Self-Recognition in Young Children Using Delayed versus Live Feedback: Evidence of a Developmental Asynchrony

Daniel J. Povinelli, Keli R. Landau, and Helen K. Perilloux

University of Southwestern Louisiana New Iberia Research Center

POVINELLI, DANIEL J.; LANDAU, KELI R.; and PERILLOUX, HELEN K. *Self-Recognition in Young Children Using Delayed versus Live Feedback: Evidence of a Developmental Asynchrony.* CHILD DEVELOPMENT, 1996, 67, 1540–1554. The ability of young children to recognize themselves in delayed videotapes and recent photographs was investigated using a delayed analog of the mirror mark test, as well as verbal reports. In Experiment 1, 42 2–4-year-old children were videotaped while playing an unusual game. During the game an experimenter covertly placed a large sticker on the child's head. The videotape was played back 3 min later to the children. Older, but not younger, children reached up to remove the sticker when the tape revealed it being placed on their heads. In Experiment 2, a similar procedure was used with 60 3- and 4-year-olds where Polaroid photographs were taken during and after the act of the sticker being placed on the child's head. When allowed to look at the photographs, young 3-year-olds did not reach up to search for the sticker, whereas older 3- and 4-year-olds did. Almost all of the children who did not appear to realize that there was a sticker on their head from the information provided by the photographs did provide a correct verbal label for the image, and reached up to remove the sticker when presented with a mirror. Experiment 3 compared the reaction of 48 2½–3½-year-olds to live versus delayed video feedback and indicated an effect of the temporal aspect of the stimulus. The results are discussed in the context of the different forms of self-conception that may underwrite the 2 manifestations of self-recognition.

By about 18–24 months of age, most children will use mirrors or live video feedback to locate and inspect a mark placed covertly on some part of their face (typically the nose) (Amsterdam, 1972; Bertenthal & Fischer, 1978; Johnson, 1983; Lewis & Brooks-Gunn, 1979; Schulman & Kaplowitz, 1977). This behavior has been termed "self-recognition" and has been interpreted as evidence for the emergence of a self-concept. Indeed, Lewis and Brooks-Gunn (1979) have argued that self-recognition in mirrors provides some of the earliest evidence of the development of objective self-awareness. Gallup (1970, 1975) has independently described the capacity for mirror self-recognition in chimpanzees and has also argued for its relation to self-awareness, or the presence of a self-concept. The basic findings of self-recognition in chimpanzees have been replicated many times, and despite questions concerning the interpretation of the phenomenon it appears to be a homologous cognitive trait shared by the two species (Gallup, Povinelli, Suarez, Anderson, Lethmate, & Menzel, 1995; Povinelli, Rulf, Landau, & Bierschwale, 1993). To date, however, the phenomenon has not been documented in primates outside the great ape–human grouping, despite repeated (and often elaborate) attempts to do so (reviews by Anderson, 1984; Gallup, 1991).

This research was supported by NIH Grant No. RR-03583-05 to the University of Southwestern Louisiana New Iberia Research Center and NSF Young Investigator Award SBR-8458111 to D. J. Povinelli. We thank the directors, teachers, parents, and children of the USL Child Development Center, the First Methodist Day Care Center, Lourdes Child Care Center, Sarah's, Kid's Korner, and the Early Learning Center for their participation and support. Donna Bierschwale, Nathan Horwitz, Pam Argus, Mia Zebouni, Rebecca Wahler, Cindy Minneart, and Janice Searle assisted in data collection and analysis. Dare Baldwin, Lou Moses, and Marjorie Taylor made a number of thought-provoking comments which assisted in the research design. Gordon G. Gallup, Jr., and several reviewers provided helpful comments on the text. Helen K. Perilloux is now at the Department of Anthropology, University of Pittsburgh. Keli R. Landau is now at the Department of Biology, University of Southwestern Louisiana. Correspondence concerning this article should be addressed to Daniel J. Povinelli, Laboratory of Comparative Behavioral Biology, USL-New Iberia Research Center, 4401 W. Admiral Doyle Dr., New Iberia, Louisiana 70560.

[*Child Development*, 1996, 67, 1540–1554. 0009-3920/96/6704-0001$01.00]

Some researchers have attempted to ascertain the cognitive significance of self-recognition by investigating its correlation with other skills such as object permanence, altruism, and synchronic imitation (Asendorpf & Baudonniere, 1993; Bertenthal & Fischer, 1978; Bischof-Köhler, 1988; Johnson, 1982). Others have attempted to determine which of the cues provided by mirrors infants use to recognize themselves. One obvious cue provided by mirrors is the contingency between one's actions and the actions observed in the mirror. Several researchers have used delayed video and photographs to investigate the role that contingency plays in mirror self-recognition (Bigelow, 1981; Lewis & Brooks-Gunn, 1979). Lewis and Brooks-Gunn (1979) showed children stimuli of themselves (photographs or live vs. delayed video) as well as control stimuli of other comparably aged young children. A variety of measures were used as indicants of self-recognition such as the child saying "That's me" or labeling the image with their proper name, as well as differences in visual interest and affect. Based on the results of these measures, Lewis and Brooks-Gunn (1979) concluded that 18–24-month-old children showed evidence of self-recognition independent of the behavioral contingencies found in mirrors. They therefore reasoned that by about 2 years of age self-recognition can be based on featural cues in the absence of contingency cues. This does not imply that contingency is an unimportant component of the process leading up to the child learning to recognize itself in a mirror. Indeed, Lewis (1986) and others have noted that contingency may assist the young child in determining the source of the image in the mirror.

The data reviewed above can be interpreted as suggesting that young children recognize themselves in photographs or delayed videotapes in much the same way as they recognize themselves in mirrors (Lewis & Brooks-Gunn, 1979). However, there are reasons for suspecting that this is not so. The evidence supporting self-recognition in delayed videotapes and photographs by 2-year-olds is based upon measures of discrimination such as visual interest or verbal labeling. To date, there has been no analog of the mark test for delayed images of the self. This represents an important gap in our understanding of the phenomenon of self-recognition in young children because discrimination measures may be tapping into different phenomenon than the mark test, which requires the infant to demonstrate that it understands that what it is true of the image in the mirror is true of himself or herself. Verbal labeling of self-images may only reflect a correct association between the constellation of features found in the photograph, videotape or mirror and the child's proper name, or the personal pronoun "me" (Anderson, 1984; Bigelow, 1981; Gallup, 1975).

Although children's reactions to delayed video playback and photographs of the self have previously been used to assist researchers in determining the necessary factors for children to recognize their physical appearance, there is another reason why delayed images may be of special interest for understanding the child's developing self-concept. Studies of self-recognition involving live feedback (mirrors or live video) provide evidence for concluding that by 18–24 months young children possess the ability to construct a stable representation of at least their physical appearance and their personal agency, but it remains unclear the extent to which this self-concept possesses temporal dimensions. In other words, studies of mirror self-recognition are silent with respect to the infant's concept of the self's continuity through time.

A sense of continuity of the self has long been recognized as an important component of our adult understanding of the self (James, 1890/1950) and must be intimately linked with what has been called autobiographical memory, or our knowledge of our personal history. Thus, our adult folk psychology contains the belief that despite temporal transformations in our physical and mental states, we are composed of a coherent, unified entity known as the self. Thus, simply because various aspects of ourselves change through time (sometimes dramatically), in most cases humans continue to believe that what happened (or will happen) to those previous or imagined future states, happened (or will happen) to them, not someone else. We are not defending such folk psychology as a valid scientific framework, but rather we note that the human belief in a temporally coherent self comprises a core aspect our belief system, and as such demands a developmental explanation in its own right (see Povinelli, 1995, for a detailed developmental hypothesis). In brief, we ask at what age do young children come to conceive of the self as possessing explicit temporal dimensions? With respect to the development of an understanding of this temporal aspect of the

self, it can be seen that mirrors present a perfect temporal contingency between one's on-line behavior (and intentions, if those actions sufficiently instantiate them) and the behavior of the mirror-image. Thus, although evidence of the emergence of mirror self-recognition in 18–24-month-olds does not exclude the possibility that these infants have a conception of self that includes temporal dimensions, it does not provide unique evidence in support of that possibility.

In summary, tasks of mirror self-recognition demonstrate that by 2 years of age children infer that what is true of their mirror image is also true of themselves. However, there is no parallel evidence that children interpret slightly delayed images of themselves (videotape, photographs) in a similar manner. In the following experiments, we modified traditional self-recognition tests in order to investigate the development of the ability of young children to integrate information about past occurrences of the self with their current self-concept. We reasoned that if infants first come to understand themselves as "on-line" agents but only later develop the resources or conceptual capacities to explicitly conceive of themselves as agents with a past and future history (i.e., an ontogeny), then we could expect to find an asynchrony between the development of self-recognition using live versus delayed feedback, with self-recognition occurring earlier in the case of live feedback (see Povinelli, 1995). Determining if such an asynchrony exists is important for at least two reasons. First, it would provide a potentially important nonverbal method for investigating the development of young children's understanding of their own ontogeny. Second, it would provide an important nonverbal methodology in the effort to reconstruct the evolution of theory of mind (Povinelli, 1993). Some researchers have argued that the ability to conceive of the self in relation to the present, past, and future is restricted to the human species (Fraser, 1987; Tulving, 1983). But given that many great apes show clear evidence of self-recognition in mirrors, the development of tasks which tap into a temporal dimension of the self-concept could provide an important avenue for testing the idea that autobiographical memory is restricted to humans.

Experiment 1

In the first experiment, we investigated the extent to which young children are able to understand the connection between slightly delayed images of themselves and their presently experienced self. To probe this understanding, we developed an analog of the traditional mark test for self-recognition for use with delayed videotape. Children were videotaped while they played a game with two experimenters. During the course of the game one of the experimenters covertly placed a large sticker in their hair in such a fashion that it was clearly visible on the tape. Three minutes after the marking event they were allowed to watch the videotape to determine if they would reach up to remove the sticker once the tape revealed the experimenter placing it in their hair. We predicted that if the capacity of 2-year-olds to pass the mark test using mirrors reflected the presence of a temporally differentiated conception of self, then upon seeing the events in which they had just participated result in a sticker being placed on their head, they would reach up and remove it. On the other hand, an alternative hypothesis is that the mirror mark test at 18–24 months of age reveals only children's ability to construct an identity relation between their current sensation of self and their mirror image (presumably due to contingent feedback and previously learned featural similarity; see Povinelli, 1995). If this were true, 2-year-olds should make no attempt to reach up and remove the sticker in the delayed video test. In either case, we predicted that children should be able to produce a correct verbal label of the image on the screen.

Method

Subjects.—The subjects were 42 children attending one of several preschools in Lafayette, Louisiana. The children were divided into three age groups: 10 2-year-olds (M = 28 months, range = 22–34 months, two girls, eight boys), 16 3-year-olds (M = 39 months, range = 35–46 months, eight girls, eight boys), and 16 4-year-olds (M = 51 months, range = 47–59 months, 10 girls, six boys). Although socioeconomic and ethnic data were not systematically collected, the children in the studies reported in this article were mainly from working and middle-class families, and the majority were Caucasian, with smaller numbers of African- and Asian-Americans.

Procedure.—The children were invited one at a time to play a game with two adult experimenters with whom they were familiar in a quiet room at the preschool. The children were seated at a table and the experi-

menter introduced a game in which the children looked for stickers hidden under one of three opaque cups. The main experimenter then pointed to a stationary videocamera positioned about 2 m from the child and explained to the child that the camera was taking pictures of them and that after they were finished playing the game they would get to see themselves on television. In order to provide a temporal marker on the videotape for what was about to happen, the experimenter asked the child for the name of an animal that he could pretend to be. The experimenter then turned to face the camera, pretended to be the animal specified by the child, and told the child that they would be able to see him pretending to be that animal again on television in a few minutes. The purpose of the temporal marker was to aid the children in understanding when the action on the tape had occurred.

Marking procedure.—Each child was administered five trials of looking under the cups to find stickers and then placing them on a blank paper. The first two trials served as opportunities for sham marking events in order to habituate the subject to the experimenter touching his or her head. Thus, on trials 1 and 2, immediately after the children found the sticker under a cup, the main experimenter patted the child on the hair just above the forehead in the context of praising how well they were doing. On trial 3, the experimenter repeated this procedure, but also surreptitiously placed a large sticker in the child's hair as he patted their head. Finally, two control trials were conducted in which the child continued to look for stickers hidden by the second experimenter. The main experimenter did not touch the subject's head during these control trials. If the child discovered the stickers either immediately (because they felt them being placed there) or inadvertently (in the context of brushing their hair), they were not tested further and were replaced with new subjects. This happened in four cases (age range = 37-44 months).

Playback procedure.—At the end of trial 5, the main experimenter announced that it was time to "watch what we just did on TV." The second experimenter ushered the child several feet away to a chair in front of a television set. The main experimenter explained to the child that he was fixing the tape so that they could see what they had just done on the television. Meanwhile, the second experimenter and the child sat in front of the blank television screen (neutral blue to eliminate its reflective property) and discussed the stickers that the child had found and put on their paper. Rewinding and cuing the tape to the appropriate location (the main experimenter pretending to be an animal) required approximately 2 min from the end of trial 5. Thus, 3 min had elapsed since the sticker had been placed on their head. Once the tape was ready for playback, the two experimenters sat on either side of the child, and the tape was started. Each playback lasted approximately 2 min.

Data analysis.—Two observers scored the videotapes of all children which depicted the marking event and the two control trials, as well as the tapes of the children's reactions to the playback of the marking procedure (excluding the four children who discovered the stickers in the control phase and who were not tested further). The observers were instructed to note if the subjects' hands came to within about 1 inch of the sticker at any point during the control trials. This criterion was used because occasionally the children touched their faces or brushed their hair as they were playing the game, and we realized that in some cases it might not be clear whether they were looking for the sticker. In five cases (range = 47–59 months) both observers judged that the children had brought their hand to within 1 inch of the sticker on their head. In each case, the observers reported that these near contacts appeared to occur during the context of the children rubbing their faces or brushing their hair. Nonetheless, to be conservative these children were not used in the analysis and were replaced with peers of the same age range. The observers were also instructed to use the same criteria for scoring the tapes which depicted the playback procedure, noting if the subjects reached up for the stickers, and were also instructed to note if the subjects touched the sticker or actually removed it. The two observers agreed in 100% of the 47 cases from the control and 100% of the 47 cases from playback tapes. Transcripts of the informal question session were also recorded by one of the observers.

Results and Discussion

After the subjects who failed the control period had been replaced, 42 subjects were available for final data analysis. Because none of these subjects made any discernible attempts to reach up during the control trials it was presumed that they were unaware that a sticker had been placed in their hair.

In order to examine the main results, the 42 subjects were classified as either having reached up to the sticker on their head after the video presentation revealed the experimenter placing the sticker on their head, or as having not done so. Next, the results were examined for gender effects by placing the subjects into a 2 (gender) × 2 (test result) contingency table. The results revealed no effect of gender, $\chi^2 = 0.65$, $df = 1$, $N = 42$, N.S., and thus the results from boys and girls were collapsed within each of the four age groups. Finally, the data were examined for age effects. A clear developmental trend was present with 0% (0/10) of the 2-year-olds, 25% (4/16) of the 3-year-olds, and 75% (12/16) of the 4-year-olds reaching up and removing the sticker after seeing it placed on their heads, $\chi^2 = 16.6$, $df = 2$, $N = 42$, $p < .001$.

These results may be considered as unexpected in the context of previous findings that most 2-year-old children are able to distinguish between contingent (live) and noncontingent videotapes of themselves, as well as noncontingent videotapes of themselves versus a same age/sex peer (Bigelow, 1981; Lewis & Brooks-Gunn, 1979). However, the dependent measures used by these researchers were attention, interest, imitation, and affect, none of which necessarily require an explicit understanding of the source of the image in the same fashion as do mark-directed responding on the traditional mirror tests of self-recognition (e.g., Amsterdam, 1972; Gallup, 1970). Thus, although traditional delayed videotape procedures have demonstrated that 2-year-olds can discriminate between noncontingent video of self and other, such data do not speak directly to the issue of recognition of the image as referring to the child's presently experienced self (see "General Discussion"). Indeed, our results raise the possibility that children younger than about 4 years of age have great difficulty understanding how the delayed image informs them of their current physical state. This is true even though we made an explicit attempt to localize the event in time by using a clear temporal marker (the animal imitation game) at the beginning of the sequence and by keeping the delay relatively modest (3 min).

In order to test the generality of these preliminary findings, we identified a number of methodological aspects of this task that might have interfered with the younger children's ability to infer the relation between what they were witnessing on the tape and their present appearance. First, it is possible that moving the children into a new location (albeit nearby) to view the videotapes may have disrupted the younger children to the point where they were not as sensitive to the temporal contiguity of what had just transpired. Second, the videotapes may have been distracting because of the motion inherent in the medium. Although this is true of mirrors also, the motion of a mirror image is under the child's control, but this is not true of the video image of the self. Thus, the child's inability to control his or her own behavior in the delayed videotape may have induced high levels of embarrassment. It is possible that the younger children were embarrassed by their behavior in a similar manner as adults are at seeing themselves on video and in a way that is more embarrassing than simply seeing one's image in a mirror (which one can control) or in a static photograph. In both cases, the distraction or embarrassment may have interfered with the younger children's motivation to reach up and remove the sticker. A third limitation was that although there is ample evidence of mirror self-recognition in children even younger than our sample, the study did not incorporate a control condition in which those who failed the videotape task were presented with a mirror. Fourth, we felt that a stronger temporal marker might help the younger children localize the temporal position of the events depicted on the delayed images, thus maximizing the likelihood that they make the inference that a sticker was on their heads.

Finally, the children may have performed better if some verbal prompting was included to draw their attention to relevant aspects of the delayed image. Evidence for this was suggested by informal questioning of 26 of the children who did not reach up for the stickers at the conclusion of the video playback. The children were asked a number of questions, including "Who is that?" (pointing to the child's image on the television), "What is that?" and "Where is that?" (pointing to the sticker on their heads). The results were suggestive in that 75% (3/4) of the 4-year-olds who had not reached up in the playback did so when these questions were asked. In contrast, despite often extended and leading questions and comments about the image, no similar cases were observed in the 21 2- and 3-year-olds who originally had not reached up during the playback. In addition, although all of the children who gave answers to the "Who is

that?" question either said "me" or gave their proper name, many of the younger children seemed to talk about the image in a dissociated fashion (referring to it as "him" or "her" or talking about the sticker on "his" or "her" or "the" head). These informal results indicated that a more systematic investigation would be useful because they seemed consistent with the fact that surprisingly few 2- and 3-year-olds passed the test.

Experiment 2

The second experiment attempted to combat the methodological factors mentioned above by employing a paradigm analogous to the one described above but using Polaroid photographs instead of videotape as the delayed self-image. Unlike video, Polaroid photographs contain no motion, thus eliminating potential distraction and embarrassment factors; in addition, their static nature is conducive to an experimenter's carefully questioning the children about the images. The use of photographs seemed reasonable given that DeLoache (1991) has shown that even 2½-year-old children can apparently use photographs to guide their searches for hidden objects in real space. In addition, a stronger time marker was used in which the child was introduced to a large stuffed gorilla that they had never seen before. A photograph was taken of the main experimenter and the child, who was holding the gorilla. Finally, a photograph was taken of the experimenter in the act of placing the stickers on the children's heads in order to focus their attention on the marking event itself. A series of standardized questions were also asked to all children as the photographs were presented to them. Finally, all children who did not reach up and remove the stickers upon seeing their photographs were presented with a mirror.

Method

Subjects.—The subjects were 60 children between the ages of 35 and 58 months recruited from one of five day care centers in the Lafayette, Louisiana, area. The children were evenly divided into four 6-month age groups (15 young 3-year-olds, M = 36 months, range = 35–40 months, five girls, 10 boys; 15 old 3-year-olds, M = 43 months, range = 41–46 months, five girls, 10 boys; 15 young 4-year-olds, M = 49 months, range = 47–52 months, six girls, nine boys; 15 old 4-year-olds, M = 55 months, range = 53–58 months, seven girls, eight boys). Because no 2-year-olds in Experiment 1 passed the delayed mark test, none were used in this experiment.

Apparatus and setting.—The children were brought to a quiet testing room and were introduced to the apparatus described in Experiment 1. They were next shown a Polaroid camera and were asked if they knew what it was. The experimenter explained that it was a camera and that they were going to play a game where they would look for stickers and that the other experimenter would take some pictures of them.

Marking and photographing procedure.—The children were administered five trials of looking for stickers under cups in a manner identical to that used in Experiment 1, except as noted. Thus, trials 1 and 2 served as sham marking trials, trial 3 served as the vehicle to deliver the actual mark, and trials 4 and 5 served as the control trials. If the children discovered the stickers in their hair during the control period or wiped their hand within about 1 inch of them, the session was ended, and the subjects were later replaced with new children.

Two photographs were taken of the children with the sticker on their head. On trial 3, just before the sticker was placed on their heads, the main experimenter interrupted the children as they were placing the sticker on their paper and told them that the other experimenter wanted to take a picture of them because they were "doing such a great job." The second experimenter took a picture which depicted the child facing the camera and the main experimenter's arm and hand placing the sticker on the child's head in the context of praising them. The child was shown the photograph and asked if it was ready. Since it was not, the experimenter told the child that they would place it out of the way for a few minutes until it was ready and look at it later.

The second photograph was taken after the control trials. The main experimenter announced to the child that he had a friend to whom he wanted to introduce him or her and produced a large stuffed animal (a gorilla) from behind the table. The child was asked who it was and was then told that the gorilla's name was Alex. Finally, the experimenter explained that the second experimenter wanted to take a picture of the three of them (the child, the main experimenter, and Alex). The child was given Alex and a photograph was taken that depicted the three individuals, along with the sticker on the child's head. Again the child was shown

that the photograph was not ready yet and was told that he or she would get to look at it after they had found a few more stickers.

Presentation of the photographs.—After the photographs were fully developed (approximately 2–3 min after the second one was taken), the experimenter produced the photographs and suggested that it was time to look at them. The game was moved out of the way, and the photographs were presented to the child, one at a time, and a series of standardized questions were asked. The second photograph (showing the experimenter, the child, and Alex the "monkey") was presented first for two reasons. First, it was the most recent event in which the child had participated, and second because we felt it provided the most salient event marker (the experimenter next to the child who was holding the stuffed gorilla). The child was allowed to look at the photograph for about 3 sec and then was asked, "Who is that?" as the experimenter pointed to the child's image with a pen. The question was repeated if the child did not answer. Next, the child was asked, "What's that?" while pointing to the sticker on the child's head in the photograph. If the child did not answer correctly, he or she was told it was a sticker, and the experimenter then asked, "Where is that sticker, really?" and the photograph was turned over. Finally, the child was shown the photograph again and was asked, "Can you find where that sticker really is?" The first photograph (showing the main experimenter placing the sticker into the child's hair) was then shown and the child was again asked, "Who is that?" and then "What is that?" while pointing to the sticker. The child was then asked, "What's [name of the first experimenter] doing right there?" Finally, the child was asked, "Where is that sticker right now?"

Mirror presentation.—For the children who did not reach up to remove the sticker on the head while viewing the photographs, the main experimenter suggested that the child, Alex the gorilla, and himself look at themselves in a mirror. Alex was placed on the table near the child and a large (46 × 60 cm) mirror was then produced and set on the table in front of them. The experimenter squatted next to the child so that all three individuals were visible in the mirror. After about 30 sec if the child had made no attempt to remove the sticker, the experimenter pointed to the child's image in the mirror and asked, "Who is that?" After about 45 sec if the child had still not reached for the sticker, the experimenter asked the child, "Can you get me that sticker?" If there was no response after 1 min 30 sec had elapsed on a handheld stopwatch, the presentation was discontinued. Although it would have been ideal to test all children for mirror self-recognition, the children who had already reached up and removed the stickers could not be introduced to a mirror immediately and tested. Repeating the covert marking procedure and then retesting them seemed questionable. We therefore utilized the mirror condition as a motivational, within-subject control for the subjects who had not reached up already.

Data analysis.—Two observers scored the videotapes for attempts to remove the stickers during the control, photograph, and mirror presentation sessions using the procedures described in Experiment 1. The observers agreed in 60/60 (100%) of the cases in the control period, 59/60 (98%) of the cases for the photograph presentation sessions, and in 23/23 (100%) of the cases in the mirror condition. In the one case of disagreement, the subject was excluded from the analysis and replaced.

Results and Discussion

In addition to the 60 subjects tested and scored by the observers, 10 children failed the control trials by reaching up and discovering the stickers in their hair during the control period (one between 53 and 58 months, two between 47 and 52 months, six between 41 and 46 months, and one between 35 and 40 months). Of these, two detected the sticker as it was placed in their hair and reached up immediately. The remaining eight appeared to discover the stickers inadvertently as they wiped, scratched, or brushed their head or hair during the two control trials. Most of these eight looked surprised and asked how the sticker had gotten there. For the 10 children who discovered the stickers in the control period, the testing sessions were ended and the children were replaced with new subjects.

As in Experiment 1, all subjects were classified as either having reached up to search for the sticker during the presentation of either the first or second photographs, or as having not reached up. The subjects were placed into a 2 (gender) × 2 (test result) contingency table, and a chi-square test was used to determine if there was an overall effect of gender. The results revealed a nearly identical number of children who reached up for the stickers for both genders

(boys = 57%, girls = 56%) and no overall gender effect, $\chi^2 = 0.0003$, $df = 1, N = 60$, N.S. In all subsequent analyses, boys and girls were collapsed within each of the four age groups.

The main results of the children's reactions to the two photographs are presented in Table 1, which shows the percentage of subjects who reached up to their heads to search for the stickers at some point during the presentation of the two photographs. Although two photographs were presented to the children which showed the sticker on their heads, the second photograph (which showed the experimenter placing the sticker on the child's head) appeared to have little additional effect. Of the total of 37 subjects who reached up during photograph presentations, 34 did so during the first photograph, whereas only three did so during the presentation of the second photograph. In the youngest age group, no children reached up while viewing the second photograph. In the oldest three age groups combined, there were 13 children who did not reach up during the presentation of the first photograph, and of these only three did so during the presentation of the second one. Thus, the addition of the second photo did not substantially alter the performance profile of the children. An overall significant age effect is present, $\chi^2 = 23.34$, $df = 3$, $N = 60$, $p < .0001$. The most dramatic age transition in the number of children who reached up to search for the stickers was between the younger and older 3-year-olds, an increase in success from 13% to 60% between these two age groups. Table 1 suggests a developmental trend across the four age categories.

Table 1 also provides the results of the mirror control session that was given to those subjects who did not reach up during the presentation of the photographs. The overall results were that of the 23 children to whom the mirror was presented, 20 of them reached up to the remove the sticker. Seventy-five percent (15/20) of the successful children in the mirror test reached up spontaneously; 25% were verbally prompted either by, "Who is that?" or by, "Can you get me that sticker?" as the experimenter pointed to the mirror. Most important, of the 19 youngest children who did not reach up while looking at the photographs, 16 of them (84%) reached up while looking in the mirror.

TABLE 1

PERCENTAGE (and Ratio) OF CHILDREN REACHING UP TO FIND STICKERS IN PHOTO AND MIRROR TESTS

Age (Months)	Photo Test	Mirror Test
35–40	13 (2/15)	85 (11/13)
41–46	60 (9/15)	83 (5/6)
47–52	80 (12/15)	100 (3/3)
53–58	93 (14/15)	100 (1/1)

NOTE.—Numbers reflect number of subjects who reached up at any point during presentation of photos 1 and 2 (see text for details).

Table 2 summarizes the children's answers to the "What is that?" question as the experimenter pointed to the sticker on their head in the first photograph that was presented. (If the children did not answer this question correctly they were told that it was a sticker, therefore their answers to the same question for the second photograph are not diagnostic.) As can be seen from Table 2, 80% of the children in the youngest age group answered correctly ("a sticker") or gave another plausible answer (e.g., "a bow," "a white paper," or by naming what the sticker depicted—e.g., "a dog"). If the two correct categories are collapsed and compared to the collapsed incorrect/no reply category using a 4 (age group) × 2 (response) contingency table, there was no significant effect of age (chi-squared test for trend, $\chi^2 = 0.27$, $df = 1, N = 60$, N.S.). This is important, because it demonstrates that the younger children's poor performance was not the result of an inability to identify the nature of the item on the head of the image in the photographs.

Next we analyzed the children's responses to the question, "Who is that?" in reference to their image on the two photographs. Table 3 presents a summary of these results for the children's responses to the first photograph they viewed. (We do not detail their responses to the second photograph because they were nearly identical to the first; 87% [51/59] of the children gave the exact same answer to both photographs.) The important aspect of these results is that the younger children used their proper name to identify themselves more often than the personal pronoun "me," an effect reversed in the older groups. A statistical analysis of a 4 (age group) × 2 (phrase type) contingency table revealed that as age increased, use of the proper name decreased, whereas use of the first person pronoun increased (chi-squared test for trend, $\chi^2 = 13.70$, $df = 1, p < .0002$). If the subjects are placed into a 2 (successful, unsuccessful)

TABLE 2

PERCENTAGE (and *Ns*) OF CHILDREN ABLE TO IDENTIFY STICKER ON THEIR HEAD FROM PHOTOGRAPH 1

AGE (Months)	*N*	CHILDREN'S RESPONSES		
		Sticker	Other "Correct"	No Reply/ Incorrect
35–40	15	40 (6)	40 (6)	20 (3)
41–46	15	53 (8)	13 (2)	33 (5)
47–52	15	47 (7)	33 (5)	20 (3)
53–58	13[a]	70 (9)	15 (2)	15 (2)

[a] One child in this age group was inadvertently not asked this question, and another's response could not be determined from the tape.

× 2 (proper name, first person pronoun) contingency table (see Table 3), the group of who did not reach up to search for the sticker tended to use their proper name more often than the group who did, but this difference was not significant (Fisher's exact test, p = .18, N.S.).

Finally, the children's answers to the questions, "Where is that sticker right now?" (photo 1) and "What's [the experimenter's name] doing right there?" (photo 1) were classified according to whether they used the phrase "my head" or "his/her/the head" or both, in formulating an answer about the sticker's location. The results of a 4 (age group) × 2 (phrase type: "his/her/the head" vs. "my head") chi-square test for trend revealed that the younger children used the dissociative phrase ("his/her/the head") significantly more often than did the older groups, which almost exclusively used the phrase "my head," $\chi^2 = 16.15$, $df = 1$, $p < .0001$ (see Table 4). If the subjects are analyzed by whether or not they reached up to remove the sticker, the ones who did not reach up used both phrases almost equally often, whereas only a single child who did reach up used the phrase "his/her/the head" (Fisher's exact test, $p = .0003$).

The results of this investigation provide a similar developmental picture as those obtained in Experiment 1. Using delayed videotape, 75% of the children between the ages of 47 and 59 months searched for the sticker ($N = 16$). This compares to 87% of the same aged children in the photograph experiment ($N = 30$). In addition, all 3-year-olds in both experiments compare favorably as well (videotape = 25%, $N = 16$; photographs, 36%, $N = 30$). These results seem to rule out several procedural interpretations of the results obtained in Experiment 1. For instance, the younger children's difficulty did not appear to stem from possible distractions in the motion of the videotapes, nor from the fact that they were moved to a new location to view the tapes. In addition, a more salient temporal marker did not appear to significantly alter their performance. The results of the mirror control test also indi-

TABLE 3

PERCENTAGE (and *Ns*) OF CHILDREN USING FIRST PERSON PRONOUN VERSUS PROPER NAME IN DESCRIBING THEMSELVES FROM PHOTOGRAPH 1 AS A FUNCTION OF AGE AND TASK PERFORMANCE

GROUP CLASSIFICATION	*N*	CHILDREN'S RESPONSES				
		Me	Proper Name	Both	Point to Self	Don't Know/ No Reply/Other
Age (in months):						
35–40	15	27 (4)	40 (6)	0 (0)	13 (2)	20 (3)
41–46	15	47 (7)	40 (6)	0 (0)	0 (0)	13 (2)
47–52	15	80 (12)	13 (2)	7 (1)	0 (0)	0 (0)
53–58	15	93 (14)	0 (0)	0 (0)	0 (0)	7 (1)
Task performance:						
Not reach up	23	44 (10)	30 (7)	0 (0)	9 (2)	17 (4)
Reach up	37	73 (27)	19 (7)	3 (1)	0 (0)	5 (2)

TABLE 4

PERCENTAGE (and *Ns*) OF CHILDREN USING VARIOUS DESCRIPTIONS OF THE LOCATION OF STICKER ON THEIR HEAD AS SEEN IN PHOTOGRAPH 1 AS A FUNCTION OF AGE AND TASK PERFORMANCE

GROUP CLASSIFICATION	*N*	CHILDREN'S RESPONSES				
		His/Her/the Head	My Head	Both	Other	No Reply
Age (in months):						
35–40	15	40 (6)	13 (2)	7 (1)	0 (0)	40 (6)
41–46	15	7 (1)	60 (9)	0 (0)	7 (1)	27 (4)
47–52	15	0 (0)	73 (11)	7 (1)	0 (0)	20 (3)
53–58	14[a]	0 (0)	86 (12)	7 (1)	7 (1)	0 (0)
Task performance:						
Not reach up	23	26 (6)	17 (4)	9 (2)	0 (0)	48 (11)
Reach up	36[a]	3 (1)	83 (30)	3 (1)	6 (2)	6 (2)

[a] One child was inadvertently not asked this question.

cated that the younger children who did not reach up during the presentation of the photographs, did reach up while in front of a mirror. This would appear to rule out a general inhibition account of our results.

Finally, systematic questioning revealed important verbal correlates of the results of the nonverbal test. First, even the youngest children who did not reach up to search for the stickers could correctly label their images in the photographs using either their proper name or the first person pronoun ("me"). However, the use of the proper name and other dissociative phrases (such as describing the sticker as being on "his/her" or "the" head) was significantly associated with not passing the mark test. Children who reached up to remove the sticker from their heads rarely used their proper name when asked to identify the image and virtually never used "his/her" or "the" to describe the image's head. These verbal results provide important converging evidence that the younger children do not understand that their delayed images refer to their presently experienced self.

Experiment 3

The previous studies revealed significant developmental trends between 2 and 4 years of age in young children's abilities to use delayed images of the self as a cue to a specific aspect of their current appearance. Experiment 2 also included a motivational control to assess the possibility that the particular response in question was inhibited for some general reason. However, that design was not a direct within-medium comparison of live versus delayed self-image presentation. Thus, to further explore the factors that might be responsible for the developmental trends observed in the previous studies, we compared the reactions of 2½–3½-year-olds to two kinds of video feedback which revealed a sticker on their head: live feedback versus delayed feedback. We chose this age because we obtained very low success rates in this age range in the previous two studies using delayed feedback, but this age range typically shows high levels of self-recognition using live feedback (e.g., mirrors).

Method

Subjects.—The subjects were 48 children between the ages of 30 and 42 months and were tested at one of five day care centers in the Lafayette and Baton Rogue, Louisiana, area. None of the children had participated in the previous experiments. Children were matched for age and then randomly assigned to one of two groups, Live versus Delayed Feedback. The final age and gender composition of each group was as follows: Live Feedback Group, nine girls, 15 boys, M = 35.7 months, median = 35 months (range = 30–42 months); Delayed Feedback Group, 11 girls, 13 boys, M = 35.2 months, median = 35 months (range = 30–42 months).

Procedure.—The children in the Delayed Feedback group underwent the same procedures as in Experiment 1 with the following exceptions. First, the television monitor on which the children were to see themselves was placed adjacent to the apparatus. The monitor was covered with an opaque

screen which could be removed to reveal a video playback. Thus, as in Experiment 2, the child did not move from one location to another in order to view the playback. The second modification was that before the child started to watch the playback, the tape was covertly cued by the second experimenter to the point just after the sticker had been placed on his or her head. Thus, unlike Experiment 1, the children did not see the experimenter actually place the mark on their heads. Because subjects in both groups had to be administered a control period before seeing the feedback of the self, the subjects in the Live Feedback group would see a sticker on their head as soon as the video screen was revealed, whereas the subjects in the Delayed Feedback condition would not see themselves with a sticker on their head until approximately 1 min into the delayed videotape. This presented a choice between having both groups observe themselves for the same amount of total time or having both groups observe themselves for the same amount of time with a sticker on their heads. We chose to cue the delayed tapes up to the point immediately after they had been marked, thus providing children in both groups with an equal amount of time viewing themselves with the sticker on their heads.

Children in the Live Feedback group were administered the same marking procedure as the children in the Delayed Feedback group. However, instead of observing the events that had just happened, they received live video feedback from the same camera and position which had recorded the children in the other group. Thus, both groups observed themselves for 2 min with the sticker on their head with the only difference being the contingency of the image. Following the 2-min playback, the children were asked the same series of questions about the image as in Experiment 2, although their answers were not systematically recorded. Given the high reliability attained in previous studies, the two experimenters coded the subjects' responses live and recorded if they reached up to remove the sticker during the control and playback periods. As in the first two experiments, children who reached up during the control period were dropped from the study and replaced.

Results and Discussion

Seven children reached up to remove the stickers during the control period; five were from the Live group (age range = 36–42 months) and two were from the Delayed group (age range = 32–33 months). As noted above, these children were replaced with peers of the same age.

As in previous experiments, all subjects were classified as either having reached up to search for the sticker during the presentation or questioning sessions, or as having not reached up. We first screened the data for an effect of gender by placing the subjects into a 2 (gender) × 2 (test result) contingency table. A Fisher's exact test revealed no overall gender effect and therefore the data from boys and girls were collapsed for subsequent analysis.

An examination of the main results revealed a pattern in the direction predicted; 62% of the children in the Live group reached up to the stickers whereas only 37% did so in the Delayed group, a difference which approached significance (Fisher's exact test, one-tailed, $p = .07$). In order to obtain a measure comparable to Experiment 1, where there was no questioning period following the stimulus presentation, the successful children were placed into a 2 (during playback, during questioning) × 2 (Live, Delayed) contingency table to examine if more of the successful children in the Live Feedback group reached up during the playback period than during the questioning period. A Fisher's exact test revealed a significant effect (two-tailed, $p < .04$). Only two of the nine successful children (22%) in the Delayed group passed the test during the 2-min stimulus presentation period, whereas 10 out of the 14 successful children (71%) in the Live group did so (the exact point at which one of the successful children reached up was not recorded).

These results suggest that the temporal dimension of the playback may be one of the critical factors in the developmental pattern obtained in the first two experiments. In the previous two studies, the children in this age range showed very low rates of passing the two versions of the delayed test. The results of this investigation show that 2½–3½-year-old children of the same age, when responding to carefully matched stimuli which differed only with respect to the point in time in which the child's self-image was portrayed, show substantially higher rates of success in response to the live feedback.

However, despite the differences between the two groups, the results were not fully consistent with our predictions. First, a higher percentage of 2½–3½-year-olds

passed the Delayed Feedback test than had in our previous studies, although this effect was exclusively limited to the questioning period. One factor contributing to positive results in this age range during the questioning period may be that after answering several of the questions they began to use themselves as a model to explain where the sticker was on the head of the child they saw on the screen. Thus, as in Experiment 2, a number of the children used the third personal pronoun, stating that the sticker was on "her" or "his" head. But a number of these children also simultaneously pointed to or tapped their own head, thereby discovering the sticker. Many seemed puzzled, as if they had not expected such an outcome. A second surprising finding was that fewer children reached up in the Live Feedback condition than was expected based on previous studies of mirror self-recognition. One may speculate that this is because the most salient kind of stimuli to cause children to form the equivalence relation between the image and themselves is that involving mirror-symmetrical feedback. In other words, part of the motivation for a child to form an equivalence relation between themselves and what they see in a mirror or on Live video feedback may concern not just sensitivity to contingency but a certain form of identical contingency—symmetrical contingency. This is not the kind of symmetry present in the kind of feedback we used, which was standard live video feedback, which presents the image exactly reversed from a mirror-image. This hypothesis predicts that if the live feedback had not been "reversed," a higher percentage of children would pass the test (details of why this may be so is provided in Povinelli, 1995).

General Discussion

The results of these investigations suggest a significant developmental delay in young children's success on mark tests of self-recognition using delayed feedback as compared to live feedback. These findings may have important implications for characterizing the development of the temporal dimension of young children's self-concept. In addition, this development may reflect other aspects of cognitive change during the preschool years. However, before we examine these ideas, we explore an important methodological question about the results not discussed thus far.

It is possible that both the younger and older children interpreted the video images and photographs in the same manner; as events that had just happened to them. However, it is also possible that, although the younger children knew that there had been a sticker on their heads a few moments earlier, they simply found no reason to infer that it was still there. In other words, they may have assumed that because they could not directly see or feel a sticker on their heads, there could not still be one there. Their willingness to make the inference in the mirror and live video situations could be explained by arguing that the contingency (temporal) cues of such live feedback provide them with a necessary and sufficient reason for inferring that the sticker is on them at the present.

However, this account of the difference between the younger and older children does not explain three aspects of the results. First, why do older children make the inference nearly all of the time? In other words, what underlies this potential shift in logic? Second, at least half of the younger children should have assumed that the sticker might still be there and hence should have reached up. Finally, why do the younger children tend to talk about the image in a dissociated manner? Although they "correctly" label the image using the first person pronoun (me) or their proper name, the younger children tend to objectify it as well by labeling parts of the image as belonging to "him" or "her." Indeed, one of the most striking findings of Experiment 2 was the manner in which the younger (unsuccessful) children used dissociative phrases such as "his," "her," or "the" head in describing the image in the photograph. Even in their "correct" use of the first person and possessive pronouns ("me" and "my") and their proper names, evidence of a relation between task performance and type of phrase used was evident. For example, the children who did not reach up for the sticker during the presentation of the photographs used the first and third person possessive pronouns approximately equally often (17 vs. 26%, respectively). In striking contrast, 83% of the successful children used the first person pronoun exclusively, and only 3% of them used the dissociative third person pronouns (see Table 4).

Although we recognize the methodological limitations of the present series of investigations, we tentatively propose that the asynchronous development of self-recognition in live versus delayed conditions is the result of a developmental lag between the emergence of an "on-line"

self-concept, and a self-concept that includes an understanding of the temporal continuity of the self. In particular, our results are consistent with the hypothesis that young children who recognize themselves in situations of live feedback may not assume that the state of their currently experienced self is determined by previous states. There are at least two interpretations of this claim. First, one version of this hypothesis is that the younger children's difficulty reflects a weak disposition to objectify the image because it does not possess contingent feedback. This would suggest that with sufficient verbal cuing and additional scaffolding the younger subjects might be induced to consider the relation between their delayed images and themselves, resulting in the production of the criterion response of reaching up to search for the sticker. To a significant extent, we attempted to make the identity and temporal position of the delayed image as obvious as possible, but this does not rule out the possibility that even stronger cues and support in future studies might elicit the behavior. On the other hand, at some point such scaffolding may produce the behavior without measuring the same phenomenon. For example, if we had asked the youngest children (while they were looking at the image) if they thought there was a sticker in their hair, we suspect that many of them would have reached up to their heads. But this would offer little evidence that their success had derived from the information contained in the delayed image.

A related, but stronger, version of this hypothesis is that the younger children possess a different understanding of the self than the older children. In particular, they may not readily appreciate that past events in which they participated (and hence of which they have memories) happened *to them*. Nelson (1993) recently examined the data concerning the phenomenon of infant amnesia in young children and concluded that whereas studies of spontaneous infant verbalizations demonstrate at least some form of general episodic memory (Tulving, 1983), they provide no comparable evidence for autobiographical memory before about 4 years of age. The data support the view that while children as young as 2 years of age may refer to specific past events (general episodic memory), these memories are typically short-lived and do not escape the infant amnesia barrier (Nelson, 1993). She therefore offers the view that rather than representing the loss of something, the phenomenon of infant amnesia is better viewed as the development of autobiographical memory. In general, this view is consistent with our findings. Children younger than about 3½ to 4 years may not treat delayed images of themselves in the same manner as live images because although the events depicted may be recalled, they were not encoded as autobiographical memories and hence the children do not understand that they happened to them. Thus, in order to interpret the results of our experiments in the second (stronger) light, it is not necessary to contend that the younger children have forgotten the events in which they participated 3 min earlier; rather, it is only necessary to assume that because of the absence of autobiographical memory, the events are stored as general episodic memories and thus have no explicit relation to the child's current concept of self. In contrast, as autobiographical memory develops in older children, memories can be encoded as having happened to oneself, thus adding a new category for storing representations of specific events, in particular, the ability to construct a personal history (see Nelson, 1993). One prediction of this idea is that 2- and young 3-year-olds ought to (1) possess fairly accurate memories of what they did in situations such as ours after a brief delay and (2) be accurate at labeling who the participants (including themselves) were in the events—but still not interpret those events as constituting a causative link in a temporal progression leading up to their present state.

If our results reflect changes in young children's concept of self, it is worth exploring the basis of such a conceptual shift. In other words, it is possible that the developmental transition we observed is related to other aspects of cognitive development in 3–4-year-old children, especially those exposed in recent theory of mind research. Indeed, using very different methods and nonverbal techniques, our results follow a similar developmental transition as found in research related to preschoolers' abilities to reason about false beliefs, representational change, the appearance-reality distinction, and sources of knowledge (Astington & Gopnik, 1988; Flavell, 1986; Gopnik & Graf, 1988; Gopnik & Slaughter, 1991; Perner, 1991; Wellman, 1990; Wimmer, Hogrefe, & Perner, 1988; Wimmer & Perner, 1983). Flavell (1988), for example, has interpreted much of the theory of mind literature as indicating that young preschoolers have great

difficulty in understanding dual representations of the same thing. For the younger children, then, a videotape or photograph that depicts them in a state other than that which they currently believe to be true about themselves may present a situation of conflicting representations, and they may simply defer to what they currently believe to be true. This may explain why the younger 3-year-olds tended to talk about the photograph or videotape using third personal pronouns; they recognize the featural correspondence between the image in the tape or photograph and their mental representation of their physical appearance (presumably acquired via exposure to mirrors), but they do not understand that it is a representation of that self. Of particular interest in this general context is a study by Zaitchik (1990) which revealed that 3-year-olds had trouble understanding that photographs represent a past situation rather than a current, altered situation. She interprets this as being consistent with the view that young children have trouble understanding representations in general (as opposed to mental states in particular) and simply defer to the existing state of affairs in order to determine the state of the as-of-yet-unseen photograph (see also Leekam & Perner, 1991).[1] Perhaps young children have difficulty simultaneously integrating past and current physical representations of themselves, just as they have problems understanding dual representations of other things. Gopnik and Slaughter (1991) have reported some data suggesting that 3-year-olds can perform fairly well on reporting on their previous nonepistemic mental states but have great difficulty in reporting on previous beliefs. In general, however, the hypothesis does not imply that young children have no memory of their previous states. It could be that they do not appreciate those memories as bearing a causal relation to their present states (see Povinelli, 1995).

Thus, young 3-year-olds might fail our task because their general difficulty in understanding representations precludes them from simultaneously considering themselves to be in two places (or states) at once. Older children, in contrast, who understand representations as such can neatly follow the temporal structure of the events represented in the videotapes (or photographs) and use them to discover something about themselves that was previously unknown. Conversely, passing a mark test of self-recognition using live stimuli such as that found in mirrors (or live videotape) does not necessarily involve an explicit understanding that the mirror image is a representation of the self; it may only require the child to draw an isomorphism between its currently experienced (on-line) sense of agency and the immediate and unbreakable correspondence to what is occurring in the mirror. In contrast, the developmental emergence of a self-concept independent of its current temporal state (and hence the construction of a personal history) might have to await the construction of a more general ability to cope with multiple, simultaneous representations of the same object or event, and hence the construction of a personal history. Only when children are able to appreciate that the same objects can have multiple states can they begin to knit together a coherent time line which links separate personal self-memories as temporal instantiations of a permanent, but changing self.

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[1] Lillard (1993) has suggested that perhaps the 3-year-olds may simply assume that photographs represent the state of affairs that is true when they develop. However, if this were the case it would imply that our 3-year-olds should have assumed that there was, in fact, a sticker on their heads at the moment they saw the photographs. Hence, they should have reached up to search for it. In addition, it is much more difficult to apply this logic to the videotape presentations which confront the child with a rich record of his or her previous actions.

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