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Variations in 10-month-old infant imitation of people and things

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Abstract

To explore 10-month-old infants' abilities to engage in intentional imitation, they were shown a human agent, a non-human agent (stuffed animal), and a surrogate object (mechanical pincers) model actions on objects. The tendency of infants to perform the target act was compared in several situations: (a) after test items were manipulated but the target action was not shown, (b) after the target act was demonstrated successfully, and (c) after the target act was demonstrated unsuccessfully. Although infants imitated the successful actions of human and non-human agents, they completed the unsuccessful actions of humans only. Toward the surrogate object infants did not respond differentially. These findings suggest that although infant may mimic the actions of human and non-human agents, they only engage in intentional imitation with people.

Keywords: Intentional imitation; Animacy

In recent years, with an increasing interest in the development of infant socio-cognitive abilities, attention has focused on imitation as a tool for the assessment of infant awareness of the mental states of others (Meltzoff, 1995). In order to reproduce a new behavior with both the proper form and function, infants must understand the model in terms of her intentions towards things (e.g., as an intentional agent). Without this understanding, infants would not know which aspect of the new behavior is relevant or irrelevant; this would hinder their ability to adopt or modify this new action for their own personal use (Tomasello, Kruger, & Ratner, 1993).

In a recent study, Meltzoff (1995) showed that 18-month-old infants would impute intentions into the actions of people when they failed to complete a task, but not when objects did. In intentional imitation involving objects, infants need to pay attention to the actions that are modeled and understand the reason why the actions are performed (e.g., she picks up an apple, because she wants to put it into the bowl). Accordingly, if the model tries, but for some physical reason is unsuccessful in completing the action, then infants who understand the meaning underlying the model's actions should re-enact the unseen goal, rather than the spatio-temporal movement of the seen event (Meltzoff, 1995). Using this principle, Meltzoff (1995) found that 60% of infants imitated a full demonstration of a target action, and also completed a target action after seeing a failed action demonstration of people, whereas only 10% imitated the behavior of a mechanical device (poles for arms and pincers for hands). Thus, "we see the bodily movements of people

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and interpret them in terms of acts, and we see the movements of things and interpret them as such, as movements" (Meltzoff, 1995, p. 846).

Meltzoff's (1995) landmark study provided a useful paradigm to assess an understanding of others' intentions in imitation research, and stimulated further investigations aimed at determining the onset and the meaning of this ability. For instance, Johnson, Booth, and O'Hearn (2001) presented infants with a stuffed Orangutan puppet that was handled by an experimenter out of the infants' view, to embody the behavior of an intentional agent (i.e., the presence of a face, eyes, self-generated movements, and contingent behavior). Because infants completed the unsuccessful actions of the Orangutan puppet, the authors proposed that 15-month-old infants have a conceptual representation of a mental agent, which can be evoked by the physical features of faces, hands, and displays of reciprocal behaviors.

However, it is not clear why 15-month-old infants would complete the failed actions, and thus attribute intentions to non-human agents. Legerstee and Barillas (2003), for example, demonstrated that 12-month-old infants attributed intentions to people only. In a pre-test, the infants were conditioned to follow the head turns (gazes) of human and non-human agents, but in a post-test, they produced declarative points in the presence of people and not non-human agents. These findings bring into doubt that infants in the Johnson et al. (2001) study were engaged in intentional imitation with the non-human agent.

Empirical evidence indicates that the ability to imitate progresses from imitating bodily movements primarily during the first 6 months of life, to imitating simple actions on objects between 6 and 9 months, to imitating novel and combined action sequences between 9 and 12 months (Bjorklund, 1987; Killen & Uzgiris, 1981; Meltzoff, 1988; Piaget, 1951; Want & Harris, 2002). It is also around 9 months of age that infants begin to increasingly engage in other triadic behaviors, involving self, other persons, and objects, such as joint attention and social referencing, which suggest that infants perceive human actions to be purposeful and guided by goals (Baldwin & Moses, 1994; Camaioni, Perucchini, Bellagamba, & Colonnesi, 2004; Legerstee & Barillas, 2003; Messer, 1997; Moses, Balwin, Rosicky, & Tidball, 2001).

Given that 12-month-old infants are able to engage in imitation involving actions on objects, and are aware of the intentions of people, it is not clear why Bellagamba and Tomasello (1999), when using the re-enactment paradigm, were only able to replicate Meltzoff's findings for 18-, but not for 12-month-olds. The failure of 12-month-old infants to complete the target act could not be a function of physical immaturity, because the infants did re-enact the spatio-temporally witnessed event. Rather, it suggests that infants may not have been familiar with the various tasks (e.g., pulling apart a dumbbell) and, consequently, were unable to 'complete' a part of the task (i.e., the unseen goal) for which they did not have a 'representation'.

To address these inconsistencies, we conducted two re-enactment studies with 10-month-old infants that focused on infant completion of unsuccessful actions modeled by human and non-human agents, and a surrogate object. During the tasks, the agent successfully modeled the actions, such as taking a toy out of a container, or putting one in. At other times the agent was unsuccessful in completing the task.

Authors of classical imitation studies (Bjorklund, 1987; Kaye, 1982; Kaye & Marcus, 1981; Killen & Uzgiris, 1981; Piaget, 1951) suggested that young infants' imitative attempts should not be scored according to the "all-or-none" principle that is used with older infants (i.e., Bellagamba & Tomasello, 1999; Johnson et al., 2001; Meltzoff, 1995). Instead, infant behavior should be characterized as *attempts* that approximate the target action (Kaye & Marcus, 1981). Therefore, in the present study we coded infants' responses on a 5-point scale in order to measure their approximations to the model's target actions.

Furthermore, we used tasks that infants are familiar with so that they could represent the unseen goal of the unsuccessful actions. Consequently, we used simple tasks, namely putting things into, or taking them out of bowls. Thus, the procedure was adjusted to the infants' physical and cognitive level in order to optimize participation.

Finally, to facilitate infant participation, imitation was elicited in the context of social interaction, where toys were exchanged in a playful turn taking paradigm (i.e., Kaye, 1982; Kaye & Marcus, 1981; Masur, 1987; Uzgiris, 1981).

The first hypothesis was that if infants were able to engage in intentional imitation, then they should reproduce the actions of the model in the successful action demonstration, and complete the actions of the model in the unsuccessful action demonstration. Both completion and reproduction responses should be higher-level approximations than during baseline. The second hypothesis was that if infants perceive intentions as specific to people, then they should complete the unsuccessful actions of human agents only and not those of non-human agents or surrogate objects.

Fig. 1. Human (E) and non-human (BD) agent in study 1.

1. Study 1

1.1. Method

1.1.1. Participants

Forty-two infants were recruited for the study. Twelve were excluded, five due to experimenter error, four due to equipment failure, and three due to infant fussiness. Consequently, 30 infants participated in this study. Infants were 10 months of age at the time of testing ($M = 10$ months, 18 days; S.D. = 23 days; 14 girls), and had been recruited from birth lists. Mothers and infants were North American, from low to middle class families. SES was based on parental education. Mothers and infants received a small gift for participating in the study.

1.1.2. Design and materials

The experimental sessions were conducted in a 4 m × 5 m room. To limit environmental distractions the infants were facing three white walls, of which one corner was closed off with a white curtain behind which a camera was placed and the experimenter produced the actions of the non-human agent. The room contained a table (76.3 cm × 91.6 cm) and two chairs. Two digital cameras were used to film the sessions. One camera was positioned behind the infant. The other camera was placed behind the shoulder of the experimenter with the lens protruding through an opening in the white curtain. The images were fed into a digital split-screen generator, providing two pictures of the experimental scene: one of the infant, and the other of the experimenter.

The human agent (E) wore a black sweater and beige woolen gloves, and exposed a clear view of her face (see Fig. 1). She was instructed to display a friendly but neutral facial expression, and not to speak so that she could not reinforce the responses of the infants one way or another, and thus remained comparable in responsiveness to the non-human agent.

In the Johnson et al. (2001) study, the non-human agent was a large orangutan puppet. In order to be able to compare our results with those of Johnson et al. (2001), we also chose a large stuffed animal as the non-human agent, namely a brown and beige dog (BD). When seated, BD was the same height as the human agent, and like E, displayed a neutral/friendly facial expression. Research has shown that mothers and infants frequently engage in social interactions with toy animals and attribute feelings and actions to these toys (Slade, 1987), consequently we expected infants to warm up quickly and to engage in interaction with BD.

BD was seated behind the table on which the imitation games were played, and in front of the white curtain. BD wore a large white sweater that covered the arms and paws and the body. The sleeves had been removed from the sweater and were worn by E instead, who, while standing behind the curtain, moved her covered arms through openings in the curtain, and with one arm at each side of BD's body manipulated the toys. E's hands were again covered in woolen beige gloves. This way E was able to surreptitiously manipulate the test objects, making it appear as if the arms belonged to BD, and as such, BD seemingly performed the actions independently (see Fig. 1).

In order to monitor the accuracy of her actions in the BD condition, E observed her movements on a video monitor on her left side. Thus, E performed the actions in both the human and non-human agent conditions.

Table 1
Design and characteristics of study 1 and 2

	Put in	Take out
	Tasks for E and BD conditions (study 1)	
Group 1	S	US
Group 2	US	S
	Tasks for OE and SO conditions (study 2)	
Group 1	S	US
Group 2	US	S

Note: S, successful action; US, unsuccessful action.

1.1.3. Procedure

During the sessions, infants were seated in their mothers' lap, in an upright position, facing either E or BD. Mothers were instructed not to interact with their infants, either verbally or tactually. Infants were supported gently around the waist by their mothers in such a way to allow for free movements of arms and upper bodies.

In order to minimize the complexity and length of the sessions, we administered the conditions to the infants according to the following mixed-model design. All infants were presented with both the human and non-human agent conditions randomly, so that 50% of the infants received the human agent condition first. Each human and non-human agent condition had two tasks: Put in and Take out. Each task consisted of a Baseline and a Model test event. In the Model test event of each task the action was modeled either successfully or unsuccessfully. Half of the infants were modeled the successful action, the other half of the infants were modeled the unsuccessful action. The modeling of successful or unsuccessful actions was counterbalanced among tasks and between infants (see Table 1).

The agents presented the test objects one at a time for each task. Different objects were used for each task, in a random order. When the task was finished, the objects were taken away, stored out of sight, and a new set was used for the next task. These object sets are shown in Fig. 2.

To allow E to change from the human to non-human agent, and vice versa, a research assistant entered the experimental room and asked the mother and infant to leave. This research assistant then interacted with mother and infant in another room of the Infancy laboratory, so that E could change costumes, out of sight of the infant. This 'intermission' lasted approximately 2 min.

Fig. 2. Object sets used in study 1 and 2.

The session was set up as a game of give and take. All tasks were administered while infants were in an alert and attentive state (state 4; Wolff, 1966) and began with a warm-up period and baseline.

1.1.4. Warm-up period

At the beginning of both the human and non-human agent conditions, infants played a game with E or BD, respectively. The agent would bang a drum, play a xylophone, and press a squeaky toy, before giving each instrument to the infants, to allow them to play with the objects for a period of 20 s. This game was repeated until infants began to smile and reciprocate with the agent in play. The warm-up toys were not used during the imitative games.

1.1.5. Tasks

There were two tasks: Put in and Take out. The modeling of the successful or unsuccessful actions in each task was preceded by a Baseline.

1.1.5.1. Baseline. During the Baseline, the agent placed the two objects side by side in front of her, then lifted them up and put them down, making sure the objects did not touch. This sequence was presented consecutively four times within 6 s. The agent then placed the objects side by side in front of the infants and within their reach. The infant was left to respond for a period of 20 s. Infants received three trials.

1.1.5.2. Successful action. In the Successful action, the agent placed the objects side by side in front of her, and then modeled the target act for the infants. In the Put in task the agent put an object into a container, and in the Take out task she took an object out of the container. The agent modeled the actions in an exaggerated way, in order to emphasize the Put in and Take out motion.

1.1.5.3. Unsuccessful action. In the Unsuccessful action, the agent again placed the objects side by side in front of her, and then modeled the actions in the same way as above, except that now the agent was trying, but failed to complete the target acts. That is, rather than putting the object in, or taking it out, as was done in the Successful action, the agent either dropped the object against the outer side rather than inside the container, or tried to lift the object out, but let it slip back. Thus, during the Unsuccessful actions, the two objects touched, but the target act was not achieved.

Successful and Unsuccessful actions were modeled four times within 6 s. Thereafter, the agent offered the test objects to the infants, by placing them in front of the infants side by side and within reach. Infants had 20 s to respond after modeling. This modeling and response period was one trial. To allow for individual difference in response time and to optimize responsiveness, infants were allowed three trials (Kaye, 1982; Killen & Uzgiris, 1981). For analyses, infant response on the best trial was used.

Different object sets were used for the baseline and the subsequent modeling tasks. The order of presentation of the different object sets was randomized among tasks and between infants.

1.1.6. Behavioral categories

In the studies by Meltzoff (1995) and Johnson et al. (2001), coding focused on whether infants produced the target actions or not, in an all-or-nothing manner. Ten-month-old infants are physically less able to perform the relatively fine hand–eye coordination required to reproduce the target actions than are 15- and 18-month-old infants (Kaye, 1982; Kaye & Marcus, 1981; Uzgiris, 1981). As suggested by Kaye and Marcus (1981), a microanalysis of imitative behaviors needs to be employed in order to capture the imitative approximations toward the target actions (see also Moerk, 1989). Consequently, the present study has developed a detailed analysis of the infant behaviors, with the goal to provide some insight into the behavioral strategies they use.

Infant responses were assigned a score ranging from 1 to 5, depending on the extent to which infant responses resembled the target acts (e.g., putting an object into or taking it out of a container), as follows: (code 1) infant plays with *one object at a time*; (code 2) infant plays with *both objects*, but objects do not touch; (code 3) infant plays *with both objects, objects touch*, but target act is not reproduced; (code 4) infant reproduces actions of the agent clumsily, for example, takes ball out of bowl while tipping bowl (not be confused with emulation learning where infant would turn bowl *before* taking ball out); (code 5) immediate, consistent, and complete imitation of target act.

Table 2
Means (and standard deviations) of infant responses in study 1 during successfully and unsuccessfully modeled actions in the E and BD conditions during Baseline and Model for Put in and Take out

Tasks	Successful actions		Unsuccessful actions	
	Baseline	Model	Baseline	Model
	E condition			
Put in	2.84 (.84)	4.08 (.83)	3.12 (1.02)	4.36 (.70)
Take out	2.78 (.66)	4.84 (.26)	2.61 (.95)	4.71 (.71)
	BD condition			
Put in	3.12 (.40)	4.29 (.55)	2.74 (.82)	3.40 (.74)
Take out	2.94 (.73)	4.71 (1.13)	2.77 (.63)	2.71 (.96)

1.1.7. Reliability

All coding was done from videotapes. To assess inter-observer reliability on infants' imitative responses, one coder coded all the sessions. A second coder, who was naïve to the experimental paradigm, independently coded a random sample of 20% of the data. The part of the screen that showed the agent was covered so that the coder only saw the responses of the infants. Cohen's $\kappa = .936$ was obtained, indicating an excellent level of agreement on this coding scheme.

1.2. Results

Infants' responses were submitted to a mixed-model ANCOVA, with task (Put in, Take out), condition (E, BD), and test event (Baseline, Model) as the within-subjects factors, and action group (1, 2) as the between-subjects factor. To control for learning effects, trial (1, 2, or 3) and order of presentation (E first, BD first) were included as covariates.

Results revealed no significant main effects of trial and order of presentation, nor were these covariates involved in interactions with any other variables. Therefore, trial and order of presentation were not included in further analyses.

Analyses indicated a four-way interaction between task, condition, test event, and action group ($F(1, 28) = 7.544$, $p = .010$, $\eta^2 = .212$). This result was followed up by post-hoc analyses of simple effects (see Table 2 for means and standard deviations).

When actions had been modeled successfully, no differences were found between the E and BD conditions in both Baseline and Model test events for both Put in and Take out tasks. When actions were modeled unsuccessfully, infants produced similar level responses in the E and BD conditions in the Baseline for both tasks, but produced higher level responses to E as compared to BD in the Model test event for both Put in ($F(1, 28) = 13.020$, $p = .001$, $\eta^2 = .317$) and Take out ($F(1, 28) = 47.531$, $p < .001$, $\eta^2 = .629$).

Moreover, in the E condition no differences were found in infant responses between Successful and Unsuccessful actions in the Model test event for both tasks. In contrast, in the BD condition infants produced significantly higher-level responses after viewing Successful actions as compared to Unsuccessful actions in the Model test event for Put in ($F(1, 28) = 11.693$, $p = .002$, $\eta^2 = .295$) and Take out ($F(1, 28) = 30.694$, $p < .001$, $\eta^2 = .523$).

1.3. Summary and discussion

In summary, as predicted, the results of the first study showed that infants who were shown the successful actions imitated these actions. In contrast, infants who were shown the unsuccessful actions reproduced the actions of the non-human agent, but completed the unseen goal of the human agent. This finding was shown across different tasks, bolstering the strength of the results.

It could be argued that the infants in study 1 interpreted the non-human agent as a person in an odd dress, because the non-human agent had hands. Given that infants interpret hands as belonging to human agents (Leslie, 1984; Woodward, 1998), it is possible that their differential responsiveness to the two agents when modeling unsuccessful actions was merely due to the fact that infants were distracted by the experimenter's costume. To preclude this interpretation of the results, we conducted study 2, where an experimenter wore an unconventional outfit, using the same procedure as in the previous study. However, this time, we contrasted the human agent with a surrogate object, similar to the

mechanical device used by Meltzoff (1995). That is, infants were presented with two pincer grips which modeled the same spatio-temporal actions as the human agent.

2. Study 2

2.1. Method

2.1.1. Participants

Thirty infants were recruited from birth lists for study 2. Ten were excluded, two due to experimenter error, six due to fussiness, and two infants did not complete the task. Thus, 20 10-month-old infants ($M = 10$ months, 23 days; S.D. = 22 days; 8 girls) participated in this study. Mothers and infants were North American, and came from low to middle class families. SES was based on parental education. Mothers and infants received a small gift for participating in the study.

2.1.2. Design, materials, and procedure

Materials and the general procedure were the same as in study 1. The human agent was an experimenter who wore a green hat with tentacles and had a light beige/black cloak wrapped around her, from which her hands protruded. Thus the experimenter wore an odd dress (see Fig. 3). The odd experimenter (OE) displayed a friendly, but neutral facial expression. OE did not speak to the infants so that she could not reinforce their responses.

The same experimenter who had demonstrated the actions of OE demonstrated the actions of the surrogate object (SO). She operated the test objects from behind the white curtain, by inserting each arm and hand into chrome-paper tubes, and manipulating two sets of chrome tongs that protruded from the tubes (see Fig. 3). As a result, the tongs appeared to move by themselves. SO observed her actions through two openings in the curtain. The experimenter was trained to perform the same actions in the same manner for the OE and SO conditions.

After the warm-up, infants were presented with two tasks: Put in and Take out. Each task had a Baseline and a Model test event. In the Model test event of each task, half of the infants received the Successful actions, while the other half received the Unsuccessful actions. This was counterbalanced across the two tasks and between infants (see Table 1). Infants were tested when they were in an alert and attentive state (state 4; Wolff, 1966).

2.1.3. Behavioral categories and reliability

The same coding scheme was used as in study 1. To assess inter-rater reliability, the same coder as in study 1 coded all sessions, while a second coder, who was naïve to the experimental paradigm, independently coded 20% of the data. The part of the screen that showed the agent was covered so that the coder only saw the responses of the infants. Cohen's $\kappa = .878$ was calculated, indicating a high degree of agreement on the coding scheme.

Fig. 3. Experimenter in odd dress (OE) and surrogate object agent (SO) in study 2.

2.2. Results

Infants' responses were submitted to a mixed-model ANCOVA, with task (Put in, Take out), condition (OE, SO), and test event (Baseline, Model) as the within-subjects factors, and action group (1, 2) as the between-subjects factor. To control for learning effects, trial (1, 2, or 3) and order of presentation (OE first, SO first) were included as covariates.

Results revealed no significant main effects of trial and order of presentation, nor were these covariates involved in interactions with any other variables. Therefore, trial and order of presentation were not included in further analyses.

Analyses showed a significant stimulus × test event interaction ($F(1, 18) = 56.665$, $p < .001$, $\eta^2 = .759$). No effect of task or action group was found. This interaction was followed up by post-hoc analyses of simple effects. Due to the fact that no effect of task was found, the mean of infant responses across tasks was calculated and used in post-hoc analyses.

It was found that infants produced significantly higher-level responses in the OE ($M = 4.28$, S.D. = .51) as compared to the SO ($M = 1.70$, S.D. = .76) in the Model test events ($F(1, 19) = 137.611$, $p < .001$, $\eta^2 = .879$). No significant difference between OE and SO was found in the Baseline. Additionally, infants produced higher level responses in the Model test event as compared to the Baseline ($M = 1.93$, S.D. = .91) in the OE condition ($F(1, 19) = 110.624$, $p < .001$, $\eta^2 = .853$). In contrast, there was no difference between infant responses in the Model test event and their responses in the Baseline in the SO condition.

2.3. Summary and discussion

In summary, the results of study 2 provided additional information on the features infants used to complete the agent's unseen goals. When faced with the person in an unusual dress, infants imitated the successful actions and when the actor failed to complete the actions, infants inferred the goal of the unsuccessful actions. In contrast, during the surrogate object condition, infants did not reproduce the actions of the surrogate object, nor did they infer the goal of the unsuccessful actions. In fact, during the surrogate object conditions infants did not differentiate between the Baseline, the Successful, and Unsuccessful actions.

Taken together, regardless of the physical features of the person (i.e., conventional dress in study 1, and unusual dress in study 2), infants treated the two human agents as belonging to the same class and different from the non-human agent and the surrogate objects, respectively. The finding that the infants completed the unsuccessful actions of human agents only suggests that they perceive human, and not non-human, agents with purposes and goals.

3. General discussion

The purpose of the present research was to determine whether 10-month-old infants are able to engage in intentional imitation. In the present two studies, 10-month-old infants responded appropriately, both when a human agent modeled a successful action, which the infants reproduced, and when the human agent modeled an unsuccessful action, which the infants completed successfully. These different responses (i.e., copying vs. completing) were robust across the tasks in both studies. These findings indicate that 10-month-old infants do not just focus on bodily motions, but interpret people's behavior as a function of their underlying motives. The results support those of previous studies on intentional imitation reported by Meltzoff (1995), and Bellagamba and Tomasello (1999) with 18-month-olds.

The present studies are the first to show intentional imitation in 10-month-old infants using Meltzoff's (1995) re-enactment paradigm. One of the reasons such young infants successfully completed the tasks was because we implemented important improvements and controls, which facilitated their performance. Thus, in order to assess infant intentional imitation appropriately and reliably, we relied on the work of pioneers who have examined infant imitation during the first year of life, such as Piaget (1951), Kaye and colleagues (Kaye, 1982; Kaye & Fogel, 1980; Kaye & Marcus, 1981), Uzgiris and colleagues (Killen & Uzgiris, 1981; Uzgiris, 1981), and Moerk (1989). Accordingly, we examined infants in a socio-interactive context, rather than under strict laboratory conditions. Although the experimenter did not speak to the infants, her actions on objects incited the infants to imitate. Uzgiris (1981) argues that when infants are presented with moderately novel acts (as in the present study), infants are impelled to imitate, because it increases pleasure in them and enhances contingent control. However, we used age-appropriate tasks not only to ensure that infants were motivated and physically able to reproduce the modeled actions, but also to make them understand the task in order to know what the goal of the actor could be. Such understanding is important, because if infants could

not represent what the goals are, then how would they be able to re-enact the goals of human actors (e.g., taking out a toy of the bowl).

Finally, rather than coding infant responsiveness on an all-or-nothing basis, infants' approximations were examined in a systematic fashion. As a result, we found that 10-month-old infants engaged in intentional imitation when interacting with a human agent. These methodological improvements may also explain why Bellagamba and Tomasello (1999) did not find intentional imitation in 12-month-olds. Not only were infant responses coded as success or failure, but it is our contention that many of the tasks used by the authors with 18-month-old infants cannot be equally sensitive for 12-month-olds. Thus, overall, it seems that their study was not suitable to assess intentional imitation in 12-month-old infants.

To shed light on the idea that infant awareness of intention is not isomorphic to a concept of people (cf. Johnson et al., 2001), we compared infant responses to a human and non-human agent. Infants in study 1 reproduced the successful actions of the non-human agent, but they did not complete the agent's unsuccessful actions. Because these results contrast with those of Johnson et al. (2001), but support those of Meltzoff (1995), and Legerstee and Barillas (2003), in study 2, we examined in more detail the features infants might use to engage in intentional imitation. In particular, it could be argued that infants in the Johnson et al. (2001) study completed the unsuccessful actions of the non-human agent because they perceived the orangutan puppet to be a person in an odd dress. Consequently, we compared infants' responses to a human agent in an odd dress to those of a surrogate object that appeared to act independently. Again, we found that infants completed the unsuccessful actions of the human agent (irrespective of her unusual attire), but not of the surrogate object. These findings refute the idea proposed by Johnson et al. (2001) and others that human infants' goal attribution is not specific to people. The findings that infants did not differentiate with their responses between the actions modeled by the pincers cannot be due to lack of interest, because infants were only tested if they actively monitored the actions produced during the action demonstrations. In a recent study examining infant responses to a surrogate object, Slaughter (personal communication, June 22, 2006) reported similar results when examining infant responses to actions modeled by a surrogate object. That is, infants in her studies did not imitate successful actions, nor did they complete failed actions of surrogate objects, nor did they perform better than during the baseline.

Although infants did not complete the unsuccessful actions of the non-human agent, they did reproduce the successful actions. The finding that infants mimicked the actions of the stuffed animal that had arms, hands, face, and independent movements can be explained within the context of early social interactions infants engage in with their mothers. Many studies have shown that maternal scaffolding plays an important role in the acquisition of various symbolic skills, such as pretence (Bornstein, Haynes, Watson O'Reilly, & Painter, 1996; Dunn & Wooding, 1977; Fiese, 1990), and that imitation is often used by mothers as a mechanism to promote pretence (Ungerer, Zelazo, Kearsley, & O'Leary, 1981). For instance, when playing with their infants, mothers make comments about the internal states of dolls or toy animals and may model an action such as eating with a replica spoon, and then while giving the spoon to her child, say "I think the doll is hungry, give her some"; or while talking on a toy-phone, hand the phone to her child and say "I think Big Dog wants to say something" (Barac, 2006; Haight, 1999; Haight & Miller, 1992; Slade, 1987). Studying 9- to 24-month-old infants, Nielsen and Dissanayake (2004) found that early imitative exchanges significantly predicted pretend play. Given that mothers encourage imitation and pretence activities involving themselves as well as inanimate agents, it is not surprising that infants in the present study readily engaged in imitative play with both agents.

In summary, it was hypothesized that toward the end of the first year infants are able to engage in intentional imitation in a re-enactment paradigm that simplified the experimental tasks and modified the coding scheme. This hypothesis was confirmed. Secondly, it was expected that infant attribution of mental states is restricted to people only. Consequently, we compared the responses of 10-month-old infants in a baseline, successful, and unsuccessful actions by human agents to those of a non-human agent or surrogate object. This is the first time in the literature that such a complete design has been used to study intentional imitation, particularly with such young infants. This paradigm allowed us to demonstrate that 10-month-old infants (1) are able to participate in re-enactment paradigms using successful and unsuccessful actions, when appropriate tasks are employed; (2) are aware of goal-directed behavior underlying actions modeled to them; and (3) only perceive people as goal-directed agents.

Cognitive developmental studies have shown that 10-month-old infants demonstrate their own intentional actions by separating means from ends (Piaget, 1951), and an awareness of other's intentions in triadic interactions when they point to direct another person's attention to an interesting event (Camaioni et al., 2004; Legerstee & Barillas, 2003). Infants are able to do this because they perceive other humans to be similar, that is, 'like me' (Fogel, 1993;

Meltzoff, 2002; Trevarthen, 1979), and consequently they reproduce with their behavior the goal-directed actions, thereby identifying themselves within the intentional space of other humans.

The results of the present studies indicate that by 10 months infants use interpersonal matching as a meaningful analysis, "parsing interactions in terms of relationships rather than particular behaviors *per se"* (Meltzoff & Moore, 1997, p. 189). The level of socio-cognitive awareness demonstrated in the present studies illustrates one of the many achievements infants make toward the end of the first year that involve objects, and reveals an important advance in the mentalizing abilities of infants.

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