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Self-Awareness and Other-Awareness II: Mirror Self-Recognition, Social Contingency Awareness, and Synchronic Imitation

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Eighteen-month-old children were tested for mirror self-recognition using the classic rouge test or an alternative procedure, for social contingency awareness by being closely imitated for a long time, and for the capacity for communication by synchronic imitation. The classic mirror rouge test was shown to produce false negatives. Most recognizers and nonrecognizers became aware of being imitated and imitated the activity of a model, but only recognizers engaged in sustained synchronic imitation of the model. The results support our hypothesis that self-recognition and spontaneous perspective-taking develop in close synchrony because both require a capacity for secondary representation.

During the second year of life, children's social-cognitive competence shows a dramatic increase. They begin (a) to recognize themselves in mirrors (Lewis & Brooks-Gunn, 1979), (b) to react self-consciously when in the center of others' attention (Lewis, Sullivan, Stanger, & Weiss, 1989), (c) to react with empathic behavior to victims of distress (Zahn-Waxler, Radke-Yarrow, & King, 1979), (d) to communicate with peers preverbally through the synchronic imitation of each other's activity (Nadel-Brulfert & Baudonnière, 1982), and (e) to cooperate with peers (Brownell & Carriger, 1990).

We (Asendorpf & Baudonnière, 1993) have attempted to integrate these findings within a social-cognitive framework. The five rapidly developing abilities are instances of two particular kinds of cognition: self-awareness (self-recognition ability) and other-awareness (self-consciousness, empathy, communication through synchronic imitation, and cooperation). We have proposed that these two kinds of cognition develop in close synchrony during the second year because both types of cognition are based on one common cognitive capacity: the capacity for secondary representation.

Infants can form *primary representations* of their actual situation that are more or less accurate reflections of the perceived reality (Leslie, 1987; Perner, 1991). What seems to emerge during the second year of life is the ability to coordinate primary representations with *secondary representations* (Perner, 1991), cognitions that represent past, future, pretended, or purely hypothetical situations in propositional form. That is to say, they represent situations that are detached from one's immediate perceptual reality.

Self-awareness requires a capacity for secondary representation because the self as an object of knowledge (the representational self: Emde, 1983; the "Me": James, 1890; or the categorical self: Lewis, 1986) is a secondary representation: It is not a perception of oneself but rather a constructed mental model of oneself that can be manipulated in fantasy. Therefore, the ability to recognize oneself in a mirror that requires linking a mirror image (a primary representation) with one's self marks the capacity for secondary representation.

Similarly, other-awareness requires a capacity for secondary representation, because other-awareness means to spontaneously (but not necessarily reflectively) take the perspective of another person into account. This perspective, in turn, is a secondary representation: It is not a perception of a situation but rather a constructed mental image of another person's perception of this situation. Therefore, those forms of empathic, self-attentive, communicative, or cooperative behavior that require other-awareness mark the capacity for secondary representation (see Asendorpf & Baudonnière, 1993, for a more detailed discussion of other-awareness).

Empirical evidence for our hypothesis of a synchrony of the emergence of self- and other-awareness rests on cross-sectional findings of a consistency between (a) mirror self-recognition as an indication of self-awareness and (b) self-conscious behavior when in the center of others' attention (Lewis et al., 1989), empathic behavior directed toward a victim of distress (Bischof-Köhler, 1988, 1991), and communicating with unfamiliar peers via the synchronic imitation of their object use (Asendorpf & Baudonnière, 1993) as indications of other-awareness. These consistencies were found for the age of 18–20 months when about half of the children of a normal sample can be shown to recognize themselves in a mirror.

The first goal of the present study was to further specify the relation between mirror self-recognition and synchronic imita-

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tion by studying the components of synchronic imitation in a more controlled experimental setting. Communicating by sustained synchronic imitation of each other's activity emerges during the second year of life and quickly becomes the most important preverbal form of communication among peers (Baudonnière, 1988a, 1988b; Eckerman, Davis, & Didow, 1989; Nadel & Fontaine, 1989; Nadel-Brulfert & Baudonnière, 1982). In synchronic imitation, two children simultaneously play with the same type of object in a similar, though not always identical, way. They regularly look at the partner and seem to realize and enjoy the reciprocity inherent in their joint play, as is indicated by a positive mood, and they often begin and end the object use at the same time or shift to a different activity almost synchronically. The reciprocity involved in the activity distinguishes synchronic imitation from simple immediate imitation (Baudonnière & Michel, 1988; Baudonnière, Werebe, Michel, & Liégeois, 1988) and from parallel play (Mueller & Brenner, 1977; Parten, 1932).

Ritualized forms of social coordination such as peek-a-boo can be observed much earlier in life, but these infant games only require the acquisition of simple stimulus–response rules such as turn alternation (Baudonnière & Michel, 1988; Ross & Kay, 1980). What emerges during the second year is the more advanced ability of coordinating one's behavior with the nonritualized behavior of another person. Ritualized behavior can be excluded when the partner is a stranger and the behavior is unfamiliar.

Asendorpf and Baudonnière (1993) studied dyads of unfamiliar 19-month-old children in a room equipped with pairs of toys, a setting that facilitates synchronic imitation. The children were systematically paired with regard to self-recognition as defined by the classic rouge test. Sustained synchronic imitation was defined as continuous synchronic use of the same kind of object for at least 20 s, with visual orientation toward the partner at least once every 10 s. Only 1 out of 9 dyads comprising nonrecognizers showed sustained synchronic imitation in comparisons with 10 out of 12 dyads consisting of recognizers, indicating a strong association of $\kappa = .71$ between self-recognition and sustained synchronic imitation.

This approach has the advantage that the spontaneous emergence of this type of communication can be observed. Its disadvantage is that it may underestimate children's competence because synchronic imitation requires two cooperative partners. Furthermore, this approach cannot identify the cognitive capacities that underlie synchronic imitation. In our view, three such capacities are essential for sustained synchronic imitation to take place.

First, the children must be able to imitate an unfamiliar activity of a stranger. Many studies have shown that infants as young as 9–14 months can do this (Bauer & Mandler, 1992; Hanna & Meltzoff, 1993; Meltzoff, 1985, 1988). Thus, it seems that children can imitate others before they can recognize themselves in the mirror. This is consistent with our theoretical view, because infants can imitate another's activity only by copying the overt behavior, without understanding the intentions behind it.

Second, the children must be able to recognize the contingency between their own behavior and that of their partner. Lewis and Brooks-Gunn (1979) found that a majority of 12-month-olds engaged in contingent play in front of a mirror ("movement testing" by repeating particular actions under close visual control). Meltzoff (1990) had an unfamiliar adult imitating activities of 14-month-old children and compared this imitation condition with a control condition in which another adult performed a different activity. The children in the imitative condition showed more "testing behavior" according to the subjective judgment of observers. Meltzoff (1990) described this testing behavior as a systematic variation of activity while closely watching the adult partner. Thus, it seems that children recognize a contingency between their own behavior and a mirror image or the behavior of another person and engage in contingency testing before they can recognize themselves in a mirror. Again, this is consistent with our theoretical view because (social) contingency awareness requires only the coordination of two primary representations, not the capacity for secondary representation.

The third cognitive capacity that children must have to engage in synchronic imitation as a form of communication is, in our view, the critical one that develops synchronically with mirror self-recognition: They must be able to spontaneously take the perspective of an interaction partner. Such an intuitive understanding of another's intentions or plans for action is needed to coordinate one's behavior with the (nonritualized) behavior of the partner.

This theoretical analysis of the cognitive capacities that underlie synchronic imitation leads to three testable hypotheses. At an age when about half of the children recognize themselves in a mirror, (a) both recognizers and nonrecognizers show an awareness that they are continuously being imitated by an experimenter, (b) both recognizers and nonrecognizers can imitate an unfamiliar activity performed by an adult stranger, but (c) only recognizers engage in sustained synchronic imitation with an unfamiliar person when this person adopts this particular mode of communication. Whereas Asendorpf and Baudonnière (1993) tested only Hypothesis c, the present study was designed to test all three hypotheses.

To test Hypotheses b and c, we observed 18-month-olds' behavior with an unfamiliar adult who invited them to communicate via synchronic imitation by performing an activity with a toy, offering a second similar toy to the child, and repeating the activity for an extended period of time once the child took the second toy. Thus, the adult behaved as an ideal partner for synchronic imitation, providing a "scaffold" for the child's behavior (see Bruner, 1983). We expected that most children would imitate the adult's activity but that only recognizers would engage in sustained synchronic imitation.

One advantage of this approach is that the experimental control over the experimenter's behavior makes it relatively easy to decide whether or not a child imitated the partner's activity. Therefore, we could use a stricter criterion for synchronic imitation than did Asendorpf and Baudonnière (1993), whose only criterion for the occurrence of synchronic imitation consisted in a simultaneous use of the same object by both partners. In the present study, we added the further requirement that the child should use the experimenter's object in a similar way.

To test Hypothesis a, we had the adult imitate the child's activity continuously for a long time. We expected that all children would test the contingency between their behavior and the behavior of the adult after some delay. We attempted to define children's recognition of being imitated and the subsequent period of "contingency testing" not only by observer judgments but also by more objective criteria that were based on temporal characteristics of the children's activity and looking behavior.

The second goal of the present study was to improve the validity of the classic mirror self-recognition test by designing an alternative procedure. During the last two decades, Amsterdam's (1972) rouge test has become widely accepted as the best empirical test for mirror self-recognition (Lewis & Brooks-Gunn, 1979; Priel & De Schonen, 1986). Children are unobtrusively marked with a spot of rouge on their face. Mark-directed behavior (instead of mirror-directed behavior or no reaction) is interpreted as evidence that children infer from the mirror image that they themselves have a mark. Because they cannot see their face directly, they must coordinate their mirror image with a secondary representation of their face. The median age when children from a normal sample pass the mirror rouge test is approximately 18 months (Lewis & Brooks-Gunn, 1979).

The main problem with this test is, in our view, that it can produce false negatives. If children do not show mark-directed behavior, one cannot exclude the possibility that they have recognized themselves after all but have not reacted appropriately. This possibility appears to be particularly likely for those children who closely inspect their mirror image for a long time but neither react to their face nor to the mirror.

To reduce this potential ambiguity of the classic mirror test, we devised an alternative procedure. Before the children are marked, they are shown a doll with a spot of rouge on the face and are asked to clean the doll's face with a tissue. Later, the classic test is applied. If the children do not show mark-directed behavior, they are offered a tissue and are asked to "clean the face." If they now show mark-directed behavior while observing themselves in the mirror, they are also classified as recognizers. In the present study, one group of children received the classic rouge test and another group the revised procedure; we expected that the number of ambiguous cases would be reduced by the new test.

Method

Participants

The parents of all 473 children born in Munich, Germany, during a 3-month period in 1990 were asked by letter to participate in a study on ego-development. Parents of 161 children (34%) agreed to participate in the study. From this sample, 52 children were excluded because parents reported some risk factor (e.g., preterm baby, complications during pregnancy or birth, or major illness of the child after birth). Thus, 109 children participated in the study. Their age at the day of testing varied between 18.2 months and 18.9 months ($M = 18.6$, $SD = 0.2$). The data of 5 children were excluded because they were very tired during most of the observations or ill. The first 45 children were tested with the classic mirror rouge test, and the remaining 59 children were tested with a revised mirror self-recognition test. These two samples did not differ significantly with regard to age, sex, sibling status, and peer interaction history.

Observational Setting

Each child was videotaped by two cameras in a room sized 20 m^2. The accompanying parent was sitting behind a table in a corner, pretending to read a magazine. A mirror was placed in the opposite corner 0.5 m away from the wall. One of the cameras was arranged at a slight angle to the mirror so that the mirror images of children's faces were visible just above their head on the video recording. After completion of the mirror test, the mirror was covered by a cloth.

Mirror Tests

Classic test. The first 45 children were tested with the classic procedure proposed by Amsterdam (1972). A female experimenter involved the children in warm-up play in front of a mirror, making sure that the children visually fixated the mirror image of their face at least three times. Then the parent cleaned the child's nose and unobtrusively applied a large dot of rouge below the child's right eye. Finally, the experimenter played with the child in front of the mirror, making sure that the child fixated the mirror image of his or her face at least three times. When children looked at the mark for the first time, the experimenter asked, "Who is that?" and if the child hesitated, again asked, "Who is that?" (Asendorpf & Baudonnière, 1993, used the same procedure).

Three children refused to play in front of the mirror. All other children met the looking criteria both for the baseline and for the mark phase. Two observers independently coded the video recording of the mark phase for any mark-directed behavior of the remaining 42 children (trying to touch the mark, including touching the corresponding part on the left side of the face). Children who showed at least one mark-directed behavior were classified as *immediate recognizers.* Children who looked at least once at their mirror image without gross body movement for at least 5 s and who did not try to touch the mark or who touched their mouth or nose were classified as *ambiguous.* All other children were classified as *nonrecognizers.* The two observers disagreed in two cases (5%); these were resolved by consensus.

Revised test. The remaining 59 children were tested with an alternative procedure. After the warm-up play period and recording three mirror-directed glances as above, the experimenter showed a big doll with a spot of rouge under its right eye; said, "Look, this doll has a mark. We must clean the doll. Can you help me clean the doll?"; and offered a paper tissue to the child. If the child did not respond, the experimenter repeated the invitation up to two times; if the child still did not respond, the experimenter cleaned the doll, trying to involve the child in this activity. After cleaning the doll's face, the experimenter said, "Well done, now the mark has gone away, the face is clean." The experimenter put the doll away and played with the child in front of the mirror for at least 1 min. Then the parent applied the mark on the child's face as before.

When the child returned to the mirror, the experimenter said, "Oh, look, there is a mark!," attracting the child's attention to the mirror without pointing to the child's face or to its mirror image. The experimenter repeated her statement up to two times, waiting each time for the child's initial response. If the child did not show mark-directed behavior (see above) in response to these statements, the experimenter offered a paper tissue to the child and said, "Look, there is a mark on the face. We must clean it. Can you help me to clean the face?" The experimenter was instructed not to point to the child's face or to its mirror image while asking this question, which was repeated up to two times.

To avoid the possibility that the experimenter missed a mark-directed response of the child or wrongly identified one, a second experimenter watched the video recording outside of the observation room and assisted the main experimenter via earphones (infrared voice transmission). Therefore decisions about mark-directed responses were always consensual.

Two children refused to play in front of the mirror. All other children met the looking criteria both for the baseline and for the mark phase. One child was excluded from analysis because the dot of rouge was too small. Two observers independently coded the video recording of the mark phase for any mark-directed behavior of the child (see above). According to both observers, the experimenter and her assistant correctly identified all mark-directed behavior. Children who showed mark-directed behavior in response to the first two questions were classified as *immediate recognizers.* Children who showed mark-directed behavior under visual control of the mirror image after the tissue was offered to them were classified as *delayed recognizers.* Among the remaining children, *ambiguous* children were identified by the same criteria as in the classic test. All other children were classified as *nonrecognizers.* The two observers disagreed in two cases (3%); these were resolved by consensus.

Experimenter Invites the Child to Synchronic Imitation

The following tests were also conducted by the same experimenter who was unaware of the hypotheses of the study. She arranged five pairs of objects along the sides of the room: two sandmills, two dolls, two ninepins, two rattles, and two frogs. The experimenter performed the following overture with each type of object: (a) taking one object, beginning the first activity with the object, calling the child, smiling and looking at the child, (b) pointing to and naming the second object, and (c) offering the second object to the child. Each of the three steps of the overture lasted maximally 10 s.

After the full 30-s overture or after the child had taken the second object, the experimenter continued the activity with the object for 15 s and then performed a second activity with the same object for another 15 s, looking and smiling at the child every 5 s. After each trial, the experimenter replaced the object.

The following activities were performed with the objects: *sandmill:* (a) rattling rhythmically and vertically and saying "bam-bam" and (b) turning up-and-down rhythmically and saying "tick-tock"; *doll:* (a) handling as a baby and humming a lullaby softly and (b) letting the doll march along the floor and saying "march-march"; *ninepin:* (a) tapping on the floor and saying "clop-clop" and (b) walking with the ninepin using it as a stick and saying "tap-tap"; *rattle:* (a) moving rhythmically and vertically and saying "ding-ding" and (b) turning up-and-down rhythmically and saying "up-and-down"; *frog:* (a) moving and saying "croak-croak" and (b) laying "to sleep" on the floor and making snoring noises. Each vocalization was pronounced twice for each action.

All five trials were performed in the same way, proceeding from the sandmill to the frog, if possible. If the child already held the object when a new trial began, the experimenter skipped this trial and made up for this trial as soon as it was possible. During all trials, the child was free to engage the parent, engage the experimenter from a distance, or play with the other objects. If the child approached the parent during an imitation sequence, this sequence was interrupted and continued when the child left the parent.

The videotaped behavior was coded trial by trial for (a) whether the child was attentive to the experimenter and (b) the duration of synchronic imitation during the trial. Synchronic imitation was coded according to the communicative criteria developed by Asendorpf and Baudonnière (1993) but with a more strict definition of imitation. An imitation sequence began when the child took the second object, looked at the experimenter within ±3 s, and imitated the activity of the experimenter. The sequence lasted for as long as the child continued to both imitate the activity of the experimenter and look at the experimenter for at least every 10 s. Contrary to Asendorpf and Baudonnière (1993), using the same kind of object in a different way was not coded as imitation. Whether or not the child followed the activity switch by the experimenter was additionally coded. An imitation sequence ended when the child or the experimenter stopped the activity or when the child did not follow the experimenter's activity switch for more than 3 s.

Coding reliability was checked by a different coder's parallel coding of 10 children for each type of mirror test. Intercoder agreement was satisfactory (for inattentive–attentive, $\kappa = .88$; for the incidence of synchronic imitation, $\kappa = .78$; for following the experimenter's activity switch, $\kappa = 1.00$, and for the duration of synchronic imitation, $r = .77$).

Experimenter Synchronically Imitates the Child

The experimenter put three additional pairs of objects on the floor: two hats, two bears, and two washbasins (thus, there were now eight pairs of toys). As soon as the child took an object, the experimenter took the second object and closely imitated the activity, posture, and vocalizations of the child. The child's activities were imitated even if the child did not have an object. If the child took both objects, the experimenter took two of the next-similar object. If the child approached the parent, the experimenter waited until the child left the parent. The imitation period ended when 5 min were over, not counting the time spent with the parent, or when children did not leave the parent any more.

The videotaped behavior was coded second by second on a microcomputer for the child's proximity to the parent, looking to the experimenter, and all activities of the child. These activities were coded in terms of activity changes. Whenever a change occurred, the coder noted the time and object used and freely and briefly described the new activity. The coder also assigned numbers to the activities: The same activities were assigned the same number, and different activities different numbers. If the child was not interested in the experimenter, molar levels (e.g., "goes to table") were sufficient. If the child "tested" the contingency with the experimenter, it was sometimes necessary to distinguish activities at a more molecular level (e.g., "touches mouth with sandmill" and "puts sandmill on head").

Coding reliability was checked by a different coder's parallel coding of 10 children for each type of mirror test. Intercoder agreement was satisfactory (looking, $\kappa = .87$; proximity to the parent, $\kappa = .90$; object use, $\kappa = .96$; frequency of activity changes, $r = .74$; and frequency of different types of activity, $r = .76$).

Jens B. Asendorpf, who was unaware of children's mirror status, searched through half of the sample for children's first "testing sequence." A testing sequence was identified whenever children rapidly varied their activity with one object of the eight pairs of objects for an extended period of time, while paying close visual attention to the experimenter, particularly after activity changes. A different observer was trained in this task and completed an independent coding of the children. Intercoder agreement was satisfactory ($\kappa = .74$). Coding disagreements were resolved by consensus.

In an attempt to replicate these high-inference judgments using only low-inference criteria, the judgments of testing sequences were approximated by criteria of looking, activities, and object use. A systematic variation of these criteria indicated that the following definition of a testing sequence best approximated the high-inference judgments: (a) at least four successive, different activities with the same type of object, and (b) at least every 5 s visual orientation to the experimenter, and (c) visual orientation within 3 s following each change in activity, and (d) minimum length of 20 s for the whole sequence. The agreement between the computer-generated testing sequences that were based on these criteria and the consensually judged sequences was high ($\kappa = .82$). Further analyses used only the computer-generated sequences because of their more objective definition.

Results

Mirror Self-Recognition

Table 1 contains the number and percentage of children who were classified as immediate recognizers, delayed recognizers, ambiguous, or nonrecognizers in the classic and the revised tests. Because the 113 children in Asendorpf and Baudonnière's (1993) study were tested with the same classic test, the videotapes of the fifty-four 19-month-old nonrecognizers in this study were reanalyzed for ambiguous children; these results are also presented in Table 1.

Table 1 indicates that the percentages of immediate recogniz-

Table 1
Mirror Self-Recognition in Two Classic Tests and Revised Test

Mirror status	18-month classic		18-month revised		19-month classic	
	n	%	*n*	%	*n*	%
Immediate recognizers	19	45	25	45	59	52
Delayed recognizers	—	—	9	16	—	—
Nonrecognizers	12	29	16	29	29	26
Ambiguous cases	11	26	6	11	25	22

Note. Data for 18-month-olds stem from the present study, and data for the 19-month-olds stem from a reanalysis of Asendorpf and Baudonnière (1993).

ers and nonrecognizers in the present study were identical across the two types of tests and that the percentage of ambiguous cases was reduced to less than half in the revised test. Because of the relatively small number of children in this category, this reduction and the accompanying increase in the percentage of recognizers (combining delayed and immediate recognizers) was not significant, $\chi^2(2, N = 98) = 4.38, p = .11$. However, the consistency in the proportions of ambiguous children between the present study and Asendorpf and Baudonnière's (1993) study further supports the present finding of a relatively high proportion of ambiguous children in the classic test (the slightly lower proportion of both nonrecognizers and ambiguous children in Asendorpf & Baudonnière's, 1993, study appears to be due to the slightly older age of the children in this study). It seems that the majority of nonclassifiable children in the classic mirror test would react with delayed recognition in the revised test. Thus, the revised test appears to be a useful, less ambiguous procedure for identifying mirror self-recognition.

Because the mirror status for the ambiguous children was not clear, these children were not analyzed further. As in Asendorpf and Baudonnière's (1993) study, girls recognized themselves more often (78%) than did boys (54%) in the mirror, $\chi^2(1, N = 81) = 5.01, p < .03$.

Experimenter Invites the Child to Synchronic Imitation

Three children were excluded from analysis because they were inattentive to the experimenter in all five trials. The remaining 78 children were inattentive in 10% of the trials on average. As a threshold for imitation we chose a minimum duration of 2 s. All children stopped imitating the experimenter's first activity when they recognized that the experimenter had changed her activity; thus, their behavior during synchronic imitation was strongly contingent on the experimenter's activity.

Table 2 presents the frequency, duration, and mean length of (non)recognizers' imitation of the experimenter in those trials in which they were attentive to her. The majority of the nonrecognizers (52%) and of the recognizers (69%) imitated the activity of the experimenter at least once, and the recognizers did not engage in imitation more often than did the nonrecognizers, $t(76) = 1.57$, *ns*. Furthermore, the nonrecognizers followed the activity change of the experimenter during a trial as often as did recognizers ($t < 1$). Thus, as expected, recognizers and nonrecognizers did not differ in the tendency to imitate the adult's activity.

However, Table 2 shows that recognizers imitated the experimenter for more than twice the time than nonrecognizers, $t(76) = 2.36, p < .03$, and the mean length of their imitation phases was twice as long as those of the nonrecognizers, $t(76) = 2.44, p < .02$. Thus, in line with our hypothesis, the recognizers engaged more in sustained synchronic imitation. Table 2 indicates that delayed recognizers showed a behavior similar to that of immediate recognizers ($t < 1$ in all cases); this finding confirms the usefulness of the revised mirror test.

Because we were interested in the competence of the children rather than in their mean performance, we analyzed in more detail their best performance, that is, the longest duration of synchronic imitation shown in the five trials. An inspection of the distribution of children's longest duration of synchronic imitation showed a highly skewed distribution. Therefore, we analyzed these durations by survival analysis (see Griffin & Gardner, 1989), using the SAS Institute's program LIFETEST (SAS Institute Inc., 1990). Survival analysis tests group differences in survival functions by nonparametric tests. A survival function

Table 2
Frequency, Duration, and Mean Length of Imitation of Experimenter by Mirror Status

Mirror status	*n*	Frequency		Duration		Mean length	
		M	*SD*	*M*	*SD*	*M*	*SD*
Nonrecognizers	27	1.19	1.18	6.11	8.08	3.01	3.12
Recognizers	51	1.67	1.34	14.69	17.87	5.92	5.76
Immediate	42	1.64	1.19	13.79	15.45	6.06	5.70
Delayed	9	1.78	1.99	18.89	27.33	5.29	6.38

Note. Two recognizers and one nonrecognizer had missing values because of inattention.

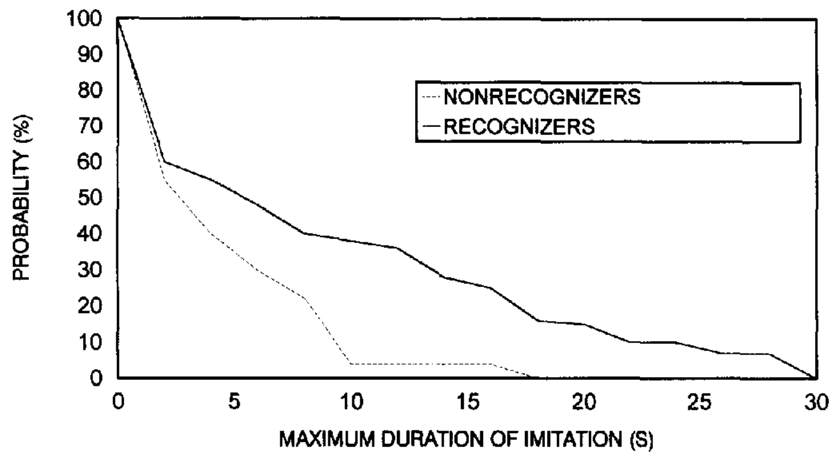

Figure 1. Survival functions for recognizers' and nonrecognizers' longest duration of imitation when they were invited to synchronic imitation by the experimenter.

plots the probability against time that a duration exceeds a particular time. Figure 1 shows nonrecognizers' and recognizers' survival functions for their longest duration of synchronic imitation in the five trials.

The log-rank test for differences between the survival functions of recognizers and nonrecognizers was significant, $\chi^2(1, N = 78) = 7.28, p < .01$. Figure 1 indicates that the group differences became most marked at about 10 s of imitation. When sustained synchronic imitation was defined as imitation for more than 10 s, only 1 nonrecognizer showed sustained synchronic imitation at all, whereas 17 (33%) of the recognizers did so, $\chi^2(1, N = 78) = 8.73, p < .003$. Thus, with only one exception, only recognizers engaged in long phases of synchronic imitation, whereas the majority of both recognizers and nonrecognizers imitated the experimenter at least once. The survival functions of boys and girls did not differ ($\chi^2 < 1$).

Reanalysis of Asendorpf and Baudonnière's (1993) Study

To compare these results with Asendorpf and Baudonnière's (1993) findings on children's synchronic imitation during dyadic free play with a peer, we reanalyzed the latter data in an identical fashion, using Asendorpf and Baudonnière's (1993) definition of synchronic imitation. We determined the longest synchronic imitation sequence for each dyad and analyzed these data by survival analysis (because synchronic imitation is a property of a dyad rather than an individual, the analysis was done at the dyadic level). Figure 2 shows the survival functions for the 9 dyads comprising nonrecognizers and the 12 dyads comprising recognizers.

The log-rank test for differences between these survival functions was significant, $\chi^2(1, N = 21) = 11.78, p < .001$. Figure 2 indicates that the group differences increased steadily until they became most marked at about 20 s of imitation. Five of the 9 nonrecognizer dyads showed imitation sequences lasting longer than 10 s. These results suggested that the longest imitation sequences produced by the nonrecognizer dyads were clearly longer than those produced by the nonrecognizers in the present study.

A possible reason for this difference between Asendorpf and Baudonnière's (1993) study and the present study was a less strict coding criterion for imitation sequences in the former study: There it was only required that the two peers simultaneously used the same kind of object, whereas in the present study a similar activity with the same kind of object was regarded as being necessary for synchronic imitation.

To test this possibility, we had two coders independently recode the 21 longest imitation sequences for recognizer and nonrecognizer dyads in Asendorpf and Baudonnière's (1993) study according to the stricter criterion for synchronic imitation of the present study. Second-by-second intercoder agreement was satisfactory ($\kappa = .72$), and intercoder disagreements were resolved by consensus. A log-rank test indicated a strong difference between the survival functions of the two types of dyads, $\chi^2(1, N = 21) = 12.36, p < .001$. Only 1 of the 9 nonrecognizer dyads showed synchronic imitation sequences longer than 10 s, but 10 of the 12 recognizer dyads did so ($\kappa = .71$ for the association between mirror status and synchronic imitation); accidentally, the same association had been found for the 20-s criterion for imitation.

Experimenter Synchronically Imitates the Child

Five children (3 nonrecognizers and 2 recognizers) were excluded from analysis because their imitation times were below 1 min. The remaining 76 children were imitated for 63–300 s ($M = 272.3$, $SD = 48.1$). They engaged in 0–3 computer-detected sequences of testing the experimenter ($M = 0.88$, $SD = 0.94$). A majority of both the recognizers (57%) and the nonrecognizers (56%) showed at least one testing sequence. Because only 25% of the children engaged in two or three sequences, only the first sequence was further analyzed. It began after 1–235 s ($M = 68.9$), had a length of 20–122 s ($M = 50.0$), and involved 4–12 different activities with the most used object in the sequence ($M = 5.74$). Recognizers and nonrecognizers did not differ significantly in these variables.

The rate of different activities per minute for the first testing sequence varied between 5 and 21 ($M = 9.68$). This rate was significantly higher than the rate of different activities per minute in the remaining observation period ($M = 6.68$), $t(42) =$

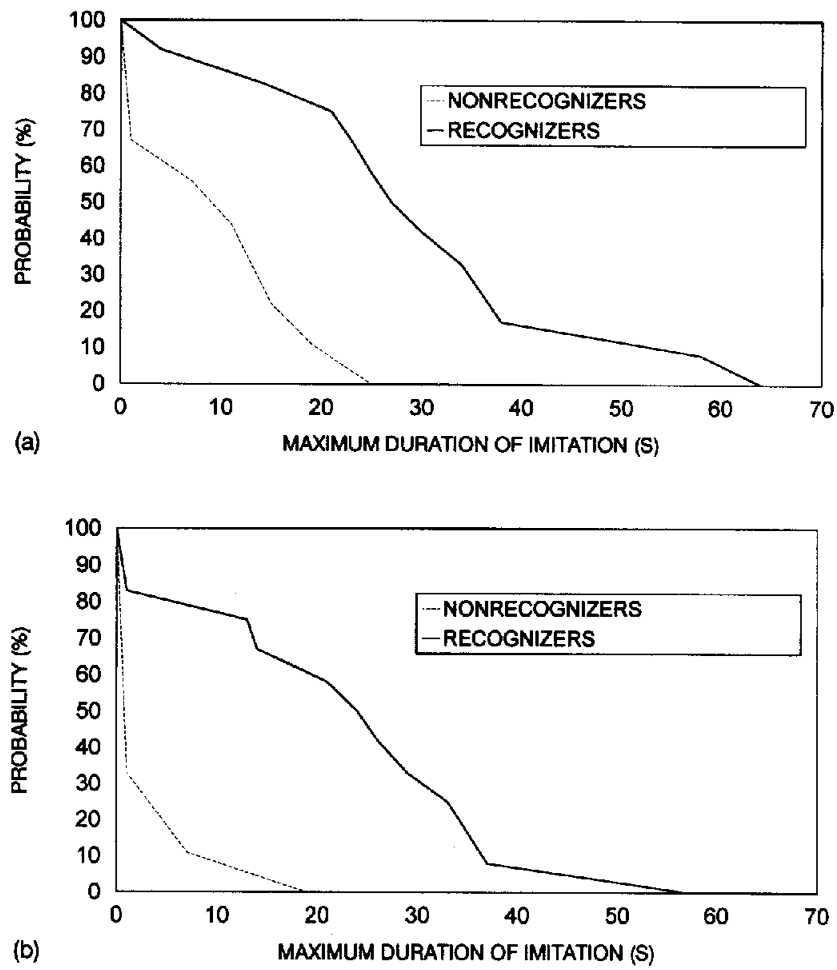

Figure 2. Survival functions for dyads' longest duration of synchronic imitation in Asendorpf and Baudonnière's (1993) study according to two different criteria for synchronic imitation (contrasted are dyads comprising only recognizers or nonrecognizers): (a) criterion is the use of the same kind of object. (b) criterion is the use of the same kind of object in an imitative way.

4.62, $p < .0001$. Thus, children were more variable (less repetitive) in their activity during the first testing sequence than overall. Recognizers were more variable than nonrecognizers ($M = 10.5$ vs. $M = 7.98$), $t(41) = 2.19$, $p < .04$. This result suggests that recognizers tested the experimenter more intensively than did nonrecognizers but that both recognizers and nonrecognizers were aware of and tested the social contingency in this situation. According to t tests, sex differences were not significant for all these variables.

Discussion

This study attempted a replication of Asendorpf and Baudonnière's (1993) finding of a consistency between mirror self-recognition and sustained synchronic imitation by means of a different methodological approach. Eighteen-month-old children were tested for mirror self-recognition by the classic rouge test or by an alternative procedure and were observed in interactions with an unfamiliar adult who invited the child to imitate her activity. As was expected, a majority of both recognizers and nonrecognizers imitated the adult's activity, but only mirror self-recognizers engaged in long phases of synchronic imitation when they were invited to synchronic imitation. When the children were imitated by the adult, apparently most recognizers and nonrecognizers became aware of the social contingency and tested it. The classic mirror self-recognition test was shown to produce false negatives.

Both the classic and the revised mirror rouge tests classified 29% of the 18-month-olds as nonrecognizers, but the revised procedure resulted in 61% recognizers in comparison with only 45% recognizers in the classic test. The increased recognition rate in the revised test appeared to be due to a reduction in ambiguous cases, children who closely watch their mirror image but do not show a response to the mark on their face or to their mirror image. As a note of caution, it should be noted that the order of the two tests was not balanced; thus, the results of the revised test are potentially confounded with an order effect.

The higher rate of recognizers in the revised test does not seem to reflect false positives. If there had been a direct transfer from the cleaning of the doll to the mirror situation, the children should have cleaned the mirror rather than their faces because this was the simplest thing to do if they did not understand the meaning of their mirror images. Instead, the doll-cleaning situation apparently helped them to understand that a mark on their face should be cleaned.

The classic test rests on the assumption that all children who correctly recognize the mark are also motivated to clean their faces. The results of the revised test suggest that this assumption is wrong and that the mirror rouge test can be improved. One consequence of our finding is that the age when 50% of a normal sample recognize themselves in a mirror seems to be below 18 months of age. Future studies on mirror self-recognition should use 17- or 16-month-olds.

Even our revised test failed to classify 11% of the children as recognizers or nonrecognizers. Furthermore, both the classic and the revised tests ultimately rely on a response to a specific violation of a self-related expectation, that one has a clean face. It would be highly desirable to invent new self-recognition tests that do not rely on this specific procedure.

As was expected, a majority of both recognizers and nonrecognizers imitated the adult's activity when they were invited to synchronic imitation, but only immediate and delayed recognizers imitated the activity for longer periods. A detailed analysis of the length of the imitation periods showed that the difference between recognizers and nonrecognizers became most pronounced after 10 s of imitation. A reanalysis of Asendorpf and Baudonnière's (1993) data showed a highly similar pattern when the same strict criterion for synchronic imitation used in the present study was applied to these earlier data.

Synchronic imitation was coded only when the child looked to the partner at least once every 10 s. Because behavioral contingencies in social interaction occur within 10 s (see, e.g., Mueller & Brenner, 1977), the 10-s criterion for sustained synchronic imitation is an appropriate threshold for communication through synchronic imitation. With this criterion, the present findings support our hypothesis that only recognizers understand and use synchronic imitation as a form of communication. Further work is needed, however, to confirm this hypothesis through a more detailed analysis of reciprocal exchanges within sustained synchronic imitation phases.

One third of the recognizers engaged in sustained synchronic imitation. Similarly, Eckerman and Didow (1989) found that 16- or 20-month-olds engaged in 19%, or 28%, of the cases, respectively, in imitative games consisting of turn alternations, for example, an unfamiliar adult's action, the child's imitation, repetition of the action by the adult, and repetition of the imitation by the child. Although these games cannot be equated with synchronic imitation, they are another example of extended communication through nonritualized imitation.

When the children were imitated by the experimenter, a majority of both recognizers and nonrecognizers engaged in testing the behavior of the adult. This testing behavior was initially coded by subjective judgment, but later it could be identified by low-inference behavioral criteria such as close visual orientation toward the experimenter and rapid variation of the activity. Recognizers spent as much time with testing as did nonrecognizers, but they varied their activity more than did the nonrecognizers. It seems that they tested for social contingency more intensively than did nonrecognizers. This result supports the view that children are aware of social contingency before they can recognize themselves in a mirror. However, this finding should be considered with caution, because the two groups did not differ significantly in any other aspect of their behavior.

From the theoretical perspective that was originally developed by Asendorpf and Baudonnière (1993) and that was elaborated further in this study, the results of both studies support the view that mirror self-recognition and sustained synchronic imitation as a form of preverbal communication among unfamiliar partners develop in close synchrony. The present study suggests that two necessary cognitive capacities for synchronic imitation develop before children can recognize themselves in a mirror: imitation of unfamiliar activities of an unfamiliar person and social contingency awareness. A third necessary ability, however, appears to be closely linked to self-recognition: coordinating one's perspective of the situation with another's perspective of the same situation (other-awareness; Asendorpf & Baudonnière, 1993). It is this ability of spontaneously taking the perspective of others that seems critical for synchronic imitation. Because other-aware children do not appear to be able to deliberately take the perspective of others, one may claim that they have an "intuition of others' mind" but not a "theory of others' mind" (Astington, Harris, & Olson, 1988).

Alternatively, the results of both studies could be interpreted from a temperamental perspective. As one reviewer suggested, recognizers may be more sociable in general: They may be generally more interested in people than in nonsocial objects. If this were true, they may be more attracted to mirror images of human faces and therefore learn to recognize themselves in mirrors earlier, or they may be misclassified less frequently because of indifferent behavior in front of the mirror. Also, they would be more interested in communicating with the experimenter in the invitation task, whereas less sociable children might be more interested in exploring the objects used by the experimenter. Thus, the results of our two studies would simply reflect differences in children's general sociability.

We cannot dismiss this alternative interpretation on the basis of our data. Future studies could try to decide between the social-cognitive and the sociability interpretations. One promising approach is to assess independently the capacity for secondary representation in a nonsocial setting of both self-awareness and other-awareness. Demonstrating a correlational link between such a pure cognitive assessment and both self-awareness and other-awareness would support our social-cognitive view on the synchrony between self-awareness and other-awareness. One possibility would be to use the spontaneous generation of pretend play with an imaginary object in nonsocial settings as an indication of the capacity for secondary representation.

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