

Unwilling Versus Unable: Infants' Understanding of Intentional Action

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Infants experienced a female adult handing them toys. Sometimes, however, the transaction failed, either because the adult was in various ways unwilling to give the toy (e.g., she teased the child with it or played with it herself) or else because she was unable to give it (e.g., she accidentally dropped it). Infants at 9, 12, and 18 months of age reacted with more impatience (e.g., reaching, looking away) when the adult was unwilling to give them the toy than when she was simply unable to give it. Six-month-olds, in contrast, showed no evidence of this differentiation. Because infants' behavioral responses were appropriately adapted to different kinds of intentional actions, and because the adult's actions sometimes produced results that did not match her goal (when having accidents or failed attempts), these findings provide especially rich evidence that infants first begin to understand goal-directed action at around 9 months of age.

At some point late in infancy, young children come to perceive the bodily motions of other people as intentional actions. Determining precisely when this developmental transition occurs is theoretically important because it marks infants' first step toward theory of mind and culture (Tomasello, 1999). The methodological challenge is that in smooth and successful intentional actions, the actor's goal and the environmental outcome match (e.g., an actor has the goal of picking up a cup and does so). In such cases, it is mostly not possible to tell if an observing child is reacting to the external result of an action or to the actor's underlying goal. For this reason, the truly diagnostic cases are such things as failed attempts and accidents (e.g., an actor tries to pick up a cup but cannot reach it or knocks down the shelf on the way to reaching it). In these cases, the child has the possibility of demonstrating an understanding of successful versus unsuccessful actions (i.e., of determining whether the actor's goal matches the external result produced), which is in fact the defining feature of truly goal-directed action.

The preferred method for studying older infants' understanding of intentional action is imitation tasks that separate goal and result, that is, which involve demonstrations of trying or accidents. Thus, 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) showed the same pattern of results.

With regard to accidents, Carpenter, Akhtar, and Tomasello (1998) had a female adult approach an apparatus and, for example, spin a wheel deliberately (exclaiming "There!") but then catch her hand on a lever and open it accidentally (exclaiming "Woops!"), whereupon an attractive set of lights was suddenly activated (the assignment of actions to conditions and the order of intentional and accidental actions varied across children and trials). When it was then the infants' turn to perform the action also, infants from 14 to 18 months of age imitated the spinning of the wheel—the action done on purpose—not the operating of the lever—the action done by accident. Infants thus distinguished the outcome the adult had produced intentionally (her goal) from the outcome she had produced accidentally.

On the basis of these studies, we may be fairly certain that by around 15 months of age infants understand that actions are guided by underlying goals. But imitation is a fairly demanding response measure, and so the question arises whether younger infants could demonstrate the same understanding in another task paradigm. Looking-time tasks come immediately to mind, and indeed visual habituation has been used in various ways to explore the development of action understanding. For example, Baldwin, Baird, Saylor, and Clark (2001) found that infants nearing their first birthday are not surprised when films of people doing things are stopped at the completion of goal-directed actions, but they are surprised when goal-directed actions are stopped in the middle.

The looking-time methodology has also been used to examine infants' understanding of people's actions directed at objects. These studies show that infants from 12 to 14 months of age expect an actor to behave toward the object she or he has previously been looking at (A. T. Phillips, Wellman, & Spelke, 2002; Woodward, 2003), or touching, or pointing to (Moore, 1999; Woodward & Guajardo, 2002)—sometimes even taking note of contextual in-

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formation in the process (Woodward & Sommerville, 2000). In general, however, no one interprets these studies as demonstrating that infants understand truly goal-directed action but only that they understand something like object-directed action (with the same applying to Woodward's, 1998, findings for reaching and grasping in 6-month-olds).¹

There are two habituation studies that might be interpreted as evidence for infant understanding of goal-directed action because they focus on something like trying and accidents. First, Gergely, Nádasdy, Csibra, and Bíró (1995) found that 12-month-old infants expect actors to pursue the most efficient path to a terminus, taking account of any obstacles present in the process (Csibra, Gergely, Bíró, Koós, & Brockbank, 1999, replicated these findings with 9- but not 6-month-olds; see also Csibra, Bíró, Koós, & Gergely, 2003, for a variation on this paradigm). Going around obstacles might conceivably be thought of as a kind of trying, but the critical point for current purposes is that no condition in these studies actually showed the actor trying but failing to reach the target point. There is thus no need for infants in these studies to posit a distinct, internal goal underlying and guiding the actor's behavior, and indeed Gergely et al. (1995) do not claim that infants do—preferring instead to attribute to infants a teleological action interpretation.

Second, Woodward (1999) found that 9-month-old infants only discriminated inconsistent events when the action shown was a hand grasping an object but not if the action shown was a hand falling onto an object in a desultory manner (back of hand touching object). One interpretation of this finding is that 9-month-olds distinguish between purposeful and nonpurposeful actions. Infants this age, however, also showed no differential response when observing cues that adults would probably consider purposeful behavior, such as touching an object with the index finger (Woodward & Guajardo, 2002). Thus, the interpretation of the negative findings in the back-of-hand condition is not clear cut.

The situation is thus that studies using an imitation methodology are convincing in showing that from around 15 months of age infants do indeed understand an actor's goal as distinct from the result of an action, but it is difficult to use this method with younger infants. Studies using looking-time measures are of course built for younger infants, but to date they have yet to demonstrate that young infants clearly distinguish between an actor's goal and the result of an action. In the current study, therefore, we used a new methodology—that is, new in this context—to investigate what 6- to 18-month-old infants know about the goals underlying human action.

The basic idea was that in the context of giving infants toys to play with, we sometimes brought out a new toy but did not give it to them. In some conditions, this withholding of the toy was the female experimenter's goal; for some reason she was *unwilling* to give it to the infant. But in other conditions, the experimenter's goal was to give the infant the object, however, for some clearly visible reason, she was *unable* to do so—and so in these cases the experimenter's goal (to give the infant the object) and the environmental outcome did not match. We then looked at infants' reactions toward the experimenter in these two types of cases. The question was thus whether infants would react to the unwilling and unable conditions in a way suggesting some understanding of the experimenter's underlying goal, even though the outcome (infant not receiving object) was the same in both cases.

The reactions we scored were the kinds of things scored in infant social interaction studies such as the "still face procedure"

(Tronick, Als, Adamson, Wise, & Brazelton, 1978)—for example, gestures to the adult, turning or looking away, and so forth—with an eye to determining whether the infant was frustrated with the adult, or whether the infant was waiting patiently for the adult to achieve her goal. The method thus also owes something to the study of W. Phillips, Baron-Cohen, and Rutter (1992), who observed that in response to an adult teasing infants with a toy or blocking their play, 9- to 18-month-old infants tended to look to the adult's face and not to the hand—giving at least a very global indication that they knew that faces often provide important information about adult actions (see Carpenter, Nagell, & Tomasello, 1998, for similar findings with 9- to 10-month-olds). The main point is that infant reactions in this study provide more than just evidence of a discrimination because social behaviors can be specifically and appropriately adapted to adult action, for example, patience when the adult is making a good-faith attempt but impatience when the adult is being intransigent.

As noted above, the experimental conditions in which the infant did not receive the toy were interspersed within a game of passing toys (see Call, Hare, Carpenter, & Tomasello, 2004, for a similar methodology used with chimpanzees). There were three conditions in which the adult was unwilling in different ways. Each unwilling condition was paired with an unable condition (or in some cases two). For each group of paired conditions, the movement and position of the toy and the adult's pattern of movements were closely matched. For instance, in one unwilling condition, the adult held out a toy to the infant (looking to the infant's face) and then pulled it away teasingly. In a matched unable condition, she also held out a toy to the infant (again looking to the infant's face) but kept dropping it "accidentally" before the infant could grasp it, so that the toy rolled back to her. Thus, in each group of actions, the adult's pattern of movements and her looking behavior were kept as similar as possible but her goal varied. The difference in the adult's goal (to pass the toy or to keep it for herself) could be inferred from the precise context of the situation and from the adult's expressive features, for example, her facial expression. Because in each group the unwilling and unable actions differed from one another in different ways, if infants showed a similar pattern of responses to all unwilling and unable conditions across the three groups, it would suggest that they understood the adult's underlying goal in similar ways in the different cases.²

¹ Indeed, Moore's (1999) claim is that the expectations infants form in these studies do not even relate the adult to the object she or he is behaving toward, as the same pattern of looking responses is found when in the habituation phase and the test phase different adults point at one of the objects. Furthermore, some of the effects go away if there is not an initial habituation phase, which should not be the case if infants come to the experiment with expectations about human actions (A. T. Phillips et al., 2002).

² We expected more or earlier disengagement from the game and more actions and/or gestures in the unwilling than the unable conditions (as in Call et al., 2004) but had no explicit predictions about what precise behaviors children would exhibit. As some of the possible behavioral responses cannot be performed simultaneously (for instance, it is not possible to turn away from the game and at the same time gesture to the experimenter), one would not necessarily expect differences in all parameters.

Table 1
Conditions and Characteristics of the Matching

Group	Conditions			Matching
	Unwilling	Trying	Distracted	
Tease	Tease	Clumsy	Talk	Toy moved toward child. The experimenter generally looked toward the child.
Refuse	Refuse	Reach	Telephone	Toy was stationary. The experimenter alternated gaze.
Play	Play	Open	Search	The experimenter was engaged with toy. The experimenter did not look at child.

Study 1

On the basis of findings from imitation studies, we conducted the first study with 12- and 18-month-old infants. Each condition in which the experimenter was unwilling to pass a toy was compared with matched unable conditions from two types of situations: a condition in which the experimenter was trying unsuccessfully to pass the toy and a condition in which the experimenter was distracted from the game. In order to investigate a variety of different actions, we tested children with three activity groups, each comprising an unwilling, a trying, and a distracted condition.

Method

Participants

Twenty-four 12-month-olds (16 girls, 8 boys; mean age = 12 months 8 days; range = 11 months 20 days to 12 months 15 days) and 24 18-month-olds (9 girls, 15 boys; mean age = 18 months 5 days; range = 17 months 15 days to 18 months 15 days) participated in this study. In addition, 14 12-month-olds took part but were not included in the study either because of loss of interest in the game (7 infants), procedural error (5 infants), or interference by a parent (2 infants). Similarly, nine 18-month-olds were not included because they lost interest in the game before all experimental conditions were completed. Infants were recruited in Leipzig, Germany, from a list of parents who had expressed interest in participating in child development studies.³ Infants received a small gift for participating.

Design and Materials

Each infant participated in three activity groups (tease, refuse, play; see below for more details). Within each group, there was one trial for each experimental condition: an unwilling, a trying, and a distracted trial. Each infant thus participated in nine experimental trials, three in each experimental condition (see Table 1). These experimental trials were interspersed in a game of passing toys. The order of the three groups and the order of conditions within each group were counterbalanced across children.

The same type of toy was used for all conditions within a group, and the individual toys were assigned randomly to conditions within a group. In the tease group, three different balls were used; in the refuse and play groups, three different toy cars were used in one group and three toy animals in the other, with type of toy counterbalanced across children.

During the experiment, the infant sat on the parent's lap at a table (80 cm × 80 cm) across from a female experimenter. On the experimenter's side of the table, a ramp (38 cm long, 30 cm wide, 5 cm high at one end) attached to the table sloped down toward her, so that when she dropped the ball in the clumsy trial, it rolled back to her. At the end of the ramp, directly in front of the experimenter, there was a small platform attached to it (8 cm long × 30 cm wide, 7 cm high), on top of which the infant could clearly see a toy when the experimenter placed it in front of her. A telephone sat

on a small table next to her. When appropriate (in the distracted: telephone trial), the sound of a ringing telephone was produced when the experimenter pressed a button on a toy telephone hidden underneath the table with her foot. Dozens of small toys were passed to the infant in random order, and various containers (e.g., a spaghetti jar, a transparent box, and a bucket) were used for some test trials and part of the setup. An assistant sat next to the parent and infant holding a chute, which was used to encourage the infant to discard toys in between trials. The session was filmed with two video cameras, one facing the infant (and the experimenter from the side and back) and one facing the experimenter.

Procedure

At the beginning of the session, the experimenter and the assistant played with the infant on the floor until the infant was comfortable. This warm-up play included the experimenter showing the infant a few toys, putting toys down the chute, and handing the infant toys to put into the chute herself. The adults and the infant then moved to the table.

To set up the game of passing toys, the experimenter handed the infant a number of toys, one at a time. Some of these toys needed to be taken out of a container before the experimenter could pass them to the infant. Often when the experimenter showed a new toy that she was about to pass to the infant, she said "Oh look." When given a toy, the infant either took it and put it down the chute right away or played with it. The assistant then prompted the infant to put the toy down the chute or to hand it to her after playing with it for a bit. The next toy was not presented until the assistant had put the previous toy out of the infant's sight. Thus, during the test trials, none of the toys that the infant had been given before were available.

At the beginning of each test trial, the infant was shown a new toy but did not receive it for various reasons described below in detail. Each trial lasted 30 s (timed by the assistant), at the end of which the experimenter put that toy away and handed the infant a different one. The infant was given four toys in turn normally before the next test trial followed.

A test trial was only started if the infant had accepted at least three of the toys offered before, including the last one. If an infant lost interest in the game and stopped taking the toys offered, the session was ended and the infant was not included in the final sample of participants. Occasionally the experimenter interrupted the game because the infant was starting to become restless, but she resumed again after a brief break if the infant was interested again. The experimenter then continued with passing several toys before the next test trial started.

Parents were instructed not to say anything nor to point or gesture during the game. They were also asked to restrain their children if they climbed

³ Parents were first contacted via the city's birth register and were from mixed socioeconomic backgrounds. Before participating, parents signed letters of informed consent. All of the procedures in the study were in accordance with the relevant regulations of Germany and the Max Planck Society.

onto the table and started to crawl across, that is, to hold them back once they reached a black line 15 cm from the far end of the table, so that they could not crawl all the way across and get the toy themselves.

At the beginning of each test trial, the experimenter attracted the infant's attention and showed the infant a toy (sometimes inside a container) saying, "Oh look." The details of each condition were as follows:

Tease group. In all three conditions, the toy continually moved toward the infant and then away again, approximately the same number of times in each condition. The experimenter generally looked toward the infant. She only vocalized in the distracted-talk condition.

1. *Unwilling-tease:* During the 30 s, the experimenter repeatedly held forward a ball, looking at the infant. When the infant reached for the ball, the experimenter pulled it back again in a teasing fashion. She smiled in a teasing way.
2. *Trying-clumsy:* During the 30 s, the experimenter repeatedly held forward a ball, looking at the infant. When the infant reached for the ball, the experimenter "accidentally" dropped it, and the ball rolled down the ramp toward the experimenter. The experimenter's facial expression conveyed surprise and frustration.⁴
3. *Distracted-talk:* During the 30 s, the experimenter repeatedly held forward a ball, looking at the infant. Then, in the process of repeatedly turning toward the assistant and saying something to her, the experimenter pulled the ball back distractedly. The experimenter's facial expression was neutral, conveying concentration on the conversation.

Refuse group. In all three conditions, the experimenter placed the toy in front of her, alternated her gaze between the infant and the toy, and said "hmm" (in a different tone of voice for each condition) every now and then.

1. *Unwilling-refuse:* The experimenter placed the toy on the platform in front of her. During the next 30 s, she repeatedly alternated her gaze, looking down at the toy and at the infant, saying "hmm" every now and then. She smiled in a teasing way, conveying reluctance to pass the toy.
2. *Trying-reach:* The experimenter placed a tall glass jar with a toy inside on the platform and put her hand (up to her forearm) into the jar in an attempt to reach the toy at its bottom. During the next 30 s, she alternated her gaze, looking down at the toy and at the infant, occasionally saying "hmm." She frowned, conveying effort and frustration at not being able to reach the toy.
3. *Distracted-telephone:* As the experimenter placed the toy on the platform, the telephone rang and she put the receiver to her ear. During the next 30 s, she repeatedly alternated her gaze, looking down at the toy and at the infant, saying "hmm" every now and then as if in answer to the person on the telephone. Her facial expression was neutral, conveying concentration on her "conversation."

Play group. In all three conditions, the experimenter held the toy in her hand and looked down while moving the toy sideways in front of her. The experimenter did not vocalize.

1. *Unwilling-play:* The experimenter showed the infant the toy and during the next 30 s she held the toy in one hand and moved it repeatedly from left to right on the platform in front of her while looking down at it (if the toy was a car, the experimenter rolled it; if the toy was an animal, she made it walk). The experimenter's

facial expression was friendly-neutral, and she looked interested in the toy.

2. *Trying-open:* The experimenter showed the infant the toy inside a transparent container and during the next 30 s the experimenter attempted unsuccessfully to open the lid of the container, moving it along the platform in front of her in her efforts while looking down at it. She frowned, conveying effort and frustration at not being able to reach the toy.
3. *Distracted-search:* The experimenter showed the infant the toy, and during the 30 s the experimenter held the toy in one hand and as she was searching in a bucket of toys on her lap with her other hand, she absently moved the toy repeatedly from left to right on the platform in front of her. The experimenter's facial expression was concentrated and determined.

Coding

Infants' behavior during each of the 30-s trial periods was coded from videotape using the program Interact (i.e., live from video; Interact 6.8 Mangold; Thiel, 1991). For response measures, we analyzed the frequency and duration of infants' spontaneous gestures such as reaching and banging and the infants' disengaging from the game as shown by looking or turning away.

Reaching was coded when the infant's arm was fully outstretched in the direction of the experimenter or the toy while the infant was also looking in that direction. A reach or gesture started when infants moved their arm forward and ended as soon as they pulled it back. (Those few occasions during which an infant was clearly reaching and just glanced away briefly were also included in the same reach.) Reaching and pointing gestures were coded as reaching because of the difficulty of distinguishing them reliably. *Banging* was coded when the infant lowered one or both hands (either flat hand or fist) onto the table or onto the chute right next to the table with an audible effect (as long as the infant was not turned away). Each audible lowering of the infant's hand counted as one bang; if both hands were lowered simultaneously this counted as one bang. Sounds that occurred as the infant lowered their hand again after reaching, when leaning on one hand, or in the process of climbing onto the table were not included. *Looking away* was coded when the infant's head was turned sideways, away from the experimenter and/or the toy, or when the infant looked down onto the table or up at the ceiling. Other behavioral responses that occurred were leaning forward, climbing onto the table, vocalizing, pointing elsewhere, banging with the feet, smiling, turning to the parent, and playing with the chute or ramp. These were not coded separately either because they occurred infrequently, because they were already subsumed in other measures, or because they were difficult to code reliably.

For each parameter, 5 infants (20%) in each age group were coded independently by a second observer, who was blind to the hypotheses of the study. Interobserver reliability was determined by calculating Pearson product-moment correlation coefficients. If the number of categories observed in the coded data was five or less, the interobserver reliability was assessed by using weighted Kappa (linear differences). Interobserver agreement was high for all parameters (for 12-month-olds, reaching: $r = .98$, banging: $r = .96$, looking away: $r = .86$; for 18-month-olds, reaching: $r = .96$, banging $\kappa = .73$, looking away $r = .99$; all $ps < .001$).

Data Analyses

Because of the heterogeneity of variance, the data were analyzed non-parametrically. For each age group, the infants' responses in the different

⁴ In both unwilling-tease and trying-clumsy trials, retraction or dropping of the ball were contingent on the infant's reaching behavior.

conditions (unwilling, trying, and distracted) were compared for each group (i.e., tease, refuse, and play) by performing a Friedman test. If significant differences were found, pairwise comparisons between the unwilling and trying conditions as well as between the unwilling and distracted conditions were performed using Wilcoxon signed-ranks tests. In order to test for effects of order, we performed a Friedman test with nine trials for each parameter and age group. All statistical tests were two-tailed.

Results

The order of conditions did not have any significant effects on the infants' responses in either age group for any of the response parameters. Thus, this factor was not included in further analyses.

Table 2 presents the results of the Friedman tests for each group. Analyses of the 12-month-olds' responses revealed significant differences between the unwilling, trying, and distracted conditions in all three groups for both the reaching and the looking parameters. The same was observed for the 18-month-olds. The banging rates were generally low, and no differences in banging between the conditions were observed at either age for any group. Thus, the infants' banging frequency was not analyzed further.

Unwilling Versus Trying

For the 12-month-olds, comparisons between unwilling and trying conditions revealed that for all three groups the infants reached significantly longer when the experimenter was unwilling than when she was trying (see Figure 1 for means of reaching and looking-away durations and Table 3 for statistical results). In addition, in the refuse and the play groups, but not the tease group, infants also looked away significantly more when the experimenter was unwilling to pass the toy than when she was trying to do so.

For the 18-month-olds, comparisons between unwilling and trying conditions also revealed significant differences in infants' reaching durations for all groups. The 18-month-olds also looked away significantly more when the experimenter was unwilling rather than trying, in both the tease and the refuse groups, with the same trend occurring in the play group (see Figure 2 for means and Table 3 for statistics).

In summary, both the 12- and the 18-month-olds reached consistently longer when the experimenter was unwilling to pass them a toy than when she was trying to do so. They also usually looked away more in the unwilling than the trying conditions, especially when the experimenter was refusing to pass the toy.

Unwilling Versus Distracted

For the 12-month-olds, comparisons of the unwilling to the distracted conditions yielded significant differences in the tease

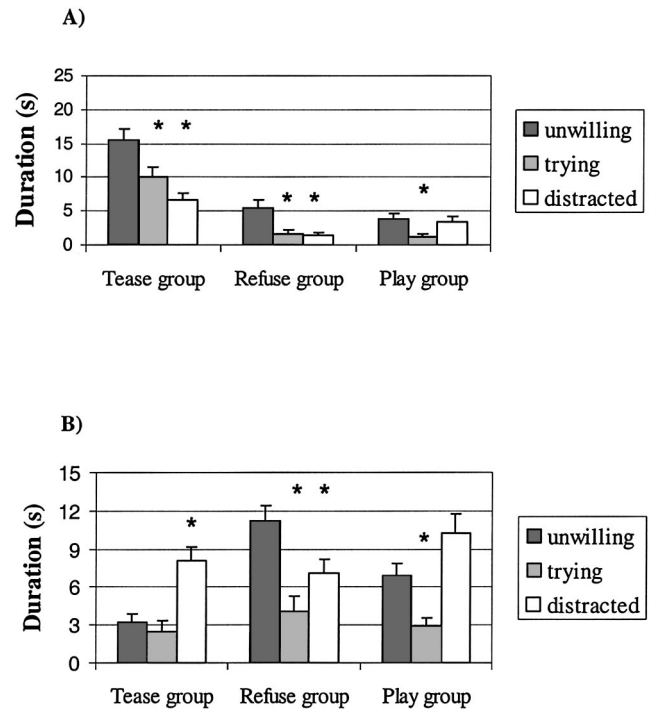


Figure 1. 12-month-olds' reaching responses (A) and looking away responses (B). The asterisks mark significant differences with respect to the unwilling conditions. Error bars represent standard error.

and the refuse groups (see Figure 1 for means of reaching and looking-away durations and Table 4 for statistical results). In the refuse group, infants reached significantly more and also looked away significantly more when the experimenter was unwilling to pass the toy than when she was distracted by a phone call. In the tease group, infants also reached significantly more when the experimenter was unwilling to pass a toy (pulling it back teasingly instead) than when she was distracted by a conversation. The looking behavior, however, showed a different pattern in this group, with infants looking away more when the experimenter was distracted. This was probably due to the fact that looking to the person the experimenter was talking to when distracted was also coded as looking away. In the play group, infants also tended to look away more when the experimenter was distracted (searching in the toy bucket) than when she was unwilling to pass the toy (playing with it herself instead).

Table 2
Results of Friedman Tests Performed for 12- and 18-Month-Olds for Each Group

Age in months	Response parameter	Tease group		Refuse group		Play group	
		$\chi^2(2, N = 24)$	<i>p</i>	$\chi^2(2, N = 24)$	<i>p</i>	$\chi^2(2, N = 24)$	<i>p</i>
12	Reaching	19.1	<.001	14.9	.001	12.5	.002
	Looking	18.7	<.001	14.0	.001	13.8	.001
	Banging	1.8	.423	0.0	1.000	0.1	.929
18	Reaching	24.2	<.001	22.1	<.001	14.9	.001
	Looking	22.1	<.001	32.0	<.001	8.3	.016
	Banging	3.9	.143	3.6	.164	0.8	.674

Table 3
Results of Wilcoxon Signed-Ranks Tests Comparing Unwilling and Trying Conditions for 12- and 18-Month-Olds in Each Group

Age in months	Response parameter	Tease group		Refuse group		Play group	
		Z	p	Z	p	Z	p
12	Reaching	3.23	.001	2.86	.004	2.64	.008
	Looking	0.67	.500	3.34	.001	2.86	.004
18	Reaching	2.73	.006	3.70	<.001	3.49	<.001
	Looking	1.96	.050	4.20	<.001	1.67	.094

Table 4
Results of Wilcoxon Signed-Ranks Tests Comparing Unwilling and Distracted Conditions for 12- and 18-Month-Olds in Each Group

Age in months	Response parameter	Tease group		Refuse group		Play group	
		Z	p	Z	p	Z	p
12	Reaching	3.99	<.001	3.24	.001	-0.33	.739
	Looking	-3.74	<.001	2.91	.004	-1.95	.051
18	Reaching	3.77	<.001	3.46	.001	2.88	.004
	Looking	-3.48	.001	0.30	.764	-1.62	.105

For the 18-month-olds, comparisons of the unwilling to the distracted conditions showed that infants reached significantly longer in the unwilling than the distracted conditions in all three groups (see Figure 2 for means and Table 4 for statistics). In the tease group, the 18-month-olds, like the 12-month-olds, also looked away more when the experimenter was distracted (probably for the same reason mentioned above).

Thus, both 12- and 18-month-old infants usually reached significantly more when the experimenter was unwilling to give them a toy than when she was distracted. An analysis of infants' looking responses, however, yielded mixed results.

Discussion

Both 12- and 18-month-old infants responded differently when an adult was unwilling, as compared with when she was trying

unsuccessfully (in the sense of both failed attempts and accidents), to give them a toy. Specifically, infants of this age tended to reach more for the toy and also look away more when the adult showed unwillingness in various ways, whereas they reached less and looked away less when the adult was trying. They did this for all three groups of actions, which differed from one another in many specifics, suggesting that infants were indeed focused not on the superficial body movements involved in the various cases but rather on the actor's underlying goal (see General Discussion for more on this point).

Unlike studies using preferential looking and habituation techniques—which simply demonstrate that infants discriminate two visual scenes—in the current study, infants' overt behavior was appropriately adapted to the social situation. That is, infants did not just discriminate the two types of adult actions but they interpreted each in its own way and reacted appropriately: They showed impatience when the adult was unwilling to give them a toy (by reaching and/or looking away), but they showed patience (less reaching and looking away) when the adult was unable to give them the toy. They appeared to know that in the unwilling condition the adult was doing just what she wanted to do (retaining the object was part of her goal), whereas in the unable condition she was not achieving what she wanted to (because giving the toy was her goal).

Infants' communicative responses indicate that they considered and addressed the experimenter. Although in the current methodology, reaching and pointing were not specifically distinguished, it is important to note that even when infants were reaching it was very likely communicative, at least in those two groups where the toy was far out of the infants' reach. This is because in noninteractive contexts, even 6-month-old infants almost never reach for objects that are clearly too far away for them to touch (Rochat, Goubet, & Senders, 1999). And so for these groups, our interpretation of the reaching–pointing behavior is as communicative acts.

When the experimenter was distracted, infants did not behave in a consistent manner. Although infants reached less in the distracted as compared with the unwilling condition, there were mixed results with regard to their looking behavior. The most obvious interpretation is that being distracted is an ambiguous state in the current experiment situation. That is, if the experimenter really wanted to give the infant a toy, she should not have allowed or herself to be distracted by other things, especially when it was possible to do both things at once. And even if the the experimenter was temporarily distracted from the interaction, communicative signs of frustration such as repeated reaching should have brought her

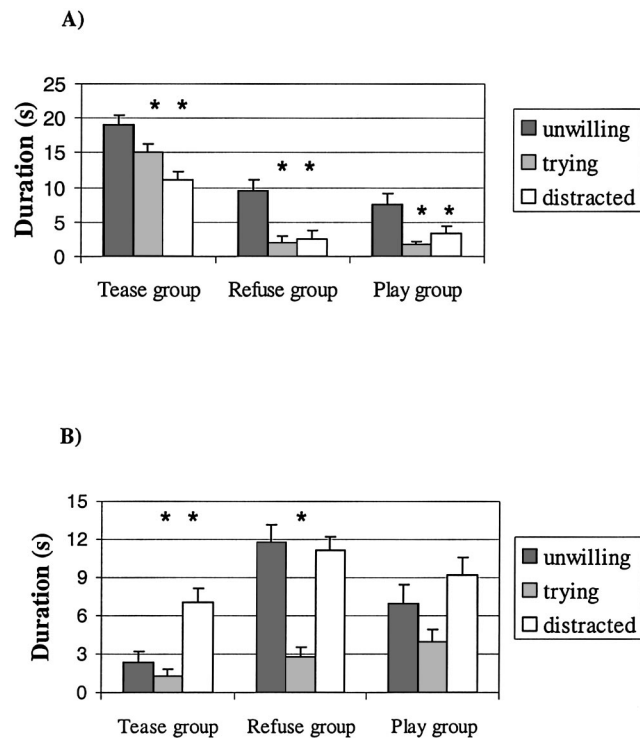


Figure 2. 18-month-olds' reaching responses (A) and looking away responses (B). The asterisks mark significant differences with respect to the unwilling conditions. Error bars represent standard error.

attention back to the interaction. Thus, distracted is neither fully unwilling nor fully unable, and that is the most likely reason that infants were not totally consistent in this condition.

Study 2

Given our strong results with 12-month-olds, who fail some tests of intention-reading in imitation, and given some positive findings with 9- and even 6-month-olds in visual habituation studies, we decided to use this same basic procedure with younger infants. Because of the interpretive difficulties of the distracted conditions in Study 1, these were omitted from Study 2.

Method

Participants

Twenty-four 6-month-olds (15 girls, 9 boys; mean age = 6 months 13 days; range = 5 months 26 days to 6 months 29 days) and 24 9-month-olds (11 girls, 13 boys; mean age = 9 months 8 days; range = 8 months 28 days to 9 months 18 days) participated in this study. In addition, four 6-month-olds took part but were not included in the final sample, either because of tiredness and loss of interest in the game (3 infants) or because of procedural error (1 infant). Similarly, two 9-month-olds were not included because of fussiness and loss of interest in the game.

Design and Materials

For the 6- and 9-month-olds, the study consisted of six experimental trials, that is, three groups of unwilling and trying conditions. The setup was exactly the same as described for Study 1 with one exception: whereas for both 12- and 18-month-olds the platform was right in front of the experimenter at the edge of the table, in the case of 6- and 9-month-olds, the ramp and platform were placed 15 cm further toward the infant's side of the table, so that the distance between the ramp and the infant's outstretched arms was comparable for the different age groups.

Procedure

The general procedure and the six experimental trials were the same as in Study 1. The 9-month-old infants were also given four toys in turn normally before the next test trial followed (just as with the 12- and 18-month-olds). In the case of the 6-month-olds, the number of toys the infant received before each test trial was three toys, instead of four, to shorten the total procedure.

Coding

The coding of response parameters and the assessment of interobserver reliability were done in the same way as in Study 1. Interobserver reliability, based on the data of 5 infants (20%) from each age group, was high for all parameters (for 6-month-olds, reaching: $r = .94$, banging: $r = .88$, looking away: $r = .88$; for 9-month-olds, reaching: $r = .82$, banging: $r = .90$, looking away: $r = .95$; all $ps < .001$).

Data Analyses

Nonparametric analyses were performed because of the heterogeneity of variance. The unwilling and trying conditions were compared using Wilcoxon signed-ranks tests. In order to test for order effects, we performed a Friedman test with six trials for each age group and parameter. All statistical tests were two-tailed.

Results

No order effects were observed for either age group. Thus, this factor was not included in further analyses. For the 6-month-olds, a comparison of the unwilling with the trying conditions revealed no significant differences in the reaching or in the looking parameter in any of the three groups (see Figure 3 for means of response parameters and Table 5 for statistics). For the banging parameter, significant differences were observed in two of the groups, but the effects were in opposite directions. Whereas in the refuse group the infants banged more when the experimenter was unwilling than unable to pass a toy, in the tease group the opposite pattern was found, with infants banging significantly more when the experimenter was unable to pass the toy. Thus, for the 6-month-olds, no consistent differences between unwilling and trying conditions were observed in any of the parameters.

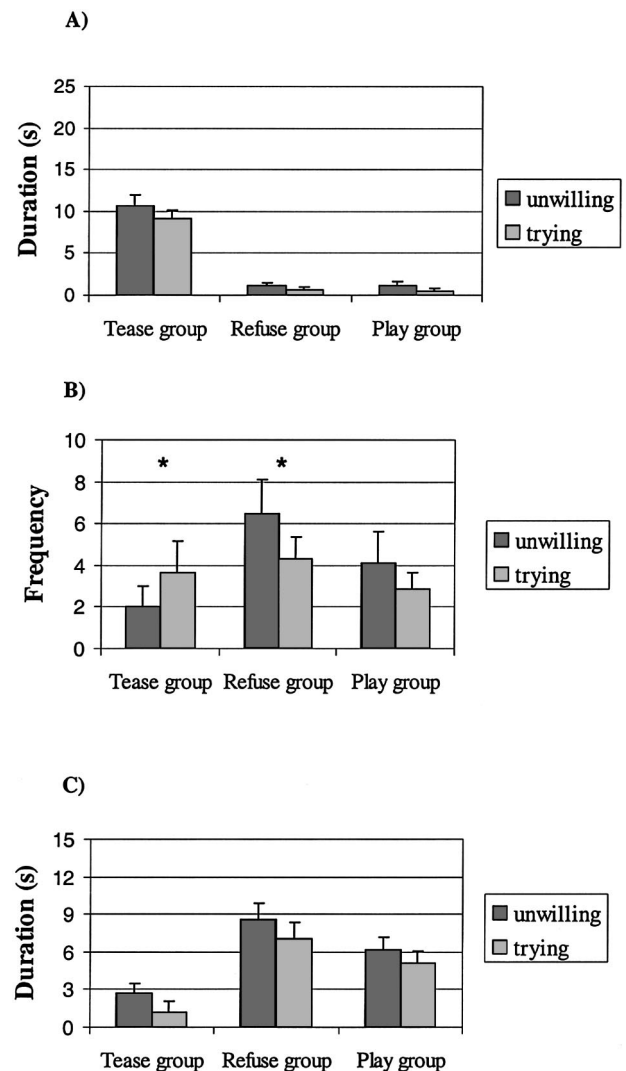


Figure 3. 6-month-olds' reaching response (A), banging response (B), and looking away response (C). The asterisks mark significant differences between unwilling and trying conditions. Error bars represent standard error.

Table 5
Results of Wilcoxon Signed-Ranks Tests Comparing Unwilling and Trying Conditions for 6- and 9-Month-Olds in Each Group

Age in months	Response parameter	Tease group		Refuse group		Play group	
		Z	p	Z	p	Z	p
6	Reaching	1.48	.139	1.23	.217	1.26	.206
	Looking	1.70	.098	1.10	.276	0.60	.542
	Banging	-2.20	.027	2.00	.049	0.90	.395
9	Reaching	2.26	.024	2.78	.005	0.39	.694
	Looking	1.34	.180	3.85	<.001	1.31	.191
	Banging	2.56	.010	2.34	.019	2.54	.011

In contrast, the 9-month-olds showed consistent significant differences in their responses to the unwilling compared with the trying conditions (see Figure 4 for means of response parameters and Table 5 for statistics). For all three groups, the infants banged more when the experimenter was unwilling to pass the toy than when she was unable to do so. In the refuse group, they also reached longer and looked away significantly more when the experimenter was unwilling than when she was trying to reach the toy in order to pass it. Similarly, in the tease group infants also reached more for the toy when the experimenter was unwilling to hand it over, pulling it away teasingly, than when she was trying to pass it but dropping it clumsily.

In summary, 9-month-olds showed consistent differences in their reactions to the unwilling compared with the trying conditions in all three groups, especially in their banging and also in their reaching responses. The 6-month-olds, however, showed no consistent differences in their responses depending on whether the experimenter was unwilling to pass a toy or trying to do so.

Discussion

In Study 2, 9-month-olds behaved very similarly to the 12- and 18-month-old infants in Study 1. They too showed more impatience (reaching more for the toy and banging more on the table) when the experimenter showed unwillingness to give the toy in various ways, whereas they showed more patience (less reaching and banging) when the experimenter was making good-faith attempts to give them the toy. In this experimental paradigm, even 9-month-olds thus showed a nascent understanding of trying and accidents—the most diagnostic cases of goal-directed action.

In contrast, there was no evidence that 6-month-olds differentiated between the adult's behavior in the unwilling and trying conditions. This is not because they were unresponsive during the experimental trials. The overall rate of banging, for example, was just as high for 6-month-olds as for 9-month-olds; it just did not differ systematically between conditions. Despite the fact that at least some of the response measures were not too demanding for 6-month-olds to perform, infants at this age did not respond differentially to these two types of intentional action. Thus, 6-month-olds showed no evidence of understanding that people's actions are governed by goals.

Individuals' Scores Across Study 1 and Study 2

In order to assess infants' individual performances across all four ages, we calculated an index for each infant by combining the

findings from different groups of conditions and response parameters. For each pair of matched unwilling and trying conditions for each response parameter, an infant received 1 point if she or he showed a differential response in the expected direction (e.g., banging more in the unwilling than the trying condition), 0 points if no difference was observed, and -1 point if the observed difference was in the opposite direction. As there were three pairs of matched unwilling and trying conditions, an infant could receive a score between -3 and + 3 for each response parameter, thus yielding an overall score between -9 and + 9 points when all three response parameters (reaching, banging, and looking away) were summed.

For the 6-month-olds, 13 out of 24 infants obtained a positive overall score, which is not significantly different from chance. For the 9-, 12-, and 18-month-olds, however, the number of infants who obtained a positive score was 20, 18, and 19 infants (out of 24), respectively, each of which was significantly above chance

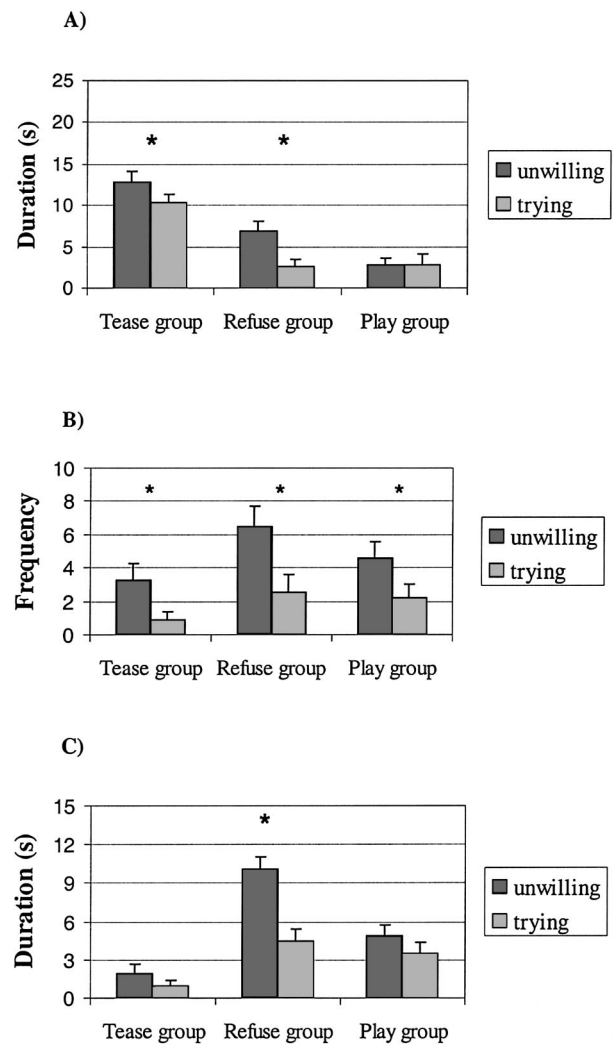


Figure 4. 9-month-olds' reaching responses (A), banging responses (B), and looking away responses (C). The asterisks mark significant differences between unwilling and trying conditions. Error bars represent standard error.

(binomial test: $p < .05$ in each case). These individual analyses thus corroborate those of the main group analyses: 9-month-old infants and older infants show evidence of some understanding of intentional action, but 6-month-old infants do not.

General Discussion

In the current studies, infants aged 9 months and older responded differently and appropriately when the experimenter was unwilling to give them a toy (with impatience) as compared with when she was trying to give them a toy (with patience)—even though they did not actually receive the toy in either case. These differences were robust across different types of unwilling and trying behaviors and for different response measures. Six-month-olds did not behave differently in these two types of social situations. Our interpretation is that beginning at around 9 months of age infants do not just perceive other people's surface bodily motions but rather they interpret their action as a function of their goal: in this case, to give the toy or not (or perhaps, more specifically, to tease them or to give it to them, etc.). The only previous solid evidence of infants' understanding of successful versus unsuccessful action has come from imitation methodologies, with an understanding of trying being demonstrated only at 15 months and an understanding of accidents only being demonstrated at 14 to 18 months (see above).

Alternative explanations of the current results involving superficial differences between conditions are unlikely. Within matched pairs of unwilling and trying conditions, the infant's distance to the toy as well as the toy's position and movement were closely matched, as was the overall topography of the experimenter's motoric and visual behavior. For example, in both the teasing and clumsy conditions, the experimenter held out the toy to the infant while looking at the infant, but before the infant could grasp it, the toy returned back to the experimenter. There were differences in the experimenter's behavior, especially in her facial expressions, but these cannot be easily related to the infants' differential responses at a superficial level. For example, the experimenter smiled more when she was unwilling to pass a toy in the refuse condition than when she was trying to pass it in the reach condition. But it was in the unwilling rather than the trying condition that infants looked away more—which is unusual because in most circumstances infants do not tend to look away from a smiling face (Nelson, 1987). And even if one could plausibly explain infants' qualitative reactions on the basis of superficial differences of adult behavior within one matched pair of conditions, a different story would have to be told for the other two matched pairs.

The toy's accessibility is another important aspect when considering alternative explanations for infants' pattern of responses. For example, in two of the three unable conditions, but not in the unwilling conditions, the toy was inside a transparent container. This difference between the conditions may account for differences in infants' reaching responses in these groups of actions. It does not, however, account for the difference in looking and banging responses that were also observed. The combination of different matched pairs of actions and different response measures is thus a particular strength of this new method, as it makes alternative explanations involving superficial cues unlikely to succeed. Instead, in our view, the most plausible explanation for the observed pattern of responses is that infants behaved similarly in

the various unwilling conditions (with impatience) and also similarly in the various trying conditions (with patience) because in each case they perceived a common thread: part of the experimenter's goal in the first set of conditions was to keep the object for herself and in the second set of conditions was to give it to the infant.

From a methodological point of view, it is important to note that well-known studies such as those of Woodward (1998) do not establish the understanding of goals in this same way. Thus, Woodward (1998) found that 6-month-olds showed a stronger novelty response (i.e., looked longer) when an actor reached to the same location as before and grasped a new object than when an actor reached and grasped the same object after its location changed. This tells us that infants perceive adult behavior as object directed. But it does not enable us to determine whether the infant distinguishes between successful acts and unsuccessful acts—the *sine qua non* of goal-directed behavior—as in both cases the actor's behavior is object-directed in similar ways. In contrast, our findings show that infants as young as 9 months of age discriminate between actions with different goals behind them even when they have the same outcome. The habituation studies of Gergely and colleagues (Csibra et al., 1999; Gergely et al., 1995) and Woodward (1999) are potentially more diagnostic of infants' understanding of goal-directed behavior, but, as argued above, they do not directly test failed attempts or accidents and so fail to distinguish successful and unsuccessful actions. Nevertheless, the age at which infants showed skill in those studies, 9 to 12 months (but not 6 months), corresponds exactly to the current findings.

From a theoretical point of view, the current results add to a growing body of findings demonstrating the remarkable social-cognitive skills of 1-year-old infants (see Tomasello & Haberl, 2003, for skills regarding attention understanding and Gergely, Bekkering, & Király, 2002, discussed below). All of these findings together suggest that 9- to 14-month-old infants operate with some understanding of others' psychological states—as argued by, for example, Carpenter, Nagell, and Tomasello (1998) and Tomasello (1999).

This is not to say that 9- and 12-month-old infants understand all aspects of intentional action. In particular, Tomasello, Carpenter, Call, Behne, and Moll (in press) argued and presented evidence that the understanding of intentional action actually emerges in two steps in human ontogeny. First, as in the current study, 9-month-old infants understand intentional action as pursuing goals persistently. But second, as Gergely et al. (2002) have demonstrated, 14-month-olds also understand that actors can choose between different possible action plans based on their perception of current reality and its constraints, that is, they understand the rational dimensions of the process. There is nothing in the current study to suggest such an understanding (because it was not designed to test this), and indeed it is not clear whether any method other than imitation—in which the infant directly acts out what she or he understands the adult to be doing—could possibly provide evidence for this second level in the understanding of intentional action.

It is important to note that these two levels of understanding are directly reflected in infants' social interactions with other people. Thus, 9- to 12-month-old infants begin to engage with other people in a variety of different kinds of triadic interactions involving joint action and/or joint attention, presumably because understanding

others as agents pursuing goals is a major prerequisite for engaging in these triadic interactions (Carpenter, Nagell, & Tomasello, 1998; Tomasello, 1995). In addition, older infants start to engage in various kinds of collaborative social activity—including such things as linguistic communication and the beginnings of cooperative play. These kinds of interactions indicate that infants now have some skills of shared intentionality that go beyond understanding that actors pursue goals to include, among other things, understanding the action plans (intentions) that others choose for pursuing those goals (Tomasello et al., in press).

Finally, it is interesting to note that in an experimental procedure very similar to the current one, Call et al. (2004) found that chimpanzees also discriminate and react appropriately to situations in which a human is unwilling to give them food and ones in which a human is trying to give them food—which presumably indicates that chimpanzees also understand others as pursuing goals (contra Tomasello, 1999; Tomasello & Call, 1997). Still, there is currently no evidence that apes understand others as choosing plans, and so they do not, for this and other reasons, engage in collaborative activities involving shared intentionality with others. Future research should be aimed at exploring further the connection between children's understanding of the intentional actions of others and the way they interact with others socially and communicatively.

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