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TARGET ARTICLE

Origins of Self-Perception in Infancy

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Most accounts of the origins of the self-concept in humans rely on the mirror self-recognition (rouge removal) task whereby the infant is credited with self-awareness at about 15 months, once it is able to use the mirror reflection to locate a dab of rouge on the nose. But mirror self-recognition may require relatively advanced cognitive abilities and may reveal relatively little about the ontogenetic origins of self-knowledge.

The aim of this article is to consider the antecedents of self-knowledge in processes of sensory perception during infancy. J. J. Gibson's ecological approach to sensory perception asserts that there is information for the distinction between self and nonself inherent in perception. Evidence from human infants who are too young to recognize themselves in mirrors is reviewed for a sensory perceptual basis for the existential self (the I) and for the categorical self (the me) in William James's terminology. Studies of the visual proprioceptive control of posture in babies may be interpreted to support an inherent distinction between self and nonself in infant perception, rather than the traditional account of an "adualistic confusion." Similarly, various aspects of bodily self-awareness manifested even by fetuses demonstrate some basis for a categorical self as an original aspect of experience. Self-specification in perception is also indicated in recent research on imitation in very young infants, a possible mechanism for the essentially social component of self-concept development.

Although a case for early self-specification in perception can readily be made, it is much more difficult to explain how self-perception gives rise to self-conception. One possibility briefly discussed is that a process of representation and re-representation of information originally obtained through interaction with physical and social objects gives rise to reflective self-awareness and the particularly autobiographical knowledge of self which we take to be species-typical of humans.

James Gibson's (1966, 1979) theory of direct perception offers some new ways of approaching fundamental issues in the development of self and raises the question of whether the self-concept may have its roots in processes of sensory perception. His ecological approach is founded on the premise that perception has two poles, subjective and objective, specified in terms of the variant and invariant properties of sensory stimulation. Invariant properties correspond to the unchanging aspects of the environment, whereas an important subset of the variants of stimulation have subjective reference, because they are transformations of sensory stimulation that occur as a consequence of the observer's movement. The inherent "duality" of sensory stimulation implies that there is information for the distinction between self and nonself inherent in perception.

This article explores the evidence for and implications of this approach to human infant perception for our understanding of the origins of self-knowledge. It distinguishes between two aspects of self: the existential self or *I* and the empirical self or *me* in William James's (1890) terms. The existential self is defined as the experiencer or the agent of activity, whereas the "me" is the empirical or categorical self, the sum total of all one's constituent parts including the body and possessions. Damon and Hart (1988) offered a comprehensive analysis of James's distinctions. The "I" is experienced through four kinds of self-awareness: (a) an awareness of *agency* from which is derived personal *autonomy*, (b) an awareness of *distinctness* from which is derived a sense of *individuality*, (c) an awareness of *continuity* in time from which is derived the *stability* of self, and (d) a capacity for *reflection* on self from which is derived a sense of personal *meaning*. These four components comprise the self as the *subject* of experience. The primary constituents of the "me" include attributes ranging from the material (bodily) self through the social (personality, roles) and cognitive characteristics of the individual. The combination of the "I" and the "me" provides a comprehensive framework for theorizing on the self-concept which can be followed in tracing the origins of self in infancy.

Self-perception should be distinguished from self-conception. A concept may be defined as a cognitive representation of self, a belief founded on reflective self-awareness. The question behind the proposals in this article is whether *antecedents* of such belief systems may be observed in the perception and behavior of human infants. The most fundamental implication is that the initial infant–environment relation, generally described as an "adualistic confusion" in so many developmental theories (e.g., Piaget, 1937/1954), is replaced

by a more appropriate stress on the complementarity of infant and environment, with no implication of fusion with the physical or social milieu. In Gibson's terminology, information that specifies the self is called *propriospecific*, whereas information that specifies objects and events in the environment is called *exterospecific*. Proprioception can be understood as a general form of self-sensitivity. He argues that self-specifying information is a general function of perceptual systems and that all the senses are both proprioceptive and exteroceptive. Thus, self-knowledge may originate in processes of sensory perception.

Mirror Self-Recognition Studies

Most research on the development of the self-concept in babies has used the mirror self-recognition task pioneered by Gallup (1970) with primates. Mirrors, of course, offer self-perception by turning back the reflected light onto its source but this is not a simple case of perception; it is not the prototypical case of self-awareness that a casual examination might imply. Mirror self-recognition requires cognitive development, experience with mirrors, and other conditions before self-recognition will develop. Self-knowledge as exemplified by studies using mirrors may nevertheless form a convenient point of departure because it enables a distinction between the information contained in re-reflected light that must be attributed to self and the more elementary idea that information is available in sensory stimulation, which may allow self-perception from an early age.

Numerous studies have been published on the development of mirror recognition in babies. These studies often use a technique similar to that of Gallup's (1970) monkey studies involving surreptitious marking of the baby's face. Additional data particularly relevant to understanding how the contingency of the image is related to self-recognition comes from delayed video-feedback (Lewis & Brooks-Gunn, 1979). The age at which babies reach to the mark on the face after it is seen in a mirror is taken as evidence for the development of self-recognition. There is no need to refer to these studies extensively here because several good reviews already exist (Anderson, 1984; Damon & Hart, 1982, 1988; Harter, 1983, Lewis & Brooks-Gunn, 1979).

Table 1 summarizes the main stages of infant self-recognition as revealed by mirror studies and by the contemporary technique of contingent or delayed video-recorded feedback. It is based on the data reviewed in Bertenthal and Fischer (1978), Damon and Hart (1988), Harter (1983), and Lewis and Brooks-Gunn (1979).

Evidence for a contribution of Piagetian, stagelike cognitive developmental processes to self-recognition as revealed by mirror tasks comes from several sources. Bertenthal and Fisher (1978) found that babies as young as 6 months would observe themselves in a mirror and detect the contingency between their own action and the reflection, as if they understood the causal relation between their own action and the contingent image. From about 10 months, babies became able to adjust their actions using information reflected in mirrors, initially directing their actions to their own body. Eventually they became able to grasp an object placed out of the direct field of view on the basis of its reflection (e.g., a hat suspended above the baby's head at about 1 year). These behaviors are said to reveal a further cognitive advance because they require the infant to distinguish between contingent movements of the self and movements of others in the mirror image. However, it was not until 15 months that infants removed rouge from the nose, the first evidence that the infant recognized self as an object of experience, through her own facial features. Mirror self-recognition is delayed commensurate with delays in cognitive development in mentally retarded children. For example, Mans, Cicchetti, and Sroufe (1978) showed that not until 3 to 4 years of age did the majority of their sample of Down's syndrome children succeed in removing rouge from the nose in a mirror test. So, cognitive development does seem to contribute to mirror self-recognition.

Table 1. *Summary of Main Stages in Mirror and Video Self-Recognition Tasks During Infancy*

Stage	Age	Description
Unlearned Attraction to Images of Others	First 3 months	[Little systematic research in first 3 months]
Contingency Detection	Between 3 and 8 months	Interest in mirror reflection; approaches, touches, smiles, behaves "socially" to reflection
Self as Permanent Object	Between 8 and 12 months	Awareness of stable categorical features of self; locates objects attached to body using mirror image; differentiates contingent from noncontingent video tape-recordings of self
Self–Other Differentiation	Between 12 and 15 months	Uses mirror to locate others in space; differentiates own video image from others' video images
Facial Feature Detection	Beginning about 15 months, well-established by 2 years	Recognition based on self-specific features; success in "rouge removal" tasks; correlates with Piaget's Stage VI in object-concept development

Cross-species comparisons also implicate cognitive developmental factors in mirror self-recognition. According to Gallup (1982), humans, chimpanzees, and orangutans are the only species to recognize themselves in mirrors on the rouge removal task (although it is interesting to note in the comparative context that the gorilla, another higher primate, apparently does not recognize self in mirrors). Thus, it can be argued that although mirror self-recognition occurs by means of perception, it is nevertheless a process that requires a fairly high degree of cognitive development before the mirror image will be attributed to self.

There is also a general suggestion that prior to self-recognition as measured by rouge removal, infants often behave to the reflected image in a social fashion, as if viewing another child but without referring the image back to self. This may be an important component of self-recognition for it may indicate that one component of self-concept development is

the perception of others as social objects. In classical, socially based accounts of self-concept development, such as that of James Mark Baldwin (1902), the process of imitation plays a central role. He said "My sense of myself grows by my imitation of you and my sense of yourself grows in terms of myself" (p. 185). One factor that may require further consideration, therefore, is whether processes in perception may underlie the ability to imitate and hence contribute a social dimension to the development of the self-concept.

These studies therefore suggest that cognitive development, at least as measured in terms of Piaget's sensorimotor stages, contributes to the development of mirror self-awareness. However, the precise interrelationships between perception of the contingent nature of the mirror image, self-identification by means of distinctive features, comprehension of the identity of the reflected image, attribution of the reflected image to self, developments in memory, reasoning, and the contribution of social experience have yet to be unraveled empirically. It seems reasonable to agree with Gallup (1982) that the level of self-awareness that mirror self-recognition tasks tap is cognitively advanced and not explicable by recourse to sensory perception alone. But this may simply mean that self-conception (as revealed by rouge removal, for instance) is ontogenetically derived from processes not themselves revealed by mirror tasks.

Visual Proprioception and Posture

A more fundamental source of information for the visual perception of self than the mirror reflection is available. Gibson (1966) coined the term *visual proprioception* to draw attention to the role of vision in providing information for movement of the self, over and above the traditionally recognized interoceptive information given by the mechanical and vestibular systems. Visual proprioception specifies self-movement by dynamic transitions of the optic array that occur when an observer moves through a stable space. As the observer moves through a textured visual environment, light reflected from the surroundings is projected as a textured flow field at the eye, outward from a stationary central point. The optic-flow field is said to specify that an observer is moving in the direction given by the stationary focus of the optic flow pattern.

Under conditions of the natural ecology (where the surroundings may be considered stable) such a flow pattern can only arise when the observer is moving; hence, it is sufficient to specify the distinction between "self" and "the world." Gibson argued that optic flow patterns are a structured form of sensory information. The developing child need only attend to the available information; there is no necessity to construct the invariants, or to learn what the visual flow pattern specifies as a result of extensive experience. He suggests that posture and locomotion are controlled through visual proprioception and that this control system may be innate. Until the early 1970s, there was little empirical information on the origins of visual proprioception. It seemed possible that optic flow patterns might equally become informative through the infant's developing mobility (and hence be learned) as be inherently informative, as Gibson maintained.

Lee and Aronson (1974) were the first to show that infants use visual information to monitor their posture. Babies who had recently learned to stand were tested standing on a rigid floor, within a moveable room comprised of three walls and a ceiling. The infants faced the interior end-wall and the whole structure, except the floor, was moved so that the end wall slowly approached or receded. Babies compensated for a nonexistent loss of balance signaled by the optic flow pattern (generated by the movement of the surroundings) and consequently fell in the direction appropriate to the plane of instability specified. If the end wall moved away from the baby, the infant fell forward and if the wall moved toward the baby, the infant fell over backward.

Subsequent studies demonstrated that vision does not acquire its proprioceptive function as a result of motor development. Butterworth and Hicks (1977) found that infants too young to walk would nevertheless compensate for visually specified instability when seated in the moving room. The research has been extended to prelocomotor infants by Pope (1984) who showed that even before babies can crawl they are responsive to discrepant visual feedback. He investigated the role of visual proprioception in the maintenance of a stable head posture in infants as young as 2 months, when supported in an infant chair. Babies too young to be able to sit without support and who are certainly not capable of independent locomotion nevertheless will make directionally appropriate compensatory movements of the head under conditions of discrepant visual feedback.

Information arriving in the extreme periphery of vision is particularly important for maintaining postural stability. Pope (1984) showed that movement in the center of the visual field did not result in postural adjustment, whereas the slightest movement in the periphery is sufficient to result in complete loss of stability when a posture is first acquired. Bertenthal, Dunn, and Bai (1986) replicated this finding. They showed that movement of the side walls was as disruptive as movement of the whole room in relation to infants aged between 12 and 15 months who were facing the interior end-wall of the room. By contrast, movement of the end wall alone did not have nearly so disruptive an effect on posture, which again suggests that the important information for postural control may fall on the periphery of vision.

Such data may be interpreted in terms of the theory of "two visual systems," whereby peripheral vision is "body centered" and maps onto a somatotopically organized representation of space (Paillard, 1974; Trevarthen, 1968) whereas focal vision is thought to be "object centered" and outer directed. Because the material, embodied self is implicated in the normal adjustments of posture that ordinarily generate the optic flow pattern, under the nonecological conditions of the moving room, postural adjustments occur to a nonexistent loss of balance specified by the discrepant visual flow field. The obvious moving-room experiment that still needs to be published is with neonates, but there is good reason to suppose that the infant's sensitivity to the optic flow pattern will prove to be innate.[1] The implication is that the optic flow pattern is inherently informative about movements of the infant in relation to the environment. From the earliest age, the infant seems to make use of the optic flow pattern to maintain the head under a stable posture as if the flow field is

[1]Francois Jouen (1990) provided evidence for visual–vestibular interactions among newborn infants that may suggest that visual proprioceptive control of posture is an innate, intrinsic coordination. Scania de Schonen (University of Marseilles, personal communication, September 1986) reported that it is possible to elicit the stepping reflex in a newborn baby placed in a "moving room."

a form of prestructured feedback, informing the perceiver about the relation between his or her own motion and the environment.

How can these studies be related to the problem of self? First, the moving-room studies suggest that Gibson was correct in arguing for an implicit polarity in perception. That is, these studies may be taken as evidence for a differentiated self–nonself starting point for development in which an existential basis for the I, in William James's (1890) terms, is available. The I is the experiencer, the agent, that aspect of self that acts in the world. Optic flow pattern may be considered to inform the infant (and other organisms) of their own agency in the natural ecology. Of course, the moving-room studies demonstrate that the infant does not yet have objective *conceptual knowledge* of self, because babies lose balance when in fact they are objectively stable. However, even adults when placed in an unfamiliar posture, such as balancing on a beam, lose stability under conditions of disrepant visual feedback (Lee & Lishman, 1975).

The acquisition of relatively autonomous self-control over posture may nevertheless be demonstrated, even under discrepant visual feedback in the months after successive "milestones" are acquired. Visual proprioceptive information becomes integrated in development with higher order forms of self-control, as demonstrated by Pope (1984) who studied the influence of discrepant visual feedback on head control in babies ages 2 to 7 months in a moving-room task. Infants were seated with support in an infant seat and head movements in relation to movements of the surround were measured. The slightest movement of the head in relation to the movement of the surround showed up in the video recordings. He found that infants made a directionally appropriate compensatory movement of the head from 2 months, the youngest age tested, with no significant decrement in response intensity until approximately 7 months, when there was a significant decrease in the effects of discrepant visual feedback. Experience of sitting was *not* responsible for this decline, because he was able to demonstrate that babies with equal amounts of sitting experience were differentially responsive, depending on whether they could crawl or not. That is, the onset of crawling coincides with a significant decrease in sensitivity to the moving surroundings relative to the precrawling level. Babies who can crawl may be said to have acquired a new level of autonomous or "self" control of activity that may override, to some extent, the misleading visual information to which they are subjected in the moving room. This model suggests that development proceeds from control by *specification* of self-stability to autonomous self-control which can to some extent override misleading specification.

Butterworth and Cicchetti (1978) showed that length of experience of the sitting or standing posture in babies was negatively correlated with susceptibility to misleading visual feedback. The maximum disruption by discrepant visual feedback occurred during the period of 3 months after each posture was acquired and declined thereafter. Both normal babies and Down's syndrome babies become increasingly able to withstand the effects of room movement. The upright, bipedal standing posture is the most unstable in the face of misleading visual feedback. During the first 3 months of standing upright, the infants would fall over on virtually every trial when the room moved. However, it is not until normal infants are about 15 months of age that they develop sufficient reflective self-awareness to turn to see "who has made the room move." That is, the infant does not attribute an *independent cause* to the discrepant visual feedback until well into the second year of life (just as the infant does not attribute the face in the mirror image to self until about the same age). The evidence suggests that under conditions of the normal ecology, perceptual specification of self is embedded within congruent self-knowledge, in those old enough and with the cognitive capacities to have acquired it. It is not a form of information for self that we outgrow.

It might be argued that these experiments have nothing to do with the development of self-control and that they may better be described as reflexive processes because it is not until relatively late in development that we observe the acquisition of mechanisms capable, at least in part, of overruling the misleading sensory input to which the infant involuntarily responds. However, to do so might be to ignore the fact that under normal conditions, the optic flow pattern would occur only under circumstances where the infant has moved. Because we have suggested that the meaning of the optic flow pattern is not something that is learned, we might wish to argue that it is inherently goal directed; it serves to maintain a stable posture. The optic flow pattern is not a stimulus that gives rise to a reflex response in the traditional sense. Rather it both provides a motive for corrective behavior (by informing about loss of postural stability) and is also goal directed in that it specifies when a well-controlled posture has been achieved. It is a mechanism which, we may conjecture from our evidence, presupposes a self in motion.

The moving room studies have been examined at length because they do seem to offer strong evidence for an existential self specified in perception from the earliest age. This is not the only evidence one can bring forward for the self as an agent of activity in infancy. There are many other examples from research on early infant perception which suggest that development begins from a differentiated self–object relationship for which an existential self may be reasonably postulated. Relevant studies range from research on neonates' responses to "looming," in which newborn infants make defensive responses to a visual stimulus on a collision course (Bower, Broughton, & Moore, 1970), to research on auditory–visual coordination in newborns (Castillo & Butterworth, 1981), which demonstrates that newborns localize a sound in visual space. Each of these examples implies a distinction between self as experiencer and the external objects of experience.

Origins of the Categorical Self

Now let us review some evidence for the perception of the categorical self in early infancy, the "me," as opposed to the "I" of our previous discussion. Church (1970) suggested that early evidence for self-awareness can be found in the baby's response to a cleaning tissue draped over the upper part of the face to occlude the eyes. He describes a developmental sequence from no response, to vocal fussing, to ineffectual reaching in the area of the head, to removal of the tissue by wiping it away, typically at about 5 months. Although Church considered the newborn baby's attempts to remove the tissue from the face as reflexive, it is interesting to note that a varied sequence of behavior is observed if the infant's initial attempts are unsuccessful, including marked head and body movements which may ensure that the airways are not

restricted. Gunther (1961) also described vigorous pushing movements of the newborn infant when there is danger of suffocation while feeding. Thus, it can be said that behaviors whose goal is self-preservation can be observed in the neonate and that the developmental relation between the innate response and the more elaborately controlled reaching to remove the tissue at 5 months is the real developmental issue to be explained.

Responses to tickling, by a change in facial expression to frowning or smiling, or movement of the body is observed between 1 and 4 months. Visual localization of the tickled part of the body is said to begin at about 4 months and manual localization is said to begin at about 6 months. Church (1970) also commented on the baby's discovery of the body through a fairly stable sequence of self-exploratory behaviors; the hands, the feet, all form objects of intense interest to the baby in the first few months of life and it seems reasonable to argue that these behaviors reveal awareness of a categorical self: The baby's response to sensory stimulation is self-referent; it relates to "me" from the baby's point of view.

Kravitz, Goldenberg, and Neyhus (1978) asked 100 mothers to keep a diary and note the order in which their babies began to explore themselves tactually by grasping themselves between two or more fingers of one hand. They found that finger-to-finger exploration occurred first (at a median age of 12 weeks), then finger to body (at 15 weeks), then finger to knee (18 weeks), finger to foot (19 weeks), and a form of tactual self-exploration that Freud would have been interested in: fingers to genitals (at 23 weeks). The evidence from tactual exploration therefore suggests that there is differentiated tactile self-awareness early in life.

A challenging and very early example of self-awareness comes from Martin and Clark (1982). They noted the well-documented tendency of newborn babies to cry when they hear the cries of another baby in the nursery and wondered what would be the effect on the infant of hearing his or her own cries. They tested 47 newborns in the first day after birth in a counterbalanced design in which calm or crying babies heard either their own cry or the cry of another newborn baby. They measured the total amount of crying in a 4-min posttest. The results showed that infants who were calm at the start of the test and heard the cry of another baby vocalized significantly more than infants who heard their own cry. Infants who were crying at the start of the test cried less after the sound of their own cry than to the sound of another baby crying. These data therefore confirm the often-noted phenomenon that babies cry when they hear the cries of another baby but they go beyond previous findings in suggesting that the newborn infant is somehow able to recognize its own vocalizations and discriminate them from those of other babies. It is difficult to explain this phenomenon away as a simple primary circular reaction to an undifferentiated crying sound, as Piaget (1937/1954) might have done. On the basis of further experiments, the authors suggested that the infant's response to crying is both species-, peer-, and self-specific. If this is correct then we may argue that there is auditory specification of self from birth (see next section for an account of how this may come about).[2]

Kravitz et al. (1978) also studied the order of emergence of hand-to-head movements in 12 newborn babies in the first day of life and noted the order of onset of tactile exploration of the mouth, face, head, ear, nose, and eyes. They noted an emerging order in the first few hours of life, beginning with the mouth (at a median of 167 min after birth), then the face (192 min), the head (380 min), the ear (469 min), the nose (598 min), and the eyes (1,491 min). Tactile self-exploration was observed almost exclusively in the waking state. Here again we have evidence for differentiated self-awareness in the neonate which may indeed be a continuation of similar movements *in utero*. Kravitz et al. reported finger-to-mouth movements as soon as 7 min after birth and these they believed to be the first examples of tactile self-exploration, important in the elaboration of the body schema.

Further evidence for self-awareness comes from the phenomenon of hand–mouth coordination in the neonate which we have been studying in collaboration with Brian Hopkins of the University of Groningen (Butterworth & Hopkins, 1988). We carried out a study of this self-directed manual behavior in neonates and it is interesting to note our main findings. We filmed the spontaneous motor activity of 17 newborns (mean age = 79 hr) using a split-screen video system.

The episodes of arm movement fell into four categories: (a) direct movement of hand to mouth (15%), (b) movements stopping short of the face and resulting in no contact (22%), (c) movements going to the mouth after contact with the face (20%), and (d) contacts with the face that did not terminate in the mouth (43%). The mouth was significantly more likely to be open throughout the arm movement in the case where the hand goes directly to the mouth than in the three other classes of arm movement. This suggests that the mouth "anticipates" arrival of the hand, even before the arm starts to move. Other analyses revealed that visual guidance of the hand to the mouth may not be necessary for this coordination, because the eyes are equally likely to be closed as open just prior to contact with the mouth. Once the hand touches the mouth it is withdrawn and there is little evidence of sucking the fingers or "self-comforting" behaviors. The hand can also reliably find the mouth after contact with the perioral region. However, when the hand lands more distantly (e.g., on the nose, ears, or eyes), it is no more likely to move toward the mouth than away from it. There is no evidence of rooting after contact, the head is invariably held still and the hand moves immediately in the direction of the mouth.

The mouth is clearly the goal of quite a proportion of the arm movements and the hand can find its way to the mouth without benefit of visual guidance. The coordination suggests that there may be an innate body schema (or schemas) relating the hand to the mouth and which may be considered as a part of the basis for the bodily self or "me." The fact that the coordination is rather specifically between the hand and the oral region suggests that it is not based on a facial schema. Other forms of neonatal sensorimotor coordination, such as eye–hand coordination (studied by Von Hofsten, 1983) or auditory–visual coordination (see Butterworth, 1981, for a review), may also be taken as evidence for the

[2]Just as an abstract level of *perceived equivalence* is needed to explain the transfer of information between motor and visual systems, or between vision and tactile exploration in neonates, auditory specification of self may also depend on an ability to perceive the equivalence between patterning of sound in perception and production. What we are describing as "body schemas" may more usefully be described as "equivalence-class detecting devices" that constitute the interface between perception and action.

existence of a coordinating body schema (or schemas) ensuring that the infant behaves as an organized totality in relation to sensory stimulation. From a developmental point of view, it is also important to note that many of the coordinations present at birth drop out in early development, to reappear later in the first year, and it is to these successive reorganizations of basic coordinations that we may wish to turn when offering a theory of the development of the self-concept from its already organized, innate constituents (see discussion of Mounoud & Vinter, 1981, to follow).

It should be said that hand–mouth coordination in the newborn has its own developmental history extending back into the fetal period. De Vries, Visser, and Prechtl (1984) in a study of fetal movement patterns found that between 50 and 100 hand–face contacts per hour occur in fetuses aged between 12 and 15 weeks. It seems possible that hand–mouth coordination observed in newborns may be an innate, movement synergy which has its origins in prenatal activity and is controlled proprioceptively. Again, one might argue the behavior is referent to the categorical self. There is no reason to suppose that species-typical movement synergies are found only in humans. For example, rat fetuses show particular "treading" patterns of forelimb movement *in utero,* which may be important after birth in letting down milk in the mother rat (Alberts, personal communication, November, 1988). The point is that movement synergies reveal properties of the material self as an *organized totality;* species-typical developmental processes will determine the extent to which such aspects of the categorical self become elaborated within higher order cognitive processes.

One more example will suffice to illustrate that information for a categorical self may be available by direct sensory perception. Recent evidence shows that babies of 4 to 6 months are sensitive to biomechanical motions specified by "point-light walkers" (Fox & MacDaniel, 1982). Point-light walkers are created by placing lights or luminous tape on the head, torso, and limb joints of a person dressed in black who is then filmed in the dark while traversing a path normal to the observer's line of sight. Adults viewing the filmed dots in motion report a compelling experience of seeing a human figure walking. Infants of about 6 months prefer to look at a display showing this biological motion than one in which the same number of dots simply move randomly (Bertenthal, Profitt, Spetner, & Thomas, 1985) so we may suppose the infant to perceive the moving light display as an animate event. The interesting implications for the development of self come from a suggestion by Bower (1982) in a report of work by Aitken, a doctoral student at Edinburgh University, who found that babies of about 14 months prefer to look at a walking point-light display of an infant of the same sex as themselves as at a point-light display of an infant of the opposite sex. Bower suggests that the dynamics in the movement patterns may be sex typical. Perhaps sex differences in skeletal articulation lead the infant to perceive the point-light display of the same sex as "like me." Further studies of this kind could be taken as strong evidence for the specification of categorical aspects of self in sensory stimulation.

Neonatal Imitation

A final source of evidence for the specification of self through perception comes from studies of neonatal imitation. We have already mentioned that imitation is a favorite vehicle for the many theories that emphasize the contribution of social experience to the child's developing knowledge of self. There is an extensive literature on the development of imitation in babies and I intend to touch only on recent studies suggesting that a form of imitation may be innate, to round off my argument. The original discovery of neonatal imitation by Olga Maratos (1973) was replicated and extended by Meltzoff and Moore (1977), and this research has itself recently been replicated by Vinter (1984) at the University of Geneva. Thus we have independent sources of evidence for neonatal imitation, and some agreement that imitation of tongue protrusion and mouth opening (gestures not visible to the infant) and of finger movements (visible gestures) is present at birth. Vinter suggested that these abilities drop out at about 6 weeks in the case of hand movement and by about 3 months for mouth and tongue movements to reappear at 7 months for manual imitation and around 1 year for facial imitation. The neonatal imitation literature suggests that babies can match visual information from the face or hand of another to kinesthetic information for their own tongue and mouth and that hand movements can also be imitated through visual and/or kinesthetic matching although the developmental relationship between "early" and "late" forms of imitation remains to be unraveled.

It is possible to understand the neonatal phenomena in terms of the previous discussion of proprioception and the body schema. An innate body schema may authorize the match between visual input and motor output in imitation tasks (Mounoud & Vinter, 1981). Meltzoff (1981) suggested that the ability to imitate "invisible" gestures, such as tongue protrusion must require an abstract ability to relate the properties of visual sensory input to motor output. This ability is similar, he argued, to that involved in detecting the equivalence of information across sensory modalities. In a series of converging studies, he showed that infants in the first month of life can relate visually perceived shapes to the same shapes perceived through oral-tactual exploration. At some abstract level of description, vision and tactual exploration yield equivalent information for shape (see footnote 2). Thus, one way to understand how imitation is possible, a process considered by many to be fundamental to the social elaboration of self, is by reference to its basis in sensory perception and the body schema, as a fundamental prerequisite for the categorical self or "me."

Conclusion

All these examples of self-specification through perception can be understood in terms of Gibson's (1964/1982) assertion that proprioception is best understood as a general form of self-sensitivity, regardless of the modality in which information arrives. In the example of hand–mouth coordination, the fact that the hand can find the mouth without visual guidance suggests that the coordination is based on kinesthetic information alone. In the case of visual proprioception, it is clear that stability of the body posture is to some degree specified in the optic flow pattern, so again a postural schema may be involved in mapping visual information to motor activity. Finally, it has also been suggested that neonatal imitation can be explained if sensory information maps onto a body schema in the neonate.

The concept of the body schema is a familiar one in psychology but it is nevertheless difficult to define, and indeed,

it may be insufficient to describe the mechanisms controlling posture. Nevertheless, Bairstow (1986) captured the essential characteristics admirably. He defined a body schema as a superordinate representation at the interface between sensory and motor processes that both externally and internally specify a posture. This definition unifies the various strands of research already discussed because it provides the necessary link between sensory and motor domains underlying both existential and categorical aspects of self.

The problem remains, however, to explain the relationship between the specification of self in perception and the acquisition of reflective self-awareness. How is a concept of self acquired that may continue to be elaborated throughout the life span? Perceptual specification and conceptual knowledge are not (in this account at least) to be considered as the same level of functioning. All that has been offered so far is an approach to the problem of the origins of self that suggests that there are a variety of ways in which even elementary sensory perception may be self-referent. This allows us to progress beyond the logical impasse presented by totally constructionist (or totally socially determined) theories of self-concept development in which the problem of accounting for the experiencing organism is glossed over. As A. J. Ayer (1968) once said:

> If one speaks of the construction of objects out of the flux of experience, it is indeed natural to ask who does the constructing and then it would appear that whatever self is chosen for this role must stand outside the construction; it would be contradictory to suppose that it constructed itself. . . (p. 261)

It is both logically and psychologically entailed that some form of self stands behind experience and perhaps all that is being said here is that the self originates in the fact that we are embodied (although motivational factors, such as "will," and the capacity for emotional expression, which we have not considered here, might also be usefully invoked even among the youngest infants). However, this is a long way from explaining self-recognition in mirrors or the advanced forms of reflection on self of which humans are capable. To connect a level of perceptual specification with the development of reflective self-knowledge, one may perhaps be permitted to speculate. Mounoud and Vinter (1981) revised the standard constructionist Piagetian stage theory of sensorimotor development to suggest that there exists a succession of processes regulating the interaction of infant and environment. The most basic, and the one that characterizes the initial state of coordination we have been discussing, they call the "sensory" code. This is not the same as Gibsonian terminology but one can see a close affinity. The approach carries with it the important assumption that the initial coordination also constitutes the program for later reorganizations of that coordination. A new level of organization, a "perceptual" code, is elaborated from about 3 months and involves the beginning of representation (i.e., recognition based on stored information). Now activity begins to be regulated not only by direct sensory information but also by memory. A further reorganization is said to occur at around 8 or 9 months by an internal coordination of the relations among representations, giving rise to recall, mental imagery, and the beginnings of symbolic thought at about 18 months. This sequence may be readily mapped into the existing body of knowledge about the development of self summarized in Table 1.

The important theoretical question is how each new level of organization develops out of the preceding one and this has not been solved. The general theory favored by many authors is of the social-cognitive type. That is, feedback from social encounters is thought to be particularly important in the elaboration of cognitions about the self (e.g., MacMurray, 1933; Mead, 1934). This entails no necessary dichotomy between physical and social objects; the emphasis on social experience arises because only in human relations can one fully recognize one's personhood (see Butterworth, 1982). Consciousness of mutual relationship, the meeting of like with like, depends most fully on feedback from people (and hence the importance of the ability to imitate in development):

> Complete objectivity depends upon our being objectively related, in action as well as in reflection, to that in the world which is capable of calling into play all the capacities of consciousness at once. It is only the personal aspect of the world that can do this. (MacMurray, 1933, p. 134)

The theoretical question in tracing self-concept development from its origins is to describe how the basic levels of self-perception and organized action systems (for which I have tried to marshall evidence) give rise to reflective self-awareness and the autobiographical memory we more readily associate with having a self-concept. This is a problem that has not been solved, but we may speculate that the infant may store information by habituating to those aspects of sensory information constantly available to sensory perception, including self-specifying information, whether this is derived from the infant's own activities in mastering the physical environment or obtained in the course of social interaction. This stored information may form the foundation for self-recognition and, in more elaborated forms, provide a substrate for self-conscious thought. Another developmental acquisition that certainly seems necessary for the level of self-awareness attained by organisms who show self-recognition in mirrors is a concept of causality. Although many organisms and young infants clearly perceive the contingency between their own behavior and its outcome, it seems that only the higher primates have sufficiently elaborated concepts of causality to attribute their own mirror reflections to themselves. How a concept of causality is acquired in development may return to the same basic problem as arises in explaining the origins of the self-concept. Even if causality is perceived directly, as Michotte (1963) maintained, it is still necessary to explain how the relatively advanced understanding of causal relationships arises that is necessary to attribute a perceived mirror-image to self. By the same token, only an organism that already has a concept of its own identity would seem able to identify itself in a mirror. Even this account is incomplete in that it does not explain how *inherent* individuality interacts with processes of perception and feedback from the physical, social, and emotional environment in generating our sense of being unique.

Further insights into the early stages of self-concept development may also be obtained from the study of developmental psychopathology, as in the case of childhood autism. Hobson (1990), for example, offered an account of childhood

autism in terms of failure of self-concept development, with specific reference to deficits shown by these children in the spheres of imitation, affective communication, and interpersonal relations. These primary deficits in interpersonal and intrapersonal aspects of bodily coordination are thought subsequently to lead to problems both in the acquisition of reflective self-awareness and in the attribution of mental lives to others.

In conclusion there is information for self in perception. This original level of functioning does not imply the capacity for thinking self-conscious thoughts or for reflective autobiography, yet the empirical evidence from infancy suggests that it is rich in implications for our theories of self-consciousness. What is required now is a theory of how successive processes of reorganization transform the product and processes of self-perception into the forms of self-conception that we typically associate with the higher primates and for which we have traditionally taken self-recognition in mirror tasks as evidence.

Notes

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