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RESEARCH ARTICLES

Imitative Games by 9-, 14-, and 18-Month-Old Infants

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Two experiments used a mutual imitation paradigm to assess 9-, 14-, and 18-month-old infants' developing understanding of intentions in others. In the first study, 1 experimenter imitated the infants' actions, and another experimenter performed contingent but different actions on an identical toy. From 9 months of age, infants show discrimination between the mimicking and the contingent experimenter. In a second study, same-age groups of infants faced either an experimenter mimicking their actions on an identical object or the object mimicking them independently of any manual contact by the experimenter. Only 14- and 18-month-olds showed discrimination between the 2 conditions, this discrimination correlating with infants' relative ability to follow gaze and points in triadic exchanges. These results are interpreted as demonstrating important developmental changes between 9 and 14 months in the construal of others as intentional.

Construing others as intentional is a major developmental achievement, possibly unique to humans. Taking an intentional stance or the ability to understand and construe the intentions of others by adopting their perspective is sometimes viewed as the foundation of human culture and cognition in comparison to other primate species (Tomasello, 1999; Tomasello, Kruger, & Ratner, 1993; but see also DeWaal, 2001; Whiten & Custance, 1996). Basic mechanisms contributing to children's language, cognitive, and general skill development entail the construal of others as intentional: that people have plans, goals, desires, and eventually beliefs guiding their actions. Instructional learning, for example, is inseparable from an

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understanding that other people (instructors) have the communicative intent to teach or convey information (Bruner, 1983; Rochat, 2003; Rogoff, 1990).

Many recent developmental studies suggest that an important transition toward the construal of others as intentional occurs by the end of the first year, when infants begin to manifest referential communication, demonstrating attempts at communicating with others in reference to objects in the environment (Bakeman & Adamson, 1984; Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Bruner, 1983; Carpenter, Nagell, & Tomasello, 1998; Rochat & Striano, 1999b; Scaife & Bruner, 1975; Tomasello, 1995; Trevarthen, 1979). Research also indicates that by this time infants begin to consider the motives underlying others' behavior (Bates et al., 1979; Bretherton, 1991; Butterworth & Jarret, 1991; Campos et al., 2000; Campos & Stenberg, 1981; Carpenter, Nagell, & Tomasello, 1998; Scaife & Bruner, 1975; Striano & Rochat, 2000; but see also Moore, 1999). In all, the coemergence at around 9 months of an understanding of communicative gestures, the behavioral manifestation of joint engagement, and social referencing are acknowledged as the first explicit signs of a construal of others as intentional (Bretherton, 1991; Carpenter, Akhtar, & Tomasello, 1998; Tomasello, 1995). However, questions remain about how this major social-cognitive advance continues to develop beyond 9 months.

Recent studies point to the fact that between 6 and 18 months infants manifest different levels in understanding the intentions of others. Woodward (1999) reported that by 6 months, infants show some understanding of goal orientation and object directedness by another person toward an object. From 9 to 12 months infants begin to differentiate between means and ends, discriminating between relevant or irrelevant manual actions, and factoring in whether such actions entail a human (intentional) hand or a mechanical (unintentional, inanimate) device (Woodward, 1999; Woodward & Sommerville, 2000). By 16 months infants are more inclined to reproduce actions on objects that are vocally marked as intentional (i.e., "there") compared to actions that are vocally marked as accidental (i.e., "whoops"; Carpenter, Akhtar, & Tomasello, 1998). By at least 18 months, infants uniquely attribute intentions to humans and not objects, and can also discriminate between an expected intentional action and an unexpected intentional action (Meltzoff, 1995; Poulin-Dubois, 1999). In all, the existing research points to an important development between 9 and 18 months in the understanding of intentional actions, from a basic understanding in terms of object directedness or goal orientation (Csibra, Gergely, Biro, & Koos, 1999; Gergely, Nadasdy, Ciba, & Biro, 1995; Rochat, Morgan, & Carpenter, 1997) to an understanding of planfulness, intentions, and desires as rudiments of theories of mind (Carpenter, Akhtar, & Tomasello, 1998; Meltzoff, 1995; Poulin-Dubois, 1999).

Recently, Meltzoff and Moore (1999) reported intriguing findings regarding imitation games that would suggest intentionality understanding in infants as young as 9 months. In a series of studies, Meltzoff and Moore (1999; see also Meltzoff, 1990) placed infants between 6 weeks and 14 months of age in front of two adults, each playing with identical toys. One of the adults systematically imitated the target actions spontaneously performed by the infant on his or her own toy. The other adult either performed different actions independently of what the infant did or performed contingent target actions of a different type. The goal of the study was to establish when infants begin to recognize being imitated. Meltzoff and Moore reported that from 9 months of age, infants tend to look and smile more toward the imitating compared to the other adult facing them. Furthermore, from 9 months of age, but particularly with 14-month-olds, infants systematically produce testing behaviors oriented preferentially toward the imitating adult. In this behavior, infants display systematic modulation of their own action on the toy while looking at the adult, checking whether he or she is intentionally mimicking. These intriguing findings would suggest that by 9 months infants already show signs of detecting intentions in a person imitating them. However, more evidence is needed to warrant such an interpretation. In particular, it is not clear whether the similar behaviors that 9- and 14-month-old infants direct to a person imitating them correspond to the same level of intentionality understanding, and further, whether from 9 months such discrimination is the index of a comparable social-cognitive competence. This question is particularly relevant considering that young autistic children who show very limited social-cognitive abilities appear sensitive and to regain social attention toward a person imitating them (Nadel, Guérini, Pezé, & Rivet, 1999).

There were three main goals to the research reported here. The first goal was to revisit Meltzoff (1990) as well as Meltzoff and Moore's (1999) original findings, using the same basic imitation game paradigm, but testing groups of infants aged 9, 14, and 18 months. The first aim was to confirm the original findings of Meltzoff and Moore, adding an age group to capture an eventual development in the discrimination of being imitated as index of an intentional stance. The second goal was to provide further testing of a putative construal of others as intentional by infants in an imitative game. Immediately following the periods of imitation games, we observed infants in a still-face period during which both experimenters (imitator and nonimitator) adopted a still face while staring at the infant. This still-face period was meant to assess the extent to which infants would differentially interact and try to reengage one or the other experimenter, depending on previous mimicking or nonmimicking interactions. The idea was that if infants discriminate between the two experimenters based on their communicative intents, such discrimination should carry over in subsequent attempts at reengagement. Finally, the third goal was to assess and possibly differentiate processes by which infants discriminate between imitating and nonimitating adults. The idea was that although 9-month-olds might already show signs of such discrimination, it could be based on a process that does not yet entail any construal of others as intentional. We tested whether this discrimination might rather be based on mere surface detection of temporal contingency. The second experiment was designed to assess such an alternative account.

The review of the literature on the origins of an understanding and discrimination of others as planning, and desiring entities with communicative intents, points to an important development from the time infants begin to engage in shared attention (9 months) to the time infants become increasingly symbolic and referential in their social interaction (18 months). It is between 15 and 18 months of age that infants begin explicitly to recognize themselves in mirrors, manifest self-conscious emotions such as embarrassment, and in general begin to manifest new levels of collaboration and perspective taking (Carpenter, Akhtar, & Tomasello, 1998; Lewis & Brooks-Gunn, 1979; Lewis, Sullivan, Stanger, & Weiss, 1989; Rochat, 1995, 2001; Tomasello, 1999). We therefore hypothesized that it is probably not prior to 14 to 18 months of age that infants would unambiguously show a construal of others as intentional in imitation games. At 9 months, we expected that if infants showed discrimination of being imitated, it is probably based on a process entailing a detection of contingency of self-produced actions (when I do something, a predictable and regular outcome occurs) rather than the construal of others as intentional (when I do something, this particular person is willfully mimicking it). Our working hypothesis was thus that if infants between 9 and 18 months show discrimination and testing of a person imitating them, they do this on different grounds according to age.

EXPERIMENT 1

We used the same basic paradigm created by Meltzoff (1990). Infants were videotaped while facing two experimenters, each manipulating the same toy. One experimenter (the imitator) systematically mimicked the target actions performed spontaneously by the infant. At the same time, the other experimenter performed contingent actions of a different type. Periods of imitative games were followed by a still-face period during which both experimenters remained still. Preferential looking and smiling toward either experimenter as well as the production of testing behaviors by the infant were systematically coded and analyzed.

Method

Participants

Forty-eight healthy, full-term infants were included in the final sample. There were 16 nine-month-olds (M = 291 days, range = 245 days–326 days; 9 boys and 7 girls), 16 fourteen-month-olds (M = 445 days, range = 408 days–469 days; 7 boys and 9 girls), and 16 eighteen-month-olds (M = 567 days, range = 531 days–608 days; 8 boys and 8 girls). An additional 21 infants were tested but not included in the final sample. Nine were excluded due to fussiness, and 12 were excluded after coding determined that the experimenters had failed to accurately perform the correct imitating or control behaviors.

The infants were recruited from a participant pool consisting of more than 1,000 infants born at the Northside Maternity hospital of Atlanta, Georgia. Races were representative of the northeastern greater Atlanta population, predominantly White and middle class.

Testing Situation

The investigation took place within a room isolated from sound and visual distraction. Infants were tested within a large, white, cloth-lined enclosure (3.0 m × 3.0 m) with the lens of a camera peeking through. The video recording (VCR and monitor) equipment was placed outside of the enclosure. Infants sat on their mothers' lap facing a large table (1.52 m × 0.762 m). On the other side of the table (0.762 m) sat two experimenters of the same gender and wearing an identical outfit (blue medical shirt) to equate as much as possible their physical appearance. Each experimenter had his or her hands on a toy, identical to the one manipulated by the infant. Experimenters were 1 m away from each other while facing the infant. The recording video camera provided a slightly overhead and side view of the infant facing the two experimenters.

Objects. Two kinds of colorful plush objects were used as toys. Each triplet of identical toys was used once in two successive testing trials. The toys were either a 10 cm × 10 cm cube or a pyramid (10 cm in height with a 10 cm × 10 cm square base), both made of a foamy, squeezable material.

Procedure

The experiment was divided into seven different periods: three baseline periods, one prior to each imitative game period, and one at the end of testing; two imitative game periods; and two still-face periods following the imitative games. Table 1 outlines the general design of the experiment, including the order, duration, and a succinct description of each condition.

The experimenters' location (left or right relative to the infant) and the kind of toys (pyramid or cube) as well as their order of presentation were counterbalanced among infants of each age group.

Baseline periods. The testing session began and ended with a 30-sec initial play period. The infant sat on the mother's lap facing the two experimenters. During this time only the experimenters had a toy (cube or pyramid) in front of them. The baseline periods controlled for any potential intrinsic preference by the infant for one of the two experimenters during nonimitative games. During these baseline periods the experimenters modeled target actions when the infants directed their

TABLE 1
Procedure Outline of Experiment 1

Condition:	Baseline	First imitative game	First still face	Baseline	Second imitative game	Second still face	Baseline
Duration:	30 sec	60 sec	60 sec	30 sec	60 sec	60 sec	30 sec
Experimenter action:	Action modeling	Imitating and contingent	Still face and still face	Action modeling	Contingent and imitating	Still face and still face	Action modeling

attention to one of them. When an infant looked at a particular experimenter, that experimenter performed a target action that was clearly visible to the infant. The experimenter continued modeling target actions over and over until the infant looked away, and no action was performed if the infant was not looking at either experimenter. Infants often quickly alternated their glances between experimenters during this portion of the experiment and throughout testing. The experimenters did their best to keep up with the dynamic behavior of the infants. The baseline served as a demonstration of particular target actions to the infant. For later analysis of gaze, it also allowed for the calibration of the infant's looks at either experimenter. As shown in Table 1, there were a total of three baseline periods: two prior to imitative games and one at the conclusion of testing following the second still-face period.

Imitative game periods. There were two 60-sec imitative game periods following baseline (see Table 1). At the start of the imitative game periods, the infants were provided with the same toy as the two experimenters facing them and the infants were free to play with it as they chose. However, the experimenters manipulated their own toy only when the infants performed one of eight predetermined target actions. Importantly, when the infants performed one of these target actions on the toy, both experimenters acted contingently on their own toy. However, only one experimenter (the imitator) reproduced this particular target action as quickly and as accurately as possible on his or her own toy. The other experimenter (contingent actor) produced a contingent but different target action on his or her toy. In other words, the imitator mirrored the particular target action spontaneously performed by the infant as the contingent experimenter reproduced a contingent but different target action, which was paired with the target action because it controlled for amount of visual dynamics.

The eight target actions were grouped into four pairs: (a) touch head with toy–touch chest with toy, (b) shake–slide, (c) poke–pound, and (d) squeeze toy in hands–press toy to table. Table 2 outlines the actions that occurred when an infant performed one of the eight target actions.

Each pair corresponded to what either the imitator or the contingent experimenters did in response to the infants' free manipulation of their own toy. The experimenters did not respond to any other actions performed by the infants. For example, if infants shook their toy, the imitator shook his or her toy in the same way (both in dynamic and form), whereas the contingent experimenter slid his or hers on the table in a manner that resembled the dynamics of the infants' actions, but not the actual form.

Still-face periods. As indicated in Table 1, each imitative game period was immediately followed by a 60-sec still-face period. During this period both experimenters ceased all actions and remained still while facing the infant. The goal of

TABLE 2
List of Target Actions and Corresponding Responses by Either the Imitating or the Contingent Experimenter

Infant's Behavior	*Imitating Experimenter*	*Contingent Experimenter*
Shake	Shake	Slide
Slide	Slide	Shake
Pound	Pound	Poke
Poke	Poke	Pound
Press on table	Press on table	Squeeze in air
Squeeze in air	Squeeze in air	Press on table
Toy touches body	Toy touches body	Toy touches head
Toy touches head	Toy touches head	Toy touches body
Other	Passive	Passive

this period was to assess whether infants were differentially inclined to reengage one particular experimenter during the still face, based on previous imitative interactions. Once the first still-face period was over, a new baseline followed and the whole procedure was repeated using the other object toy.

Coding and Analysis

Video recordings of the infants were coded separately by two naive observers using a computerized event recorder. To prevent scorers from having to monitor and code a multitude of simultaneous actions and glances, coding was achieved through multiple passes. In so doing, one experimenter always coded the direction of looks (to C or I), while the other experimenter either coded smiling or testing behaviors. This enabled us to always determine where the infants were looking when they were smiling or performing one of the target actions. Coding was repeated until all actions were coded with the looking direction and also enabled us to determine the reliability of our code for looking direction. While viewing the online video recording of the infants' frontal view and pressing a particular key of a computer corresponding to a specific behavior, observers activated a channel of the event recorder. Once coded, a program computed the cumulated occurrences of a particular behavior and its proportion (percentage) over total test period time. The coding corresponded to the occurrence of five behaviors indexing infants' visual attention and social engagement relative to the two experimenters (imitator vs. contingent) in absolute seconds, frequency, and proportion. These behaviors were operationally defined as follows:

- *Gazing:* Infants' gaze oriented toward either the imitator or the contingent experimenter.

- *Smiling:* Infants' cheeks raised and sides of the mouth raised up while gazing at the either the imitator or the contingent experimenter.

Testing behaviors. The testing behavior is the most important measure to be used as an indicator of recognition that someone is imitating the self. Testing behaviors are a constellation of actions that indicate that the infant intends to check the reliability of the experimenters' matching actions. For this experiment, the definition of testing behaviors as outlined in Meltzoff (1990) and Meltzoff and Moore (1999) occurred "when the infant performed some sudden and unexpected actions on the toy while gazing at either one of the experimenters (imitator or contingent)" (Meltzoff & Moore, 1999, p. 25). These sudden movements included stopping actions and dramatic changes in speed or intensity of the action. For example, the infants might slide the toy across the table. Then, suddenly while looking at the experimenters, they increased the speed of their action, as if to check if their own actions are truly being shadowed. Or, the infants may suddenly freeze and then start again to check the contingency of the interaction between the experimenters and themselves. Testing behaviors could only occur when the infant was looking at the action of either experimenter and when the infant's action had the dynamic feature of a sudden stop and restart. The frequency of testing behavior was first recorded. In further analysis, the gaze orientation accompanying testing behavior was recorded (the infant either looking at the imitating or the contingent experimenter while they engaged in testing behavior).

Social initiatives. Clapping, banging, or reaching while gazing toward one of the present individuals (parent, imitator, or contingent experimenter) were considered social initiatives (see previous research by Striano & Rochat, 1999). Parent as a target of social initiatives was added as he or she was a potential social partner for the infant. It was also possible to clap, bang, or reach outward, but not direct that action toward an individual. These instances were also coded.

Interobserver reliability measured on 20% of all tested infants in every testing period yielded kappas of .83 or above for all measures.

Preferential index calculation. The relative proportion and orientation of all dependent measures as a function of testing periods was calculated by subtracting the amount of time the infant directed a particular behavior toward the imitator from the amount of time the infant directed the same behavior toward the contingent experimenter. This difference was then divided by the total amount of time the behavior was manifested toward both experimenters: (imitator – contingent) / (imitator + contingent). The resulting preferential index variable was a value that ranged from –1 to +1. A negative index value indicated a preference for the control experimenter, whereas a positive index value indicated a preference for the imitating experimenter, and an index value of 0 indicated that the infant directed a particular behavior at each experimenter equally, or that the infant did not direct the particular behavior to either of the two experimenters.

Note that during testing, each caregiver was instructed to look straight ahead and not to interfere with his or her infant's interaction with the experimenters. However, because the infants sat on their caregivers' lap it was still possible that the behavior of the caregivers could have affected the infant's behavioral orientation toward the experimenters. To ensure that this was not the case, index values of gazing were calculated for each caregiver, and then were compared to the infants' behaviors. Pearson's correlation analyses revealed that directions of the parents' looks did not correlate significantly with the index values of their infant for gazing and smiling. This finding indicates no apparent influence on the part of the parent holding the infant.

Results

We present first the data obtained during the baseline periods. We then turn to the data obtained in the imitative game and still-face periods, respectively.

Preliminary Comparisons

No significant effects of toy type, $F_{\text{looking}}(1, 45) = 2.54$, $F_{\text{smiling}} = 0.849$, or experimenters' location were found, $F_{\text{looking}}(1, 45) = 2.15$, $F_{\text{smiling}}(1, 45) = 2.95$, during baseline periods. Kind of toys and experimenters' location were not factored in subsequent analyses.

To investigate the infants' relative stability of response across testing, we compared the index values of gazing and smiling behavior as a function of the three baseline periods. A series of repeated measures analyses of variance (ANOVAs) yielded no significant differences in the three baseline periods for both gazing and smiling. Mean looking and smiling index values were $M_{\text{B1}} = 0.010$, $M_{\text{B2}} = 0.005$, and $M_{\text{B3}} = 0.029$ for gazing, and $M_{\text{B1}} = 0.017$, $M_{\text{B2}} = 0.041$, and $M_{\text{B3}} = 0.071$ for smiling, $F(2, 90) = 0.10$ in both cases.

In addition, one-sample t tests indicated that each of these obtained index values were not significantly different from a value of zero, indicating that infants did not have an increased propensity to direct behaviors toward either the imitator or contingent experimenter during each of the three baseline periods: first baseline looking, $t(47) = 0.146$, smiling, $t(47) = 0.208$; second baseline looking, $t(47) = 0.069$, smiling, $t(47) = 0.500$; and third baseline looking, $t(47) = 0.329$, smiling, $t(47) = 0.853$. These preliminary baseline analyses confirmed that the infants had no intrinsic preference toward directing gazing and smiling behaviors to one of the two experimenters.

Preliminary comparisons using a repeated measures ANOVA revealed that there were no differences between the duration of infants' looks or smiles in the first and second instance of each repeated imitation or still-face periods: imitative game periods, $t_{\text{looking}}(47) = -0.564$, $t_{\text{smiling}}(47) = 0.822$; still-face periods, $t_{\text{looking}}(47) = 1.314$, $t_{\text{smiling}}(47) = -0.703$. Consequently, these periods were pooled in the analyses that follow.

Finally, the relative stability in motor arousal between baseline and test period was assessed by comparing infants' overall propensity to look at either experimenter. No significant main effect of condition (baselines vs. test period) was found, $F(1, 45) = 0.34$, *ns*. However, the ANOVA revealed a significant increase in overall smiling during the first test period when compared to the first baseline period, $F(1, 45) = 19.64$, $p < .01$. Despite the fact that infants did not appear significantly more active in terms of looking during the test period as compared to baseline, they demonstrated an increase in social engagement when they also had a toy to play with when compared to infants having no toy during baseline.

Imitative Game Periods

Looking and smiling index values were first compared in one-way ANOVAs, with age (9 months, 14 months, and 18 months) as a between-subjects factor.

Figure 1 presents the infants' index values of looking as a function of age. The one-way ANOVA yielded a significant main effect of age, $F(2, 45) = 15.892$, $p = .001$. As shown in Figure 1, there is a marked increased looking preference by the 14-month-olds to gaze at the imitator experimenter. Follow-up paired comparisons revealed that the 14-month-old infants gazed toward the imitator experimenter ($M = 0.39$) in the imitative game periods significantly more

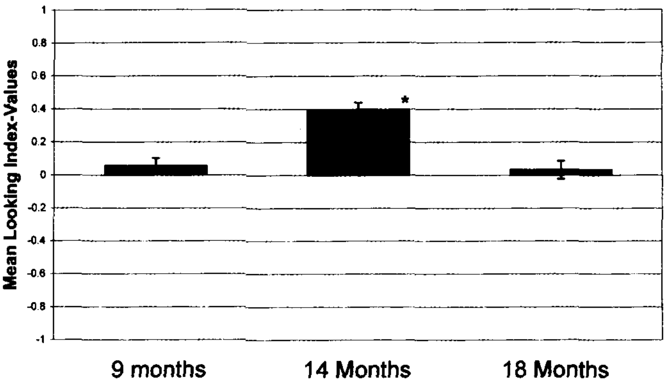

FIGURE 1 Mean index value for looking in the imitative game periods for each age group. The 14-month-old index values are significantly different from the index values of the 9- and 18-month-old groups and from chance.

than either the 9-month-old infants (M = 0.06) or the 18-month-old infants (M = 0.03); 9 months versus 14 months, $t(30) = -4.96$, $p < .001$; 18 months versus 14 months, $t(30) = -4.89$, $p < .001$. Note that these results hold when using either Newman–Keuls or Tukey post hoc tests. There was no difference in the index values of the 9- and 18-month-old infants, $t(30) = 0.336$, $p = .657$. Analysis of the index value of gazing indicates that compared to 9- and 18-month-olds, the 14-month-old infants tended to look significantly more toward the imitator than toward the contingent experimenter.

One-way t tests on gazing index values performed on each age group separately confirm that only the 14-month-old infants (M = 0.39) gazed significantly more at the imitator compared to chance (0), $t(15) = 8.096$, $p < .001$.

The same analysis was performed for the index values of smiling. Figure 2 presents the smiling index values as a function of the three age groups. The one-way ANOVA with age as a between-subjects factor yielded a significant effect of age, $F(2, 45) = 32.045$, $p < .001$. Confirming the age trend visible in Figure 2, paired comparison t tests indicated that the index values of smiling for the 14-month-old infants were significantly different from both the 9- and 18-month-olds, $t(30) = -7.16$, $p < .001$, and $t(30) = -8.20$, $p < .001$, respectively. There was no significant difference between the groups of 9- and 18-month-old infants, $t(30) = -0.599$, $p = .164$.

One-way t tests on smiling index values performed on each age group separately confirm that only the 14-month-old infants (M = 0.836) smiled significantly more at the imitator compared to chance (0), $t(15) = 16.316$, $p < .001$. In all, smiling data are analogous to the gazing data presented earlier, showing the same age trend toward discrimination between imitator and contingent experimenters by 14-month-olds, who tended to gaze and smile more at the imitator.

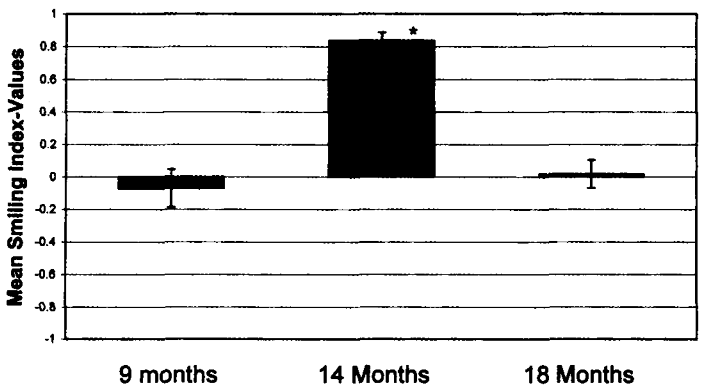

FIGURE 2 Mean index value for smiling in the imitative game periods for each age group. The 14-month-old index values are significantly different from the index values of the 9- and 18-month-old groups and from chance.

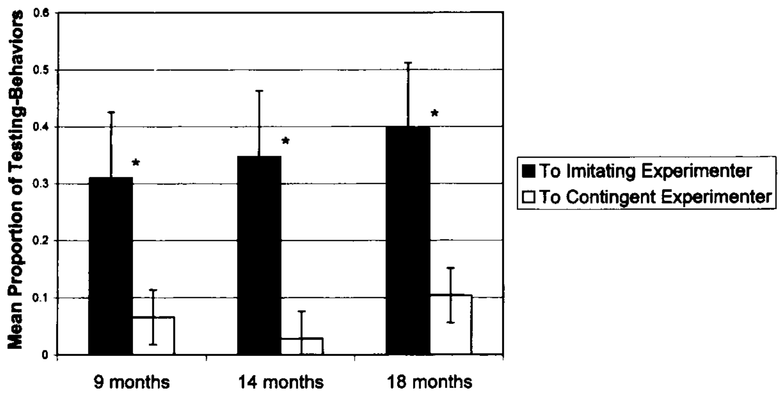

FIGURE 3 Mean proportion of testing behaviors (frequency) performed by each age group to either the contingent or the imitating experimenter during the imitative game periods. The remaining proportion of testing behaviors not accounted for in Figure 3 corresponds to testing behaviors that were coded as such but not directed toward either experimenter.

Figure 3 shows the mean proportion of testing behaviors oriented toward either the imitator or the contingent experimenter as a function of the three age groups. As shown in this figure, at all ages the frequency of testing behaviors oriented toward the imitator tends to be greater compared to the frequency of testing behaviors oriented toward the contingent experimenter. A 3 (age: 9-, 14-, and 18-month-olds) × 2 (testing behavior direction: imitator vs. contingent experimenter orientation) ANOVA on the frequency of testing behavior confirmed this impression, revealing a significant main effect of testing behavior direction, $F(1, 45) = 15.883$, $p < .001$, with no significant main effect of age, nor any significant Age × Direction interaction.

We further analyzed each age group's propensity to produce testing behaviors at some point during one or both imitative game periods (38% of the 9-month-olds, 38% of the 14-month-olds, and 50% of the 18-month-olds produced testing behaviors). A 3 (age) × 2 (presence or absence of testing behaviors) chi-square analysis yielded no significant age effect. The proportion of infants manifesting testing behaviors was comparable across ages. It is worth noting that as depicted in Figure 4, there seems to be some developmental trend toward a larger proportion of infants producing testing behaviors toward the imitating rather than the contingent experimenter. The small sample size did not warrant further statistical testing of this trend.

Still-Face Periods

In relation to looking and smiling, one-way ANOVAs with age (9 months, 14 months, and 18 months) as a between-subjects variable was used to assess the in-

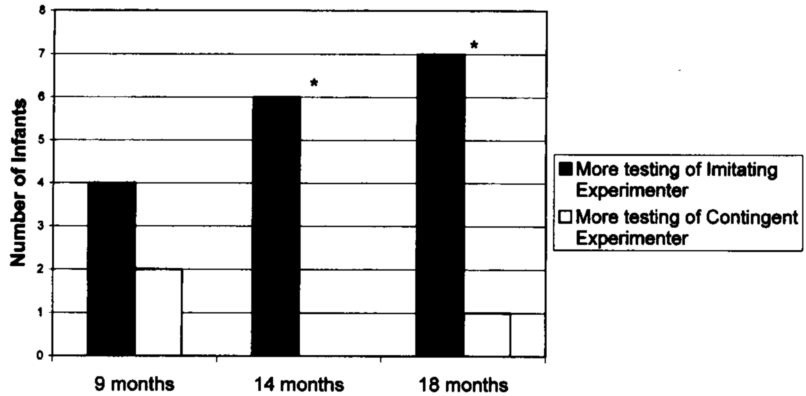

FIGURE 4 Number of infants that produced either more testing behaviors toward the imitating experimenter or the contingent experimenter during the imitative game periods. There were more 14- and 18-month-old infants that directed testing behaviors to the imitative experimenter than to the control experimenter.

fant behaviors during the still-face periods. The analyses revealed no main effect of age for any of these behaviors: $F_{\text{looking}}(2, 45) = 0.236$, and $F_{\text{smiling}}(2, 45) = 0.480$.

The mean looking index values for the 9-, 14-, and 18-month-old age groups were $M = 0.020$, $M = -0.052$, and $M = -0.063$, respectively. The mean smiling index values for the 9-, 14-, and 18-month-old age groups were $M = 0.082$, $M = 0.010$, and $M = 0.008$, respectively. One-way t tests were conducted to assess if any age groups showed an overall propensity to direct looks, smiles, or target actions to one of the experimenters in the still-face periods. These tests revealed no significant effects: looking: $t_{9\text{ months}}(30) = 0.300$, $t_{14\text{ months}}(30) = -0.806$, $t_{18\text{ months}}(30) = -0.996$; smiling: $t_{9\text{ months}}(30) = 0.781$, $t_{14\text{ months}}(30) = 0.123$, $t_{18\text{ months}}(30) = 0.114$. These results show that the infants' previous interactions with the experimenters did not result in any particular propensity to direct more smiles or looks to either one of the experimenters (imitator or contingent). It appears that for all infants, either of the two still-faced adult partners was a good candidate for reengagement initiatives, independent of previous experience.

We assessed the frequency of initiatives to reestablish contact with either the imitator or the contingent experimenter during the still-face periods.

Paired sample t tests comparing the relative production of social initiatives by the infants occurring in the first and second still-face periods yielded no significant differences. The proportions of nondirected, imitator-directed, contingent-experimenter-directed, or parent-directed social initiatives across the two still-face periods were comparable, and therefore were pooled in subsequent analyses.

A 3 (age: 9-, 14-, and 18-month-old) × 4 (initiative direction: no direction, imitator, contingent, or parent) mixed design ANOVA was performed to determine the infant's preference for social initiatives. There was no main effect of initiative direction, $F(3, 135) = 1.881$, and no main effect of age, $F(2, 45) = 0.003$, $p > .05$. Similarly there was no Age × Initiative Direction interaction, $F(2, 135) = 0.886$. Consequently, infants produced approximately equal amounts of nondirected social initiatives, social initiatives to the parent, and to both the imitator and contingent experimenters ($M_{\text{nondirected}} = 0.187$, $M_{\text{parent}} = 0.232$, $M_{\text{imitator}} = 0.139$, and $M_{\text{control}} = 0.195$). These results indicate that although infants at all ages manifest social initiatives during the still-face periods, no significant orientation toward a particular social partner was found.

Discussion

This first experiment confirms the observations succinctly reported by Meltzoff (1990) and Meltzoff and Moore (1999), suggesting that by 14 months infants manifest an understanding of being imitated, looking and smiling preferentially toward a mimicking rather than a contingent adult. Also, our observations confirm the contention made by Meltzoff and Moore that from 9 months of age infants engage in testing behavior, checking if the experimenter is shadowing them by suddenly freezing or accelerating the pace of target actions. The research reported here also provides new information on the emergence and meaning of such behaviors. By testing groups of 9-, 14-, and 18-month-old infants, our data point to developmental changes. Only 14-month-olds show a significant propensity to gaze and smile more toward the imitating compared to the contingent experimenter. The 18-month-olds' behavioral pattern was unexpected, resembling the pattern of 9-month-olds. However, the behavioral analogy between 9- and 18-month-olds might be only a surface resemblance covering highly different processes. Regardless, it does appear that an important development takes place between 9 and 18 months in the infants' construal of the imitative game. Nine-month-olds tend already to engage in testing behaviors, suggesting that they understand that there is a functional link between actions they perform on their toy and the actions performed by either one of the experimenters on their respective toys. However, they do not yet demonstrate a clear discrimination between the two adults facing them, as do the 14-month-olds. Again it is interesting that only the 14-month-olds manifest reliable preferential gazing and smiling toward the imitating experimenter, as testing behavior demonstrated equally at all tested ages.

If by 14 months infants appear to display clearer discrimination between mimicking and contingent actions produced by a social partner in relation their own, it is not yet clear whether such discrimination rests on the construal of the partners as being intentional or planful in their imitative game. Rather than taking an intentional stance, it is feasible that infants might simply orient preferentially to matching consequences of their own actions observed in another person, without necessarily having to take an intentional stance (i.e., construing this person as deliberate, planful, or intentional). In sum, the observations reported by Meltzoff and Moore (1999) and that our data to some extent confirm, could be based on infants' early understanding of their own effectivity on objects and people, as well as an early propensity to detect matching consequences to their own actions (Bahrick & Watson, 1985; Rochat & Striano, 1999a, 2001; Watson, 1984, 1994).

EXPERIMENT 2

The second experiment was designed to provide clearer evidence and better understanding of the development between 9 and 18 months of infants' putative construal of an imitating person as intentional. In particular, we attempted to untangle the basis of infants' discrimination of being imitated: whether it is based on a causal action and matching effect relation, or whether it is based on a construal of others as intentional in their communicative exchanges. Following our general working hypotheses, we expected that between 9 and 18 months, infants would develop from a discrimination based on contingency detection to a discrimination based on an intentional stance. Furthermore, to determine the degree to which behavioral changes in the context of imitative games are part of a general development toward the construing of others as intentional, we complemented our testing with assessments of general social cognitive abilities, in particular triadic competencies, including pointing, gaze following, and attention sharing together with mirror self-recognition testing. The rationale for such additional testing was to assess the degree to which the putative intentional stance development captured in imitative games would correlate with self-concept development and general social cognitive abilities that are considered as indexing the understanding of intention and intentional communication in others (Bruner, 1983; Carpenter, Nagell, & Tomasello, 1998; Tomasello, 1995).

In Experiment 2, infants faced only one experimenter with an identical toy in front of her. In one condition (experimenter condition), following a baseline period, the experimenter via direct manipulation of the toy imitated target actions that were spontaneously produced by the infants on their toy. In another condition (object condition), the experimenter facing the infant had her hands resting on the table without any contact with the toy. The toy moved and approximated what the infants did on their own toy in terms of speed and amount of squeezing action via a lever that was surreptitiously activated from under the table by the experimenter. At each age (9, 14, and 18 months), half of the infants participated in either the experimenter or the object condition.

Method

Participants

One hundred nine full-term, healthy infants were included in the final sample. There were 39 nine-month-olds (M = 275 days, range = 245–313 days; 21 boys and 18 girls), 34 fourteen-month-olds (M = 435 days, range = 399–482 days; 17 boys and 17 girls), and 36 eighteen-month-old infants (M = 553 days, range = 511–618 days; 19 boys and 17 girls). An additional 6 infants were tested but excluded due to fussiness. The infants were recruited from a participant pool consisting of more than 1,000 infants born at the Northside Maternity Hospital of Atlanta, Georgia. Races were representative of the northeastern greater Atlanta population, predominantly White and middle class.

Testing Situation

One experimenter sat across the table from the infant within the same basic setup described for Experiment 1. Two toys (foamy cube from Experiment 1) were attached to the table, one placed in front of the infant and the other placed in front of the experimenter. The recording equipment was the same as in Experiment 1. Again, the recording video camera provided a slightly overhead and three-quarter side view of the infant facing the experimenter. The same was true for the pretest social-cognitive testing. This view was chosen to allow unambiguous coding of infant's gazing and activities oriented toward either the experimenter or the object.

Objects. The toys were plush, squeezable cubes identical to the one used in Experiment 1. However, both cubes were attached to the table, the experimenter's rigged so that it could be compressed by moving a lever beneath the table. The experimenter could move the lever by applying lateral pressure with her right leg from under the table unbeknownst to the infant. The experimenter's leg movements were entirely out of view of the infant, who only witnessed the apparently autonomous squeezing motion of the cube.

Procedure

The experiment was divided into six periods: a pretest period, two baseline periods (one at the beginning and one at the end of imitative games), two imitative game periods, and one still-face period. Other than age, there was one between-subjects condition. Half of the infants in each age group were imitated by the experimenter (experimenter condition), and the other half were imitated by the object, with the experimenter surreptitiously activating the object via the invisible rigging mechanism (object condition). Note that 19 of the 39 nine-month-olds were tested in the object condition and 20 in the experimenter condition. The same number of infants were tested in either condition for the other age groups. Table 3 outlines the general design of the experiment including the order and succinct description of each condition and testing periods.

Pretest. Prior to baselines and imitative game periods, infants were tested in five tasks: (a) gaze following, (b) point following, (c) teasing, (d) blocking, and (e) mirror self-recognition. Details of the procedure for each task are presented later. Once again, this pretest was meant to establish an eventual relation between basic triadic competencies indexing intention understanding in communication (Bruner, 1983; Carpenter, Nagell, & Tomasello, 1998), as well as self-concept and the behaviors recorded in the context of imitation games.

Baseline periods. The imitation game experiment began and ended with baseline periods. As in the first experiment, during the two 30-sec baseline periods the experimenter compressed her plush cube repetitively every time the infant looked toward her face, not acting when the infant was not looking at her face.

Imitative game periods. There were two imitative game periods. One began immediately after the first baseline, and the second began after the still-face period that followed the first imitative game period. During this time, if the infants performed the target action (squashing their cube) the experimenter squashed her toy either directly with her hands (experimenter condition) or via the rigging mechanism (object condition). In either condition, the experimenter squashed her toy as closely as possible to the manner in which infants performed their actions on their toy (i.e., approximation in terms of speed and amount of squeezing action via either hands or the lever that was surreptitiously activated from under the table by the experimenter). Once again, infants in the object condition witnessed the experimenter's toy being squashed but the experimenter's hands were not in contact with it. Note that for the analysis, the second imitative game was only analyzed in relation to recovery behavior from still face and not to assess infants' response to being imitated per se. In particular, for the second imitative game period, we analyzed whether the first target action by the infant was oriented either toward the object or the experimenter. This latency was used as an index of infants' propensity to reengage with either the object or the experimenter following the still-face period and depending on condition (recovery effect). The two imitative game periods of this experiment were not pooled or compared because the conditions that preceded them were not the same. Prior to the first imitative period, infants participated in a baseline period. In contrast, prior to the second imitative period the infants experienced a 60-sec still-face period.

TABLE 3
Procedure Outline of Experiment 2

Time:	30 sec	60 sec	60 sec	60 sec	30 sec
Condition group:	First baseline	First imitative game	Still face	Second imitative game (recovery)	Second baseline
Experimenter-imitated infants:	Action modeling	Imitating experimenter	Still-face experimenter	Imitating experimenter	Action modeling
Object-imitated infants:	Action modeling	Imitating object	Motionless object	Imitating object	Action modeling

Still-face period. Immediately following the first imitative game period, there was a 60-sec still-face period, during which the experimenter ceased all actions and remained still while staring at the infant with a pleasant expression on her face.

Social Cognitive Tasks During Pretest

The tasks and methodology were the same as the one described and used by Carpenter, Nagell, and Tomasello (1998; see also Phillips, Baron-Cohen, & Rutter, 1998).

In all the pretest tasks, one experimenter interacted with the infant, a second experimenter monitored the time and the video equipment recording the session, and a third experimenter coded online the infant's behavior in each task. This online coding was subsequently compared for reliability to the coding by another observer based on the video recording. The video recording consisted of two camera views synchronized and mixed on a split screen, one providing a close-up view of the infant, the other a global view of the infant within the experimental setup.

Four target stuffed animals and toys were hung at different locations on the walls of a 10 × 15 ft (3.0 × 4.6 m) carpeted room. Each object hung about 3 ft (0.9 m) above the ground on each wall at its center. These objects were on adjacent walls. Two other objects were positioned directly across from these toys, one hung from beneath a bench and the other hung from a cabinet in the experimental area. These objects were randomly used as the target location for the gaze- and point-following tasks.

Gaze- and point-following tasks. The experimenter and infant sat facing each other engaged in play. At some point, when the infant was looking down, the experimenter called the infant by name, waited for eye contact, and then with an excited facial expression and vocalization turned her head and eyes, looking at a particular target object (gaze-following task; see Butterworth & Jarrett, 1991; Moore, 1999). The experimenter alternated her gaze between the infant's eyes and the target several times, maintaining the excited expression and completely turning her head each time.

The procedure for the point-following task was identical to that for the gaze-following task, except that the experimenter added a pointing gesture toward the target with extended arm and index finger while alternating her gaze between the infant's eyes and the target location. Infants were allowed 30 sec to respond to the experimenter's gazing and pointing gestures. For coding, infants were scored as having successfully passed the test if they oriented their gaze at least once toward the gazed or pointed target object location. A target was randomly chosen for each test, up to two gazes and two points in a counterbalanced order, one gaze and one point test if the infant followed each.

Blocking and teasing tasks. In the blocking task, while playing with the infants, the experimenter presented them with a small toy for reaching. Once infants began to reach for it, the experimenter suddenly covered the object with her hands for approximately 10 sec, preventing the infant from manually reaching and contacting the object. In the teasing task, the experimenter once again presented the infants with an object for reaching and when they began to reach for it, the experimenter abruptly withdrew the toy toward her and held it out of reach of the infant for approximately 10 sec.

For coding, in both the blocking and teasing tasks, infants' gaze orientation toward the experimenter's face following the experimental intervention was recorded. Infants passed the blocking or teasing task when they looked toward the experimenter's face at least once during the 10 sec that followed blocking or teasing.

Mirror self-recognition task. Prior to mirror exposure, the experimenter patted the infants on the head while playing with them in a few instances. The repeated head-patting served to familiarize the infants to head touch by the experimenter. On the last head-pat, the experimenter gently and surreptitiously placed a small yellow 5 cm × 4 cm self-adhesive note on the infant's forehead above the hairline. The yellow piece of paper stuck to the hair, unbeknownst and unfelt by the infants. Infants could not see the sticker directly. After 60 sec elapsed, during which the infant resumed playing oblivious of the sticker on his or her forehead, a 66.04 cm × 50.80 cm mirror was placed in front of the infant.

When infants did not spontaneously look at themselves in the mirror, the experimenter attracted infants' attention to the mirror by pointing toward it asking, "Who is in the mirror?" The experimenter continued to encourage infants to look in the mirror for up to 5 min, or until the infants touched the self-adhesive note while looking at themselves in the mirror. Infants were recorded as passing the self-recognition test if they touched or reached for the note on their forehead while looking at themselves in the mirror.

Coding and Analysis

For the pretest assessment, in each of the social-cognitive tasks infants were scored as having either passed or failed each test.

For the actual mutual imitation game and subsequent still-face tests, coding and analysis were basically the same as in Experiment 1. Again, multiple observers coded four dependent measures: gazing, smiling, testing behaviors, and social initiatives. Because infants faced only one experimenter, visual attention and social engagement were assessed as either oriented toward the experimenter or the toy resting in front of her. Aside from this change in relative orientation, the dependent measures were operationally defined in the same way as in Experiment 1. One additional measure considered here was the recovery effect as indexed by the first target action oriented either toward the object or the experimenter following the still-face period.

Preferential index calculation. As in Experiment 1, the relative proportion and orientation of all dependent measures as a function of testing periods was calculated by subtracting the amount of time the infant directed a particular behavior toward the experimenter from the amount of time the infant directed the same behavior toward the object toy, and dividing that difference by the sum of the total time the infant directed behaviors to both the experimenter and the object toy: (imitator – object) / (imitator + object) = index calculation.

Interobserver reliability measured on 20% of all tested infants in every testing period (including pretests) yielded kappas of .79 or above for all measures.

Results

We first present the data pertaining to the first and second baseline periods. We then present data pertaining to the first imitative game period, followed by data regarding infants' behavior during the still-face period. To investigate differential recovery of response we included a second imitative game following the still-face period. However, no significant recovery effects were found. Thus, this analysis is not considered further. Finally, we present the data on infants' social-cognitive assessment during pretest in relation to their behavior during the first imitative game period.

Preliminary Comparisons

To investigate the infants' relative stability of response across testing, their looking and smiling index values for the first and second baselines were compared. The mean looking index values in the first baseline ($M = -0.021$) and the second baseline ($M = 0.014$) periods were not significantly different from each other, $t(102) = 0.195$, $p = .846$. Similar results were obtained for the smiling data ($M_B = 0.007$ and $M_P = 0.071$), $t(102) = 1.159$, $p = .249$.

In addition, one-sample t tests indicated that for each of these measures the obtained index values did not indicate a significant divergence from a value of zero, indicating that infants did not have an increased propensity to direct behaviors either toward the object or the experimenter during these periods: baseline$_1$ looking, $t(108) = -0.467$, $p = .641$, smiling, $t(108) = 0.159$, $p = .874$; baseline$_2$ looking, $t(102) = 0.118$, $p = .906$, smiling, $t(102) = -1.403$, $p = .164$. These preliminary analyses show that, overall, infants' motor activity and behavioral arousal were stable across testing and that they did not express any significant preference toward either the experimenter or the object during the session, independently of the experimental conditions. The stable, equal smiling and looking at either the object or the experimenter during first and second baseline might be linked to joint attention engagement, infants looking back and forth between the object and the experimenter (Tomasello, 1995).

Finally, as in Experiment 1, the relative stability in motor arousal between first baseline and first test period was further assessed by comparing infants' overall propensity to look at either the experimenter or the object. No significant main effect of condition (baselines vs. test period) was found, $F(1, 103) = 1.59$, *ns*. However, the ANOVA revealed a significant increase in overall smiling during the first test period when compared to the first baseline period, $F(1, 103) = 6.525$, $p < .02$. As in Experiment 1, despite the fact that infants did not appear significantly more active in terms of looking during the test period compared to baseline, they demonstrated an overall increase in social engagement during the first imitative game period.

Imitative Game Periods

The infants' responses to being imitated by either the experimenter or the object toy were assessed with a series of 3 (age: 9 months, 14 months, and 18 months) × 2 (imitator condition: experimenter vs. object) ANOVAs on the index values calculated for looking, smiling, and testing behaviors.

Looking. Figure 5 presents the index values for the infants' looking behaviors as a function of age and condition (experimenter imitated or object imitated). The analysis yielded a significant main effect of condition, $F(1, 103) = 6.32$, $p < .013$,

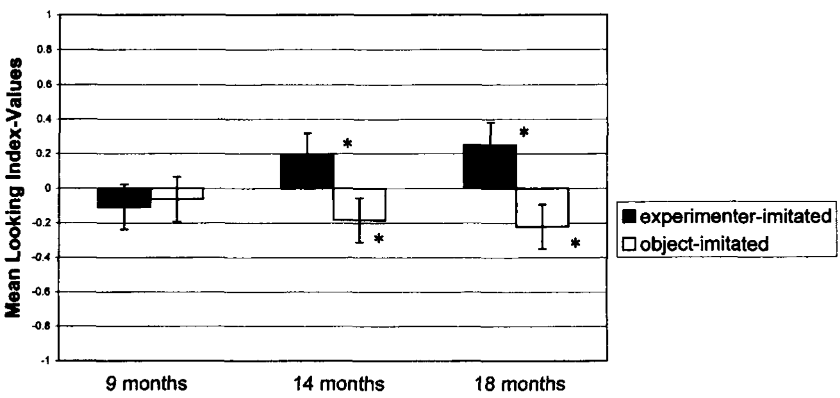

FIGURE 5 Mean index value for looking in the first imitative game period as a function of age and imitator condition. The index values of the experimenter- and object-imitated groups of 14-month-old infants were significantly different from each other and from chance. The index values of the experimenter- and object-imitated groups of 18-month-old infants were significantly different from each other and from chance.

and no significant main effect of age, $F(2, 103) = 0.363$, nor any significant Age × Imitator Condition interaction, $F(2, 103) = 2.303, p < .105$.

In a complementary analysis, independent-sample *t* tests were performed to assess the extent to which at each age looking toward either the object or the experimenter was greater than chance across conditions. Results show that for 9-month-olds, there were no significant differences between the looking index values in the experimenter- or object-imitated condition, $t(37) = 0.196, p > .05$. In contrast, both 14- and 18-month-old infants tended to look significantly longer toward the experimenter's face in the experimenter-imitated condition compared to the object-imitated condition, $t(32) = 2.120, p = .042$, and $t(34) = 2.85, p = .007$, respectively. Figure 5 displays this trend.

We investigated further the condition effect as a function of age by performing a series of one-way *t* tests assessing whether looking preference for each age group and according to condition was significantly different from what would be expected by chance (0).

The experience of being imitated by an object or another individual did not affect the propensity of the 9-month-old infants to look toward either the experimenter's face or the imitating object toy. The experimenter-imitated 9-month-old infants did not have an increased propensity to look toward the experimenter's face ($M = -0.107$) in the first imitative game period, $t(20) = -0.874$. Likewise, in the object-imitated condition, the 9-month-olds did not have an increased propensity to look toward the object toy rather than the experimenter's face compared to what would be expected by chance ($M = -0.062$), $t(17) = -0.399$.

In contrast, both 14- and 18-month-old infants looked significantly more toward the experimenter's face during the experimenter-imitated condition than what would be expected by chance, $t(15) = 2.73, p = .015$, and $t(16) = 3.23, p = .005$, respectively. Likewise, in the object-imitated condition, both 14- and 18-month-olds looked significantly more toward the object toy than what would be expected by chance, $t(15) = -2.12, p < .049$, and $t(16) = -2.45, p = .025$, respectively.

Smiling. Figure 6 presents the index values of the infants' smiling behaviors as a function of age, and condition (experimenter imitated or object imitated). A 3 (age: 9-, 14-, and 18-month-old) × 2 (condition: experimenter or object imitated) ANOVA yielded only a marginally significant Age × Condition interaction, $F(2, 103) = 2.55, p = .083$.

Testing behaviors. As in Experiment 1, at all ages infants produced testing behaviors. However, not all infants manifested such behavior. We compared, in each condition and according to age, the number of infants producing testing behaviors, regardless of orientation (toward object toy or experimenter). Note that the use of a dichotomous (nonparametric measure) is different from the one used in

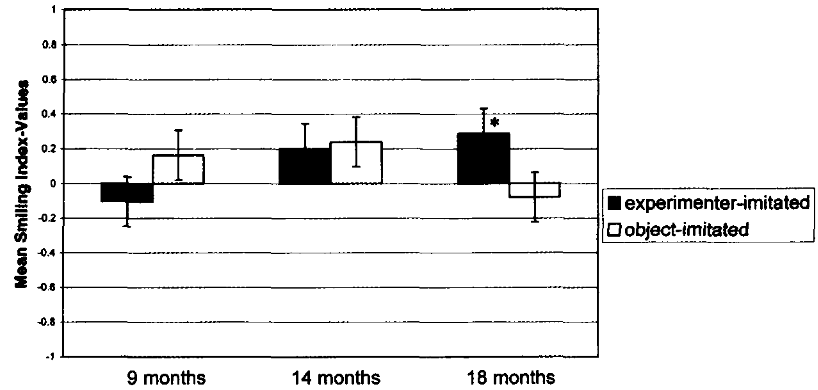

FIGURE 6 Mean index value calculations for smiling during the first imitative game period as a function of age and imitator condition. The Age x Imitator Condition interaction was marginally significant ($p < .083$). The index value of the experimenter-imitated 18-month-old infants approached significance ($p < .071$).

the previous experiment where orientation could be reliably measured, unlike this experiment.

Figure 7 presents the proportion of infants in each age group that produced and did not produce testing behaviors. Binomial tests revealed that, overall, significantly more infants manifested testing behaviors in the experimenter-imitated condition ($p < .01$). No such difference was found in the object-imitated condition. It appears that this trend existed for the three age groups considered together. To in-

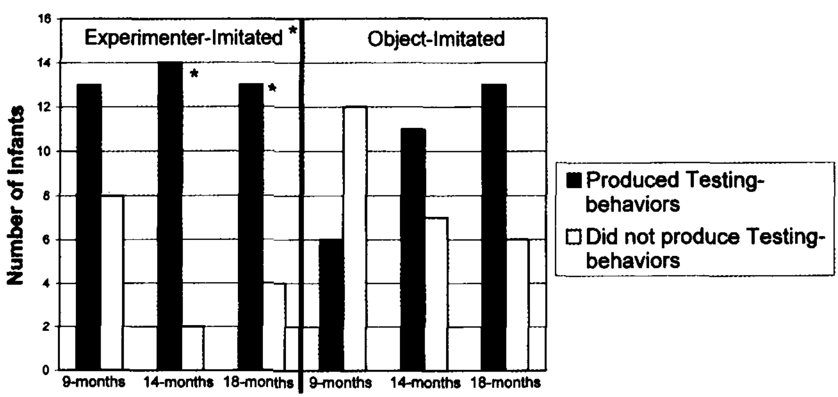

FIGURE 7 Number of infants that did and not produce testing behaviors during the first imitative game period as a function of age and imitator condition. Experimenter-imitated infants were more likely to produce testing behaviors. The 14- and 18-month-old experimenter-imitated infants were more likely to produce testing behaviors.

vestigate eventual signs of a developmental trend, we performed the same test for each age group treated separately. Results show that only the groups of 14- and 18-month-olds had a significantly greater number of infants producing testing behaviors in the experimenter-imitated condition ($p < .04$ and $p < .049$, respectively, using binomial tests). In contrast, such significant differences were not found in the object-imitated condition ($p < .48$ and $p < .16$, respectively). Nine-month-olds did not show significant trends in either condition. They appear to have responded differently in the object- versus experimenter-imitated condition, but this difference was not significant.

Still-Face Period

We compared each dependent measure during the still-face period as a function of age and condition. Once again, the goal of including the still-face period in this experiment was to investigate how the infants' previous imitative experience affected their attempts to reinitiate an interaction via looking, smiling, and social initiatives.

Looking. Figure 8 presents the looking index values of the infants as a function of age and condition. A 3 (age) x 2 (condition) ANOVA yielded no significant main effects of age or condition, nor any significant interaction. Thus, analyses based on the index value of relative preference yielded no significant results. The comparison of the index values to chance (value of zero) for experimenter-imitated or object-imitated infants at each age yielded some significant results, presented next. Note that this comparison is different from the previous ANOVA.

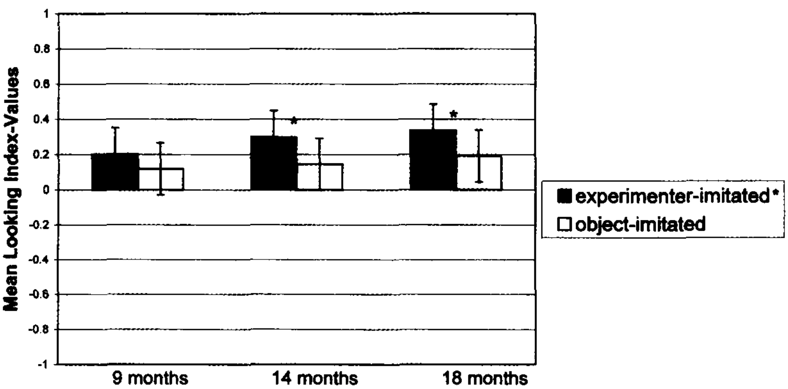

FIGURE 8 Mean index value for looking in the still-face period as a function of age and imitator condition. Index values of experimenter-imitated infants and 14- and 18-month-old infants were significantly different from chance.

Across all ages, only the looking index values of the experimenter-imitated infants were significantly greater than would be expected by chance, $t(53) = 3.314$, $p < .002$. The looking proportion of the object-imitated infants ($M = 0.153$) only approached significance, $t(54) = 1.778$, $p < .081$. The data show that on the whole, infants demonstrated a propensity to direct their looks to the experimenter when previously imitated by the experimenter, but not when previously imitated by the object. Treated separately, only the 14- and 18-month-old infants demonstrated the same condition effect, showing more looking toward the experimenter during the still-face period following the experimenter-imitated but not the object-imitated condition: at 14 months, $t(15) = 2.264$, $p < .039$, and $t(17) = 0.898$, *ns;* at 18 months, $t(16) = 2.325$, $p < .034$, and $t(18) = 1.333$, *ns.*

In summary, when compared to chance via *t* tests, both 14- and 18-month-old infants (but not 9-month-olds) tended to look significantly more toward the experimenter during the still-face period following the experimenter-imitated condition, and not the object-imitated condition.

Smiling. Figure 9 presents the smiling proportions of the participating infants as a function of age and imitator condition. The ANOVA performed on the smiling behaviors of the participating infants revealed no significant main effect of age, $F(2, 103) = 0.018$; no significant effect of imitator condition, $F(1, 103) = 0.325$; and no significant interaction, $F(2, 103) = 0.151$.

Comparing the index values to chance via a separate set of *t* tests (see earlier looking measure), experimenter-imitated infants, as a whole, had an increased propensity to smile while looking at the experimenter ($M = 0.214$) in the still-face period, $t(53) = 2.282$, $p < .027$, whereas the object-imitated infants ($M = 0.139$) did

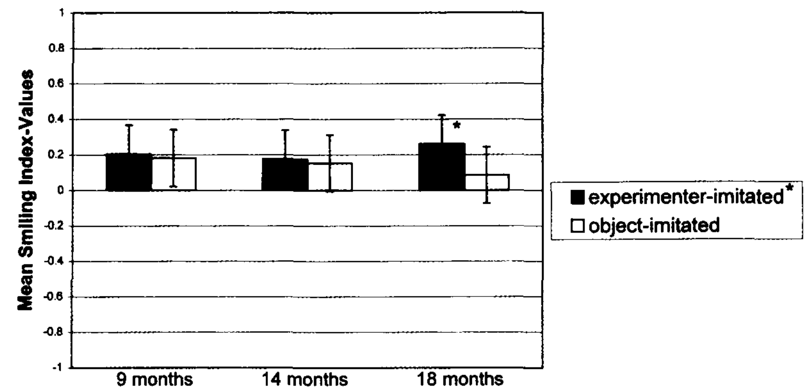

FIGURE 9 Mean index value calculations for smiling in the still-face period as a function of age and imitator condition. Index values of experimenter-imitated infants were significantly different from chance. Index values of 18-month-old infants were marginally significant from chance ($p < .083$).

not have an increased propensity to smile toward either the experimenter or the object, $t(54) = 1.603$. This pattern, however, did not manifest itself within any single age group alone.

Social initiatives. A 3 (age: 9-, 14-, and 18-month-old) × 2 (condition: experimenter and object) × 4 (initiative direction: no direction, imitator, object, and parent) mixed-design ANOVA was performed to determine the infants' preference for social initiative direction. This analysis revealed only a significant main effect of initiative direction, $F(3, 309) = 40.762$, $p < .001$. The analysis also revealed a significant Age × Initiative Direction interaction, $F(6, 309) = 3.795$, $p < .001$, and a significant Imitator Condition × Initiative Direction interaction, $F(3, 309) = 4.803$, $p < .007$. No other significant main effects or interactions were found.

The significant Age × Initiative Direction interaction was examined by conducting four one-way ANOVAs, one for each initiative direction (parent-directed, experimenter-directed, object-directed, and nondirected) with age as the between-subjects variable. These analyses revealed a significant difference in the amount of nondirected social initiatives produced by each age, $F(2, 106) = 6.822$, $p < .002$. Follow-up analyses indicated that the 9-month-old infants ($M = 0.571$) produced significantly more nondirected social initiatives than both the 14-month-old infants ($M = 0.398$) and the 18-month-old infants ($M = 0.295$), $t(71) = 3.247$, $p < .028$, and $t(73) = 3.534$, $p < .001$, respectively. However, the 14-month-old infants' production of nondirected social initiatives did not differ from that of the 18-month-old infants, $t(68) = 1.366$. No other differences between age groups were found.

In addition, four independent sample t tests were used to follow up on the significant Imitator Condition × Initiative Direction interaction. These analyses revealed that object-imitated infants directed more social initiatives toward the parent ($M_{\text{object}} = 0.201$) than did the experimenter-imitated infants ($M_{\text{experimenter}} = 0.101$), $t_{\text{parent}}(107) = -2.062$, $p < .042$. In addition, compared to the object-imitated infants, the experimenter-imitated infants produced significantly more social initiatives toward the experimenter ($M_{\text{experimenter}} = 0.303$ compared to $M_{\text{object}} = 0.168$), $t_{\text{experimenter}}(107) = 2.634$, $p < .010$.

Social-Cognitive Measures

Prior to the main experiment, each infant was tested in five social cognitive tasks. Ninety-five of the 109 infants that participated in Experiment 2 completed both the imitative games and all of the social-cognitive pretest tasks. Thirty-three 9-month-old infants, thirty-two 14-month-old infants, and thirty 18-month-old infants participated in these tasks of social cognition. The results pertaining to each age's relative success at these tasks are presented in Table 4.

TABLE 4
Percentage of Success for Each Age Group in the Five Social-Cognitive Tasks

	Age		
Task	*9 Months*	*14 Months*	*18 Months*
Gaze following	51%	97%	100%
Point following	85%	97%	100%
Teasing	33%	38%	33%
Blocking	24%	50%	53%
Mirror self-recognition	0%	21%	63%

Relation Between Social-Cognitive Measures and Testing-Behavior Production

To determine if the infants' social-cognitive abilities were in some way related to their propensity to engage in testing behavior in imitation games with an adult, presumably the behavioral expression of an intentional stance, we assessed the extent to which performance in the various social-cognitive tasks related to the presence or absence of testing behaviors in imitation games.

We first performed a binomial comparison comparing the number of infants that both passed a particular social-cognitive task and produced testing behaviors in the imitation games to the number of infants that did not pass the social-cognitive task but produced testing behaviors. As a complement, in a second binomial comparison, we compared the number of infants that both passed a particular social-cognitive task and produced testing behaviors to the number of infants that passed the social-cognitive task but did not produce testing behaviors (see Carpenter, Nagell, & Tomasello, 1998, for a similar approach).

Significant results were found only between infants' propensity to produce testing behaviors during imitation games and their ability to follow point as well as gaze in the pretest battery of social-cognitive tasks. Of the infants (n = 80) that successfully followed the experimenter's point, there were significantly more infants (66%) that produced testing behaviors than infants that did not (34%; $p < .003$). Moreover, of the infants that performed a testing behavior (n = 62) there were significantly more infants (95%) that also followed the experimenter's point than there were infants that did not follow the experimenter's point (5%; $p < .001$).

In relation to age, of the 9-month-old infants that produced testing behaviors during imitation game periods, there were significantly more infants that followed the experimenter's point (n =16) than there were infants that did not follow the experimenter's point (n = 2; $p < .001$). However, of the 9-month-olds that did follow the experimenter's point, there were approximately equal numbers of infants that produced testing behaviors ($n = 16$) and infants that did not produce testing behaviors ($n = 12$; $p = .571$).

For those14-month-old infants that followed the experimenter's point, significantly more produced a testing behavior than did not ($p < .031$), and of the infants that produced testing behaviors, there were more that followed the experimenter's point than did not follow her pointing direction ($p < .001$). The same pattern of results was found for 18-month-olds ($p < .045$ and $p < .001$, respectively).

Interestingly, analysis of testing behaviors in relation to gaze following yielded remarkably similar results. Overall, of the infants that successfully followed the experimenter's gaze ($n = 78$), there were significantly more infants (69%) that performed testing behaviors than there were infants that did not (31%; $p < .001$). Moreover, of the infants that performed a testing behavior ($n = 62$), there were significantly more infants (87%) that also followed the experimenter's gaze than infants that did not follow the experimenter's gaze (13%; $p < .001$).

Once again, in relation to age, of the14-month-old infants that followed the experimenter's gaze direction, there were significantly more infants that produced a testing behavior than did not ($p < .031$), and of the infants that produced testing behaviors, there were more that followed the experimenter's gaze direction than did not ($p < .001$). The same pattern was found for the 18-month-olds ($p < .045$ and $p < .001$, respectively). In contrast, 9-month-olds did not demonstrate any apparent link between their ability to follow gaze and their propensity at testing behavior during imitation games.

Discussion

The data of Experiment 2 suggest that, at least by 14 and 18 months, infants do respond differentially when interacting with an adult whose behavior demonstrates that he or she is imitating them. In contrast, by 9 months, infants show a comparable engagement whether the object or the experimenter imitated them. They produce testing behaviors, both when imitated by the experimenter acting manually on the toy, and when imitated by the toy. The two older age groups did respond differentially as a function of condition, modulating their visual responses and social monitoring depending on the active involvement of the experimenter in manipulating the toy.

Note that a possible interpretation of the differential visual attention and enhanced testing behaviors in the experimenter-imitated condition could result from an increase in activity observed by the infant in this condition. Specifically, in the object-imitated condition, only the object moved. In contrast, in the experimenter-imitated condition the object moved with the experimenter's manual actions (hands and object moved together). Therefore infants might have responded to the enhanced visual information by being more engaged and attentive in the experimenter-imitated condition than in the object-imitated condition. However, this latter interpretation is unlikely.

Infants did not merely demonstrate enhanced overall visual attention in the experimenter-imitated condition as would be predicted by such interpretation. Not only did infants distribute their looks differentially toward either the object or the experimenter depending on condition, they also showed a differential propensity toward social testing behaviors. In addition, any alternative "leaner" interpretation should account for the reliable developmental trend reported here between 9 and 18 months. It is unlikely that increased sensitivity to movement information can account for this trend considering that high sensitivity to movement information is established within the first 2 months of life and even at birth (see Jouen & Gapenne, 1995; Kellman, 1993). Within the paradigm used here and to provide further empirical facts controlling for a leaner interpretation, future research should compare infants' attention to two conditions in which the experimenter has his or her hands moving with the object either while in physical contact with the object or while placed at a distance from the object. However, this control comparison would still leave open the possibility that infants might perceive a causal link between hand and object movements in both conditions, and thus has perceptual ground for inferring an intentional action in both. A possible way to further analyze the extent to which infants discriminate the causal link as intentional would be in future research to compare conditions in which either the experimenter's hand acts on the object or an inanimate object would act as an agent on the object.

From 14 months of age, we found that infants did look significantly more toward the object or the experimenter depending on condition (object vs. experimenter imitated; see Figure 5). A significantly greater number of 14- and 18-month-old infants engaged in testing behaviors in the experimenter-imitated condition (Figure 7). Also, the 18-month-olds tended to smile more toward the experimenter during the imitative game in the experimenter-imitated compared to the object-imitated condition (Figure 6).

Evidence of a developmental transition in the construal of the experimenter by 14 months is also provided by the infants' behavior during the still-face period following the first imitative game in either condition. By 14 months, infants tended to gaze significantly more toward the experimenter during the still period in the experimenter-imitated compared to the object-imitated condition (Figure 8). Unlike the 9-month-olds, both 14- and 18-month-olds demonstrated enhanced checking and exploration of the experimenter's face.

Finally, the results indicate a significant relation between infants' propensity to produce testing behaviors during the imitative game and their propensity to follow the experimenter's gaze and points as measured in the pretest assessment of social-cognitive and self-recognition abilities. Although no other significant relation was found in the other three social-cognitive tests, these results do suggest some functional link between the understanding of intentional and directional communicative gestures (gaze and point following; Bates et al., 1979; Carpenter, Nagell, & Tomasello, 1998) and the propensity to produce testing behaviors in imitative games. Interestingly, and consistent with the idea of a developing intentional stance between 9 and 18 months, this link was clearer in 14- and 18-month-olds compared to 9-month-olds. Once again, it appears that only by 14 months do infants show clear signs of a relation between the production of testing behaviors in imitative games and intentional gesture comprehension (pointing and gaze orientation).

Overall, the results of Experiment 2 support the idea that if from 9 months infants show discrimination and testing of a person imitating them (see Experiment 1 confirming Meltzoff, 1990; Meltzoff & Moore, 1999), they do so on a different ground. The lack of differentiation of 9-month-olds' behavior in the experimenter- versus object-imitated condition suggests that their discrimination of an imitating adult is based primarily in the detection of contingency and a sense of self-agency, and not in the construal of others as intentional.

GENERAL DISCUSSION

Using the imitative game paradigm introduced by Meltzoff (1990), the research reported here demonstrates that beyond the considerable changes that occur at 9 months (e.g., secondary intersubjectivity via joint attention, the understanding of communicative gestures, and social referencing; Bates et al., 1979; Carpenter, Akhtar, & Tomasello, 1998; Carpenter, Nagell, & Tomasello, 1998; Tomasello, 1995; Trevarthen, 1979), there is also a marked development of an intentional stance between 9 and 18 months.

Confirming the observations succinctly reported by Meltzoff (1990) and Meltzoff and Moore (1999), we found evidence that by 9 months, infants are able to discriminate between an imitating compared to a merely contingent adult. Overall, infants at all the ages tested tended to produce testing behavior that was preferentially oriented toward the imitator (e.g., Figures 3 and 4) with some evidence of developmental variations in the manifestation of this discrimination based on looking and smiling index measures (e.g., Figures 1 and 2).

The developmental variations of the looking and smiling measures that contrast 14-month-olds to both 9- and 18-month-olds, as well as the lesser number of 9-month-old infants tending to engage in testing behavior of the imitating experimenter (Figure 4), suggest that different social-cognitive competencies underlie infants' discrimination of being imitated, and these differences are apparently age related.

We identified at least two possible processes by which infants could discriminate between an imitating and merely contingent adult. One process might be the recognition of causality between one's own actions and the consequences that result from these actions. Following this lean interpretation, infants would detect and prefer actions that co-occur and appear to result from their own actions. Evidence of such sensitivity involving both temporal and spatial information exists in infants much younger than 9 months (Rochat & Morgan, 1995; Rochat & Striano, 1999a). However, an alternative, richer interpretation is possible. Accordingly, infants would detect and prefer actions performed by the mimicking adult because they construe her as intentionally (i.e., deliberately or with planfulness) reproducing their own actions. In other words, according to this second interpretation, infants would identify the adult that is more closely mapping their own actions, hence relating more closely to them as impersonator of themselves. Infants would be more inclined to test the mimicking adult, attending to her as potential partner in playful social exchanges where roles can be interchanged and mutual impersonation can take place. This latter interpretation would imply an intentional stance taken by the infant toward the imitating adult. The former (leaner) interpretation would imply that infants discriminate between mimicking and contingent adult without any inference of intentions.

Experiment 1 does not provide any direct evidence in support of either interpretation. However, Experiment 2 gets closer. We found that indeed by 14 months, and not prior, infants do factor the intentions of an adult imitating them, at least "intentions in action" if not "intentions in the mind" following Meltzoff's (1995) important distinction. The data confirm that at 14 and 18 months, infants do engage differentially toward an active adult imitating their action on an object, compared to a situation where an object is mechanically imitating what they do on the same object, independently of any visible actions performed by the adult. We propose that the results of Experiment 2 demonstrate that between 9 and 14 months, infants appear to develop a new construal of others as deliberate social agents behaving according to plans and intentions (e.g., the plan and intention to impersonate). In other words, in the context of the imitative games studied here, by 14 months infants begin to take what appears to be an intentional stance that goes beyond a perceptual matching of information specifying temporal contingency and spatial congruence in social exchanges. However, note that this interpretation needs further testing of yet another leaner interpretation. As proposed by Watson (2001) and Gergely and Watson (1999), infants seem to develop by the end of the first year a preferential attention to perceptual events that are most resembling but imperfectly contingent to their own actions. It is thus still feasible that the reported discrimination is the expression of such preference rather than the adoption of an intentional stance per se.

In conclusion, infants by 9 months begin to manifest social behaviors that are referential (Bates et al., 1979), indexing secondary intersubjectivity (Trevarthen, 1979), as well as putatively some understanding of others as intentional (Tomasello, 1995). However, in the context of imitative games, the presented data suggest that infants, by 14 months, begin to change their construal of others as communicative agents that are intentional, not merely contingently responsive. We propose that this might be the index of the beginning of an intentional stance taken by the infant toward others. Future research should investigate further the important social-cognitive development that appears to take place beyond 9 months, in particular during the first half of the second year. We propose that this development is probably the most direct precursor and necessary antecedent of the well-documented blossoming of theories of mind by the third year of life.

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