appeared and disappeared was critically important. When, for example, the adults changed places when the infant was *not* looking, the infant paused to inspect the new person, and then, often with furrowed brows, intently performed a burst of the actions shown by the *previous* person. We might have an infant who had been watching his mother showing the mouth opening gesture. The mother surreptitiously leaves the test chamber, and the (male) stranger appears before the infant and shows tongue protrusion. When the infant sees the new adult he or she will stop acting, look at the face, and then perform an intensive bout of the previous person's gesture. What can account for this? Surely, the infant can visually discriminate the male stranger from the mother. Why should the infant produce the old person's gesture and not be driven by the gesture in current view?

In contemplating this curious pattern of behavior we found it useful to consider two interrelated ideas: (a) First, infants do not have a fully developed system for maintaining the identity of people over breaks in perceptual contact. (b) Second, infants use actions, as part of assimilating, knowing, or probing the identity of persons they see.

The first point concerns infants' rules for maintaining identity across disappearance transformations. It concerns their criteria for determining whether an object or person seen at one time is "the same as" the one seen at another time. The kind of sameness or identity we are speaking about here is what philosophers call "particular" or "numerical" identity (Strawson, 1959), and we elsewhere have called "unique identity" when discussing the development of the "object concept" in infants (Moore & Meltzoff, 1978). By what rules do we re-identify a particular object (as being the same one again) after an interruption in perception? Featural similarity alone is no guarantee as to the underlying unique identity of objects. Two encounters may look the same and be of *different* objects; conversely they may appear different and yet be of the *same* object. The unique identity of objects and people thus is not wholly reducible to featural sameness. Consider the following cases. Two featurally identical rattles can be different objects although they share all featural characteristics (they are replicas); conversely a person turning in profile or donning a kerchief is the self-same person. It would be a common experience for infants to have the features of people change, sometimes quite radically, during one continuous viewing of them (a face turning in profile or a mother leaning down over a bassinet such that her hair falls over her brow and covers her eyes). Is the mother to become a series of different people as she leans over the baby and is featurally altered? A featural analysis itself cannot be the *sole* criterion infants use for determining unique identity.

Michotte (1962) discovered that if a figure stays in a place and is transmuted into a different form, even adults are ambiguous as to whether it is the same object with transformed features or a different object in the same place. Under these circumstances adults often tend to treat it as the same object, even though they report it looks very different. Spatiotemporal rules like object location and trajectory of motion are critically important for weighing the identity of an object, and sometimes override purely featural characteristics for both adults (as in Michotte's examples) and infants (as in several experiments in the "object concept" literature [Bower, 1982; Moore, Borton, & Darby, 1978; Moore & Meltzoff, 1978; Piaget, 1954]). It is thus understandable that infants can be confused about the unique identity of persons in a multi-person situation involving appearance and disappearance, especially if they have not visually tracked the exchange.

What action might infants take to clarify an ambiguity such as: "This face does not *look* like mom, but I didn't see mom leave, and this face is in the same place. Is this my mother?" We propose that infants use facial gestures to clarify ambiguities about the identity of persons. If infants have a question about the unique identity of a new person that is perceptually present, they will be motivated to test whether this person has the same behavioral properties as the old one, whether it acts the same, *because the body-actions and expressive behavioral properties of persons are identifiers of who a person is*. It is not only how a person looks, but how a person acts and what games they afford (to adapt a Gibsonian, 1979, term) that helps to verify their identity. We are thus suggesting that one function of facial imitation for infants is to clarify who it is in front of them.

There are two puzzling findings that this approach helps to explain - one in which infants do not imitate when most theories predict they should, and the other in which they do imitate when theories predict they should not. (a) Infants who did not visually follow the exchange of people in the mother-stranger experiment duplicated the previous person's act instead of the facial gesture that was visually present (Meltzoff & Moore, 1992). Why isn't there imitation of the perceptually present stimulus? (b) Infants imitated yesterday's display when the *E* appeared after a 24-hr delay and presented only a neutral face (Meltzoff & Moore, in press). Why is there re-enactment of yesterday's behavior if the perceptually present adult is doing nothing?

This functional use of imitation helps us understand why the infants who did not see the switch in demonstrator were intent on duplicating the absent person's gesture. The identity of the person in front of the infant was indeterminate, and they were using the person's gestural games to help sort out this ambiguity. When the conditions were modified such that infants tracked the switching of the people (so that both spatiotemporal and featural criteria were in concordance that this was a wholly different person), then infants imitated each person in turn with no confusion (Meltzoff & Moore, 1992).

In the case of deferred imitation, the infant has seen a person show a tongue protrusion gesture. Twenty-four hours later a person who looks featurally the same is encountered in the same place/context, but this time with a neutral face. We believe the most salient problem raised by this social encounter for the 6-week-old is one of the identity of the person. Is this the self-same person acting differently or a fundamentally different person who looks the same? The suggestion is that infants deploy imitation to help resolve this question. Thus, we predict that situations posing identity questions will be ones that are especially effective in motivating gestural re-enactments, a prediction that has been borne out in a variety of ongoing tests in our laboratory, besides the ones discussed here. In brief, infants do not exclusively identify people by their visual features; they also use behavioral-interactive characteristics to identify them.

6. Conclusions: There Is More To Faces Than Meets The Eye

Faces capture infant attention. Two prominent hypotheses have been proposed to account for this phenomenon. The Kleiner-Banks "sensory hypothesis" holds that faces have certain psychophysical characteristics (their stimulus energy as measured by amplitude spectra) that command visual attention quite apart from stimulus meaning per se. The alternative "innate face template" or Conspec hypothesis advanced by Johnson-Morton holds that humans have evolved to recognize a visual sketch of their conspecifics, which may be as simple as "three blobs" in the eyes-mouth arrangement. Both these views emphasize the visual parameters of the face. We have suggested a new view, the "cross-modal" hypothesis. On this view visual attention can be driven by information picked up in a nonvisual sense modality. It is not only the characteristics of the visual input, but its relation to other information, both in perception and memory, that recruits attention to faces and infuses faces with special meaning to the infant.

We typically think that newborns are naive to all face information. This probably is not valid. The mother's face may be the first one they see; however, it is not the first one they experience. Infants have experience with the nonvisual sense of their own bodies, its movements and possibilities. They have this experience with their own facial movements both pre- and postnatally. The brain is not an exclusively visual outpost; it records experience from all the senses. In the case of infant face perception, we hypothesize that the seen face is related to the felt face. On this view, the representation of face is not unimodal (visual) but multimodal with consequences for visual attention.

We have provided two sorts of data that bear on this hypothesis, one from cross-modal experiments and the other from experiments on facial imitation. First, we have shown that infant visual attention is driven by information picked up in other modalities. Meltzoff and Borton (1979) showed that tactual experience influenced visual attention to objects; in particular, infants preferred to look at a shape that they had orally explored but had not yet seen. In the domain of faces, Kuhl and Meltzoff (1982) found that infants would preferentially look at a face that was moving in a way that matched a speech sound they heard. Thus if an /a/ vowel was played midway between two faces, one of which was articulating /a/, the other /i/ (both in perfect temporal synchrony with the mouth movements), infants would look longer at the face that matched the speech sound. This research and other findings in the developmental literature suggest that infants are not confined to processing unimodal, sense-specific information. Whereas Piaget (1954) proposed that there was an uncoordinated "visual space," an "auditory space," and a "tactile space" until late in infancy, the evidence now suggests that the infant can relate information from multiple modalities.

Imitation provides even more direct and concrete evidence bearing on whether infants can relate the seen face to the felt face. In the case of facial imitation infants can see the adult's face, but cannot see their own. If they are young enough they will never have seen their own face in a mirror. Yet, when the adult performs tongue protrusion, the infant does so; if the adult shows mouth opening the infant responds in turn; and so on for a variety of gestures. We documented facial imitation in newborn infants as young as 42 minutes old (Meltzoff & Moore, 1983, 1989). Many independent replications have been reported; there are more than 20 studies confirming early facial imitation. The behavior exists, but what mechanism underlies it? If, as we claim, infant imitation is mediated by an active intermodal mapping process (AIM), then infants are relating the seen face of another to their own felt but unseen face.

Three experimental outcomes support the AIM hypothesis. First, infants not only imitate one gesture, but a range of facial acts (Meltzoff & Moore, 1989, 1992, in press). Separate hard-wired IRMs (Innate Releasing Mechanisms) become extremely posthoc and unwieldy. It seems especially unlikely that novel gestures such as "tongue-protrusion-to-the-side" would be specified as an innate template, and yet infants mimic this act. Similarly they mimicked the temporal aspects of the display. Some more generative matching mechanism is desirable. Second, the response could have looked automatic and triggered, but no one studying the effect has reported this character. We have documented that infants correct their responses over successive efforts (Meltzoff & Moore, in press). This implies some sort of active error detection and cross-modal guidance to target. Third, infants have been shown to imitate when there is no sign stimulus present. When they re-encounter a person who had once shown them tongue protrusion, but now presents only a neutral face pose after a 24-hr delay, infants are prompted to imitate yesterday's gesture. This facial act is not in the perceptual field to "trigger" the response; it is represented in the infant's mind. Evidently, the faces infants see are remembered and can be used to drive motor action at a later point in time. There is more to faces than meets the eye. Faces are not only seen, they are felt. Moreover, the actions of faces are committed to long-term memory. The infant is not only multimodal, but representational as well.

However, constructing representations and memories of particular faces comes at a cost. If I remember seeing a face and currently see a face, the question can arise as to the relationship between these faces. Is it "the same" face? How could you verify whether things seen at two different times are really one and the same thing, the same unique identity? This is not purely a matter of visual feature analysis, because two things can look precisely the same and be different entities (two rattle replicas), or look different and really be the same underlying thing (a face as it turns in profile, or is visually altered by hair falling over it). For real 3-d faces moving about in the world, we think that infants are deeply motivated by basic problems such as: "Is this my mother?" "Is this the person I encountered before, or a new stranger?" "Do I know you?"

It is here that facial acts and imitation play a special role. Our hypothesis is that young infants not only identify and remember people by their visual features, but also by their actions. The facial actions and expressive behaviors of people are important, perhaps of equal importance, as a visual feature analysis, for confirming who they are. We believe that infants use imitative reenactments of the other's gestures to probe whether this is the same person they saw before.

Imitation thus is a channel not only for exploring infant's reactions to a face, but a way for us to explore their understanding of *persons* - where persons are thought of as reidentifiable particular others. The growth of genuine love and infant attachments depend crucially on such a construction of person, and we believe it is one of the infant's prime cognitive concerns. Thus the examination of face perception leads to the psychology of faces and eventually to the representation of persons.

7. References

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