# THE DEVELOPMENT OF VISUAL SELF-RECOGNITION IN INFANCY: CROSS-SECTIONAL AND LONGITUDINAL SAMPLES



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## Abstract

In the past, mark-directed behavior in the rouge task, using one's name or personal pronouns, identifying one's photo image, and being able to locate an object that has been reflected in a mirror have been seen as components of self-knowledge. In the present study, tasks measuring these abilities were given to a cross-sectional group consisting of 90 children (on one occasion) ranging in age from 15 to 23 months of age. An additional longitudinal group consisting of 10 children was given the same tasks bi-weekly between the age of 15 and 23 months of age. Results indicate: (1) these abilities develop independently and that, developmentally, children recognize their mirror image before they begin using personal pronouns, which occurs before children are able to recognize their photo image, (2) the ability to locate an object reflected in a mirror does not fit into this developmental scale, (3) neither knowledge of the reflective properties of mirrors nor the amount of exposure to mirrors has an influence on the development of mirror self-recognition, (4) there appears to be a sudden spurt in the development of mirror self-recognition at 17 months of age and photo self-recognition at 22 months of age, but the development of the use of personal pronouns appears to develop in a linear pattern, (5) there does not appear to be a clear pattern of development in the ability to locate an object reflected in a mirror. Comparison of data from the longitudinal and cross-sectional groups revealed that (6) practice effects were apparent among the longitudinal group for the mirror self-recognition, photo, and toy tasks, but not for the development of the use of personal pronouns and (7) there was also a great deal of between and within variability in the development of each skill measured. Finally, no gender effects were present among any measures in the present study.

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## Table of Contents

## List of Tables

**Page**

## List of Figures

Page

# The Development of Visual Self-Recognition in Infancy: Cross-sectional and Longitudinal Samples

Historically, the young infant was believed to have little self-awareness, largely because the self was defined so as to require the capacity for representational or symbolic thought. Theorists such as Piaget (1954) claimed that infants are not capable of mental representation until about 18 to 24 months of age. However, more recent research on infant development has revealed an unexpected array of early cognitive achievements (see Courage & Howe, 1999) and theories of a sense of self have expanded to include the onset and development of self-awareness earlier in infancy (e.g. Lewis & Brooks-Gunn, 1979, Neisser, 1993). The focus of this study will be on the acquisition and development of a sense of the self in infancy, specifically, the aspect of the self assessed by visual self-recognition.

The acquisition of a sense of self is important as it provides a new base for organizing and regulating experience (also see Emde, Biringen, Clyman, & Oppenheim, 1991; Kagan, 1981) and provides the foundation for early autobiographical memory (Howe & Courage, 1997). Additionally, many of the infant and toddler's developing cognitive, social, and emotional capacities are tied to the development of the self, such as directives to adults, self-descriptive utterances, memory for location, transposition, drawing a face, symbolic play, imitation, interaction with peers, and language (for a discussion, see Kagan, 1981). Our understanding about the self and the self- system is complex and multifaceted. Some aspects of the mature self do not develop until later in childhood (e.g. self-esteem and self-control) and continue to develop well into

adolescence (for a review see Harter, 1983). However, consideration of these characteristics is beyond the scope of the present study.

William James (1890) proposed that there are two fundamental facets of the self: (1) the "I," the self as actor or subject, and (2) the "Me," the self as an object of one's knowledge. As this distinction was initially intended to apply to the adult self, Lewis and Brooks-Gunn (1979) defined this duality of selves in terms of its relevance for infancy. They made the parallel distinction between the existential self and the categorical self. In the existential self, infants realize (though perhaps not consciously) that they exist separately from others and are active agents in the environment which is evidence that this realization begins at an early age. For example, Rovee-Collier (1987) trained 2- and 3-month old infants to produce a foot kick to move a mobile overhead, thereby showing that the infants were able to act on the environment to produce an effect repeatedly whenever so motivated. Although infants of this age do not show visual self-recognition (e.g. see Lewis and Brooks-Gunn, 1979), they do exert control over their actions. They seem to have a sense of agency, which is thought to be a prerequisite to the development of an understanding of self as an object, the categorical self.

In the categorical self, infants have developed categories by which to define themselves vis-a-vis the external world and realize that they have unique and recognizable features and characteristics. At first they develop knowledge of their physical characteristics, then later, a sense of their skills, characteristics, attitudes, and values (see Harter, 1983, for a review). The categorical self is thought by Gallup (1994) to be a special cognitive achievement that is demonstrated only in humans and some of

the great apes such as chimpanzees (*Pan troglodytes*), orangutans, (*Pongo pygmaeus*), and bonobos, (*Pan paniscus*). The categorical self develops much later in infancy than the existential self. Empirically, there has been a much greater focus of attention on the study of the categorical self as compared to the existential self. This is due, in part, to problems of measuring the early development of the existential self, or a self as a subject of experience. Although development of the existential self or "I" is important for a full understanding of the self-system, it is beyond the scope of the present study and will be discussed only briefly below.

Measuring the Categorical Self

To date, our knowledge of the categorical sense of self in preverbal children is based primarily on assessing one aspect of the development of self, that is, visual self-recognition. Although aspects of the self can be experienced through other sensory modalities, for example, proprioceptive, auditory, and tactile, and may be of equal importance, they have not been systematically investigated because of the difficulty in generating nonverbal measures for their study. In addition to visual self-recognition measures, locating an object reflected in a mirror and using personal pronouns have also been used to represent self-knowledge (Berthenal & Fischer, 1978; Lewis & Brooks-Gunn, 1979).

Visual self-recognition refers primarily to the infant's earliest knowledge of the self as an object in the sense that one can identify one's unique physical features. This ability can be measured by assessing the behaviors displayed by a child when presented with an image of themselves in mirrors, photographs, or movies (Amsterdam, 1972;

Amsterdam & Greenberg, 1977; Asendorph & Baudenniere, 1993; Brooks-Gunn & Lewis, 1984; Bullock & Lutkenhaus, 1990; Gallup, 1970; Johnson, 1983; Lewis & Brooks-Gunn, 1979; Lewis, Brooks-Gunn & Jaskir, 1985; Lewis & Ramsay, 1997; Papousek & Papousek, 1972; and Schulman & Kaplowitz, 1977). Visual self-recognition involves more than a simple discrimination of body features. To determine that a mirror reflection, picture, or video is a representation of the self rather than another person, some rudimentary knowledge of one's own identity that is continuous in time and space is necessary (Gallup, 1977). However, it is important to be careful not to equate the self with visual self-recognition, it is only one aspect of understanding the self, measured in one modality.

Presently, the best measure of visual self-recognition in preverbal children is the classic mirror self-recognition test, or rouge task, originally proposed by Amsterdam (1972) and Gallup (1970). In this test, children are discretely marked with an obvious spot of rouge on their face, usually the nose, and then shown their mirror image. Mark-directed behavior, in which they touch their own nose (as opposed to mirror-directed behavior or no reaction) is taken to indicate that the child has a sense of self in that they realize the image in the mirror represents themselves. Mark-directed behavior is thought to imply that the child recognizes that the self and the representation are one and the same, has some knowledge about its location in space vis-a-vis other objects or visual images, and is directing behavior toward the self in a purposeful manner. Mark recognition or touching the mark is the most compelling example of visual self-recognition to date (Brooks-Gunn, and Lewis, 1980).

## Development of Visual Self-Recognition

Research suggests that the objective sense of self develops gradually through a succession of types of behaviors, all of which relate to self-recognition (Berthenal & Fischer, 1978). For instance, the experimental literature provides a fairly precise account of the types of behaviors that are demonstrated by infants of different ages, when seeing themselves in a mirror. As early as 1 to 3 months of age, interest in and attention to the mirror image can be observed. Also, within the first year, infants demonstrate pleasure (smiling and vocalizing), mirror-directed behavior (sociable or an other-directed response such as kissing, hitting, touching, or pointing), and imitation (can be both other-directed and self-directed, since they require the infant to watch the self and act) when presented with a mirror (Brooks-Gunn & Lewis, 1984). Infants generally begin to demonstrate mark-directed behavior in response to the rouge task between 15 and 18 months of age, and such behavior is seen in most infants by 21 to 24 months (Brooks-Gunn & Lewis, 1984).

The self-conscious emotion, embarrassment, emerges between 15 and 24 months of age (DiBiase & Lewis, 1997). Upon viewing the rouge on their noses, infants often show embarrassment behaviors while in front of the mirror, such as smiling, gaze aversion, and movement of the hands to touch hair, clothing, face, or other body parts (Amsterdam & Greenberg, 1977; Lewis, Sullivan, Stanger, & Weiss, 1989; DiBiase & Lewis, 1997). Embarrassment follows the emergence of the "primary emotions" such as joy and fear, but before the emergence of self-conscious evaluative ones, such as shame and guilt (DiBiase & Lewis, 1997). Research indicates that children do not show

embarrassment unless they show self-recognition, suggesting that children must have self-awareness to exhibit embarrassment. Moreover, it is agreed that infants must have the cognitive capacity to perceive that they are the object of others' attention in order to feel embarrassed (Buss, 1980).

Visual self-recognition using a photo task, wherein the infant is asked to find his/her picture among an array of photos of other same age, same sex infants is generally accomplished between 21 and 24 months of age (Lewis & Brooks-Gunn, 1979). Recognizing the self from a picture is quite different than a mirror image task, as this task involves the infant's ability to generalize from one situation to another, to represent persons in other forms, to recognize themselves without the aid of contingent feedback, and to use feature recognition rather than contingency cues (Lewis & Brooks-Gunn, 1979). While contingency cues allow an infant to learn that the self-image "acts like me" featural cues allow the infant to learn that a self-representation "looks like me" (Harter, 1983). Lewis and Brooks-Gunn (1979) suggest that the contingency between visual and proprioceptive information for self-motion could serve as a basis of self-perception in the first months of life and thus self-recognition using contingency cues comes earlier than self-recognition using only featural cues.

Consistent with this, Bahrick and Watson (1985) conducted a study in which infants were shown (via video) a perfectly contingent live display of their own leg motion and a noncontingent display of self or a peer. They found that 5-month-old infants showed a robust discrimination of the contingent and noncontingent displays, even when prohibited from seeing their own legs moving. Thus, Bahrick and Watson (1985)

proposed that the infants must have detected contingency by perceiving the invariance between the proprioceptive stimulation from their own motion and the visual stimulation from the live video display of that motion. These results indicate that 5-month-old infants possess perceptual capabilities that are fundamental to the perception of self. This evidence provides support for Lewis and Brooks-Gunn's (1979) proposal, that the detection of proprioceptive-visual invariants may be fundamental to the infant's perception of self and may underlie the development of visual self-recognition. Furthermore, the ability to recognize one's image without contingency cues, such as identifying a photo image, follows the onset of mirror self-recognition.

Finally, the production of spoken language about the self via the use of the self-referent pronouns, "I" or "me", has generally been accepted as evidence for self-recognition, and usually occurs several months after the emergence of mark-directed behavior in the rouge task (Amsterdam, 1972; Berthenal & Fischer, 1978; Lewis & Brooks-Gunn, 1979; Harter, 1983; Mans, Cicchetti, & Sroufe, 1978; Schulman & Kaplowitz, 1977). There is little evidence of the use of these pronouns before 18 months of age (Fenson et al., 1994) and most children begin using them between 22 and 24 months of age (Charney, 1978; Lewis & Brooks-Gunn, 1979). Howe and Courage (1997) have suggested that it is not until children are capable of visual self-recognition that they can consolidate their knowledge of self and move to a new level of competence that enables them to use self-referent pronouns. Even in the gestural modality, an infant's comprehension and use of self-referent signs does not occur before 18 months of age. Pointing to the self usually occurs at approximately the same time as the onset of self-

referent pronouns (Bates, O'Connell & Shore, 1987). Howe and Courage (1997) propose that the coincident advances witnessed in the gestural achievements of self-pointing, self-recognition, and infants' beginning comprehension of self-referent pronouns, all of which emerge when infants are about 18 months old, signal that the infants' sense of self is being consolidated at some level in this time frame.

## Individual Differences in Self-Recognition

Individual differences in both the onset of self-recognition and affective responses to the rouge task are influenced by a variety of maturational, biological, genetic, social, and experiential factors (Lewis & Ramsay, 1997; Cicchetti, rogosch, Toth, & Spagnola, 1997), as outlined below.

### Maturational Factors

Some of the evidence that maturational factors are influential stems from the finding that the onset of self-recognition in children with developmental disabilities is related to mental as opposed to chronological age. For example, Mans, Cicchetti, and Sroufe (1978), and Brooks-Gunn and Lewis (1980) found that, of the children with Down's syndrome, only those with a mental age of 15 months or older demonstrated visual self-recognition to their mirror image. Additionally, Mans, Cicchetti, and Sroufe (1978) found that the affective reactions of these children were similar to those of normally developing children.

Similarly, it has been found that for children with autism, higher levels of functioning, such as communicative speech, are necessary for self-recognition (Dawson and McKissick, 1984). In addition, self-recognition research with autistic children shows

that there is a total lack of affective expression both before and after the rouge placement even when the children wipe the rouge from their nose immediately after being placed in front of a mirror (Dawson & McKissick, 1984;Spiker & Ricks, 1984). Autistic children also show very little evidence of embarrassment in response to the rouge task (Spiker & Ricks, 1984).

Temperament

Various dimensions of temperament such as reactivity to stress and mood have been found to be related to the actual onset of self-recognition. For example, Lewis and Ramsay (1997) investigated the role of one infant temperament difference, reactivity to stress, in self-recognition onset. They assessed self-recognition with a longitudinal sample of infants whose adrenocortical and behavioral responses to inoculation had been observed at 2, 4, 6, and 18 months of age. It was found that high stress reactivity from early infancy was associated with an earlier onset of self-recognition. Lewis and Ramsay (1997) have suggested that high stress reactivity reflects a reduced capacity to regulate internal information stemming from stressful events. It is this reduced capacity to regulate internal information which appears to facilitate or accelerate the emergence of self-recognition, although the causal link is not clear.

DiBiase and Lewis (1997) investigated the relationship between temperament, self-recognition, and embarrassment with children between five and 22 months of age. Although they did not find a significant association between heart rate variability scores and self-recognition, the infants who demonstrated characteristics such as fussiness, irritability, and fearfulness (which is termed difficult-like) were most likely to show self-

recognition. For example, a greater percentage of children who recognized themselves exhibited fear and were negative in mood than those who did not. Additionally, the infants who showed self-recognition and had more difficult-like temperament characteristics exhibited significantly more embarrassment than any of the other groups.

Attachment

Individual differences in the timing of the onset of self-recognition have also been found to be a function of the mother-infant attachment relationship. For instance, Lewis, Brooks-Gunn, and Jaskir (1985) assessed the relation between the attachment relationships of infants at 12 months of age and subsequent performance on the rouge task. They found that the insecurely (avoidant and ambivalent) attached infants were significantly earlier recognizers than were securely attached infants. Lewis et al. (1985) have proposed two possible explanations for this finding. First, they have suggested that children who are stressed and who have less effective parents, may become more vigilant, and that early self-awareness may be one manifestation of this vigilance and attention. Second, as discussed above, relationships have been found between temperament and self-recognition. Lewis et al. (1985) have proposed that temperament may interact with parenting and, through that pathway, affect the child's developing self-awareness.

Depression, Maltreatment, and Socioeconomic Status

Finally, depression, maltreatment, and socioeconomic status have been found to influence affective responses in the rouge task. As for depression, some theoreticians contend that depression is not possible until the self, with the concomitant capacity for

negative self-evaluation, has been firmly established (Cicchetti & Schneider-Rosen, 1986). In a study by Cicchetti et. al (1997), no differences were found in the onset of visual self-recognition for infants with depressed or nondepressed mothers, however, differences in affective responses were observed. The infants of depressed mothers who demonstrated self-recognition displayed significantly more nonpositive affect than infants with mothers that were not suffering from depression, while examining themselves in the mirror after rouge had been applied to their faces, yet no differences had been observed between the two sets of infants when they viewed their mirror image before the rouge had been applied.

Nor did Schneider-Rosen & Cicchetti (1991) find any differences in the timing of the acquisition of visual self-recognition between the infants in families with low, middle or high socioeconomic status, or that had or had not been maltreated. However, differences were found in the infant's affective responses, in that both the maltreated, low and high SES infants were equally likely to display positive or negative/neutral affects in response to their mirror images, whereas the middle SES group was more likely to show positive affect.

In sum, visual self-recognition appears to be tied to cognitive maturation, in that children with developmental disabilities must have a mental age of approximately 15 months in order to recognize their mirror image. Also, it appears that infants who are highly reactive to stress, irritable/fussy, or have an insecure attachment with their primary caregiver generally demonstrate visual self-recognition at earlier ages than children who do not demonstrate such temperament characteristics or have secure attachments.

Finally, children with depressed mothers, children who were maltreated and children of low socioeconomic status families are more likely to demonstrate negative or neutral affect to the rouge task than positive affect in contrast to other kids.

## Interpreting the Mirror Self-Recognition Test

### Methodological Issues

When the rouge task was first proposed as an index of self-recognition, methodological questions arose concerning its validity and its meaning as a measure of self-recognition. One major challenge to the validity of the rouge task as an index of self-recognition, is that the critical act of touching ones own nose in response to the marked visual image does not unambiguously signify self-recognition, but may reflect a generalized inquiry as to whether "people now have red marks on their noses", or a new level of consciousness about physical appearance that was not present earlier (for discussion see Bahrick, 1995; Mitchell, 1993; Berthenal & Rose, 1995). However, it is commonly found that a high percentage of infants who demonstrate mark-directed behavior also show signs of embarrassment (Lewis et al., 1989; DiBiase & Lewis, 1997). Buss (1980) has proposed that an infant must feel that attention is being directed towards him/herself in order to exhibit embarrassment, hence, the relationship between self-recognition and embarrassment suggests that the infants relate the mark to their nose specifically, as opposed to all noses.

Other concerns with the rouge task have focused on the spontaneous reactions infants may have upon seeing their image in the mirror. For instance, the concern of whether or not infants might spontaneously touch their faces when they saw themselves

in a mirror has been resolved by researchers such as Bullock and Lutkenhaus (1990), who measured infants' reactions to their mirror image, when no rouge had been applied. They found that no infants spontaneously touched their faces when presented with their mirror image.

Mitchell (1993) argued that using mark-directed behavior as a measure of self-recognition must be questioned because it has been found that some infants, upon seeing a mark on the face of another infant or on their mother, wiped their own face in the same place that the mark was on the other person (Lewis & Brooks-Gunn, 1979). This result suggests that wiping the mark upon seeing their mirror reflection may represent, for some infants, only a wondering if they had a mark in the same place. However, Johnson (1983) conducted a study in which infants viewed a TV image of themselves or another infant before and after application of a mark to the nose. He found that when the infants were presented with an image of themselves, infants 18 months or older displayed mark-directed behavior, whereas when presented with an image of another infant, mark-directed behavior was infrequent at all ages. Hence, the infants did not demonstrate mark-directed behavior upon seeing another infant with rouge on his/her nose, which is not what Mitchell (1993) had suggested. This difference in response to self and other marks may be the clearest indication that mark-directed behavior is the clearest indication of self-recognition.

Further concerns about the rouge task are that children may be aware that something has been placed on their noses before seeing their mirror image. For example, it has been proposed that attention would be specifically drawn to the nose if something

(rouge) is intentionally placed there (Mitchell, 1993). However, it has been found that having the mother apply the rouge as if she were washing the child's face ensures that attention is not specifically drawn to the nose or other body part that the substance has been applied to (Lewis et al., 1985). In addition, the notion that having the face wiped may lead to an increase in nose touching was investigated and no differences were found in the amount of nose touching between the children that had their nose wiped and those that had not (Brooks-Gunn & Lewis, 1984). The notion that visual cues (parts of the nose can be seen by looking cross-eyed, down to the right or left, or alternating eyes open and closed) may elicit mark-directed behavior has also been dismissed, as no investigators have reported cross-eyed behavior and mark-placement has been slightly different across studies (for a discussion, see Mitchell, 1993).

Finally, as mentioned earlier, it is commonly held that it is only humans and some of the great apes that are capable of mirror self-recognition (Gallup, 1994). However, concerns with the rouge task lead to questions about whether the rouge task masks the ability to self-recognition. De Veer and Van Den Bos (1999) suggest that certain species' characteristics and individual motivational factors may influence the results of the rouge task. For instance, failure to demonstrate mark-directed behavior in the mirror may not mean that animals do not recognize their image. Pygmy marmosets (*Cebulla pygmaea*), for example, have never been observed to self-groom, thus it does not seem reasonable to expect them to touch the mark on their face upon seeing their mirror image (Eglash & Snowdon, 1983). Furthermore, some animals may fail to show mirror self-recognition because they are lacking motivation to examine their mirror image. For example, they

may pay more attention to the observer rather than their mirror image (De Veer & Van Den Bon, 1999). Thus, whether or not additional species are capable of self-recognition remains an open question that may be resolved with future investigations into the methodology that is used.

Experience with Mirrors

There has been discussion over whether or not experience with mirrors is necessary to pass the rouge task (show mark-directed behavior) in both nonhuman primates and children. For instance, researchers such as Priel and De Schonen (1986) suggest that experience with mirrors is not necessary to pass the rouge task. They reported that children living in tents in rural areas of Israel without mirrors show self-recognition at about the same age as their mirror - experienced urban counterparts. This issue is not resolved, however, as Gallup and Povinelli (1993) claim that this study provides no assurance that the children in the rural sample did not have prior experience with their reflections in automobile hubcaps, chrome bumpers, and rearview mirrors, as well as reflections emanating from a variety of other objects outside the home.

However, research with primates has led to conflicting conclusions. For example, in Gallup's (1970) early research on self-recognition with chimpanzees showed that only those with prior exposure to mirrors exhibited mark-directed behavior. From these findings, Gallup (1970) concluded that mirror self-recognition does not occur without some exposure to mirrors. Yet, Gallup's (1977) research indicated that self-recognition is dependent on familiarity with other chimpanzees, and independent on familiarity with mirrors. He found that isolated chimps with a great deal of exposure to mirrors are not

capable of self-recognition, but that chimpanzees reared among other chimpanzees with only little exposure to mirrors are capable of self-recognition.

Nevertheless, there is no empirical evidence to suggest that the level of experience a child has with actual mirrors will or will not have a significant impact on the rate of development of self-recognition (Berthenal & Fischer, 1978). Judging from the studies that have been done, it may be the case that both prior experience with mirrors and an understanding of at least some aspects of mirror correspondence are probably necessary, but not sufficient, conditions for self-recognition. As of yet, the question of whether or not the development of visual self-recognition can be accelerated through repeated exposure to mirrors has not been answered.

Conceptual Issues

A central issue is whether or not the rouge task is the ultimate test of self-recognition. Is there a better test that could indicate an earlier onset of self-recognition? It has been suggested that self-recognition develops much earlier in infancy, but that potential difficulties with the rouge task constrain its expression. For instance, perhaps infants do not show mark-directed behavior at younger ages because they do not understand the reflective properties of mirrors. As noted above, the nature of the relationship between knowledge of mirrors and mark-directed behavior remains controversial. While some argue that mirror knowledge (object localization) is a precursor to self-recognition (Johnson, 1983), others argue that these abilities are independent (Anderson, 1984; Robinson, Connell, & McKenzie, 1990). It is interesting to note that most studies find that an understanding of mirror reflection begins to emerge

late in the second year, between 21 and 28 months of age (Robinson et al., 1990), whereas self-recognition has been shown to develop between 15 and 18 months of age (Lewis & Brooks-Gunn, 1979). Thus, development of mirror self-recognition may have occurred before infants demonstrate mark-directed behavior in the mirror task. However, the question about the existence of a relationship between mirror knowledge and mirror self-recognition has yet to be resolved.

Furthermore, with the classic rouge task, it is possible that children may recognize their mirror image, but they may not necessarily touch their nose. As Asendorpf, Warkentin and Baudonniere (1996) have suggested, if children do not show mark-directed behavior, one cannot exclude the possibility that they have recognized themselves. For instance, Asendorpf et al. (1996) found that some children closely look at their mirror image for a long time, but do not touch their nose. It is possible that these children do recognize themselves, but are puzzled with how to respond. In an attempt to reduce this ambiguity, Asendorpf et al. (1996) designed a revised rouge task wherein they demonstrated how to respond by having the children wipe the rouge off a doll's nose, before the rouge was placed on the child. They found that the percentage of ambiguous cases was reduced to less than half in the revised task. Thus, this evidence suggests that the rouge task may not accurately identify all visual self-recognizers.

Although many argue that mirror self-recognition is the point of self-awareness, others contend that infants have a self-awareness before they demonstrate mark-directed behavior to the rouge task. However, those that support the former statement, such as Lewis (1995), do acknowledge that there is an earlier developing, subjective sense of

awareness ("I") that exists before the development of an objective sense of self ("Me"). It is important to separate the two senses of self when discussing self-awareness and the rouge task. The "I" or subjective sense of self, originates in neonatal perceptual and motor processes, includes self-regulation and self-other differentiation, and influences and directs much of our behavior. As mentioned earlier, subjectively aware infants realize (through perhaps not consciously) that they exert control over their actions, and recognize that they are active agents in the environment. Note that, both the objective and subjective selves develop along separate developmental pathways, the objective sense of self does not replace the subjective sense of self. With this in mind, it is suggested that mark-directed behavior represents the onset of an awareness of the objective sense of self, which usually occurs between 15 and 24 months of age.

The Transition in the Development of Visual Self-Recognition

Courage and Howe (in press) have suggested that mark-directed behavior reflects more than self-recognition per se and may in fact, signal a more pervasive transition in cognitive development late in the second year of life. Their suggestion is supported by the evidence of developmental synchrony with other cognitive achievements. For instance Piaget (1954) theorized that cognitive development can be divided into four major stages: sensorimotor, preoperations, concrete operations, and formal operations. He claimed that substage six of the sensorimotor period (18 to 24 months of age) was characterized by marked and discontinuous developments in cognitive contents such as deferred imitation, mental representation (symbolic thought), the ability to make causal inferences and to solve invisible displacement tasks of object permanence, and language

development. In vocabulary production, for example, new word acquisition is said to occur in the fashion of a "language explosion" during the latter half of the second year. There is a sudden onset of a period of rapid growth in children's vocabulary (Bates, O'Connell, & Shore, 1987). Prior to this "explosion", new word acquisition is characteristically a slow and laborious process as children struggle with the lexical principles of reference, extendability, and object scope (see Golinkoff, Mervis, & Hirsh-Pasek, 1994). Generally, the pace of vocabulary production dramatically increases at around 18 months of age and by the end of the second year, children have usually mastered several hundred words. Between the ages of 18 and 24 months, there are also significant achievements in categorization (Namy, Smith, & Gershkoff-Stowe, 1997), symbolic play (Belsky & Most, 1981), and means-end problem solving (Kopp, O'Connor, & Finger, 1975).

There is also anatomical evidence for major changes in frontal lobe maturation during the latter part of the second year of life, which coincides with the point that self-recognition is first apparent (Huttenlocher, 1994). For example, Grodd (1993) and Staudt et al. (1994) have found that frontal lobe myelination is largely absent until approximately the middle of the second year of life. Hence, many suspect that self-awareness depends, at least to some extent, on the maturation of the frontal lobes.

Although it initially appeared that there are dramatic changes in many cognitive abilities at approximately 18 months of age, further research, using improved methodology, has revealed that evidence for these cognitive abilities can be found at earlier ages, though not to the complexity and proficiency that is found at 18 months or

older. For example, deferred imitation is defined as the ability to reproduce a previously witnessed action or sequence of actions in the absence of current perceptual support for the action, a process that has been referred to in the earlier literature as matched-dependent behavior (Miller & Dollard, 1941) or observational learning (Bandura & Walters, 1963). Initially, Piaget (1954) claimed that infants were not able to perform deferred imitation until 18 to 24 months. Yet, a great deal of subsequent research in this area has revealed that infants are able to engage in deferred imitation possibly as early as 6 weeks of age (Meltzoff & Moore, 1994). Nonetheless, it is agreed that there does appear to be a distinct change in infant's performance late in the second year of life that reflects an underlying qualitative shift from reliance in literal representations of their past experience to hypothetical representations based on deductive reasoning.

It also appears that, at 18 months of age, infants show a marked change in the way they will spontaneously sort an array of two kinds of objects placed before them. It is only after 18 months of age that infants will sort exhaustively, placing all of the objects of each kind into spatially distinct locations. However, when modified tests that allow this measurement of categorization in young infants are used, it is found that infants can categorize at much younger ages, at a "child-basic" level of perceptual properties of the objects (e.g. shape, color, size) (Mandler & McDonough, 1993).

The question of whether infants undergo a discontinuous shift in the cognitive abilities mentioned above is very difficult to answer due in part to problems with measurement. Traditional cross-sectional and longitudinal research designs typically involve sampling the behavior of interest at intervals which are often too widely spaced

to permit observation of the routes (and the individual differences in those routes) that developmental change may take.

The Microgenetic Method

In an attempt to help resolve questions on the pattern and rate of development. Siegler (1994) employed a method to investigate cognitive developmental change, called the microgenetic method. He argues that early development is rapid, and intervals of several months or years may be too broad to provide valuable information on the rate and sequence of skill acquisition. Data obtained with large intervals provides information about what changes during a time period, but does not indicate how these changes occurred. The microgenetic method is designed to overcome these limitations by: (1) conducting observations of individual children throughout the period of change, (2) obtaining a high density of observations relative to the rate of change within that period, and (3) conducting intense trial by trial analyses intended to indicate the processes that gave rise to the change (Siegler & Crowley, 1991). Siegler and Stern (1991) state that for changes that are closely age linked, the combination of a relatively dense distribution of observations and a high degree of overlap between the period of observation and the period of rapid change allows much more discrete observations of the process of change than is typical. Furthermore, Siegler (1994) argues that cognitive growth is characterized by large-scale variability which is often overlooked or ignored by developmental researchers. Cross-sectional and longitudinal research using large intervals often misses such variability. Thus, the microgenetic method provides a means of measuring such variability which can, as Siegler (1994) suggests, allow us to discover a great deal about

the environment toward which thinking and action are directed.

The Present Research

Although research on the development of visual self-recognition has been ongoing for over two decades. several important questions remain unresolved. The first question is whether there is a sudden shift in the onset of self-recognition or whether it appears gradually. The existing literature suggests that a pervasive transition in self-development occurs at approximately 18 months of age. However, Siegler (1994) argues that such sudden shifts, or transitions may be preceded by earlier signs of development. To examine this, a microgenetic approach was applied to the study of mirror self-recognition, photo identification, object localization in a mirror, embarrassment, and the use of personal pronouns. These measures were obtained by giving participants the following tasks: the rouge task, the toy localization task, and the photo identification task. Mothers were also asked if their child had begun to use personal pronouns, and to assess embarrassment, measures were taken of the affective responses to the rouge task. Information was collected on these measures bi-weekly with ten children from the age of 15 months to 23 months of age. These measures were also obtained from a cross-sectional sample of children within the same age range. This procedure made it possible to determine if the development of self-recognition was sudden, or whether children begin to show preliminary signs of self-recognition (e.g. staring, embarrassment) before they demonstrate successful performance on the rouge task. This design also permitted a comparison between the longitudinal and cross-sectional groups, as the second question was whether or not practice with the self-tasks could accelerate the development of the

categorical self.

Third, although it has been argued that performance on the rouge task is the ultimate and most unambiguous measure of visual self-recognition, other measures of self-knowledge that occur at about the same time as mirror self-recognition (e.g. photo identification, use of personal pronouns, embarrassment) may also be significant markers of the onset of the categorical self. Thus, the question of the developmental ordering (e.g. concurrent, sequential) of these measures needs to be established.

A fourth issue concerns the role of mirror knowledge in performance on the rouge task. It has been suggested that successful performance on the rouge task may be masked if children do not understand the reflective properties of mirrors (Bigelow, 1981), and thus, children may be capable of visual self-recognition at earlier ages than that which has been found with this task. In past research children were given an object localization task, where an infant is required to locate an object from its mirror image (Berthenal & Fischer, 1978; Bigelow, 1981; Robinson et al., 1990). To locate the object, an infant must understand that the mirror is reflective, and understand that the layout seen in the mirror is a reflection of an actual layout in real space. Hence, it was investigated whether there was a relationship between performance on a toy localization task (which provided an indication of whether or not the infants had acquired an understanding of the reflective properties of mirrors) and performance on the rouge task.

The microgenetic approach also makes it possible to assess a fifth question, that is, does experience with mirrors play a role in the onset of self-recognition. This question was addressed in two ways. The parent of each child was given a mirror experience

questionnaire to assess the amount of exposure their child had to mirrors around the home. Thus, it was investigated whether different levels of experience with mirrors was related to performance on the rouge task. Additionally, a comparison between the cross-sectional group and the longitudinal group made it possible to determine whether practice with the tasks in the longitudinal group led to an earlier onset visual self-recognition, photo identification, and toy location compared to the children in the cross-sectional group who were given each task only once.

The sixth issue is whether there is a relationship between self-recognition and language development. The language explosion at approximately 18 month of age is perhaps the best documented case of a sudden onset in development in the second year, hence it was of interest to determine if there is a relationship between such an explosion in vocabulary, and the onset of visual self-recognition. To examine this, the parent of each child was given the MacArthur Communicative Development Inventory (CDI) (Fenson et al., 1994) to complete. This inventory was chosen because it is designed to provide a comprehensive measure of language development in 8 to 36 month old children.

## Method

### Participants

Ninety infants (M = 34; F =56) participated in the cross-sectional portion of the study, there were 10 infants in each of the following age groups: 15 mo (M age = 15.4), 16 mo (M age = 16.5), 17 mo (M age = 17.4), 18 mo (M age = 18.4), 19 mo (M age = 19.3), 20 mo (M age = 20.4), 21 mo (M age = 21.5), 22 mo (M age = 22.3), and 23 mo

(M age = 23.2). These infants participated in the self-recognition test activities on one occasion only. An additional nine infants were tested but excluded from the final cross-sectional sample because of incomplete data (n =6), procedural error (n = 1), an infant with a developmental disability (n = 1), an infant learning two languages (n = 1). Ten infants were followed longitudinally and participated in the test activities every two weeks when they were between the ages of 15 and 23 months of age. All participants were selected to be within one week of their month birthdate at the time of testing. Two infants were also excluded from the longitudinal sample because of persistent inattention and lack of cooperation.

All infants were white, predominantly middle SES, full term and healthy at birth (38 to 42 weeks of gestation and at least 2500 grams), and free from any developmental anomalies. They were recruited from an existing pool of volunteer parents who had indicated an interest in participating in research following a contact at the time of their child's birth.

Tasks and Dependent Measures

Infant's self-recognition, mirror knowledge, mirror experience, and language development were assessed with a series of standard tests and procedures. These were as follows: (1) *Rouge Task*. This is the classic test of visual self-recognition for infants and toddlers (see Lewis & Brooks-Gunn, 1979). The infant was seated in a booster seat and the caregiver is asked to surreptitiously place a spot of nontoxic, water-soluble, blue face paint on the infant's nose under the guise of a nose wipe. The color blue was chosen rather than red because this color was thought to be more distinct in appearance, as many

children have "rosy" cheeks and noses. After a 30 second delay, the infant is placed in front of a one-way mirror (50 cm x 90 cm) and his/her reactions to the mirror image in a 90 second period are noted. If the infant touches his/her own nose it is assumed that he/she recognizes that the mirror image is him/herself (i.e., the blue spot is not a normal part of the infants' face). The infant's behavior was categorized as follows: *Immediate Recognizer*: the child looks at the mirror and touches his/her own nose or indicates this orally (e.g., my nose, dirty ...) within 30 seconds; *Delayed Recognizers*: The behavior described above occurs between 30 and 90 seconds; *Ambiguous*: the infant stares at the mirror image without gross body movement, but does not touch the nose mark; *Non-recognizer*: The child does not display any of the above behaviors.

(2) *Affective Response to the Rouge Task*. The infant's affective responses (embarrassment/shyness, distress, surprise) to the mirror image were also recorded and rated. Accordingly, behaviors related to embarrassment/shyness were: smiling facial expression, gaze aversion, and movement of the hands to touch hair, face, or clothing. All three had to be present for embarrassment to have been recorded (see Lewis & Brooks-Gunn, 1979). Distress was rated on a 4-point scale with 1 = neutral face, 2 = fussing/whining/vocal protest, 3 = trembling lower lip, 4 = crying (see Ekman & Rosenberg, 1997). Surprise was rated on a 3-point scale with 1 = neutral face, 2 = slight dropping of the jaw and/or raising the eyebrows, 3 = large jaw drop, eyebrows raise, eyes move down and head moves up and back (see Ekman & Rosenberg, 1997).

(3) *Photo/Name Task.* The infant was prompted to identify/name his/her photo (taken with a Polaroid camera upon arrival in the lab) from an array of three photos of same age, same sex infants. The infant had to make a correct identification of his/her photo on two of three trials (with the position of the correct photo placed left, right, and center) to be considered a Recognizer. The dependent measures include looking longer at, pointing to, or naming him/herself correctly. The child was given the chance to identify his/her photo spontaneously, followed by prompts "Where is (child's name)?" and "Who is that?" for 90 seconds on each trial.

(4) *Toy Task.* To assess mirror knowledge, the infant's ability to locate a toy in real space from its reflection in the mirror was tested (see Bertenthal & Fischer, 1978; Robinson, Connell, McKenzie, & Day, 1990). With the infant facing the mirror directly, the experimenter (hidden behind a large white screen) silently lowered a toy suspended on a clear string such that it swung just over the infant's head. To pass this test, the infant had to turn to locate the toy within 60 sec of first seeing it reflected in the mirror.

(5) *Mirror Experience Questionnaire.* To evaluate the infant's previous experience with mirrors in the natural environment, the parents were asked about the type and frequency of the infant's exposure to mirrors - specifically, whether the infant had any mirrored toys, whether there were household mirrors visible to the child, whether (and how often - daily, weekly, monthly) the child and parent play with these mirrors (see Appendix B)

(6) *Language Development (MCDI).* After the first visit to the lab, parents were given the *MacArthur Communicative Development Inventories* (Fenson et al., 1994), a standard test of language comprehension and production designed for use with infants between 8

and 16 months of age (*Words and Gestures*) and 16 to 30 months of age (*Words and Sentences*). Both the Words and Gestures and the Words and Sentences questionnaires demonstrate high internal consistency, yielding alpha levels of .96 and .96 respectively. Test-retest correlation scores have been reported to be .95 (at $p < .01$) for the production in the Words and Gestures questionnaire. For the Words and Sentences, the test-retest correlation for production was reported to be .90 (at $p < .01$). As for the validity of the MacArthur questionnaire, when compared to the laboratory observation methods such as observed vocabulary and the expressive one work picture vocabulary test, the CDI appears to assess a broader vocabulary range than either the direct observation or the structured test (Fenson et al, 1994).

The mothers of the infants in the cross-sectional group were given the MacArthur questionnaire to complete at home. The mothers of the infants in the longitudinal group were given the MacArthur Words and Gestures questionnaire when the infants were 15 months of age, and the MacArthur Words and Sentences questionnaire when the infants were 18 and 23 months of age. The data taken from these questionnaires were the total productive vocabulary scores and the personal pronoun use scores. Using the behavioral definitions above, two observers coded the data. With any particularly difficult cases, a third observer was asked to give her opinion and the case was discussed. Hence, there was a 100% agreement on all cases.

Procedure

The infants were placed on a mat on the floor and given several minutes to play with a toy and to familiarize themselves with their surroundings. During this period, the

experimenter explained the procedure to the parent(s) and obtained informed, written consent for the child's participation (see Appendix A). The parents also filled in the *Mirror Experience Questionnaire* at this time. Infants who were in the cross-sectional component of the study were seated in a booster seat on the floor and allowed to examine themselves in the mirror for five minutes. After this familiarization period, the mirror was turned away and the caregiver was asked to apply the blue face paint to the infant's nose. After a one-minute distraction period, the mirror was again placed in front of the infant. The *Rouge Task*, the *Photo/Name Task*, and the *Toy Task* were conducted in a counterbalanced order, with a three-minute break for play between each task. After these tasks were completed, the parents were given the *MCDI* in a self-addressed, stamped envelope and asked to complete and mail it within 24 hours. As soon as the parents had left, two observers coded the videotape for the infant's affective reaction to the *Rouge Task* and recorded the latencies to respond to the mark and to turn to locate the toy was also recorded.

Infants who were in the longitudinal component of the study were treated in an identical manner except that the testing was done in the infant's home. As these infants were to be tested every two weeks for a 6-month period, this was done as a convenience to the parents and to minimize data loss through participant attrition.

## Results

Several of the measures used in the present study, such as the rouge task, produced categorical data (e.g. yes/no, pass/fail), while others such as the language score on the MacArthur questionnaire produced quantitative data. Hence, the analyses in this

study include both nonparametric and parametric statistics. Outlined below for each measure in the present study is a description of: the criterion for success, the pattern of onset, an evaluation of the presence of practice effects, and individual variability. Following this is an evaluation of the relationships among the measures, the relationship between mirror knowledge and self-recognition, the relationship between mirror experience and self-recognition, and the relationship between productive vocabulary and self-recognition.

To investigate whether sex differences existed among any of the measures in the present study, chi square analyses were computed. No differences were found between males and females for either of the rouge task, $\chi^2$ (1, $\underline{N}$ = 90) = 3.38, $\underline{p}$ = .07, toy task, $\chi^2$ (1, $\underline{N}$ = 90) = 2.04, $\underline{p}$ = .15, photo task, $\chi^2$ (1, $\underline{N}$ = 90) = 2.13, $\underline{p}$ = .15, and the use of personal pronouns, $\chi^2$ (1. N = 73) = 3.35, p = .07.

Criterion for Success

The classic rouge task was used to determine if the participants were able to recognize their mirror image. If the participant touched his/her nose within 30 seconds after seeing his/her mirror image, he/she was classified as an immediate recognizer. If the participant touched his/her nose after 30 seconds but before 90 seconds after seeing his/her mirror image, he/she was classified as a delayed recognizer. If the participant stared at his/her mirror image without gross body movement, but did not touch his/her nose, he/she was classified as ambiguous. If the participant did not display any of the above behaviors, he/she was classified as a nonrecognizer. In addition to this criteria, an operational definition of task mastery, wherein an infant must have passed a task three

times, was employed with the longitudinal group for the purpose of examining individual variability.

The photo identification task was implemented to determine if the participants were able to recognize their image without the aid of contingency cues. The infant had to point to his/her picture in two out of three trials to pass the task. The toy task was used to provide an indication of whether or not the participants understood the reflective properties of mirrors. The infants had to turn and locate the toy behind them within 60 seconds after seeing the image of the toy in the mirror.

Information on whether or not the participants were using personal pronouns was obtained to indicate the infant's self-knowledge. In the cross-sectional group, this information was taken from the MacArthur language questionnaire. The infant was recorded as using personal pronouns if any of the following personal pronouns were checked: I, me, my, myself, or mine. In the longitudinal group, the information on personal pronoun use was obtained from the MacArthur language questionnaires, in addition to asking the mothers if their infants were using any of the personal pronouns at the end of each testing session.

Sudden Onset in the Development of the Self-Recognition Tasks

A central question of the present study was whether a shift or sudden spurt occurs in the development of any or all of the self-recognition measures or whether these behaviors emerge in a gradual manner. To investigate this question, trend analyses were computed on the data collected from the cross-sectional group of participants. Figure 2 shows the percentage of participants that passed each task at each age group tested (15,

16, 17 months etc). For the rouge task, the data are best described by a quadratic trend, $R^2 = .40$, $p = .00$. Inspection of Figure 2a supports this as there appears to be a sudden increase in the proportion of participants passing the rouge task between 16 and 17 months of age.

Figure 2c, representing the proportion of participants passing the photo task is best described by a cubic trend, $R^2 = .35$, $p = .02$. As can be seen in Figure 2c, no children between 15 and 16 months of age passed the photo task, but a few of the 17-month old children tested passed the task. Additionally, the number of children that passed the photo task remained at a plateau between 17 and 21 months of age, and then a large increase in the children passing the task occurs at 22 months of age

No significant trends were found for success on the toy task. As can be seen in Figure 2d, the proportion of participants passing the toy task varied a great deal across the different age groups, indicating that the ability to locate an object in the mirror, and hence, knowledge of the reflective properties of mirrors is highly variable between 15 and 23 months of age, and that no clear pattern of development is evident at these ages.

Finally, as for the use of personal pronouns, Figure 2b, representing the proportion of participants at each age group tested using personal pronouns is best described by a linear trend, $R^2 = .251$, $p = .00$. There does not appear to be an age at which there is a sudden onset of the use of personal pronouns, rather, as age increases, the proportion of participants using personal pronouns consistently increases.

Comparison between the Longitudinal and Cross-sectional Groups

Concerning the role of practice with the tasks in the present study on the

development of visual self-recognition, a comparison of the age of acquisition of each of the measures between the cross-sectional and longitudinal groups was conducted. After computing the age at which 75% of the cross-sectional participants passed each measure, one-sample t-tests were calculated comparing these ages with the age of onset for each measure with the longitudinal group. The age at which 75% of the participants passed each measure was chosen as the age of comparison as opposed to the mean ages because it is a stricter criterion, and this method was used in past research to determine the age of onset for self-recognition (Lewis & Brooks-Gunn, 1979). Furthermore, a calculation of the mean age of the recognizers would merely represent the average age of the children that were recognizers, not the age of *onset*. It was found that the participants in the longitudinal group were significantly younger than those in the cross-sectional group at the age of acquisition of the rouge task, $t(9) = -2.85$, $p = .02$, the toy task, $t(9) = -27.89$, $p = .00$, and the photo task, $t(9) = -10.78$, $p = .00$. However, the participants in the longitudinal group did not begin using personal pronouns at a significantly younger age than those in the cross-sectional group, $t(9) = .00$, $p = 1.00$. This indicates that repeated testing of the rouge, toy, and photo tasks did lead to an earlier age of acquisition of the tasks, and hence, there was a practice effect. Yet, because the information on the age at which the participants began using personal pronouns was obtained from the mothers, as would be expected, there were no practice effects.

Furthermore, as can be seen in Figures 3a, 3b, and 3d, the number of participants at each age (15, 16, 17 months, etc.) passing the rouge, toy and photo task in the longitudinal group was visibly higher than those in the cross-sectional group. Moreover,

as can be seen in Figure 3c, the number of participants at each age using personal pronouns in the longitudinal group was not significantly higher than those in the cross-sectional group.

Individual Variability

Traditionally, the results of cross-sectional data have led researchers to presume that once a child has successfully performed a task, he/she has fully acquired a new skill. However, according to Siegler (1994) the performance of young children who are learning new skills is quite fragile and highly variable in the beginning. That is, a child may pass a task, then fail the same task on a subsequent trial, or use a less mature strategy to perform the task. Because the longitudinal group in the present study was tested at such short time intervals during the period of the onset of self-recognition, we were able to observe and record such variability and this can be seen in Table 1. For instance, Table 1e is a good example of the performance of an individual in the longitudinal group. As can be seen in Table 1e, this participant first passed the rouge task at 15.5 months, but then demonstrated ambiguous behavior to their mirror image (staring, embarrassment) between 16.5 and 18.5 months of age. He did not show mark-directed behavior on three consecutive occasions until 19 months of age. This individual also passed the photo task at 17.5 and 18 months, then failed the task between 18.5 and 20 months and did not consistently pass this task until 21 months. Thus, initial acquisition of these abilities is quite unstable and individual variability can be seen between each testing period.

There is a discrepancy between the child's onset of these tasks depending on

whether cross-sectional or longitudinal data is examined. While there was no measurement of variability in the development of personal pronoun use (mothers were not asked if their child began and then stopped using personal pronouns), variability was recorded for the rouge, toy and photo tasks. A comparison of the mean age at which the infants in the longitudinal group first passed the rouge (M = 17.1, range = 15.5 – 21), toy (M = 16.5, range = 16 – 17.5) and photo (M = 17.9, range = 16 – 20) tasks, with the mean age at which there were three consecutive passes in each of the rouge (M = 19.1, range = 16.5 – 22), toy (M = 17.5, range = 17 – 18.5, and the photo (M = 19.9, range = 17 – 21) tasks indicates that the largest difference in age occurred in the rouge task. It appears that the highest level of variability occurred in the development of mirror self-recognition in this longitudinal sample. Thus, this shows that the age at which a child first passes a task may not necessarily be a valid representation of the age at which they have fully acquired a skill.

Co-appearance or Independence of Measures

To investigate whether success on the rouge, toy, and photo tasks, and the use of personal pronouns develop concurrently either across the age range tested (15-23 months), or in the age category before self-recognition has generally been found to occur (15-17 months), the age category in which self-recognition usually begins (18-20 months), or the age category in which most children are found to demonstrate self-recognition (21-23 months), Cochran *Q* tests (see Siegel & Castellan, 1988) were performed. The Cochran *Q* test provides a method for testing whether three or more matched sets of frequencies or proportions differ significantly among themselves. This

test indicated how the number of children passing each task compares to the others over time. The null hypothesis is that the proportion of children passing each task is the same. The overall Cochran $Q$ test on the cross-sectional data in the present study indicates that success on these measures does not co-occur (Cochran $Q$ test, $Q(3) = 36.6$, $p < .01$) across the age range tested. A similar pattern of non co-occurrence in the cross-sectional group was found for both the 15-17 month age category (Cochran $Q$ test, $Q(3) = 16.75$, $p < .01$) and the 18-20 month age category (Cochran $Q$ test, $Q(3) = 20.56$, $p < .01$). That is, success on one task did not necessarily predict success on any of the other tasks. However, the Cochran $Q$ test reveals that success on these tasks does appear to co-occur in the 21-23 month age category (Cochran $Q$ test, $Q(3) = 6.073$, $p > .05$). At 21 to 23 months of age, the majority of participants passed both the rouge and toy task, and used personal pronouns.

Knowledge of Mirrors and Visual Self-recognition

Recall that it had been argued that children must understand the reflective properties of mirrors before they can pass the rouge task. To determine whether success on the rouge task depends on an understanding of the reflective properties of mirrors, chi square analyses were conducted with the performance scores on the rouge and toy tasks with both the longitudinal and cross-sectional data, whereby performance on the toy task indicated whether or not children understood the reflective properties of mirrors. It was found that there were no significant differences in success on the rouge task between those that did have knowledge of reflective properties of mirrors (locating the object in the toy task) versus those that did not (failing to locate the object in the toy task) for both

the longitudinal group, $\chi^2$ (1, N = 10) = .63, p = .43, and the cross-sectional group, $\chi^2$ (1, N = 90) = 0.254, p = .61. Thus, from these analyses and with the results of the scalogram analyses, we can conclude that knowledge of the reflective properties of mirrors as revealed by the toy task is not necessary to identify one's mirror image.

The Role of Experience

The design of this study permitted us to assess the role of experience and the self-recognition measures in two ways: a) mirror experience in the home, and b) comparison of the cross-sectional group with the longitudinal group. To determine if the level of exposure to mirrors in the home affects performance on the rouge task, a chi square analysis was performed. The analysis compared performance on the rouge task between the participants rated by parents as having had high exposure with mirrors according to the mirror experience questionnaire (a score of 3 or 4, n = 60) and the participants rated as having low exposure (a score of 1 or 2, n = 30). There were no differences found on the performance in the rouge task between children with high levels of experience versus low levels of experience with mirrors, $\chi^2$ (1, N = 90) = 0.104, p = .75. Having more or less exposure to mirrors in the home does not significantly influence whether an infant can identify their mirror image.

Scalability of Measures

As the Cochran *Q* test indicated that success on the four self-recognition measures did not co-occur, except for the 21-23 month age group, the next question was to determine whether or not there was an order of acquisition in the measures used. This was investigated by conducting scalogram analyses to see if the sequence demonstrated a

Guttman-type scale. The scalogram analysis is designed to determine if responses to an array of dichotomous items are scalable or homogenous. To do this, the expected order of measurement items and each participant's responses in both the cross-sectional and longitudinal groups were placed in a scalogram matrix (Green, 1956). The scalogram analysis also permits the determination of the coefficient of reproducibility, which measures the extent to which the respondent's success in the items can be reproduced from the relationship that defines a perfect scale. The coefficient of reproducibility is equal to 1 minus the proportion of responses that must be changed to produce a perfect scale. Green (1956) states that a value greater than .50 indicates scalability. When the scalogram analysis was performed on the expected order of appearance based on past literature (Berthenal & Fischer, 1978; Brooks-Gunn & Lewis, 1984), which was that children would first pass the toy task, then the rouge task, then the photo task, and finally begin using personal pronouns, only 53% of the participants in the cross-sectional sample fit this scale and the coefficient of reproducibility was .56. Although scalable according to Green (1956), this coefficient of reproducibility is not high.

However, when the scalogram analysis was performed on what seemed to be the order of appearance during testing in the present study, a coefficient of reproducibility of .87 was found after omitting the toy task which other statistics showed was not related to self-recognition. This was the order of appearance: rouge task, personal pronouns, photo task. That is, if the participants had passed the photo task, it was expected that they would have also passed the rouge task and are using personal pronouns; if they were using personal pronouns, they would have passed the rouge task, but not necessarily the

photo task. Eighty-six percent of the participants in the cross-sectional group and 80% of the participants in the longitudinal group fit this scale. Also, it can clearly be seen in Figure 1 that children within each age range, were more likely to recognize their mirror image than they were to use personal pronouns, which was more likely than passing the photo task. Moreover, the toy task doesn't appear to fit within this developmental scale.

The Relationship between Language and Self-Recognition

The fourth question of the present study was, how does productive vocabulary relate to the onset of self-recognition? To investigate this, we obtained the vocabulary scores from the MacArthur questionnaires that had been received (74 out of 90) and compared these scores between the participants that demonstrated mirror self-recognition with the participants who did not demonstrate mirror self-recognition, using an independent two sample t-test. It was found that the participants who demonstrated mirror self-recognition had a significantly higher vocabulary score ($M$ = 140.38, $SD$ = 138.24) as compared to those that did not demonstrate mirror self-recognition ($M$ = 74.31, $SD$ = 94.21), $t(71) = 3.079$, $p = .00$.

However, these results are likely confounded by age, because a high percentage of the participants that passed the rouge task were older children in the sample, and thus were expected to have a larger number of words in their productive vocabulary than younger, non self-recognizers. To determine if the results were purely an effect of age, we investigated whether there was a difference in the vocabulary scores of the participants that were categorized as early recognizers (15-17 month old recognizers) and late recognizers (21-23 month old *non*recognizers). If it were the case that vocabulary

scores were only influenced by age alone in the present study, we expect the late recognizers to produce a higher vocabulary score. An independent-sample t-test indicated that there was no significant difference in the productive vocabulary scores in the early ($M$ = 76.33, $SD$ = 104.05) versus late ($M$ = 202.00, $SD$ = 120.82) groups of recognizers, $t(66) = -1.032$, $p = .31$. Hence, language development appears to play a role in the development of visual self-recognition.

## Discussion

As previously discussed, the present study measured children's ability to identify one's mirror image, locate a toy reflected in a mirror, identify one's photo image, and use personal pronouns with two groups of participants: a cross-sectional group and longitudinal group. The cross-sectional group was tested only once at either 15, 16, 17, 18, 19, 20, 21, 22, or 23 months of age. The longitudinal group was followed from 15 to 23 months of age and tested every two weeks. The design of this study allowed an investigation of several questions about the development of the categorical self. Some questions were best addressed with the cross-sectional data, while others were best addressed with the longitudinal data. This design also allowed a comparison of both the cross-sectional and longitudinal groups.

### Sudden Onset in the Development of the Self-recognition Tasks

A major question addressed in the present study was whether a developmental shift occurs in the development of any of the self-recognition measures. Results indicate that there does appear to be a sudden spurt in the development of mirror self-recognition. Analysis of the proportion of participants passing the rouge task at each age shows that a

quadratic trend is present, and that there appears to be a marked increase in the number of children that passed the rouge task between 16 and 17 months of age. Past literature also suggests that a discontinuous shift occurs in mirror self-recognition. For example, investigators, Brooks-Gunn and Lewis (1984) conclude that the development of self-recognition has a sudden onset based predominately on the results of three specific studies: Lewis and Brooks-Gunn, 1979; Amsterdam, 1972; and Schulman and Kaplowitz, 1977. The results of these studies indicate that mark-directed behavior was never demonstrated in children less than 15 months of age, and was demonstrated in 5 to 50% of children from 15 to 18 months of age, and approximately three quarters of children between 18 and 24 months of age. Thus, Lewis and Brooks-Gunn (1984) believe that at 18 to 24 months a dramatic shift occurs in visual self-recognition. Furthermore, Aspendorpf, Warkentin, and Baudonniere (1996) found that this shift occurs at approximately 17 months of age when a revised rouge task is applied in which children were first shown a doll with a spot of rouge on the face and are asked to clean the dolls face with a tissue, and then given the classic rouge task. The findings of the present study are consistent with past research and support the argument that a dramatic shift occurs in visual self-recognition development when in the second year.

The pattern of development of the photo identification task revealed the proportion of children at each age tested passing the photo task was best described by a cubic trend. As can be seen in Figure 2c, no children were able to identify their photo image at 15 or 16 months of age, and only 10 % of the children were able to do this at 17 months. However, an increase occurred between 17 and 18 months of age, with 20% of

the 18-month old children passing the photo task. Between 18 (20%) and 21 (20%) months of age, there was a plateau in performance on the photo task, while a large increase in the number of children who passed the photo task occurred between 21 (20%) and 22 (70%) months of age. Thus, although a small increase is evident between 17 and 18 months, the most significant increase occurred between 21 and 22 months. Therefore, there does appear to be a discontinuous shift in the development of photo identification at approximately 22 months of age.

There has been much less research on the ability to identify one's photo image in contrast to the rouge task, and, much of that research suggests that photo image identification emerges much later than observed in the present study. For instance, Povinelli, Landau, and Perilloux (1996) have found that a dramatic transition occurred in photo identification between a group of younger (35-40 months) and older (41-46 months) three year olds. However, others such as Bigelow (1981) suggest that photo identification generally develops between 23 and 27 months of age. The discrepancy in ages across studies may be due to both procedural differences and differences in the ages tested. For instance, Povinelli, Landau, and Perilloux (1996) required children between 22 and 58 months of age to view a picture of themselves with a sticker in their hair, and then to reach up and remove the sticker. Perhaps this task is a higher level of difficulty than is pointing to one's picture, which was required in both the present study, and that by Bigelow (1981). Also, the age at which a transition occurred in the study by Povinelli et al. (1996) must be higher than that of the present study because the age range in their study was between 22 and 58 months in contrast to 15 to 23 months in the present study.

Additionally, in the study by Bigelow (1981), infants were followed longitudinally from 18 to approximately 26 months of age. The photo task in her study required children to identify their photo image among an array of nine other black and white polaroid pictures of the same age and same sex of the infant. Infants in the present study were required to identify their photo image among an array of three colored polaroid pictures of the same age and same sex of the infant. Because of the fact that the pictures in Bigelow's (1981) study were black and white, and that there were more pictures to choose from, this photo task may have been of a higher level of difficulty in comparison to the photo task in the present study. It must also be noted that the pictures used in the present study were small polaroids.

As for the use of personal pronouns, it was found that the proportion of participants using personal pronouns at each age tested followed a linear trend. Although the literature to date has not suggested that a sudden burst occurs in the onset of personal pronouns, because such transitions have been reported for other self-measures (Lewis & Brooks-Gunn, 1979), it was of interest to determine if a transition would be apparent with the personal pronoun data presented here. In part, there does not appear to be a discontinuous increase in the onset of personal pronoun use in children. The children in the present study who were reported to use personal pronouns ranged in age from 15 months to 23 months with the proportion of children using such pronouns continuously increasing over age.

The age at which 75% of the children in the present study were using personal pronouns was 20 months, which is consistent with previous findings. For example,

Lewis and Brooks-Gunn (1979) found that personal pronoun use appeared at approximately 21 and 22 months of age, when children were asked to label their photograph. Additionally, Charney (1978) investigated the ages at which children began to use personal pronouns and found that the use of "I" appeared around 22 months of age.

Not surprisingly, no significant trends were apparent in the toy task. The proportion of participants passing the toy task varied among each age group, with no clear pattern of development. This result is consistent with past research on mirror knowledge. For instance, both Chapman (1987) and Robinson et al. (1990) found inconsistent performance across different mirror tasks, and considerable individual differences in the emergence of mirror skills. Furthermore, there are conflicting results on the age at which children are able to locate an object reflected in a mirror. While Priel and De Schonen (1986) found ceiling levels of the toy task between 20 and 26 months, Loveland (1987) found that children of the same age failed to locate the reflected objects. Robinson et al. (1990) also noted that over half of the infants (14 - 21 months of age) in their study failed to turn toward the toy despite evidence that they were interested in the image. Because such a high number of children did not pass the toy task, they suggested that this task may not adequately measure mirror knowledge because of methodological problems.

The present study was designed to eliminate problems that have been suggested in the literature. For example, Robinson et al, (1990) have suggested that the location of the toy may be signaled through social referencing. That is, the child may see his/her mother looking at the toy and then turn to find it. However, in the present study, the mothers

were seated in front of the children, facing the mirror, and asked to refrain from looking towards the location of the toy. Because all mothers followed this request, social referencing should not have occurred here. Furthermore, Robinson et al. (1990) also suggested that children may hear the toy when being lowered from a pulley. However, a pulley was not used in the present study; instead, the toy was silently lowered from a piece of clear string by hand. Thus, the chance that the children heard noise behind them is very low. It appears that the development of mirror knowledge across age is quite variable, and the causes for such variability have yet to be resolved.

Comparison between the Longitudinal and Cross-sectional Groups

Another of the major goals of the present study was to conduct comparisons between the longitudinal and cross-sectional groups, specifically, to compare the average age of acquisition of each of these skills. Comparisons of the onset of each measure, between the cross-sectional and longitudinal groups revealed that the children in the longitudinal group had an earlier age of onset for the rouge, photo and toy task as opposed to the cross-sectional group. However, there were no significant differences in the age of onset of personal pronoun use. Because the children in the longitudinal group were given the same tasks, in the same atmosphere every two weeks, we can conclude that the differences between the two groups indicate that there were practice effects evident within this group. Thus, repeated exposure to the tasks led the children to learn the skills required to pass each task and thus accomplish them at an earlier age as compared to the children who were not given repeated exposure to the tasks. As the present study also revealed that the level of exposure to mirrors did not influence the age

of onset for self-recognition, this indicates that it was repeated exposure to the actual rouge task, and not merely exposure to mirrors alone that resulted in an earlier onset of visual self-recognition.

Based on early research in self-recognition it was generally thought that the age of onset for self-recognition was due purely to biological maturation (e.g. see Lewis & Ramsay, 1997). However, more recent research has revealed that the child's reaction to his/her mirror image is influenced by genetic, social and experiential factors (Cicchetti & Scneider-Rosen, 1986; Lewis, Brooks-Gunn & Jaskir, 1985). The results of the present study support such recent findings, as experience with the rouge, toy and photo task enhanced the age of acquisition. Furthermore, in support of the effects of practice with the toy task, as discussed earlier, Priel and De Schonen (1986) found that there were significant differences in the children's ability to locate an object reflected in a mirror between the children who had previous experience with mirrors in comparison to the children who had not. A significantly greater number of children with previous experience were able to locate the object, and were able to do so at earlier ages than those with no previous experience. Therefore, their study suggests that practice with mirrors would lower the age of acquisition of the toy task as we have presently found. The finding that there were no practice effects present in the onset of personal pronoun use is logical as there was no task that was given to the children in the longitudinal group repeatedly. The mothers of this sample simply informed us if the child had or had not used a personal pronoun at every two-week visit. Thus, it was not expected that practice effects would exist within this measure.

Individual Variability

A close examination of the longitudinal data revealed that there was within subject variability as well as between subject variability in the emergence of each skill measured. Of particular interest is the within subject variability. It was found that many individuals would pass a task during one testing session and then fail the same task the following session. This variability was evident in each of the rouge, toy and photo tasks. However, it was most prevalent in the rouge task. For instance, several children in the longitudinal group would pass the rouge task during one session, and then appear as though they had never seen the task before during the following session.

As noted earlier, Siegler (1994) argues that the acquisition of a new skill is quite fragile and variable in the beginning. He states that a child may acquire a new skill, then lose it and acquire it again, and thus suggests that cognitive development is not stable at its onset. For instance, Siegler and Stern's (1998) research on quantitative strategy development using the microgenetic method revealed that even after children had discovered sophisticated scientific experimentation strategies, many continued to use less sophisticated ones as well. Siegler and Stern (1998) state that the existing research using the microgenetic method reveals that cognition and cognitive growth are far more variable than traditionally thought and that the traditional view that a child "has" or "does not have" a cognitive skill is incorrect. The individual variability evident in the present study provides further support for this conclusion and to our knowledge is the first to show such variability in the acquisition of a social cognitive skill in toddlers.

Furthermore, the high degree of individual variability indicates that conclusions

about cognitive activity based on cross-sectional and longitudinal research will differ. That is, as cross-sectional research provides information with just one testing session, it cannot be determined if the participant has or has not been capable of demonstrating the required behavior previous to this period, or if the participant's behavior is stable. Thus, it cannot be determined if the obtained data truly represents the participant's capabilities. Hence, the findings of the present study emphasize the importance of longitudinal research when studying cognitive development.

It is interesting to note that very little embarrassment was observed in the present study. For instance, only 15 of the 90 participants in the cross-sectional group demonstrated gaze aversion, movement of the hands to touch parts of the body (besides the nose), and smiling, which was the criterion for embarrassment with young children proposed by Buss (1980). This is a notably lower level of embarrassment than reported by Lewis and Brooks-Gunn (1979). There doesn't appear to be a clear explanation as to why such a small number of children showed embarrassment in the present study. However, past research has not clearly explained how many people were present in the laboratory during testing, nor how large the laboratory was. Perhaps the small number of people present during our testing (three including the mother) and the small size of the room allowed the children to become more relaxed and less embarrassed by the rouge task in contrast to the atmospheres in past research.

Ambiguous Behavior in the Rouge Task

As noted earlier, several concerns have been raised about the rouge task. For example, researchers Asendorpf et al. (1996) argue that some children may be capable of

recognizing their mirror image, but may not respond to the mark on their nose by touching it. Thus, they argue that the rouge task may produce false negatives. For example, Asendorpf et al. (1996) reported that several children are reported to demonstrate ambiguous behavior during the rouge task, where they closely inspect their image for a long time but neither react to the sight of their face nor to the mirror. These investigators devised a procedure wherein children are shown a doll with a spot of rouge on the face and are asked to clean the dolls face with a tissue. The classic rouge task is then applied. Implementation of this procedure significantly reduced the number of ambiguous cases normally found when the classic task is implemented alone, and lowered the age of mirror self-recognition onset from 18 months to 17 months of age (Asendorpf et al., 1996).

In the present study, ambiguous responses were found in both the cross-sectional and longitudinal samples of children. In the cross-sectional sample, 60% of the 18-month old children were classified as recognizers according to the traditional criterion of touching the mark, yet 90% of the 18-month old children were recognizers when ambiguous behavior was included in the classification. Thus, classifying ambiguous behavior as self-recognition increased the proportion of recognizers. It is interesting to note that a great deal of ambiguous behavior was observed in the longitudinal group of children. Some of the children would touch the mark on their nose during one testing session, and then revert to ambiguous behavior the next session. Additionally, many children demonstrated ambiguous behavior for several weeks before touching their nose. After observing the behavior of each child in the longitudinal group repeatedly, it

became evident that several children seemed to recognize their mirror image but did not touch their nose. For example, some children would stare in the mirror then gaze away shyly, while others would appear surprised to see the mark on their nose at first, but then continue to look around as though they knew something was there, but did not mind. After several months of testing, it became very clear that in many cases, self-recognizers demonstrated ambiguous behavior rather than mark-directed behavior. From this observation, it can be concluded, as did Asendorpf et al. (1996), that the criterion of touching the nose may not accurately represent *all* of the children that are self-recognizers and thus, the rouge test yields an underestimation of the number of children that recognize their mirror image.

Children who recognize their mirror image may not touch the mark on their nose for several reasons. They may not know how to react, they may not care about the mark, or they may be too self-conscious to react. Because of the inability to determine if ambiguous behavior represents self-recognition, one must make their own judgment, and in the case of the present study, it was felt that this behavior, or the classic criterion of touching the nose both indicates self-recognition. However, it is clear that a more explicit test of mirror self-recognition is needed.

Co-appearance of Measures of Self-knowledge

As noted earlier, Courage and Howe (in press) suggested that children undergo a pervasive transition in cognitive development late in the second year. Moreover, it has been suggested that a sudden shift occurs in self-development at approximately 18 months of age (Lewis et al., 1989). Hence, one of the main questions addressed in the

present study was whether successful performance on the rouge, toy and photo tasks, and the use of personal pronouns occur together and form a general construct, or whether they are independent of each other, either over all ages tested (15-23 months of age), or at any of the following age categories: 15-17, 18-20, or 21-23 months. Although the measures did not co-occur overall, at the 15-17 month or 18-20 month age categories, but that they did occur together at 21-23 month age category. However, the meaning of the finding that the measures occur together between 21 and 23 months of age is questionable because by this age, almost all children will pass these tasks whether they are linked or not. That is, 21 to 23 months was the oldest age group of children tested, and these children were more likely to pass each of the measures than were children between 15 and 20 months of age. However, this is likely due to advanced cognitive maturity rather than to any change in the self-construct per se. For example, we might expect that if these children were given other cognitive tasks, such as an object permanence task or deferred imitation, that these tasks may also appear to occur with the other measures in the present study.

Overall, the results indicate that the development of the various aspects of self-knowledge measured here emerge independently and do not form a unitary construct – at least prior to 21 months of age. Hence, it can be suggested that the objective sense of self may not develop suddenly at approximately 18 months of age, but that development of the objective sense of self occurs gradually and in steps during the second year. Consistent with these results, Berthenal and Fischer (1978) have also found that self-recognition develops in the context of a cognitive-developmental sequence of behaviors

such as touching the mark after seeing the mirror image in the rouge task, and stating his/her name or using personal pronouns to identify his/herself in a name task. They proposed that children develop each skill independently over time, which appears to be the case with the measures in the present study.

Knowledge of Mirrors

As mentioned earlier, there is a controversy in the literature over whether knowledge of mirrors is or is not tied to mirror self-recognition. Researchers such as Berthenal and Fischer (1978), Bigelow (1981), and Chapman (1987) argue that locating an object from the mirror is a general measure of self-recognition. For instance, Bigelow (1981) argues that children will turn to find an object reflected in a mirror only if they recognize their own image, and use it as a reference to determine the object's location. However, other researchers such as Anderson (1984), Priel and De Schonen (1986), and Robinson et al. (1990) argue that there is no relationship between self-recognition and mirror knowledge. For instance, Robinson et al. (1990) found that children aged 18 and 22 months were able to locate a toy, regardless of whether or not their own images could be seen in the mirror, which refutes Bigelow's (1981) argument. Furthermore, Robinson et al. (1990) gave a self-identification task in which the children were shown their mirror image and asked "Who's that?" and found that the responses on this task did not differentiate infants who could and could not locate the toy.

Due to the controversy over the importance of mirror knowledge in the development of the self, a further issue addressed in the present study was to determine if mirror knowledge is related to the ability to recognize one's mirror image. As locating an

object in real space after viewing it's reflection in a mirror (passing the toy task) is thought to indicate that a child has some understanding of the reflective properties of mirrors, it was of interest to determine whether this understanding is a necessary precondition to identifying one's mirror image. The results of this investigation show that there were no significant differences in the performance on the rouge task between the participants who passed the toy task and those who did not. Thus, it was found that knowledge of the reflective properties of mirrors was unrelated to mirror self-recognition.

Although the methodology used in most studies that have investigated mirror knowledge is quite similar, Robinson et al. (1990) note that the positioning of the infant's mother is unclear in several studies. During testing, the infants in the present study would frequently alternate looking at the mirror and their mother. This can cause two problems: 1) if the mother is able to see the location of the toy, he/she may obtain visual cues by observing his/her mother's eye movements, 2) if the mother was sitting slightly behind the infant, the infant may see the toy in his/her peripheral vision when looking towards her. In the present study, the mother was seated ahead and to the right of the infant, facing the mirror. This prevented the mother from seeing the toy behind the infant, and also prevented the infant from seeing the toy in his/her peripheral vision when looking towards his/her mother. The same precautions were taken in the study by Robinson et al. (1990). It may be that the investigators who argue that infants must pass the toy task before passing the rouge task did not follow such precautions and may have found an earlier age of onset for the toy task because of such cues. As the positioning of the mothers is not clearly described in such studies, this is merely a suggestion.

Nevertheless, the present study supports the argument that there is no relationship between visual self-recognition and mirror knowledge.

## The Role of Experience

Another issue addressed in the present study was whether the level of exposure to mirrors in the everyday environment, or familiarity with mirrors, influences the ability to identify one's mirror image, and thus, pass the rouge task. Results demonstrate that there were no significant differences in the performance on the rouge task between the children rated as having a high level of exposure to mirrors and the children rated as having a low level of exposure. This result indicates that the level of mirror experience does not directly influence the development of visual self-recognition.

The influence of familiarity with mirrors on self-recognition has been investigated with both children (Priel & De Schonen, 1986) and primates (Gallup, 1977; Anderson, 1984). Priel and De Schonen (1986) investigated self-recognition with children who had been raised in a rural population with no previous exposure to mirrors. They found that these children recognized and named their mirror image at approximately the same ages as did children that were familiar with mirrors. Additionally, they found that a significantly greater number of children who were familiar with mirrors were able to locate an object reflected in a mirror, and did so at earlier ages in comparison to the children who were unfamiliar with mirrors. Therefore, it appears that the level of exposure these children had with mirrors did not influence their ability to recognize their mirror image but did influence their ability to use a mirror to locate an object. Hence,

this result suggests that several of the children were able to demonstrate mirror self-recognition without having an understanding of the reflective properties of mirrors.

Research with chimpanzees indicates that self-recognition seems to depend on cognitive capacity and familiarity with other subjects of the same species, and appears to be independent of familiarity with mirrors. For instance, Gallup (1977) found that chimpanzees reared among other chimpanzees demonstrated mirror self-recognition after only little exposure to mirrors, yet isolated chimpanzees with a great deal of exposure to mirrors were not capable of self-recognition. However, these isolated chimpanzees are able to recognize their mirror image after only little socializing with other chimpanzees. In addition, it is interesting to note that only the great apes are capable of demonstrating mirror self-recognition and locating objects reflected in a mirror, yet primates such as macaques seem unable to recognize their mirror image even after thousands of hours of exposure (Anderson, 1984). Thus, it appears that both familiarity with mirrors, and knowledge of the reflective properties of mirrors does not influence the development of mirror self-recognition. It can therefore be suggested that recognizing one's mirror image and using a mirror to locate a toy are operating under different processes.

Scalability of Measures

The next question addressed was that, if the measures were not homogeneous, did they occur in a predicable scale or order? Guttman's scalogram analysis showed that children first learn to recognize their mirror image, then begin using personal pronouns (e.g. I or me), and then learn to identify their photo image. Additionally, it was found that locating an object reflected in a mirror does not fit within this developmental scale of

self-recognition. That is, performance on the toy task was not related to performance on any of the other measures.

Generally, research in the past has tended to use mark-directed behavior on the rouge task, using one' s name or personal pronouns, identifying one's photo image, and turning toward an object that has been reflected in a mirror, as correlated indices of self-knowledge (Berthenal & Fischer, 1978; Lewis et al., 1979; Povinelli, Landau & Perilloux, 1996). As for the developmental sequence of these measures, conflicting results have arisen concerning the order of onset of mark-directed behavior and turning to the object behaviors. While Zazzo (1977) reported that, developmentally, finding the object occurs after mark-directed behavior (as cited in Povinelli, Landau & Perilloux, 1996), Berthenal and Fischer (1978) and Priel and De Schonen (1986) found that locating the object develops earlier than does visual self-recognition. In the present study, the toy task did not fit into the scale of the order of appearance of the other self-measures. Moreover, 24% of the children in the cross-sectional group passed the rouge task but failed the toy task, while 12% of the children passed the toy task but failed the rouge task. Thus, no clear order of appearance of these two tasks was evident in the present study. It appears that the toy task is an independent cognitive ability and that performance on the toy task does not provide information on a child's knowledge of the self, contrary to what has been previously thought.

As for the order of onset of the use of personal pronouns and identifying one's photo image, the literature states that both develop after the onset of mirror self-recognition. For example, Charney (1978) found that children began using the personal

pronoun "I" at approximately 22 months of age and the onset of photo identification was found to be between 23 and 27 months in a study by Bigelow (1981). Hence, the present results are consistent with the past literature, and further add to the existing knowledge base, the finding that the onset of the use of personal pronouns occurs before the onset of photo identification. The fact that the onset of personal pronoun use occurred after the onset of mirror self-recognition also supports Howe and Courage's (1997) suggestion that children must be capable of visual self-recognition and consolidate their knowledge of self before they can move on to a new level of competence that enables them to use self-referent pronouns.

The Relationship between Language and Self-recognition

A further goal of the present study was to determine whether there was a relationship between visual self-recognition and language. Our results show that the children demonstrating visual self-recognition had a significantly larger productive vocabulary than those that did not demonstrate visual self-recognition. Furthermore, it was found that there were no significant differences in the number of words produced between the children who were early recognizers (passing the rouge task at 15-17 months) and late recognizers (failing the rouge task at 21-23 months). Thus, because there were no differences in the language ability between the early and late recognizers despite the age differences, it appears that language and self-recognition develop simultaneously. This finding is also consistent with the argument proposed by Mead (1934) that self-development is dependent upon the development of language. He believed that gestures and language provide the infant with the means to interact with

others, to anticipate others' reactions, to take the role of the other person, to perceive the self as an object, and to differentiate between self and others.

The relationship between language and self-recognition may well be mediated by a general advance in cognitive maturity. In fact, the age of onset of visual self-recognition is said to be primarily a function of cognitive development or cognitive maturation. The role of maturation is best illustrated in self-recognition research on children with developmental disabilities. For example, the studies that have investigated the age of mirror self-recognition onset in children with Down's syndrome have found that the majority of these children do not demonstrate mark-directed behavior to the rouge task until they have reached a mental age of 15 months, as opposed to a chronological age of 15 months as found with normal children (Loveland, 1987).

Summary

In summary, the research presented here has revealed several insights into the development of self-recognition. There were sudden spurts in the development of mirror self-recognition and photo identification at 17 months and 22 months respectively. Yet, there were no sudden increases in the development of personal pronouns, which showed a continuous increase. There was no evident pattern of development in the ability to locate a toy reflected in a mirror.

Comparisons of the cross-sectional and longitudinal groups of children showed that the children in the longitudinal group demonstrate an earlier age of acquisition of mirror self-recognition, location of the reflected toy, and identification of the photo image as opposed to the cross-sectional group. Hence, practice effects are apparent here. Yet,

there were no significant differences in the ages at which children in both the cross-sectional and longitudinal groups began using personal pronouns. Investigation of the longitudinal group also revealed that there is a great deal of both within and between individual variability in the development of each skill measured. In addition, it was found that several children in the present study demonstrated ambiguous behavior to the rouge task, which was thought to indicate that several of these children were capable of self-recognition, but did not respond to the rouge task by touching their nose. Thus, it was concluded that the criterion of mark-directed behavior to the rouge task may underestimate the age at which children can recognize their mirror image.

Measurement of the ability to recognize one's mirror image, to locate a toy reflected in a mirror, to identify one's photo image and the use of personal pronouns revealed that these abilities develop independently. Additionally, it was found that children tend to first recognize their mirror image, then begin using personal pronouns, and finally, are able to identify their photo image. Thus, these abilities develop in a predictable order. The ability to locate a reflected toy does not fit into this sequence. Neither knowledge of the reflective properties of mirrors nor the amount of exposure to mirrors has an influence on the development of mirror self-recognition. But practice did affect the toy task, and the toy task does not appear to be a measure of self-knowledge.

The present study also reveals that language development, specifically, vocabulary production develops simultaneously with mirror self-recognition, and may play a role in the development of visual self-recognition. Finally, no gender differences were found among any of the measures in the present study. In conclusion, a substantial

amount of knowledge was gained from the present study, and future cross-sectional and longitudinal research focusing on the age at which each skill was found to develop, and additional issues such as motivation and/or temperament will further add to the current knowledge base of the development of the categorical self.

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Table 1a-1j.

Individual Performance of Each Participant in the Longitudinal Group Across Time.

Table 1a

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rouge | Y | | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ |
| | N | ♠ | | | | | | | | | | | | | | | | |
| Affect | Y | | | | | | | | | | | | | | | | | |
| | N | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × |
| Toy | Y | | | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ |
| | N | ♦ | ♦ | | | | | | | | | | | | | | | |
| Photo | Y | | | | | | | | | | | * | * | * | * | * | * | * |
| | N | * | * | * | * | * | * | * | * | * | * | | | | | | | |
| Pronoun | Y | | | | | | | | | | | o | o | o | o | o | o | o |
| | N | o | o | o | o | o | o | o | o | o | o | | | | | | | |
| Age | | 15 | 15.5 | 16 | 16.5 | 17 | 17.5 | 18 | 18.5 | 19 | 19.5 | 20 | 20.5 | 21 | 21.5 | 22 | 22.5 | 23 |

Table 1b

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rouge | Y | | ● | ● | | ● | | ● | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ |
| | N | ♠ | | | ♠ | | ♠ | | | | | | | | | | | |
| Affect | Y | | | | | | | | | | | × | | | | | | |
| | N | × | × | × | × | × | × | × | × | × | × | | × | × | × | × | × | × |
| Toy | Y | | | | | | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ |
| | N | ♦ | ♦ | ♦ | ♦ | ♦ | | | | | | | | | | | | |
| Photo | Y | | | | | | | | | | | | | | | | | |
| | N | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Pronoun | Y | | | | | | | | | | | | | | | | | |
| | N | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Age | | 15 | 15.5 | 16 | 16.5 | 17 | 17.5 | 18 | 18.5 | 19 | 19.5 | 20 | 20.5 | 21 | 21.5 | 22 | 22.5 | 23 |

Table 1c

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rouge | Y | | | | | | | ⊗ | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | N | ♠ | ♠ | ♠ | ♠ | ♠ | ♠ | | | | | | | | | | | |
| Affect | Y | | | | | | | | × | × | | | | | | | | |
| | N | × | × | × | × | × | × | × | | | × | × | × | × | × | × | × | × |
| Toy | Y | | | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ |
| | N | ♦ | ♦ | | | | | | | | | | | | | | | |
| Photo | Y | | | | | | | | | | * | * | * | * | * | * | * | * |
| | N | * | * | * | * | * | * | * | * | * | | | | | | | | |
| Pronoun | Y | | | | | | | | | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | N | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | | | | | | | |
| Age | | 15 | 15.5 | 16 | 16.5 | 17 | 17.5 | 18 | 18.5 | 19 | 19.5 | 20 | 20.5 | 21 | 21.5 | 22 | 22.5 | 23 |

Table 1d

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rouge | Y | | ⊗ | | | • | • | • | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ |
| | N | ♠ | | ♠ | ♠ | | | | | | | | | | | | | |
| Affect | Y | | | | | | × | ✓ | | | | | | | | | | |
| | N | × | × | × | × | × | | | × | × | × | × | × | × | × | × | × | × |
| Toy | Y | | | | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ |
| | N | ♦ | ♦ | ♦ | | | | | | | | | | | | | | |
| Photo | Y | | | | | | * | | | * | * | * | * | * | * | * | * | * |
| | N | * | * | * | * | * | | * | * | | | | | | | | | |
| Pronoun | Y | | | | | | | | | | | | | | | | | ○ |
| | N | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | |
| Age | | 15 | 15.5 | 16 | 16.5 | 17 | 17.5 | 18 | 18.5 | 19 | 19.5 | 20 | 20.5 | 21 | 21.5 | 22 | 22.5 | 23 |

Table 1e

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rouge | Y | | ⊗ | ⊗ | • | • | • | • | • | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ |
| | N | ♠ | | | | | | | | | | | | | | | | |
| Affect | Y | | × | | | × | | ✓ | × | × | | | | | | | | |
| | N | × | | × | × | | × | | | | × | × | × | × | × | × | × | × |
| Toy | Y | | | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ |
| | N | ♦ | ♦ | | | | | | | | | | | | | | | |
| Photo | Y | | | | | | * | * | | | | | | * | * | * | * | * |
| | N | * | * | * | * | * | | | * | * | * | * | * | | | | | |
| Pronoun | Y | | | | | | | | | | | | | ○ | ○ | ○ | ○ | ○ |
| | N | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | | | | |
| Age | | 15 | 15.5 | 16 | 16.5 | 17 | 17.5 | 18 | 18.5 | 19 | 19.5 | 20 | 20.5 | 21 | 21.5 | 22 | 22.5 | 23 |

Table 1f

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rouge | Y | | | | ● | ● | ⊗ | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | N | ♠ | ♠ | ♠ | | | | | | | | | | | | | | |
| Affect | Y | | | | × | × | × | × | | | | | | | | | | |
| | N | × | × | × | | | | | × | × | × | × | × | × | × | × | × | × |
| Toy | Y | | | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ |
| | N | ◆ | ◆ | | | | | | | | | | | | | | | |
| Photo | Y | | | | | | | * | * | * | * | * | * | * | * | * | * | * |
| | N | * | * | * | * | * | * | | | | | | | | | | | |
| Pronoun | Y | | | | | | | | | o | o | o | o | o | o | o | o | o |
| | N | o | o | o | o | o | o | o | o | | | | | | | | | |
| Age | | 15 | 15.5 | 16 | 16.5 | 17 | 17.5 | 18 | 18.5 | 19 | 19.5 | 20 | 20.5 | 21 | 21.5 | 22 | 22.5 | 23 |

Table 1g

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rouge | Y | ● | | ⊗ | ● | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ |
| | N | | ♠ | | | | | | | | | | | | | | | |
| Affect | Y | | | | × | × | × | | | | | | | | | | | |
| | N | × | × | × | | | | × | × | × | × | × | × | × | × | × | × | × |
| Toy | Y | | | | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ |
| | N | ◆ | ◆ | ◆ | | | | | | | | | | | | | | |
| Photo | Y | | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| | N | * | * | | | | | | | | | | | | | | | |
| Pronoun | Y | | | | | | o | o | o | o | o | o | o | o | o | o | o | o |
| | N | o | o | o | o | o | | | | | | | | | | | | |
| Age | | 15 | 15.5 | 16 | 16.5 | 17 | 17.5 | 18 | 18.5 | 19 | 19.5 | 20 | 20.5 | 21 | 21.5 | 22 | 22.5 | 23 |

Table 1h

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rouge | Y | | | ⊗ | • | • | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊘ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ |
| | N | ♠ | ♠ | | | | | | | | | | | | | | | |
| Affect | Y | | | | | | | | | | | | | | | | | |
| | N | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × |
| Toy | Y | | | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ |
| | N | ♦ | ♦ | | | | | | | | | | | | | | | |
| Photo | Y | | | | | * | | | | * | * | * | * | * | * | * | * | * |
| | N | * | * | * | * | | * | * | * | | | | | | | | | |
| Pronoun | Y | | | | | | | | | | | | | | | | | ○ |
| | N | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | |
| Age | | 15 | 15.5 | 16 | 16.5 | 17 | 17.5 | 18 | 18.5 | 19 | 19.5 | 20 | 20.5 | 21 | 21.5 | 22 | 22.5 | 23 |

Table 1i

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rouge | Y | | | | | • | • | • | • | • | • | • | • | • | • | • | • | • |
| | N | ♠ | ♠ | ♠ | ♠ | | | | | | | | | | | | | |
| Affect | Y | | | | | | | | | × | | | | | | | | |
| | N | × | × | × | × | × | × | × | × | | × | × | × | × | × | × | × | × |
| Toy | Y | | | | | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | |
| | N | ♦ | ♦ | ♦ | ♦ | | | | | | | | | | | | | |
| Photo | Y | | | | | | | | * | * | * | * | * | * | * | * | * | * |
| | N | * | * | * | * | * | * | * | | | | | | | | | | |
| Pronoun | Y | | | | | | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | N | ○ | ○ | ○ | ○ | ○ | ○ | | | | | | | | | | | |
| Age | | 15 | 15.5 | 16 | 16.5 | 17 | 17.5 | 18 | 18.5 | 19 | 19.5 | 20 | 20.5 | 21 | 21.5 | 22 | 22.5 | 23 |

Table 1j

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rouge | Y | | | | | • | • | • | • | • | • | • | • | ⊘ | ⊗ | ⊗ | ⊗ | ⊗ |
| | N | ♠ | ♠ | ♠ | ♠ | | | | | | | | | | | | | |
| Affect | Y | | | | | | × | × | | | | | | | | | | |
| | N | × | × | × | × | × | | | × | × | × | × | × | ✓ | × | × | × | × |
| Toy | Y | | | | | | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ | ♦ |
| | N | ♦ | ♦ | ♦ | ♦ | ♦ | | | | | | | | | | | | |
| Photo | Y | | | | | | * | | | | | | | | | | | |
| | N | * | * | * | * | * | | * | * | * | * | * | * | * | * | * | * | * |
| Pronoun | Y | | | | | | | | | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | N | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | | | | | | | |
| Age | | 15 | 15.5 | 16 | 16.5 | 17 | 17.5 | 18 | 18.5 | 19 | 19.5 | 20 | 20.5 | 21 | 21.5 | 22 | 22.5 | 23 |

Note: ♠ represents failing the rouge task

• represents ambiguous behavior in the rouge task

⊗ represents passing the rouge task (immediate or delayed)

## Figure Captions

Figure 1. Success on the self-recognition variables by age: cross-sectional sample.

Figure 2a. Success on the rouge task by age: cross-sectional sample.

Figure 2b. Success on the pronoun measure by age: cross-sectional sample.

Figure 2c. Success on the photo identification task by age: cross-sectional sample.

Figure 2d. Success on the toy location task by age: cross-sectional sample.

Figure 3a. Success on the rouge task by age: cross-sectional and longitudinal samples.

Figure 3b. Success on the photo task by age: cross-sectional and longitudinal samples.

Figure 3c. Success on the pronoun measure by age: cross-sectional and longitudinal samples.

Figure 3d. Success on the toy task by age: cross-sectional and longitudinal samples.

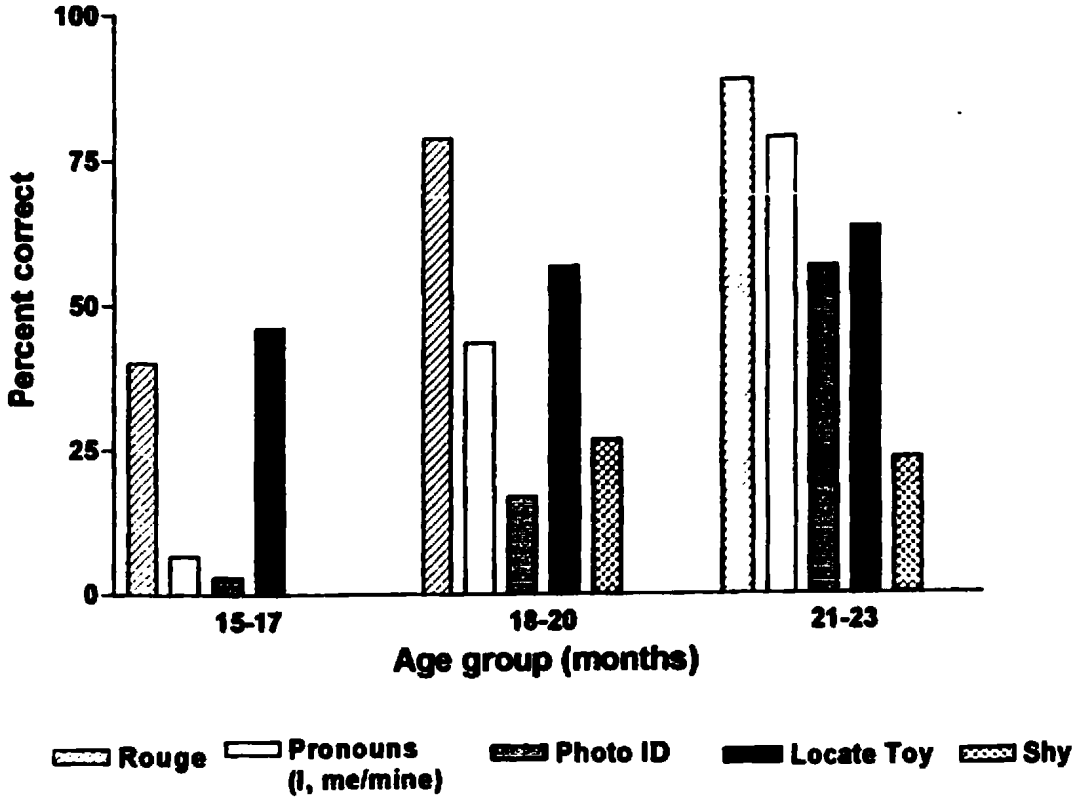
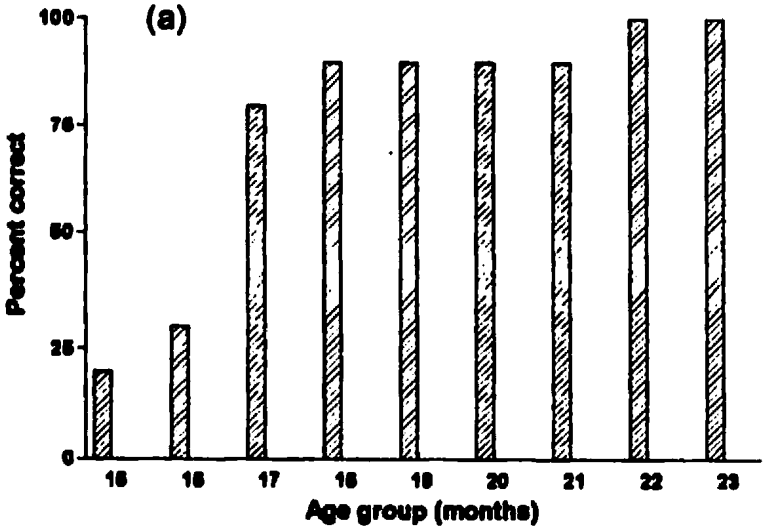
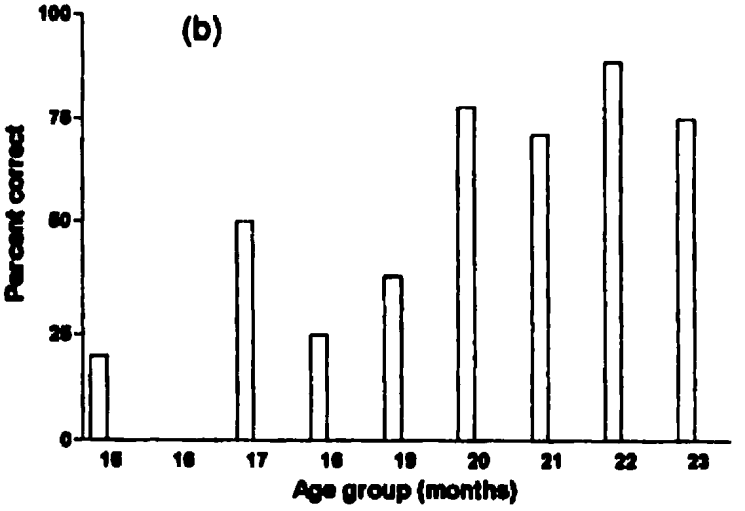

100
75
50
25
0
Percent correct
15-17
18-20
21-23
Age group (months)
Rouge
Pronouns (I, me/mine)
Photo ID
Locate Toy
Shy

Figure1

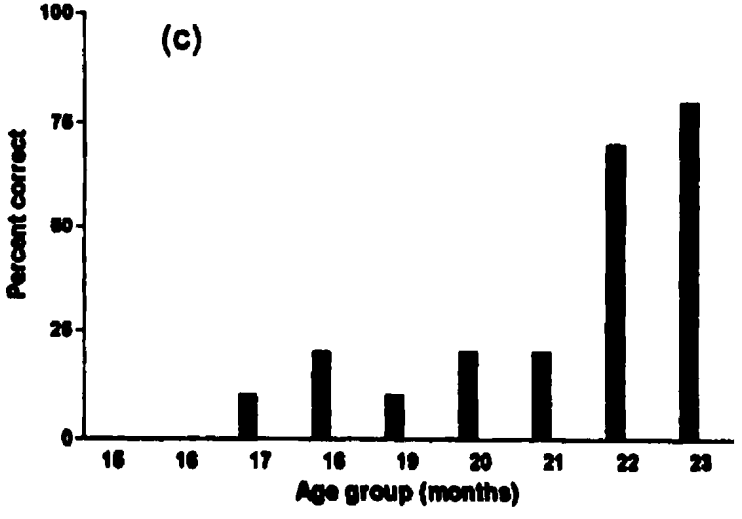
Success on the Rouge Task by Age: Cross-sectional Sample




Success on the Pronoun Measure by Age: Cross-sectional Sample




Success on the Photo ID Task by Age: Cross-sectional Sample




Success on the Toy Location Task by Age: Cross-sectional Sample

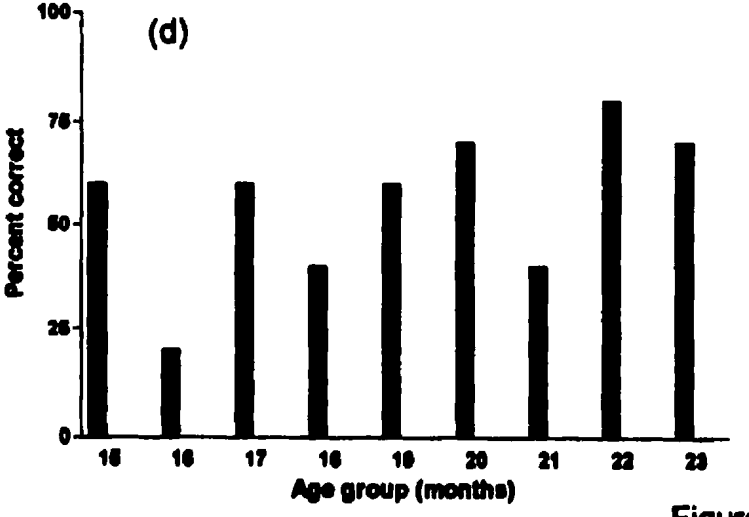
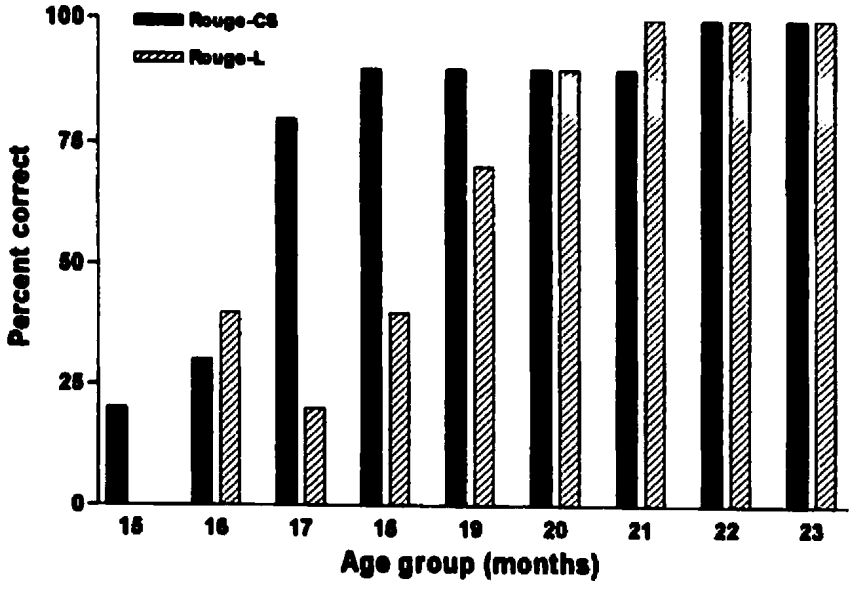
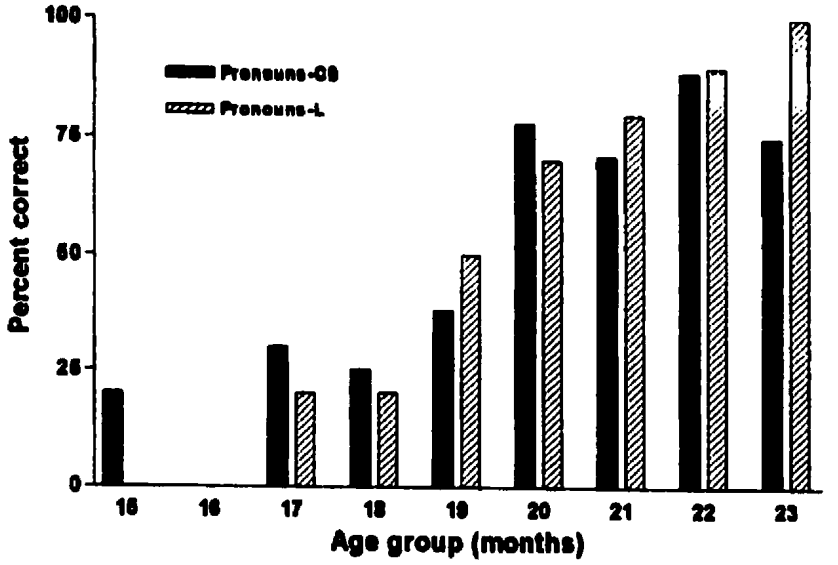


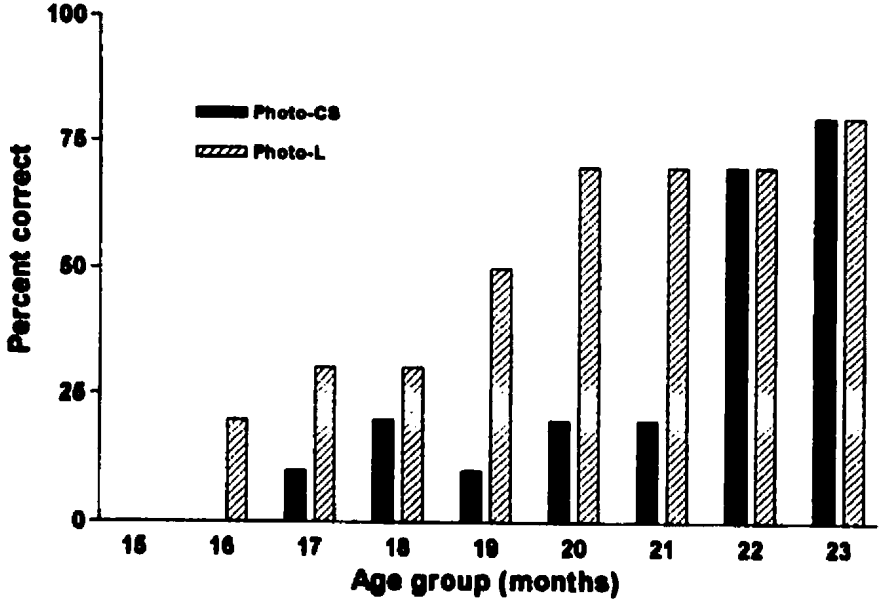

Figure 2



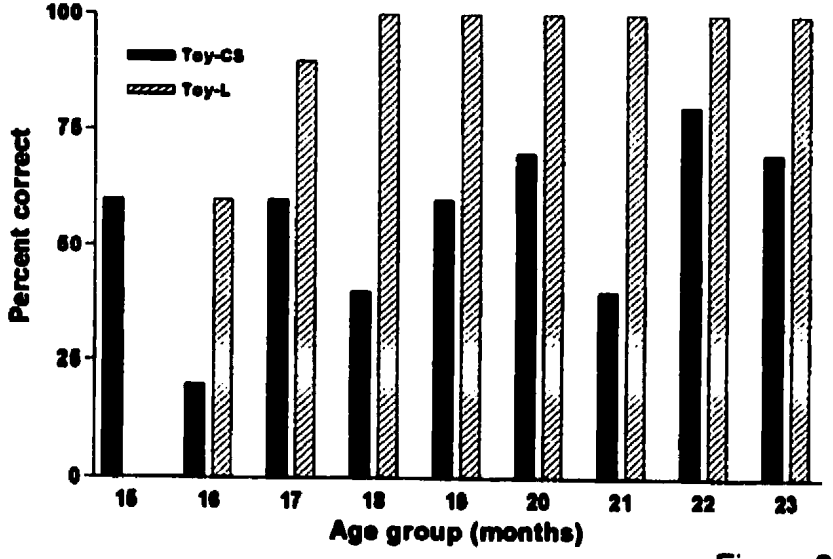

(a)




(b)




(c)




(d)

Figure 3

Appendix A

## CONSENT FORM

I agree to allow my child_____ to participate in a research project on the early development of self-recognition to be conducted at Memorial University of Newfoundland. Specifically, he/she will be seated in front of a mirror and will have a spot of nontoxic, odorless, red face paint placed on his/her nose by me and that his/her reactions will be noted. My child will also attempt to locate a toy seen reflected in the mirror, and asked to identify a photo of him/herself from an array of three photos. I understand that my child will be videotaped and observed during this procedure. I will also fill in a questionnaire regarding my child's understanding and use of language. I understand that my child's participation is voluntary, that I will be present during the procedure, and that I may withdraw him/her from the project at any time. I understand that my child's performance will be confidential, and that both the videotape and photo of my child will contain no identifying information. I understand that they will be kept in a locked filing cabinet, transcribed after the study and later destroyed. I also understand that he/she will not be identified in any published report of the study and that the results of the project will be made available to me upon its completion. If you have any further questions you can contact Dr. Mary Courage, 737-8027 or Head of the Psychology Department, Dr. John Evans, 737-8496.

Date: Signed:

Appendix B

**Mirror Experience Questionnaire**

**Please answer the following questions.**

1. Does your child play with any mirrored toys?

   Yes No

2. Are there any mirrors placed in the house so that your child can readily see themselves?

   Yes No

3. Do you and your child play in front of the mirror?

   Yes No

   If yes, how often?

   Daily____ Weekly _____ Monthly _____