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Twelve- and 18-month-olds copy actions in terms of goals

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Abstract

In the context of an imitation game, 12- and 18-month-old infants saw an adult do such things as make a toy mouse hop across a mat (with sound effects). In one condition (House), the adult ended by placing the mouse in a toy house, whereas in another condition (No House) there was no house present at the final location. Infants at both ages usually simply put the mouse in the house (ignoring the hopping motion and sound effects) in the House condition, presumably because they interpreted the adult's action in terms of this final goal and so ignored the behavioral means. In contrast, infants copied the adult's action (both the hopping motion and the sound effects) when no house was present, presumably because here infants saw the action itself as the adult's only goal. From very early, infants' social learning is flexible: infants focus on and copy either the end or the means of an adult action as required by the context.

Perhaps the most fundamental social-cognitive skill of human beings is the understanding of goal-directed action. Understanding a person's goal transforms their meaningless bodily motions into meaningful intentional actions.

The age at which human infants display an understanding of goal-directed action depends on one's choice of response measure. In habituation studies, 6-month-old infants discriminate between reaching actions consistently directed at the same object and those directed at different objects across reaches (Woodward, 1998) – what might best be called object-directed action. Nine-month-olds dishabituate to the actions of a dot on a computer screen when they are identical to those previously seen, depending on whether or not they both represent efficient action to a goal object (Csibra *et al.*, 1999). In studies using more interactive measures, 9-month-olds also react differently to an adult's very similar actions when she is seen as unwilling to give them an object as opposed to when she is trying but unable to give them an object (Behne, Carpenter, Call & Tomasello, in press).

A more demanding but also a more easily interpretable response measure for investigating children's understanding of goals is imitation or 'behavioral re-enactment,' because children reproduce what they think the other has done, and so their interpretation of the observed action is directly expressed. Of special importance are actions in which the actor's goal does not match the result of his action, because in these cases we can clearly distinguish the infant's understanding of internal goals as distinct from the external results produced in the environment. First, Meltzoff (1995) showed 18-month-olds an adult either successfully achieving a result on an object (e.g. pulling apart two halves of a dumbbell), or trying but failing to achieve that result (e.g. the adult's hands slipping off the ends of the dumbbell, with the two halves never separating). Instead of mimicking the adult's surface behavior (slipping) in the trying condition, infants produced the completed result as often as in a condition with a full demonstration, indicating that they saw the adult's action in both conditions as directed to the goal of separating the dumbbell into two parts. Fifteen-month-olds (Johnson, Booth & O'Hearn, 2001) but not 12-month-olds (Bellagamba & Tomasello, 1999) show the same pattern of results.

Second, Carpenter, Akhtar and Tomasello (1998) had an adult approach an apparatus and, for example, spin a wheel deliberately ('There!'), but then catch her hand on a lever and open it accidentally ('Whoops!'), whereupon some lights illuminated. Fourteen- to 18-month-old infants reproduced the action done on purpose, not the action done by accident. Infants thus distinguished the outcome the adult was trying to achieve (her goal) from the outcome she produced externally (accidental result).

The Meltzoff (1995) study is compelling because infants see two different actions as the same if they have the same goal (e.g. pulling apart a dumbbell and hands slipping off the dumbbell). The Carpenter, Akhtar and Tomasello (1998) study is compelling because two very similar actions are seen as different, depending on whether they appear to be done on purpose or by accident. In some

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studies with older children, the logic of this second type is taken to its limit in the sense that children are presented with an *identical* action on different occasions, the only difference being the context in which it occurs – and this different context suggests a different goal. For example, Bekkering, Wohlschläger and Gattis (2000; see also Gleissner, Meltzoff & Bekkering, 2000) showed 3- to 6-year-old children an adult reaching out and covering a dot on a table with her contralateral hand (i.e. across her body). The children did the same thing in the sense that they also covered the dot with their hand, but they tended not to use the contralateral hand. In contrast, if there was no dot on the table and the adult moved her hand in exactly the same way to the same – now blank – location on the table, children moved their contralateral hand in the same way (see also Gergely, Bekkering & Király, 2002, for a study with similar logic with 14-month-olds). One interpretation of this finding is that in the first case the exact movement of the hand is just a means to a goal (covering the dot), and since children are just trying to reproduce the goal the arm movement is irrelevant. In the second case, since there is no apparent external goal, children assume that the movement itself is the goal and seek to reproduce that. The exact same action that is in one instance interpreted as a goal is in another instance interpreted only as a means to a goal.

Similarly, Carpenter, Call and Tomasello (2002) demonstrated to 24-month-old children how to pull out a pin and open a box. What differed among groups was what children experienced just prior to this demonstration, with some children receiving information about the adult's goal ahead of time (e.g. by seeing her trying to open it in a different way or previously opening other boxes). Children were significantly better at opening the box themselves when they knew the adult's goal ahead of time, and this was the case even when the adult's actions on the test box were absolutely identical (i.e. when children gained information about the adult's goal only through her previous actions on other boxes). Children also copied the adult's irrelevant action style, the particular way in which she pulled out the pin, more often when they did not know the adult's goal ahead of time, that is, when that action appeared to be a goal (or at least some part of the overall goal) in and of itself. So again, children interpreted and recalled the exact same behaviors differently depending on what they thought the adult's goal was.

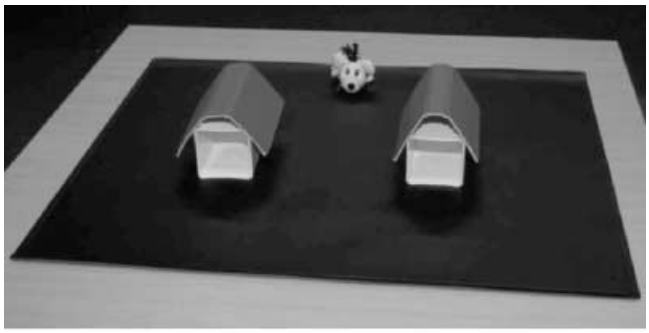
In the current study we followed the logic of these studies with 12- and 18-month-old infants. We modified the Bekkering, Wohlschläger and Gattis (2000) task to make it more interesting to infants (pilot results showed that they do not engage in the 'dot covering' game). Infants saw an adult pushing a toy mouse across a surface in one of two distinctive action styles (hopping and sliding playfully). In some cases the mouse was pushed into a toy house, whereas in other cases there was no toy house (analogous to the presence or absence of the dot in the Bekkering, Wohlschläger and Gattis study). Children were then given the toy and told it was their turn. Following the logic of the studies with older children, our prediction was that when the mouse was pushed into the house, infants would ignore the manner in which it was pushed, that is, they would not copy the hopping or sliding motion because they interpreted the action as 'putting the mouse in the house.' On the other hand, when no house was present they would interpret the hopping or sliding motion as the adult's (playful) goal by itself, and so in this condition they would copy the adult's manner and reproduce the particular action style. Compared with other studies of young infants' understanding of trying and accidents in which infants are supposed to ignore surface behavior to discern underlying goals (Meltzoff, 1995; Carpenter, Akhtar & Tomasello, 1998), in the current study the hypothesis was that infants would pay special attention to surface behavior – in the form of the particular means or style chosen – under certain conditions (when there is no apparent object-related goal) because then the style of the action is in some sense the actor's only goal.

Method

Participants

Participants were 34 12-month-old (M = 12;6; range = 11;6 to 13;0; 17 girls and 17 boys) and 66 18-month-old (M = 18;8; range = 17;3 to 19;8; 26 girls and 40 boys) infants from a middle-sized German city. An additional 53 12-month-olds and 26 18-month-olds were not included in the final sample because they did not respond in relevant ways in some trials (e.g. they refused to touch the mouse or they immediately and repeatedly threw the mouse off the table or gave it back to the experimenter). The relatively large number of subjects and their unequal distribution across age derives from the fact that this task was given to children within a series of imitation tasks administered to a large group of infants. The high drop-out rate was mostly due to the fact that in the No House condition (see below), many children apparently saw no behavior worthy of imitation and so did as they pleased with the toy mouse. Because we used within-subjects comparisons, only infants who responded on at least one trial in each condition were included in analyses.

(a)



(b)

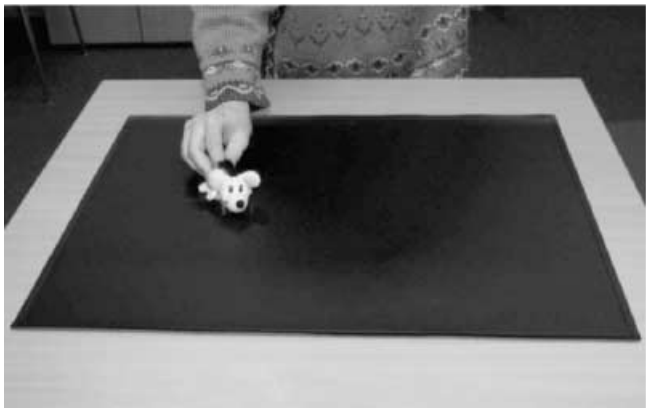


Figure 1 *(a) The mouse at the start location in the House condition. (b) The mouse at the end location in the No House condition.*

Materials

A stuffed toy mouse and two identical black 51.5 cm × 64.5 cm mats were used. Attached to the top of one of the mats were two houses made of a rectangular 6 cm × 6 cm × 12 cm tube and a cardboard roof (see Figure 1). The houses were 18 cm apart from each other and centered on the mat. The other mat was plain, with nothing attached.

Procedure

Infants sat on their parents' laps across the table from a female experimenter (E). First, E gave the mouse to infants briefly so they could become familiar with it. E then placed the assigned mat (see below) on the table, let infants explore it briefly, and then began the tests.

There were eight trials, four in each of two conditions: House and No House, corresponding to the two mats. The four trials of each condition were blocked and the order of the blocks was counterbalanced. In both conditions, E performed exactly the same actions, to the same location on the mat; the only difference between conditions was whether there was a house on the mat in the final location. For each trial, E obtained the infant's attention and then moved the mouse to the final location using one of two action styles: hopping or sliding. For the hopping action style, E made the mouse jump in a straight line to the location, breaking contact with the mat approximately eight times. Each hop was accompanied by a [bi] sound (so infants heard 'beebeebeebee . . .'). For the sliding action style, E moved the mouse in a straight line to the location, never breaking contact with the mat. This action was accompanied by one long 'beeeeeeeee' sound.

Half the trials in each condition were to the left location and half were to the right. In half of each of these trials, E made the mouse hop and in half she made it slide. For each infant, the order of left/right and hop/slide trials was the same for each of the two conditions' blocks. E held the mouse in her right hand for actions to her right side and in her left hand for actions to her left side. She started the action from the middle of her side of the mat.

In each of the eight trials, after a single demonstration of E moving the mouse to one of the locations and leaving it there for a few seconds, E picked up the mouse and placed it in front of infants in the middle of their side of the mat. E told infants, 'Now you.' E waited until infants made a relevant response or else made it clear that they did not wish to respond (e.g. by throwing the mouse or giving it back to E), and then E took the mouse and went on to the next demonstration.

Coding

It was not possible to code infants' responses blind to experimental condition (House/No House) because houses were present or not throughout the response period. However, coders did not watch demonstrations and so were blind to the action style and sound effects E used, and the left/right location in which she put the mouse.

The main measure of interest was whether infants copied E's action style differently in the House versus No House conditions. All hopping and sliding movements were coded, even those not directed at the correct locations. Hopping was coded if infants made the mouse break contact with the mat more than once and sliding was coded if infants pushed the mouse on the mat without breaking contact. However, because coders noted that infants sometimes banged or slid the mouse around randomly, we added the additional criterion that the hopping or sliding needed to be task-related, but the pattern of results was the same at the overall level when all responses were included. Actions were coded as task-

related if the hopping or sliding action was accompanied by a task-related sound, or if the infant looked at the action or at E while performing it. Infants also had to hold the mouse by its body (not tail or hair) for hopping, and put pressure on the mouse while sliding. For each trial, infants' behavior was coded as making the mouse hop or slide (i.e. matching or mismatching E's demonstration), moving the mouse directly to the location (i.e. picking it up and putting it there without touching the mat in-between), some other action style (e.g. throwing the mouse to the location), or no relevant response (e.g. throwing the mouse off the table).

We also coded whether infants copied E's sound effects. Here, a match with the adult sound effect was scored when infants made any repeated syllables (e.g. 'dedede') in the hopping condition or any long, single syllable (e.g. 'teeee') in the sliding condition. Finally, we coded whether infants went to the same location (left or right) as E did. A match was scored in the House condition if infants put the mouse in, on top of, or directly in front of the same house as E, and in the No House condition if infants put the mouse in the same left or right area of the middle of the mat as E.

Because infants did not always respond on every trial, we analyzed the percentage of matches (the number of trials in which infants matched divided by the total number of trials in which they produced a task-related response) for each of the measures. To determine whether infants were more likely to produce a match than a mismatch, we also analyzed the percentage of matches after subtracting the percentage of mismatches (e.g. the hopping style or sound effect in the sliding condition, or the left location when E went to the right one). This corrected score produced the same overall results as the percentage of matches. Only infants' first responses on every trial were used in analyses.

An independent coder re-coded 20% of infants at each age to assess inter-observer reliability. Excellent levels of reliability were achieved: Cohen's kappas were .91 for action style (with .88 for task-relatedness), .82 for sound effect, and .92 for location.

Results

Prior to analyses we investigated the effect of order of presentation of the House/No House condition on each of the dependent variables for matching action style, sound, and location. There were no significant differences between orders for any of the dependent variables (*t*-test: $p > .10$ in all cases). Therefore, we collapsed the order of presentation in all subsequent analyses. All *p* values below are one-tailed.

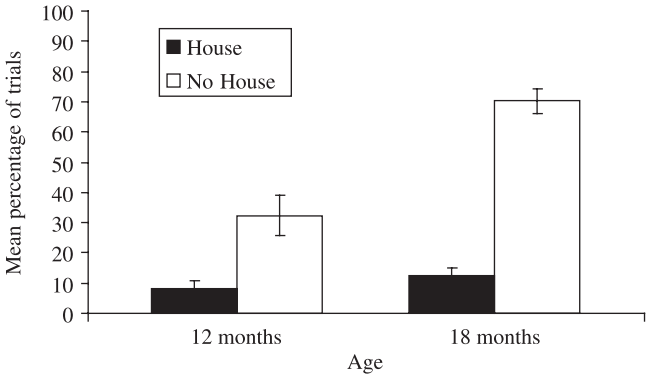


Figure 2 *The overall percentage of matches in action style across conditions as a function of age.*

Matching action style

Figure 2 presents the overall percentage of trials in which infants matched the adult's action style in the two experimental conditions. Infants matched E's action style significantly more often in the No House than in the House condition, $F(1, 98) = 117.32$, $p < .001$, and older infants produced significantly more matches than younger infants, $F(1, 98) = 20.07$, $p < .001$. There was also an interaction between age and condition, $F(1, 98) = 20.19$, $p < .001$: although the effect of condition was significant for both ages, the magnitude of the effect was larger in 18-month-olds, $t(65) = 13.2$, $p < .001$, than in 12-month-olds, $t(33) = 3.85$, $p < .001$. The analyses of the corrected percentage of matches mirrored these results and also showed that both 12-month-olds ($t(34) = 1.82$, $p < .05$) and 18-month-olds ($t(68) = 7.59$, $p < .001$) produced more matches than mismatches.

The same pattern of results held for each action style (hopping and sliding) separately. Figures 3 (a) and (b) present the percentage of matches of the hopping and the sliding styles, respectively, across conditions. Infants matched each style significantly more often in the No House than the House condition ($F(1, 80) = 70.58$, $p < .001$ for hopping and $F(1, 70) = 34.84$, $p < .001$ for sliding). Older infants produced significantly more matches than younger infants ($F(1, 80) = 12.42$, $p < .001$ for hopping and $F(1, 70) = 9.37$, $p = .002$ for sliding). There were significant age × condition effects for both styles ($F(1, 80) = 11.47$, $p < .001$ for hopping and $F(1, 70) = 9.64$, $p = .002$ for sliding). For each style separately, condition was a significant factor at both ages, although the magnitude of the effect was larger in 18-month-olds ($t(53) = 10.11$, $p < .001$ for hopping and $t(48) = 7.61$, $p < .001$ for sliding), than in 12-month-olds ($t(27) = 3.07$, $p = .003$ for hopping and $t(22) = 1.91$, $p < .05$ for sliding).

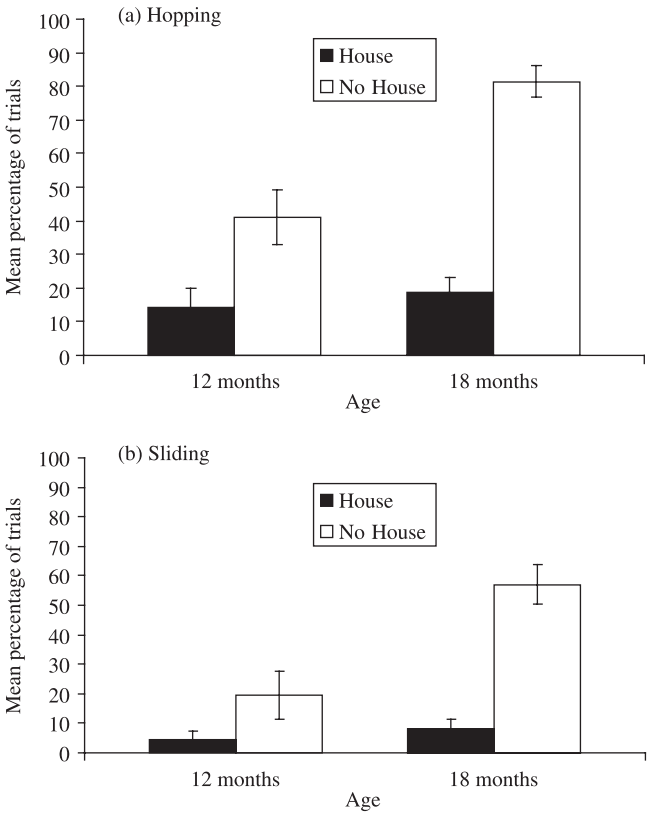


Figure 3 *The percentage of action style matches for (a) the hopping style and (b) the sliding style.*

Matching sound

Figure 4 presents the overall percentage of trials in which infants matched the adult's sound effect in the two experimental conditions. Infants matched E's sound effect significantly more often in the No House than in the House condition, $F(1, 98) = 6.82$, $p < .01$. This was the case for the hopping sound separately as well, $F(1, 80) = 7.70$, $p < .01$. Overall, older infants produced significantly more matches than younger infants, $F(1, 98) = 15.96$, $p < .001$, and this was the case for the hopping sound separately again, $F(1, 80) = 11.14$, $p < .001$. There was no significant age × condition effect, either overall or for the hopping sound separately. For the sliding sound separately, older infants produced significantly more matches than younger infants, $F(1, 71) = 10.57$, $p = .001$, but those matches occurred independently of condition (and there was no significant age × condition interaction). The analyses of the corrected percentage of matches mirrored these overall results. Moreover, 18-month-olds produced more matches than mismatches overall, $t(68) = 5.11$, $p < .001$, and 12-month-olds tended to do this, $t(34) = 1.34$, $p = .095$.

Matching location

Figure 5 presents the overall percentage of trials in which infants matched the adult's location in the two experimental conditions. In this case – differently from the above analyses – infants matched E's location significantly more often in the House than in the No House condition, $F(1, 98) = 180.83$, $p < .001$. When houses were present, infants very often placed the mouse in one of them, whereas when no houses were present, infants paid much less attention to the location that was the terminus of the mouse's travels on the mat. There was no significant effect of age and no age × condition interaction. The analyses of the corrected percentage of matches mirrored these results. Moreover, both age groups produced more matches than mismatches (18-month-olds: $t(68) = 2.32$, $p < .02$; 12-month-olds: $t(34) = 4.52$, $p < .001$).

Combinations of responses

Because we were also interested in infants' social learning skills above and beyond their understanding of the

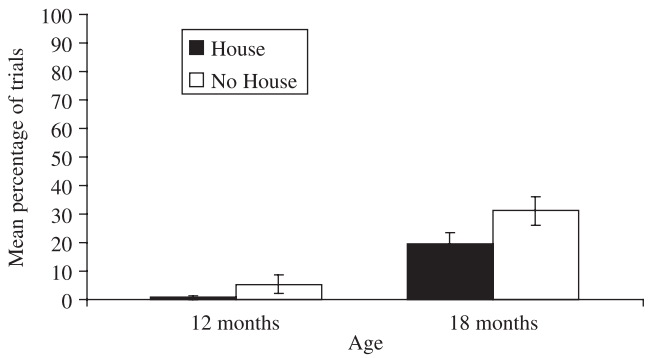


Figure 4 *The overall percentage of matches of the demonstrated sound effect across conditions as a function of age.*

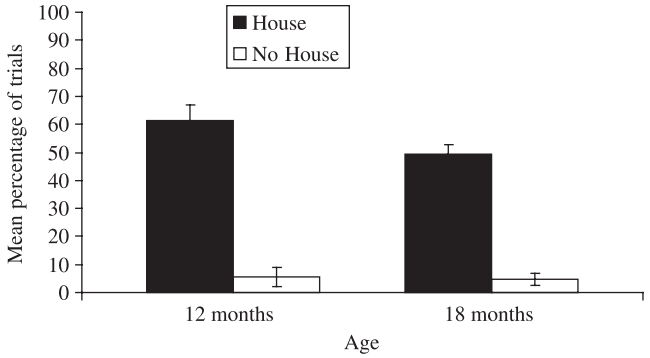


Figure 5 *The overall percentage of matches of location across conditions as a function of age.*

Table 1 *Percentage of infants who produced each type of combination as a function of age*

	12-month-olds	18-month-olds
Action + location	8.6%	4.3%
Action + sound effect	5.7%	37.7%
Sound effect + location	2.9%	21.7%
Action + sound effect + location	0	8.7%

adult's goal, we also looked at how many components of the adult's action infants were able to copy at once. Table 1 presents the percentage of infants that produced each type of combination of responses at least once. Eighteen-month-old infants produced action + sound effect (Fisher test: $p < .01$) and sound effect + location (Fisher test: $p < .001$) combinations significantly more often than younger infants. There were no significant differences between age groups in the other two types of combinations.

Discussion

Our results replicated those of Bekkering, Wohlschläger and Gattis (2000) with one-year-old infants. Both 12- and 18-month-olds interpreted an adult's action in terms of her goal and reproduced that action in terms of this interpretation. That is, even though they saw the exact same action – for example, hopping a toy mouse across a mat with accompanying sound effects – infants reproduced different aspects of the action depending on whether there was an external goal present. This study is the first to demonstrate experimentally that infants as young as 12 months of age can use the goals of others to choose which aspects of their actions to copy. It is important to note that this is a different type of study from other studies of infants' understanding of others' goals and intentions, in that the adult in this case fully achieved her intention in both conditions – there were no accidents or failed attempts. This may explain why 12-month-olds do better on this test than they do on Meltzoff's (1995) test involving behavioral re-enactment of unfulfilled goals (Bellagamba & Tomasello, 1999).

There are several possible explanations for this finding. The one we favor is similar to that of Bekkering and colleagues: that infants identify and reproduce others' goals hierarchically. Thus, in our study, when the house was present, infants interpreted the adult's action (and goal) as 'putting the mouse in the house' and so most often matched the location where the adult left the mouse, ignoring the action style and sound effects. In contrast, when there was no house, infants interpreted the action as an end in itself – 'making the mouse hop up and down and making noise playfully' – and so they matched those aspects and not the location. They thus copied the adult's action differentially depending on what they perceived her goal to be. This interpretation of the results is consistent with findings from other studies using non-imitation paradigms, which show that 12-month-old and younger infants can identify others' goals (e.g. Behne *et al.*, in press).

However, there are at least two possible alternative explanations that do not involve infants understanding goals. First, it could be that infants were using different strategies in the different conditions. They could have been emulating in the House condition and mimicking in the No House condition – neither of which involves any understanding of goals. (Or they could have seen the action in the No House condition as an atelic activity, like walking around or humming, which does not really have a goal.) If it is true that infants were using different strategies in the different conditions, then that shows how flexible infants are in being able to do both in the same task within moments of each other. But mimicking in particular does not seem to be a likely explanation because infants did not copy everything they saw (e.g. direction of movement) in the No House condition. And, in any case, we would prefer an explanation – such as identifying and reproducing goals – that can explain the different pattern of results in both conditions at once.

A second possible alternative explanation is that perhaps infants in the House condition were not even engaging in social learning at all. That is, it could be that infants were indeed imitating in the No House condition – maybe just by mimicking adult motions – but the presence of the house in the House condition was a strong stimulus to just put the mouse in there during the response period, and that this would have happened even with no demonstration. However, this alternative interpretation is undermined by the specificity of infants' location responses: even 12-month-olds placed the mouse in the same house as the adult, suggesting that infants were indeed copying the adult. One could argue that this could be a result of lower-level stimulus enhancement, but still, we do not believe that this interpretation is correct, or at least we would interpret it differently. Modern theories of adult action perception and imitation (e.g. see Meltzoff & Prinz, 2002) emphasize that the results of an action in the environment are especially salient, and so imitators focus first there and only under certain conditions do they analyze 'backward' to means and subgoals aimed at that external result (an enrichment of Tomasello's (1996) idea of emulation learning). So, in the current study, our interpretation

is that infants in both conditions were influenced by observing the adult's actions, but that when there was a salient environmental result (mouse in house) they attempted to reproduce that, and when there was not – or there was some other reason to focus on behavioral means – they focused in a more detailed way on the actual physical actions being produced (see Nagell, Olguin & Tomasello, 1993; and Hobson & Lee, 1999). In both cases this was done in the context of a means–ends analysis of the observed behavior, something that infants can do, at least to some degree, in non-imitative contexts from before the first birthday (Sommerville & Woodward, in press; Woodward & Sommerville, 2000). Other studies that address the same issues using different methods are needed to clarify what one-year-old infants understand about others' goals.

If our interpretation is accepted, the current results speak against the hypothesis of Want and Harris (2002) that there is a developmental progression from copying actions (imitation) to copying goals and results (emulation). Instead, they add to a growing body of literature documenting that infants and young children copy others' behavior in a very flexible way. They copy end-states or final goals when those are especially salient or relevant, but they can also copy others' action styles or means to a goal when those are especially relevant or necessary for the actor's goal attainment, and, importantly, they can do this even within the same task. Not only do infants respond in the same way to different surface behaviors by the adult (Meltzoff, 1995) but they also respond in different ways to the same surface behavior (current study; see also Gergely, Bekkering & Király, 2002) both depending on their understanding of the adult's goal. They can infer this goal using a variety of cues: social cues such as the adult's behavior or attitude (e.g. repeated actions, expressions of surprise; Meltzoff, 1995; Carpenter, Akhtar & Tomasello, 1998), and contextual cues such as presence or absence of an external goal (current study) or constraints on the adult (Gergely, Bekkering & Király, 2002). Along these same lines, it is also interesting and important that, in the current study, a fair number of 18-month-olds, and even some 12-month-olds, reproduced multiple components of the adult's action (e.g. both action and sound effects) simultaneously, even though these are clearly separable behaviors and do not need to be done together. We are aware of no other studies that have documented the simultaneous imitation of two actions in different modalities by infants this young.

Human infants, to a greater degree than other species, routinely analyze the actions of others into ends and means – and even have some ideas about when the means are appropriate toward the chosen end (whether they are 'rational'; Gergely, Bekkering & Király, 2002). This makes them much more flexible in reproducing the intentional actions of others – whether in terms of their ends, or their means, or some combination – in ways that are appropriate given the actor's goals and contextual situation.

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