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The reliability of a model influences 14-month-olds' imitation

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ABSTRACT

Human infants have an enormous amount to learn from others to become full-fledged members of their culture. Thus, it is important that they learn from reliable, rather than unreliable, models. In two experiments, we investigated whether 14-month-olds (a) imitate instrumental actions and (b) adopt the individual preferences of a model differently depending on the model's previous reliability. Infants were shown a series of videos in which a model acted on familiar objects either competently or incompetently. They then watched as the same model demonstrated a novel action on an object (imitation task) and preferentially chose one of two novel objects (preference task). Infants' imitation of the novel action was influenced by the model's previous reliability; they copied the action more often when the model had been reliable. However, their preference for one of the novel objects was not influenced by the model's previous reliability. We conclude that already by 14 months of age, infants discriminate between reliable and unreliable models when learning novel actions.

Introduction

Imagine watching as a stranger approaches a novel box and, instead of pushing it with his hand, sits on it to turn on a light inside. Would you copy this unusual action when interacting with the box yourself? You might if the stranger had acted confidently and you knew from previous experience that he was knowledgeable about these types of boxes; you might not if first the stranger had inspected the

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box uncertainly or if he had shown you by his previous actions that he was an unreliable model. When we learn from others, it is important to take into account their competence as models and copy their actions selectively depending on how reliable or knowledgeable they are.

Recently, preschoolers have been shown to evaluate others' reliability based on their performance in the past. For example, children as young as 3 years of age prefer to learn novel words from speakers who have previously named familiar objects correctly rather than from speakers who have previously named the objects incorrectly (Birch, Vauthier, & Bloom, 2008; Jaswal & Malone, 2007; Jaswal & Neely, 2006; Koenig, Clément, & Harris, 2004; Pasquini, Corriveau, Koenig, & Harris, 2007). And by 3 years of age, children generalize reliability across domains; they can use information about reliability gained in the verbal domain (i.e., correct or incorrect labeling of familiar objects) to decide whom to trust when learning the function of a novel object (Koenig & Harris, 2005).

However, all of these studies used verbal object labeling in the demonstrations of the adults' reliability or unreliability, so it is not possible to investigate what younger children and infants understand about others' reliability using these kinds of demonstrations due to their limited verbal skills. The closest study with infants is that of Chow, Poulin-Dubois, and Lewis (2008). They found that 14-month-olds were more likely to follow a person's gaze if that person had been a reliable looker in the past (i.e., had expressed excitement when looking into containers with toys inside as opposed to empty containers). However, that study was not designed to test infants' ability to take into account a model's reliability in imitative learning situations. Participation in human culture and acquisition of cultural practices start at a very early age, but often the reasons why we use particular actions are opaque even to adults (Gergely & Csibra, 2006). Thus, it would be prudent for even young children to imitate preferentially others who have proven their competence as good models. Because infants are deeply dependent on reliable sources of information when acquiring novel actions, it is important to know whether they already imitate reliable models over unreliable models at the beginning stages of cultural learning.

We know that, in general, infants are selective imitators. By 14 months of age, they copy intentional actions more often than accidental actions (Carpenter, Akhtar, & Tomasello, 1998), they copy actions that are causally related to the effect more often than irrelevant actions (Brugger, Lariviere, Mumme, & Bushnell, 2007), and they take into account the physical constraints present for the demonstrator when deciding which aspects of a demonstration to copy (Gergely, Bekkering, & Király, 2002). They also copy peers in different ways from adults (Ryalls, Gul, & Ryalls, 2000; Zmyj, Daum, Prinz, Nielsen, & Aschersleben, 2010); this might suggest some sensitivity to competence, but that was not directly tested in those studies.

The main aim of the current study was to provide a direct test of whether infants of this young take into account a model's previous reliability when deciding what to copy from him. We hypothesized that 14-month-olds should be able to do this given (a) infants' selective imitation skills, (b) Chow and colleagues' (2008) gaze-following findings, and (c) other evidence that by this age infants are sensitive to others' knowledge/ignorance (e.g., Liszkowski, Carpenter, & Tomasello, 2008; Tomasello & Haberl, 2003). Thus, we adapted a commonly used infant imitation task, turning on a lamp using an unusual means (Meltzoff, 1988), to provide a nonverbal measure of whether infants copy reliable models more than unreliable models. A second aim of the study was to explore the extent of this effect. To that end, we included not just imitation tasks but also preference tasks to contrast learning about potentially conventional types of information versus more idiosyncratic types of information.

For both types of tasks, infants first were shown a series of videos in which a model acted on various familiar objects either competently (reliable condition) or incompetently (unreliable condition). Then infants watched as that same model neutrally demonstrated an unusual novel action on an object (imitation tasks) or chose one of two novel objects to keep (preference tasks). We predicted that infants would copy the novel action in the imitation tasks more often after having watched the model act reliably than after having watched him act unreliably previously. For the preference tasks, the prediction was less clear. There are mixed results in the literature regarding infants' sensitivity to others' preferences (see General discussion). We did not know whether infants would tend to adopt the preferences of generally reliable people or instead treat preferences as individual dispositions that are not affected by one's competence and/or are not meant to be copied.

Experiment 1

Method

Participants

A total of sixty-four 14-month-olds (mean age = 14 months 0 days, range = 13 months 15 days to 14 months 15 days, 34 girls and 30 boys) participated in the study. An additional 9 infants were tested but not included in the final sample due to fussiness. Infants were recruited from a database of parents who had agreed to participate in child development studies.

Design

The experiment consisted of two *imitation tasks* and two *preference tasks* presented blocked (i.e., each set of tasks was conducted either in positions 1 and 2 or in positions 3 and 4) and in fully counterbalanced order. Half of the infants participated in each of the four tasks in the *reliable* condition, and half participated in the tasks in the *unreliable* condition.

Materials

For one of the imitation tasks, the *head touch task*, a round lamp (12 cm diameter) mounted on a black rectangular board (27 × 20 cm) was used. The lamp could be illuminated by pressing on the top (as in Meltzoff, 1988). Two versions of the lamp were used. For the video demonstrations, the board to which the lamp was attached was horizontally oriented, but for infants' response periods it was tilted by 30° to facilitate head touches. For the other imitation task, the *sit touch task*, a rectangular Plexiglass box (60 × 22 × 14 cm) with six small and differently colored lamps inside was used (as in Buttelmann, Carpenter, Call, & Tomasello, 2007). The lamps could be illuminated by pressing on the top of the box.

Four novel objects were used in the preference tasks. For one of these tasks, the objects were a yellow octagonal box (12 × 12 × 12 cm) and a pink cylinder (9 × 14 cm). For the other task, the objects were a blue cone (10 × 25 cm) and a green ellipsoidal box (15 × 12 × 8 cm).

Procedure

Infants and their parents were first escorted to a reception room. For approximately 10 min, infants were allowed to explore the room while the experimenter described the test procedure to the parents. Then infants and their parents were brought to the testing room. Infants sat on their parents' lap at a table approximately 80 cm from a 24-inch monitor (Sony GDM-FW900, screen resolution 800 × 600 pixels). The general procedure was as follows. For each of the imitation and preference tasks (see below), all infants first watched a series of three familiarization videos in either the reliable or unreliable condition. Then infants watched the same neutral test video. After that, infants were given the object(s) from the test video to interact with themselves. The experimenter was absent during the presentation of the videos and during the response phase; he appeared only briefly to bring and remove the test objects.

For both types of task, the model's reliability or unreliability was expressed in two ways: (a) in the model's choice of correct versus incorrect body parts or objects to use and (b) in the certainty or uncertainty he expressed while making this choice. In the reliable condition, prior to each action in the familiarization videos, the model looked at the camera, then looked at the object(s), and then illustrated his certainty by holding up both hands, making a confident facial expression and saying knowingly, "Ah!" In the unreliable condition, in contrast, at the same points in the procedure, the model illustrated his uncertainty by holding up both hands, palms up, making an uncertain facial expression, and saying uncertainly, "Hm." See Fig. 1 for a depiction of these expressions. We chose to present infants with both types of information—choice and certainty—because we wished to provide them with as much information as possible about the model's reliability. At the beginning of each video in both conditions, an "attention getter" was presented on the screen, where a picture of a smiling sun (with eyes) appeared and infants heard a friendly male voice say, "Watch!" All actions in the videos in both conditions were demonstrated by the same male model (who was different from the experimenter).

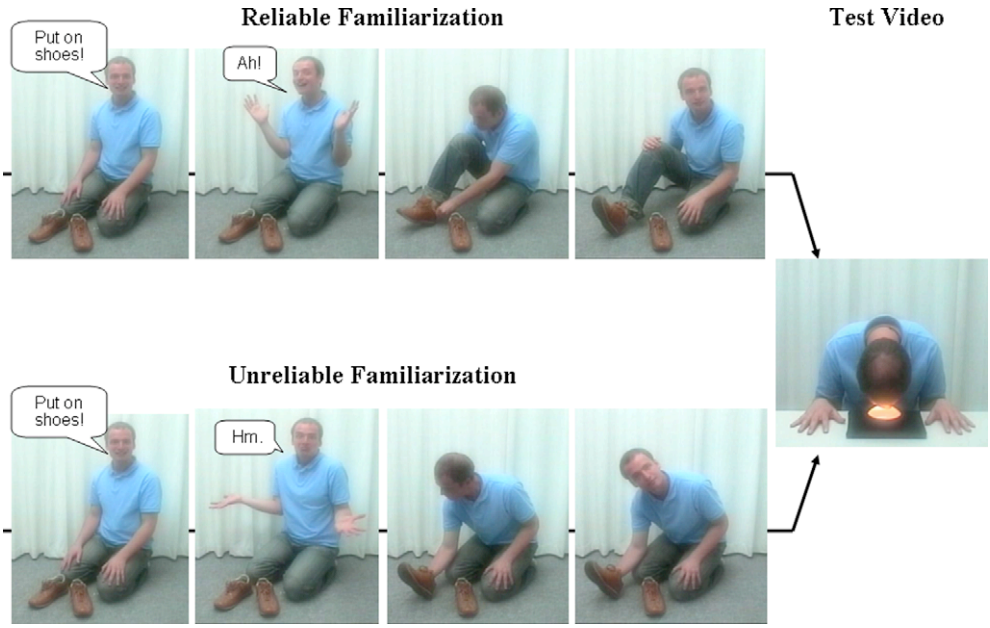

Fig. 1. Successive frames from the videos of one of the imitation tasks for the reliable and unreliable conditions.

Slightly different types of actions were shown in the imitation and preference tasks to maximize infant attention and to more closely match the actions in the familiarization videos to the actions in the test videos. Because the model used an unusual body part in the test videos of the imitation tasks, infants were familiarized with the model using body parts either correctly or incorrectly in the familiarization videos for the imitation tasks. In contrast, because the model chose a novel object in the test videos of the preference tasks, infants were familiarized with the model choosing either correctly or incorrectly between two familiar objects in the familiarization videos for the preference tasks.

Imitation tasks. Familiarization videos for the imitation tasks each consisted of the model using a familiar object with either the correct or an incorrect body part depending on the condition. For example, first the model looked at the camera and announced that he wanted to put on sunglasses. In the reliable condition he proceeded to put the sunglasses on his face, but in the unreliable condition he put them on his foot. See Table 1 for a list of all the actions modeled in the imitation videos and for the order in which the videos were presented during the familiarization phase.

After each series of three familiarization videos, infants in both conditions watched the same test video. In each of the two test videos, the model first looked at the camera with a neutral facial expression, then silently used an unusual novel action to turn on the lamp, and then looked back up to the camera neutrally. In the head touch task, the model touched the lamp with his forehead three times, illuminating the lamp briefly each time (as in Meltzoff, 1988). His hands rested naturally on the table next to the lamp. In the sit touch task, the model sat three times on the box, illuminating the lamps briefly each time as in the hands-free condition of Buttelmann and colleagues (2007).

As soon as the test video ended, the experimenter entered the room, placed the apparatus used in the video either on the table (head touch task) or on the floor (sit touch task), told infants "Now you can play with it!" and left the room. The length of the response period varied by task based on pilot results indicating differing interest and difficulty levels for the two apparatuses (i.e., infants were willing to interact longer with the sit touch box because they could move around freely, and they often took longer to manage to achieve the novel action in that task as well); response periods were 60 s

Table 1
Actions shown during familiarization and test phases of imitation tasks in each condition of Experiments 1 and 2.

Familiarization phase	Condition	
	Reliable	Unreliable
Series A		
Putting sunglasses on the ...	Nose	Foot
Putting a shoe on the ...	Foot	Hand
Putting a glove on the ...	Hand	Foot
Series B		
Kicking a ball with the ...	Foot	Nose
Putting a hat on the ...	Top of the head	Ear
Telephoning with the ...	Ear	Top of the head
Test phase		
Sit touch task: Turning on a light by sitting on it		
Head touch task: Turning on a light with the forehead		

Note. Series A and B were fully counterbalanced with both tasks.

for the head touch task and 120 s for the sit touch task, starting from the moment infants first touched the apparatus.

Preference tasks. Familiarization videos for the preference tasks each consisted of the model choosing either the correct or an incorrect object with which to achieve a goal. For example, the model looked at the camera, announced that he would brush his hair, and did so either with a hairbrush (reliable condition) or with a spoon (unreliable condition). In both conditions, the hairbrush and the spoon were located on the table at which the model was sitting, one object to the model's left side and the other object to his right side, counterbalanced across participants. See Table 2 for a list of all the actions modeled in the preference videos and for the order in which the videos were presented during the familiarization phase.

After each series of three familiarization videos, infants in both conditions watched the same test video of the model choosing one of two novel objects (as in Thomas, Due, & Wigger, 1987). In each of these test videos, the model first looked at the camera with a neutral facial expression, then looked at each object in turn (in counterbalanced order), and then chose one of the objects by picking it up and looking at it from different angles with a happy and satisfied facial expression while nodding his head. He then held it up to his cheek, caressed the object while vocalizing lovingly, and looked back at the camera. The chosen object and the side it was on were counterbalanced across participants. As soon as

Table 2
Actions shown during familiarization and test phases of preference tasks in each condition of Experiment 1.

Familiarization phase	Condition	
	Reliable	Unreliable
Series A		
Drying hands with a ...	Towel	Cap
Brushing his hair with a ...	Hairbrush	Spoon
Eating pudding with a ...	Spoon	Hairbrush
Series B		
Putting a ... on the head	Cap	Towel
Driving with a ...	Toy car	Mobile phone
Telephoning with a ...	Mobile phone	Toy car
Test phase		
Blue cone and green box task: Chose blue cone or green box		
Pink cylinder and yellow box task: Chose pink cylinder or yellow box		

Note. Series A and B were fully counterbalanced with both tasks.

the test video ended, the experimenter entered the room, placed a tray with both of the objects from that video on it (on the same sides as in the video, approximately 30 cm apart) on the table in front of the infants, told infants "Now it's your turn!" and left the room. Because infants normally responded very quickly, they were given 30 s to choose one of the two objects.

Coding and data analysis

Infants' behavior was coded from video by a coder who was unaware of which condition infants were in. In the imitation tasks, infants were scored as having copied the head touch action if they touched the lamp with their head and as having copied the sit touch action if they turned on the lamps by sitting on the box (or attempted to do so by putting one knee on top) at any point in time during the response period. In the preference tasks, the object that infants touched first was coded. For the imitation and preference tasks separately, infants received a score from 0 to 2 for the number of tasks in which they copied the model's action or chose the same object as he did. This score was converted to a percentage because some infants (24 of 64) did not participate in all trials (16 infants completed only three tasks, 6 infants completed only two tasks, and 2 infants completed only one task). Accordingly, 36 trials (18 in each condition) of 256 trials (64 children $\times$ 4 tasks) needed to be excluded due to inactivity ($n = 19$), fussiness ($n = 9$), experimenter error ($n = 5$), inattentiveness ($n = 4$), or interference by parents ($n = 38$). The 24 children who did not complete all four trials were not excluded from the analyses so as to keep the number of dropouts as small as possible. To see whether infants paid the same amount of attention to the videos in each condition, we also coded the time that infants spent looking at the familiarization and test videos for each task.

A second independent observer coded 100% of the trials. Interobserver agreement was excellent (Cohen's kappa = .93 for the imitation tasks and .90 for the preference tasks). Excellent agreement was also achieved for infants' looking time during the videos (intraclass correlation coefficient $r = .99$). Two-tailed p values are reported throughout.

Results

In the imitation tasks, as expected, infants who had previously watched the model act reliably imitated the unusual novel actions more than twice as often ($M = 52\%$, $SD = 40$) as infants who had previously watched the model act unreliably ($M = 24\%$, $SD = 34$), Mann–Whitney $U = 303.0$, $N = 63$, $p = .004$. Similar results were found for each imitation task separately; in the head touch task, 59% of infants imitated in the reliable condition compared with 30% in the unreliable condition, $\chi^2(1, N = 56) = 4.76$, $p < .05$, and in the sit touch task, 50% of infants imitated in the reliable condition compared with 21% in the unreliable condition, $\chi^2(1, N = 56) = 4.98$, $p < .05$.

It is important to note that in both imitation tasks, infants were equally likely to participate in both conditions. If they did not use the unusual body part to turn on the lamp, they used their hands. Thus, infants in both conditions were equally interested in the apparatuses and involved in the tasks, but infants in the reliable condition copied the model's unusual action more often than infants in the unreliable condition.

In the preference tasks, in contrast, infants' preference for the same object that the model chose did not differ between the reliable condition ($M = 57\%$, $SD = 40$) and the unreliable condition ($M = 55\%$, $SD = 34$), Mann–Whitney $U = 454.5$, $N = 61$, $p = .87$. Similar results were found for each task separately (χ^2 tests, both $ps > .30$). Indeed, even in the reliable condition, infants did not choose the model's preferred object more often than chance (Wilcoxon test, $Z = .73$, $N = 31$, $p = .47$). Infants were equally likely to participate actively in the test by choosing an object in both conditions; they just did not selectively choose the object the model chose in either condition.

The order of presentation of the two types of tasks (imitation tasks first vs. preference tasks first) did not influence the results in the preference tasks; infants did not choose the model's preferred object more often in the reliable condition than in the unreliable condition in either order (Mann–Whitney U tests, both $ps > .29$). However, there was an effect of the order of presentation for the imitation tasks. There was no significant difference in infants' imitation of the reliable model compared with the unreliable model when the imitation tasks were presented before the preference tasks; in this case, infants copied 38% of the unusual actions in the reliable condition and 34% in the unreliable condition,

Mann–Whitney $U = 111.5$, $N = 31$, $p = .71$ (these percentages are 47% and 36%, respectively, for the head touch task and 36 and 31%, respectively, for the sit touch task, χ^2 tests, both $ps > .65$). However, infants did selectively imitate the reliable model when the imitation tasks were presented after the preference tasks; in this case, they copied 67% of the unusual actions in the reliable condition and 15% in the unreliable condition, Mann–Whitney $U = 37.0$, $N = 32$, $p < .001$ (these percentages are 71% and 21%, respectively, for the head touch task and 64% and 13%, respectively, for the sit touch task, χ^2 tests, both $ps < .01$). The pattern of results did not change when only the data from infants who had completed either both imitation tasks or both preference tasks were used in analyses.

On average, infants watched all of the videos closely; the percentages of time spent looking at the familiarization videos ranged from 95.9% to 97.4% ($SDs = 3.1–4.6$) for each task in each condition. The percentages of time spent looking at the test videos in the imitation task were 91.7% ($SD = 12.0$) in the reliable condition and 94.3% ($SD = 9.0$) in the unreliable condition. For the preference task, these percentages were 97.0% ($SD = 4.3$) and 96.5% ($SD = 6.2$), respectively. A $2 \times 2 \times 2$ (Task $\times$ Condition $\times$ Phase) repeated measures analysis of variance (ANOVA) was performed on the percentage of infants' looking times with type of task (imitation or preference) and phase (familiarization or test) as within-participants factors and with condition (reliable or unreliable) as a between-participants factor. The most important result was that there was no main effect of condition, $F(1, 58) < 1$, indicating that infants were equally attentive during the demonstration of videos in the reliable and unreliable conditions. The only significant result was an interaction between type of task and phase, $F(1, 57) = 5.33$, $p = .025$; in the imitation tasks, but not in the preference tasks, infants looked less during the test phase than during the familiarization phase, $t(61) = 3.05$, $p < .01$, and infants' looking time during the test phase was shorter in the imitation tasks than in the preference tasks, $t(58) = 2.62$, $p < .01$.

Discussion

Our findings demonstrate that 14-month-olds can use information about others' previous reliability to copy novel actions selectively from reliable models in imitation tasks. In contrast, we found no evidence that infants use this information in tasks involving adopting similar preferences as reliable models. Thus, these findings suggest that infants take a model's reliability into account when learning how to use novel artifacts but not when observing more idiosyncratic preferences. However, we need to view these results with some caution because in the imitation tasks infants clearly demonstrated selective copying only when they were presented with the imitation tasks second after having participated in the preference tasks.

We can rule out lower level attentional explanations for both the positive and negative findings in this experiment. It was not the case that infants paid more attention to the reliable model than the unreliable model or that they paid more attention in the imitation tasks than in the preference tasks. Infants were also equally likely to act on the objects in both conditions in the imitation tasks, and equally likely to choose an object in both conditions in the preference tasks. Thus, they did not appear to find either the preference tasks or the unreliable model (or the objects he acted on) to be uninteresting or aversive in any way; they just appeared to trust the reliable model more when it came to learning unusual new actions.

However, there is another lower level explanation for the difference between the results in the imitation and preference tasks that we cannot rule out in the current experiment, and this is that we used different types of actions in the familiarization videos for the imitation and preference tasks (i.e., correct/incorrect use of body parts in the imitation tasks vs. correct/incorrect choice between two objects in the preference tasks). We did this to give infants every opportunity to see the relation between the familiarization videos and the test videos in each task. But it is possible that the familiarization videos in the preference tasks were somehow not as effective at conveying the model's reliability or unreliability as the familiarization videos in the imitation tasks, and this is why infants did not end up choosing the same object that the model did in the preference tasks.

Although it has been shown that infants as young as 6 months of age display knowledge about the correct use of some of the objects we used in the preference task (Hunnius & Bekkering, 2010), there might be other reasons why infants had difficulties in detecting the model's reliability in our prefer-

ence videos. For example, processing demands might have been higher in the preference familiarization videos because infants needed to determine which of two objects was the correct one, whereas they needed to determine only whether or not a single object was used correctly in the imitation familiarization videos. Alternatively, it is possible that infants may have mistakenly interpreted the actions in the unreliable condition of the preference familiarization videos as pretense actions instead of incompetent actions, although the fact that infants did not choose the object that even the reliable model chose above chance suggests that there is more to the story than this. In any case, the use of different types of actions during the familiarization phase of the imitation and preference tasks could have contributed to the difference in results between these tasks.

The differences in the familiarization videos also could have contributed to the order effect found in the imitation tasks in two different ways. First, it is possible that infants needed to observe the model's reliability or unreliability in two different types of situations before being able to recognize the model's competence in the imitation tasks. Second, it could be that instead of needing to observe the model in two different situations to be able to perceive him as reliable or unreliable, infants simply needed *more* demonstrations of the model's reliability or unreliability irrespective of the type of demonstrations shown and so this is why only infants who received the imitation tasks second were successful. If this were the case, infants should be able to show this selectivity in their imitative behavior after observing the same number of a single type of actions during the familiarization phase (i.e., the type of actions used during the familiarization phase of the imitation tasks).

To further investigate both the unexpected order effect and the difference in results between the preference and imitation tasks, we conducted a second experiment in which we followed the general procedure of Experiment 1 but presented infants with familiarization videos in the preference tasks that were of the same type as those in the imitation tasks. In this way, infants who received the imitation tasks second observed familiarization videos showing only a single type of demonstration.

Experiment 2

As in Experiment 1, in this experiment infants were presented with two imitation tasks and two preference tasks. However, during the familiarization phase of the preference tasks in this experiment, infants were shown the same kind of video sequences as those presented during the familiarization phase of the imitation tasks. In this way, we could start to investigate why we found an order effect in Experiment 1. That is, we explored whether infants need to see evidence of the model's reliability or unreliability in two different types of situations (i.e., body part use and choice of objects) to copy him selectively or whether their success in Experiment 1 was due simply to the number of demonstrations of the model's reliability or unreliability independent of the type of actions he performed. By making this change, we were also able to further explore the null result of the preference task. Because the type of actions presented during the familiarization phase was now identical in the imitation and preference tasks (and was a type that was successful in Experiment 1), any difference in infants' performance between these two tasks would now depend on the nature of the task itself.

Method

Participants

A total of sixty-four 14-month-olds (mean age = 14 months 1 day, range = 13 months 15 days to 14 months 15 days, 27 girls and 37 boys) participated in the study. An additional 6 infants were tested but not included in the final sample due to fussiness ($n = 5$) or parental interference ($n = 1$). Infants were recruited as in Experiment 1.

Design

The design was basically identical to that of Experiment 1. All infants participated in two imitation tasks and two preference tasks that were presented blocked as in Experiment 1 with order fully counterbalanced across participants. The only difference in this experiment was that in all familiarization

videos, independent of type of task, the model used a body part either correctly or incorrectly to act on an object. In this way, all familiarization videos were of the same type for both types of tasks.

Materials

The materials used in Experiment 2 were similar to those used in Experiment 1. Table 3 shows the new body part actions that replaced the choices of objects shown in the familiarization videos from Experiment 1.

Procedure

The procedure of Experiment 2 was identical to that of Experiment 1 except that the familiarization videos in both the imitation and preference tasks consisted of the model using a familiar object with either the correct or an incorrect body part.

Coding and data analysis

Coding and data analysis were done as in Experiment 1. Again, percentages were used in most analyses because some infants (29 of 64) did not complete all four trials. Accordingly, 48 of 256 trials needed to be excluded due to infants' inactivity ($n = 20$) or fussiness ($n = 17$), experimenter error ($n = 45$), or interference by parents ($n = 5$). A second independent observer coded 100% of the trials. Again, inter-observer agreement was excellent: Cohen's kappa = .95 for the imitation tasks and .91 for the preference tasks.

Results

As in Experiment 1, in the imitation tasks, infants who had previously watched the model act reliably generally imitated the unusual novel actions more often ($M = 59\%$, $SD = 38$) than infants who had previously watched the model act unreliably ($M = 32\%$, $SD = 40$), Mann–Whitney $U = 276.0$, $N = 59$, $p = .01$. Again, similar results were found for each imitation task separately. In the head touch task, 61% of infants imitated the unusual action in the reliable condition, whereas only 36% of infants imitated it in the unreliable condition, $\chi^2(1, N = 48) = 4.00$, $p < .05$; likewise, in the sit touch task, 50% of infants imitated the unusual action in the reliable condition compared with 22% in the unreliable condition, $\chi^2(1, N = 55) = 4.53$, $p < .05$. As in Experiment 1, infants were equally likely to participate in both conditions of the imitation tasks. If they did not use the unusual body part to turn on the lamp, they used their hands.

However, again in the preference tasks, infants' preference for the same object that the model chose was not influenced by condition. Half (50%, $SD = 35$) of infants' choices matched the model's choice in the reliable condition compared with 52% ($SD = 37$) in the unreliable condition, Mann–Whit-

Table 3
Actions shown during familiarization and test phases of preference tasks in each condition of Experiment 2.

Familiarization phase	Condition	
	Reliable	Unreliable
Series A		
Carrying a bag with the …	Hand	Mouth
Writing with a pen held in the …	Hand	Foot
Wrapping a scarf around the …	Neck	Chest
Series B		
Putting a pullover on the …	Torso	Neck
Putting a sock on the …	Foot	Hand
Using a toothbrush to brush the …	Teeth	Hand
Test phase		
Blue cone and green box task: Chose blue cone or green box		
Pink cylinder and yellow box task: Chose pink cylinder or yellow box		

Note. Series A and B were fully counterbalanced with both tasks.

ney $U = 408.5$, $N = 58$, $p = .86$. Similar results were found for each task separately (χ^2 tests, both $ps > .10$). And again, even in the reliable condition, infants did not choose the model's preferred object more often than chance (Wilcoxon test, $Z = .00$, $N = 30$, $p = 1.00$) and infants were equally likely to participate actively in the test by choosing an object in both conditions; they just did not selectively choose the object that the model chose in either condition.

We also replicated the order effect found in Experiment 1. The order of presentation of the two types of tasks (imitation tasks first vs. preference tasks first) did not influence the results in the preference tasks; infants did not choose the model's preferred object more often in the reliable condition than in the unreliable condition in either order (Mann–Whitney U tests, both $ps > .82$). However, there was an effect of the order of presentation for the imitation tasks. There was no significant difference in infants' imitation of the reliable model compared with the unreliable model when the imitation tasks were presented before the preference tasks; in this case, infants copied 43% of the unusual actions in the reliable condition and 27% in the unreliable condition, Mann–Whitney $U = 83.5$, $N = 30$, $p = .19$ (these percentages are 54% and 36%, respectively, for the head touch task and 33% and 20%, respectively, for the sit touch task, χ^2 tests, both $ps > .39$). However, infants did selectively imitate the reliable model when the imitation tasks were presented after the preference tasks; in this case, they copied 75% of the unusual actions in the reliable condition and 37% in the unreliable condition, Mann–Whitney $U = 54.5$, $N = 29$, $p = .02$ (these percentages are 77% and 36%, respectively, for the head touch task and 75% and 31%, respectively, for the sit touch task, χ^2 tests, both $ps < .05$). As in Experiment 1, the pattern of results did not change when only the data from infants who had completed either both imitation tasks or both preference tasks were analyzed.

On average, infants watched all of the videos closely; the percentages of time spent looking at the familiarization videos ranged from 91.7% to 96.5% (SDs = 4.3–7.9) for each task in each condition. The percentages of time spent looking at the test videos task ranged from 90.7% to 94.0% (SDs = 5.9–17.5) for each task in each condition. A $2 \times 2 \times 2$ (Task $\times$ Condition $\times$ Phase) repeated measures ANOVA was performed on the percentage of infants' looking times with type of task (imitation or preference) and phase (familiarization or test) as within-participants factors and with condition (reliable or unreliable) as a between-participants factor. There were no significant main effects or interactions (all $ps > .13$). Most important, there was no main effect of condition, $F(1, 58) < 1$, indicating that infants were equally attentive during both types of videos in the reliable and unreliable conditions.

Discussion

In this experiment, we replicated each of the findings of Experiment 1. We showed again that infants can use previous information about a model's reliability to selectively copy unusual actions from the reliable model in the imitation tasks. And again, we found no evidence that infants selectively adopt the preferences of a previously reliable model in the preference tasks despite using familiarization videos in the preference tasks that were of the same type as those that produced successful results in the imitation tasks of Experiment 1 and the current experiment. Thus, the difference in performance in the imitation and preference tests cannot be explained by the type of familiarization videos that infants saw prior to the test.

We even replicated the order effect found in the imitation tasks in Experiment 1. Given the difference in procedure between the two experiments, this suggests that instead of needing different types of information about the model's reliability, infants simply need more examples of it to succeed. The fact that infants need numerous demonstrations of a model's reliability or unreliability is a curious finding for at least two reasons. First, when similar imitation tasks are presented to 14-month-olds without first identifying the model as reliable or unreliable, infants generally copy the model readily after a single set of demonstrations (e.g., Gergely et al., 2002; Meltzoff, 1988). Even when video demonstrations are used instead of live demonstrations, as in the current experiments, infants imitate unknown adults at high rates (Zmyj, Daum, & Aschersleben, 2009). This suggests that in those studies infants appeared to assume that the model was reliable without any prior information about him.

Second, it is also a curious finding given the results of Chow and colleagues' (2008) gaze-following study. These authors reported that infants apparently evaluated adults as reliable lookers by default and needed repeated evidence of adults' *unreliability* to reduce their trust in adults' looking behavior.

In the current experiments, an inspection of the means reveals that the greatest difference in results across orders was seen in the reliable condition; infants greatly increased their imitation of the reliable model across orders, whereas their imitation of the unreliable model did not change much across orders. We have no ready explanation for this finding. Perhaps it is due in part to the minimal ostensive communicative cues given in these videos that might have reduced infants' tendency to copy the reliable model at first (see Csibra & Gergely, 2006). However, that cannot fully explain the current results because similar cues were given in other video imitation studies (Zmyj et al., 2009, 2010), and in those studies infants imitated at high rates from the beginning. Future studies are clearly needed to investigate what kinds of information infants need at this age to identify reliable and unreliable models.

General discussion

Our findings demonstrate that 14-month-olds can take into account a model's previous reliability when socially learning from him. In the imitation tasks in both experiments, infants in both conditions watched the exact same demonstration of a model using an unusual action to operate a novel apparatus. Overall, infants who had watched the model previously acting competently on a series of other familiar objects copied this unusual action about twice as often as infants who had watched the model previously acting incompetently. These results suggest that the ability to take into account a model's prior reliability in imitative learning tasks emerges years earlier than previously reported, already at the beginning stages of infant cultural learning.

One could argue that perhaps infants responded not based on the reliability or unreliability of the model per se but instead simply based on the certainty or uncertainty he showed before acting during the familiarization phase. This would still be an interesting finding because it would provide new and much earlier evidence of children's use of uncertainty information in their imitative learning (Birch, Akmal, & Frampton, 2010; Sabbagh & Baldwin, 2001). Certainty is also clearly one factor that adults use in deciding how much to trust information provided by someone else, so it is interesting to know that infants can use it as well.

However, we believe it is unlikely that this alternative explanation can fully account for our results for several reasons. First, Chow and colleagues (2008) found that infants of the same age distinguish between reliable and unreliable lookers, and in that study no cues of certainty or uncertainty were given. Second, unlike in previous studies of older children's use of certainty information (Birch et al., 2010; Sabbagh & Baldwin, 2001), in the current study the model did not express certainty or uncertainty during the test videos at all; in both the reliable and unreliable conditions, he acted neutrally and absolutely identically toward the test apparatuses. Finally, the other main finding of this study was that infants did not respond differently across conditions in the preference tasks. This suggests that lower level cues such as facial expressions, which were present in those familiarization videos as well, cannot fully account for the difference found in the imitation tasks.

Null results are always difficult to interpret, and those found in our preference task are no exception. Perhaps the connection between what happened in the familiarization videos (Experiment 1: the adult choosing an object to achieve a goal; Experiment 2: the adult using a body part either correctly or incorrectly) and what happened in the test videos (the adult choosing an object just for the sake of a preference for it) was not as strong as in the imitation tasks, and so infants did not generalize the adult's reliability across them. It is true that one's competence with objects or body parts does not always translate directly into one's tastes and preferences with objects, and it may be that infants have already picked up on this.

However, our preferred explanation is that infants did not choose the object that the model chose in the preference tasks because they saw the adult's preference as individual and subjective; thus, it did not occur to them to copy it. Indeed, infants did not choose the same object that the model did in *either* condition in the preference tasks, demonstrating that even the preferences of *reliable* models are not likely to be adopted. This interpretation is supported by findings from a recent study by Buresh and Woodward (2007), who showed that 13-month-olds keep track of a person's individual preference and do not expect a different person to have the same preference. Still, there are currently quite

mixed results in the literature on infants' understanding of others' preferences (see, e.g., Buresh & Woodward, 2007; Gergely, 2010; Gergely, Egyed, & Király, 2007; Luo & Baillargeon, 2005; Repacholi & Gopnik, 1997), so future research is clearly needed on this topic.

In any case, it is clear that at least under some conditions, infants see others' previous reliability as relevant in imitative learning contexts. Along with contributing to the literature on young children's sensitivity to others' reliability, the current study also contributes to the literature on infant imitation. For example, previous studies have shown that infants are sensitive to the physical constraints under which the model is operating (e.g., Buttelmann, Carpenter, Call, & Tomasello, 2008; Gergely et al., 2002). Here we suggest that infants may also be sensitive to the mental constraints under which the model is operating; that is, in the unreliable condition, the model lacked knowledge about how to operate the objects. However, an alternative possibility is that infants could have interpreted the model's incompetence more on a behavioral level (i.e., "he does things wrong") than on a mental level (i.e., "he does not know what to do"), so future research will need to look at this as well. We also found that in the reliable condition, when the imitation tasks were administered second, approximately two-thirds of the infants imitated the unusual actions, and this is comparable to other studies testing imitation of an unusual action with live models at this age (Gergely et al., 2002; Meltzoff, 1988; Schwier, van Maanen, Carpenter, & Tomasello, 2006). Thus, this study adds to a growing number of studies showing that video demonstrations are possible with 1-year-olds (see also Barr, Muentener, Garcia, Fujimoto, & Chavez, 2007; Zmyj et al., 2009). Given the advantages in terms of practicality and control over the experimental demonstration, this is a promising method for infant imitation research.

In summary, we found that at least under some conditions, 14-month-olds can use a model's reliability to guide their own imitative responses. Just shortly after their first birthday, infants are surprisingly discriminating imitators and are ready to begin participating in human cultural and conventional learning.

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