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Use of Mirror Reflection for Self and Non-self Search During the Second Year

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In their second year human infants may begin to show self-directed responses towards a novel mark placed on their face when they look at themselves in a mirror. This has been used as evidence for a change in capacity for visual self recognition that is separate from a capacity to understand how mirror reflection works. It is arguable, however, that trends found in previous research on infants' search responses to objects reflected in mirrors may be an outcome of procedural, rather than cognitive process, factors. We investigated 16-, 20- and 24-month-old infants' use of a mirror to search both for a mark on their own head and for a novel toy hidden behind their left shoulder. Contrary to many earlier reports, infants' mirror-elicited search for a non-self target did not developmentally precede their search for a mark on the face. The results suggest that important procedural factors influencing infants' responding have not received sufficient critical attention from researchers. They also suggest that infants' responses in front of a mirror reveal more about their understanding of mirror reflection than about any changes in "self awareness".

Around 18 months of age human infants begin to show self-directed, manipulative responses toward a mark placed surreptitiously on their face, when it is visible in a mirror. This procedure became widely accepted as a test for visual self recognition in both human infants and non-human primates after its appearance in the early 1970s (Amsterdam, 1972; Gallup, 1970). An assumption underlying the test is that the ability to point to a mark on one's own face, with the aid of a mirror, indicates knowledge that one's own mirror reflection is unique. Although it was realized from the beginning that this assumption can be challenged (Amsterdam, 1972) there has been quite a general acceptance of the notion that mirror-elicited self-search behaviour in itself represents an advance in self knowledge, or even a final stage in visual self recognition (Loveland, 1986).

One of the origins of the notion that mirror-elicited facial search represents a step forward in "visual self recognition" seems to be the suggestion that such search involves higher level cognitive processes than the understanding of non-self images in mirrors. The advocacy of a qualitative distinction between the cognitive developments underpinning "visual self recognition" and those underlying the understanding of mirror reflections appears in several general reviews of the development of self recognition (Anderson, 1984; Brooks-Gunn & Lewis, 1984; Harter, 1983).

Examination of the empirical work comparing infants' capacity to use mirrors for searching their own faces, with their mirror-guided search for non-self targets, reveals a majority of studies reporting that non-self search *precedes* the use of mirrors for searching one's own face. Thus, Bertenthal and Fischer (1978) reported that the majority of their 14- to 16-month-old infants could use a mirror to find a toy hanging behind them, while self search emerged only after 18 months of age. Lewis and Brooks-Gunn (1979) suggested that infants could use a live video image to locate a person behind them early in their second year, prior to self search. As part of a more general study of self and mother knowledge, Pipp, Fischer and

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Jennings (1987) found that infants tended to find a mark or sticker on their mothers' nose before beginning to find the same stimuli on their own nose. Loveland (1987) reported that 60% and 50% of her normally-developing infants could use a mirror to find their mother and a toy, respectively, while only 33% used the mirror to locate a rouge mark on their face. There seems to be only one researcher (Zazzo, 1982) who has reported that mirror-guided search for non-self objects generally occurs *after* the emergence of self search in front of a mirror. Two other experimenters (Bigelow, 1981; Johnson, 1983) using live video self images, found that self and non-self search appeared at about the same age. In summary then, a majority of reports in this area have suggested that the capacity to find a reflected spot on one's face may developmentally succeed the ability to use a mirror to find some distant object.

The inference frequently drawn from these findings is that different perceptual-cognitive processes underlie the timing of the emergence of mirror-elicited self and non-self search. Our thinking on this issue, however, was more in accord with the recent work of Loveland (1986, 1987), who has pointed out that mirror-elicited search behaviours could be most usefully studied for what they reveal about infants' capacity to use mirror reflections, rather than any implications they may have for changes in self awareness. This alternative approach emphasises the *common* perceptual and cognitive processes involved in the use of mirrors to search for an object in the spatial region of one's face as well as in spatial regions near the body. So, for example, mirror-guided prehensile movements may be used as an effective search strategy in both self and non-self reflection tasks. The important conceptual issue here is that this approach questions the usefulness of using facial self search as a special test of "visual self recognition". This way of thinking also leads us to question whether apparent differences in self and non-self search performance may be due more to some extraneous procedural variations between the tasks, rather than some underlying differences in the perceptual-cognitive processes that are involved. This question of the importance of purely procedural issues in the outcome of mirror reflection studies was the essential focus of our study. The kinds of procedural matters that seemed important were potential variations in the contribution of attentional, motivational and memorial factors to differences in infants' performance on self and non-self reflection tasks.

Studies that have reported the earlier appearance of, or superior performance in, reflected object search than self search, have generally used people, or moving toys, as object targets, while having a rouge mark on the face as a self search target. The interest or salience of these two search stimuli may differ considerably for infants. Another tricky motivational issue for researchers is the possible role of accidental rather than intentional discoveries of reflected objects. Infants over 1 year of age usually engage in a great deal of looking around and social interaction in novel or uncertain situations. Thus, their discoveries of reflected objects may not always imply the use of reflection information in order to locate them. Finally, it is worth noting that studies showing apparent earlier appearance of search may have inadvertently provided infants with memory information about the location of a target. Presenting infants with a fixed order of hiding conditions, in which two of the search targets are presented at a similar location, may have enabled potential enhancement of search on the second task due to memory factors (see, for example, Loveland, 1987).

In this study we set out to compare mirror-elicited search for objects placed on the infants' own bodies and objects placed away from their bodies, under conditions that differed in at least three ways from most of the earlier studies. First, the salience of the self target was arguably greater than in previous research. Our pilot work in this area showed us that the use of a lightweight, high-contrast, self-adhesive sticker on their hair seems to capture the attention of infants more reliably than a rouge mark on their face. This is not to say that the salience of self and non-self stimuli were deemed to be equated, but only that our two stimuli were arguably more similar in attention-getting qualities than those used in many previous studies. Secondly, there was an attempt to reduce the likelihood of including accidental discoveries of reflected targets in counts of intentional, visually-elicited searches. Finally, no potential memorial information was available about the location of stimuli as a consequence of prior search conditions. In other words, infants were forced to rely on purely

visual reflection information to locate an object in their environment, rather than being able to search initially at a remembered location.

Method

Subjects

Data were gathered from 42 infants equally divided into three age groups designated 16-month-olds (mean age = 16.2 months, $SD = 0.5$ of a month), 20-month-olds (mean age = 19.8 months, $SD = 0.75$ of a month), and 24-month-olds (mean age = 24.4 months, $SD = 0.6$ of a month). All the infants came from white middle class backgrounds and each age group was comprised of approximately equal numbers of males and females.

Apparatus and procedure

All testing was done in a laboratory and infants sat on their mother's lap facing a 50 cm wide x 40 cm high mirror on a table. In between trials the mirror was covered with a white cloth and the infants had their attention drawn to a novel hand puppet by one experimenter, while the other placed either the toy or the self target in position. In the toy condition a 15 cm, coloured dog was placed 0. 5 m behind the left shoulder of the infants and about 150° from their midline while they were being visually distracted. The mirror image of the toy was in the subject's midline. The toy dog was hung by a twisted elastic thread from a hook so that it rotated from side to side about its vertical axis during presentation. In the self condition a 2.5 cm-diameter, yellow, circular, self-adhesive sticker was placed on the front lower edge of each infant's hair above the forehead. A video camera positioned above and behind the toy location recorded both the reflected frontal image of the infants and their search for the toy, or the sticker. During testing the two experimenters stood about 1. 5 m from opposite sides of the mirror.

Each subject received three search tests denoted as the baseline, self, and toy conditions. After a 45 s baseline period in front of the mirror that provided a check on spontaneous search activities, half the subjects in each age group were given a self search test followed by a toy search test and the other half received these in reverse order. Each test lasted 45 s, or until either successful self or toy search had occurred. In the self condition, not only were tactile cues from the sticker controlled by placing it on each infant's hair, but a waiting period of about 30 s before beginning the test phase was inserted to see if there was any possibility of self search arising from tactile cues alone, or from peripheral visual detection of the sticker. No subjects showed such self-directed behaviour before seeing their own image again. Trials were initiated by uncovering the mirror and having one experimenter point at the mirror and say "Who's that?", or "Find that toy", in the self and toy conditions, respectively. These verbal instigations were characteristic of those used for the two conditions in previous studies.

Measures

Successful self searching was defined as infants' reaching, touching, or pointing movements to the top of the head region within 1.5 s of any previous facial image regard. Successful search for the toy was coded when infants searched for and found the toy within 1. 5 s of any previous visual fixation of its mirror image during a trial. Both these search criteria were set with the goal of identifying intentional, rather than accidental, discoveries of the target stimuli. The latencies of intentional searches were estimated from the time of the initial fixation of the target stimulus to the initiation of the first intentional search movement on each task. For the toy task the direction of initial lateral looks at least 45° away from the mirror image was also noted. The interobserver agreement levels on all measures was greater than 87%.

Results

During the baseline period with no target present only 3 infants showed spontaneous self search such as touching or pointing at their heads. Eleven infants (3, 4, and 4 from the youngest to the oldest groups, respectively) spontaneously turned at least 90° to their left during the baseline period, which could have enabled accidental discovery of the toy, had it been present.

The numbers of infants out of each group of 14 that were rated as successfully self searching were 3, 11 and 13 for the 16-, 20-, and 24-month-old age groups, respectively. The corresponding numbers of infants that searched for the toy successfully were 2, 5, and 8. Chi-square analyses revealed these age differences reached a conventional significance level for the self task, $\chi^2(2) = 17.41, p < .001$, but not for the toy task, $\chi^2(2) = 5.60, p > .05$.

Two-tailed binomial tests for differences in the occurrence of self and toy search within each age group yielded a finding of significantly more frequent self search than toy search at the 20-month age level, but not at the other ages. Differences between the self and toy tasks were also evident in the infants' latencies to search in each condition at 20 and 24 months of age. At 20 months the mean latency to self search was 5.1 s, while the mean latency to find the toy was 13.5 s. This difference was not statistically significant. At 24 months the mean latencies for self

and toy search were 5.2 s and 9.6 s, respectively. Of the 8 infants in the 24-month-old group who searched on both tasks, 7 had longer latencies to search for the toy, $t(7) = 2.37, p < .05$. All but one of the 20- and 24-month-old infants who apparently used the mirror to locate the toy also searched their own faces on the self test, while none of the youngest subjects succeeded on both tasks.

Discussion

In this study there was no tendency for mirror-elicited search for a toy to precede the emergence of infants' use of a mirror to search their own face region for a novel feature. By altering some procedural factors we were able to remove completely a trend commonly reported by earlier researchers: that mirror-elicited facial search *follows* the emergence of non-self search.

Our main conclusion is that earlier claims that self and non-self reflection search somehow involve different perceptual-cognitive processes need to be treated with more scepticism than they have so far received. Previous researchers and reviewers seem to have underestimated the importance of purely procedural factors in infant mirror reflection research.

Both in this study and in all previous work on the issue it is impossible to say whether the subjects initially showed equivalent interest in the search targets and equivalent motivation to respond to them. In the present study we simply decided to try and ensure that both search goals were interesting. It is worth noting that although infants were slower to search for the toy, as a search goal it attracted more prolonged attention from them than their own marked faces. Assessment of initial mirror-image fixations revealed that 11 of the 14 youngest subjects had longer first fixations to the toy image than to their self images. The toy was a moving, colourful target. Nevertheless, baseline data demonstrating equivalent interest in self and non-self stimuli may help to resolve this procedural issue and studies have not made such baseline checks before testing infants' search competence.

Some attempt was also made in this study to reduce the likelihood of including accidental discoveries in the ratings of intentional searching. Our own pilot work, and the baseline behaviours in this study, showed clearly that infants confronted with a mirror reflection of only themselves and their mother were more likely to show generalised looking around than they were to make any hand movement toward their own faces. This means that reflection tasks involving non-self targets are more prone to the possibility of accidental search success from generalised looking than are facial self-search tasks. Researchers in this area have yet to devise better methods for assessing the intentionality of infants' mirror-elicited search of their environment.

In summary then, it has been argued here that important procedural factors may confound the deductions of previous studies of infants' understanding of self and non-self reflection. Two main suggestions emerge from the present work. First, there needs to be more critical questioning of the notion that the mirror self search test is necessary or sufficient evidence either of an infant's visual recognition of his/her *unique facial features,* or of a higher level self awareness. Methods other than a simple mirror reflection test are needed to sort out this issue (see, for example, Forbes and McKenzie, 1987) and it may be misleading to infer, as many do, that infants have achieved such a high level of recognition of their unique facial features by 18 months of age. The second main point is that even at 2 years of age human infants are still very unskilled in their use of mirror reflection. Thus, for example, Loveland (1987) found that 61% of her 2-year-olds turned initially in the wrong direction when trying to find a reflected toy. It is worth finding out whether mirror reflection understanding changes significantly during the later preschool years when perspective-taking and appearance-reality distinctions are usually mastered.

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