



Published in final edited form as:

Psychol Sci. 2009 January ; 20(1): 85–91. doi:10.1111/j.1467-9280.2008.02246.x.

You can't always get what you want: Infants understand failed goal-directed actions

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Abstract

When do infants understand that goals exist independently of the actions that result from them? Exploring infants' understanding of failed intentional actions—when the goal of the action is unfulfilled and thus non-apparent in the actor's movements—critically addresses this question. Using a visual habituation paradigm, we assessed when infants understand that a failed intentional action is goal-directed and whether an understanding of successful intentional actions (actions that do overtly attain their goals) precedes an understanding of failed intentional actions. Results demonstrate that 10- and 12-month-olds recognized the goal-directedness of both successful and failed reaching actions. Eight-month-olds also recognized the goal-directedness of successful actions, but failed to do so for unsuccessful attempts. These results show that by the first year of life, infants possess an impressive understanding of intentional action and that an understanding of failed intentional actions follows an earlier understanding of successful ones.

A hallmark of human cognition is the ability to transcend information provided by the behavior stream and make inferences about the underlying causes of human action. Indeed, the success of human social interaction rests upon the recognition that people act according to internal mental states such as beliefs, desires, and intentions. An important developmental question is, thus, when do children come to perceive the motions of others as guided by intentions? A critical test for this knowledge is one that involves reasoning about the goal of a *failed* action. Inferring a goal when it is unfulfilled and thus non-apparent in the actor's movements or the outcome achieved would not be possible without penetrating deeper than the surface appearance of the action. Thus, appreciation of failed action as goal-directed provides firm evidence for understanding that goals exist independently of the particular actions performed. When and how does this understanding develop?

Two sets of findings frame this question. First, infants in the second year clearly appreciate the intentions underlying failed actions. The firmest demonstration of this comes from Meltzoff (1995) where, after witnessing an adult try but fail to fulfill several novel, object-directed goals (e.g., trying to hang a ring on a hook), 18-month-olds read through the actor's bodily movements to the underlying intention of the action. Although infants never saw the actions successfully modeled, when given a chance to act on the objects themselves they "imitated" the successful goal-directed actions much more than the failed (actually witnessed) actions. Replications of these experiments have shown that 15-month-olds (Carpenter et al., 1998) but not 12-month-olds (Bellagamba & Tomasello, 1999) also display

this pattern (see also Olineck & Poulin-Dubois, 2005). Thus, clearly by 15- to 18-months, infants appreciate the unfulfilled goals of failed actions.

Second, during the first year, infants are sensitive to the intentional structure of actions (Baldwin et al., 2001) and appreciate the goal-directedness of *successful* intentional actions (Csibra et al., 1999; Gergely et al., 1995; Phillips & Wellman 2005; Sodian et al., 2004; Woodward, 1998). These findings generally come from looking-time methods. For example, in Phillips and Wellman (2005), infants were habituated to an actor reaching over a barrier with an arcing motion to successfully retrieve a ball. After habituation, infants saw two test displays in which the barrier was removed. In the *direct* test event, the actor reached directly for the ball and successfully obtained it: the arm traced a new path, but the action was consistent with the previous goal of directly reaching the ball. In the *indirect* test event, the actor reached in an arcing path and successfully obtained the ball: the arm movement was identical to that in habituation, but, because the barrier was absent, the action was no longer consistent with attempting to reach the goal as directly as possible. If during habituation infants encoded the action in terms of its *goal* (getting the object as directly as possible), then during the test phase they should look longer at the event that is inconsistent with that goal—the indirect event. In contrast, if during habituation infants encoded the action in terms of its *perceptual features* (reaching in an arcing motion), then during the test phase they should look longer at the event that is inconsistent with those perceptual features—the direct event. Results show that infants look longer at the indirect than the direct test event and even do so for actions of computer-generated “abstract” agents (Csibra et al., 1999; Gergely et al., 1995; Phillips & Wellman, 2005; Sodian et al., 2004). Thus, by the last half of the first year (see also Woodward, 1998), infants are sensitive to the goal-directedness of various successful actions.

That infants appreciate *successful* actions as goal-directed does not necessarily imply that they appreciate the intentions underlying those actions. In the case of successful actions, infants may identify the goal-object that the actor is moving toward on the basis of the external result of the action—a teleological rather than intentional understanding (Gergely & Csibra, 2003). As proposed by Gergely and Csibra (2003), a teleological stance interprets goals as manifest in *actions*. In contrast, an intentional stance focuses on internal states of *intention* — even in the absence of or at odds with observed action. Thus, infants’ ability to reason about the goal of a *failed* action—when visible achievement of the goal-object is not available to instantiate the actor’s goal—is of special import.

Although it is clear that older infants (15- to 18-month-olds) understand failed goal-directed actions, it is less clear whether and when younger infants also understand them (see Behne et al., 2005; Hamlin et al., in press). Moreover, it is an important open question whether or not an understanding of failed actions builds off of an understanding of successful ones. Some have proposed developmental accounts whereby a simplified understanding of object-connectedness precedes a later intentional understanding (Phillips & Wellman, 2005; Woodward, 1998) or a teleological understanding precedes an intentional, mentalistic one (Gergely & Csibra, 2003). On this view, understanding failed actions would represent an advance in intentional understanding over an initial awareness of object-directedness in successful actions that transparently instantiate their goals. However, other theorists attribute to infants a deep, innate understanding of intention that is automatically elicited when seeing animate movements (e.g., Baron-Cohen, 1995; Premack, 1990). On this account, an understanding of failed intentional actions would co-occur in development with an understanding of successful intentional actions because the same animacy cues are present in both actions.

To explore these questions, we devised a visual habituation paradigm suitable for younger infants and directly compared infants' understanding of successful and failed intentional actions. The habituation and test events are shown in Figure 1. Our *successful action* condition was identical to the experimental condition of Phillips and Wellman (2005): an actor reaches over a barrier with an arcing arm motion and successfully retrieves a ball. In our *failed action* condition, infants saw a parallel display in which the actor reaches over the barrier with an arcing arm motion, however, crucially, the actor's reach is unsuccessful: the reach falls short of grasping the ball. In both conditions, test events were identical (and identical to those in Phillips & Wellman, 2005). In the *direct* test event, the actor reaches directly for the ball and, with no barrier to interfere, successfully obtains it. The arm traces a new path, but the action is consistent with the previous goal of directly reaching the ball. In the *indirect* test event, the actor reaches in an arcing path (although the barrier is gone) and successfully obtains the ball. The arm movement is identical to that in habituation and the action is successful, but it is no longer consistent with attempting to directly reach the goal-object.

If infants can infer the goal of a *failed* reaching action, they should look longer at the indirect than the direct test event, just as they do when habituated to successful reaches. Furthermore, if understanding of successful goal-directed actions precedes understanding failed actions, we should find an age at which infants in the successful-reaching condition look longer at the indirect event and infants in the failed-reaching condition do not. In sum, we ask: (1) Do younger infants (8-, 10-, 12-month-olds) understand both successful and failed goal-directed actions? (2) When conditions are as comparable as possible, does understanding failed actions follow understanding successful goal-directed actions?

Method

Participants

Participants included 132 8-, 10-, and 12-month-olds¹ (66 males, 68 females; 8-month-olds: $n = 46$, $M = 7.91$, $SD = .28$; 10-month-olds: $n = 44$, $M = 9.73$, $SD = .48$; 12-month-olds: $n = 44$, $M = 11.80$, $SD = .40$). Thirty-seven additional infants were excluded for fussiness ($n = 18$), observer error ($n = 14$), interference ($n = 4$), and computer problems ($n = 1$). Infants were assigned to the *successful-reaching* (8-month-olds: $n = 23$, $M = 7.79$; 10-month-olds: $n = 24$, $M = 9.55$; 12-month-olds: $n = 24$, $M = 11.70$) or *failed-reaching* conditions (8-month-olds: $n = 23$, $M = 8.03$; 10-month-olds: $n = 20$, $M = 9.94$; 12-month-olds: $n = 20$, $M = 11.91$). Participants were predominantly European American and from middle-income homes.

Procedure

Infants sat before a computer monitor. Video events were presented in an infant-controlled habituation design (Cohen et al., 2004). Phillips and Wellman (2005) demonstrated that 12-month-olds treated videos of an actor reaching identically to equivalent live displays. A trial ended when the infant looked away for 2 continuous seconds or after 60 seconds, whichever came first.

Infants saw a minimum of 4 and maximum of 10 habituation trials, followed by 6 test trials. Test trials began once the average looking-time across three consecutive trials dropped below 50% of that during the first three trials. Looking-times to each trial were coded on-line. Test trials for 33% of participants were recoded by a second coder. Observers' judgments agreed within 1 second or less on 93.7% of trials.

¹Data from 12-month-olds in the successful-reaching condition were reported in Study 2 of Phillips & Wellman (2005).

Habituation events—Infants saw one of two events. In the *successful-reaching* condition, a man is seated (in profile) at a table in front of a wall-like barrier and ball. The actor reaches over the barrier (with an arcing motion), grasps the ball, brings it back to his torso (tracing the same arcing motion), and the video freezes (Figure 1a). The *failed-reaching* condition habituation event is identical except that the reach is *unsuccessful*. The actor reaches over the barrier with the same arcing motion as in the successful-reaching condition; however, his reach falls short of the ball. He neither grasps nor occludes the ball with his hand. He brings his empty hand back to his torso and the video freezes.

Test events—Following habituation, infants in both conditions were shown two test events (identical to Phillips & Wellman, 2005). In both events, the barrier is absent and the actor successfully grasps the ball. In the *direct-reach event*, the man reaches directly (in a straight line) for and grasps the ball. He brings it back to his torso (following the same straight path) and the video freezes. The arm traces a path that is perceptually different from the arcing path in habituation; however, the action is consistent with the prior goal of directly reaching for the ball (Figure 1b). In the *indirect-reach event*, the actor reaches for the ball in the same arcing path as in habituation though the barrier is absent. He grasps the ball, brings it to his torso, and the video freezes. Here the path is perceptually identical to that in habituation; however, the action is inconsistent with the prior goal of directly reaching for the ball. Test events were shown three times each in an alternating sequence and counterbalanced order.

Results

Habituation

On average, infants watched 9.06 trials ($SD = 1.56$) and spent 96.77 seconds ($SD = 42.84$) viewing the habituation events. This did not differ across condition or age group. Many infants did not meet the habituation criterion (successful-reaching condition: 63.4% of infants; failed-reaching condition: 65.1% of infants), but what is critical is that infants received sufficient exposure to and began to lose interest in the habituation events. Average looking times to the first and last habituation events were entered into an ANOVA with trial (first, last) as the within-subjects factor and age group (8-, 10-, 12-months) and condition (successful-reaching, failed-reaching) as the between-subjects factors. There was a main effect of trial, $F(1, 125) = 48.14, p < .001, p_{rep} = .99, \eta_p^2 = .28$, and an interaction of trial by condition, $F(1, 125) = 6.14, p = .015, p_{rep} = .94, \eta_p^2 = .047$. Looking-times declined significantly across the habituation phase in both conditions, although the decrement of attention was greater in the failed- (first trial: $M = 14.76$; last trial: $M = 7.56$) than in the successful-reaching condition (first trial: $M = 11.63$; last trial: $M = 8.22$). This looking-time decline did not differ as a function of age group.

Test

Our hypotheses concern (a) whether infants look longer at the indirect test event in the failed- as well as the successful-reaching condition, and (b) whether at some age infants do so in the successful- but not the failed-reaching condition. We tested for these patterns using planned comparisons between the conditions at each age. We began with ANOVA to examine the overall pattern of results and, because looking-time data are consistently skewed and non-normal (in this and other research; e.g., Spelke et al., 1992), we confirmed our parametric planned comparisons with nonparametric tests.

In the ANOVA with test event (direct, indirect) as the within-subjects factor and age group (8-, 10-, 12-months), condition (successful-reaching, failed-reaching) and gender (male, female) as the between-subjects factors, there was no effect of gender, but there were

significant effects of condition, age, and test event. Critically, there was a main effect of test event, $F(1, 122) = 38.09, p < .001, p_{rep} = .99, \eta_p^2 = .24$, and an interaction of condition by age group $F(2, 122) = 4.72, p = .011, p_{rep} = .95, \eta_p^2 = .072$. Bonferroni-adjusted pairwise comparisons revealed that, overall, infants looked significantly longer at the indirect ($M = 9.47, SD = 4.38$) than the direct test event ($M = 7.62, SD = 3.41$). Moreover, both 10- and 12-month-olds looked longer at the test events in the failed- than in the successful-reaching condition, whereas 8-month-olds looked equally during both conditions.

For our planned pairwise comparisons (Bonferroni-adjusted), in the *successful-reaching* condition, infants of all ages looked significantly longer at the indirect- than the direct-reach events (see Figure 2; 8-month-olds: $F(1, 122) = 5.30, p = .023, p_{rep} = .92, \eta_p^2 = .042$; 10-month-olds: $F(1, 122) = 10.19, p = .002, p_{rep} = .98, \eta_p^2 = .077$; 12-month-olds: $F(1, 122) = 11.40, p = .001, p_{rep} = .99, \eta_p^2 = .085$). In contrast, in the *failed-reaching* condition, only the 10- and 12-month-olds looked significantly longer at the indirect- than the direct-reach events (10-month-olds: $F(1, 122) = 5.81, p = .017, p_{rep} = .93, \eta_p^2 = .045$; 12-month-olds: $F(1, 122) = 9.37, p = .003, p_{rep} = .97, \eta_p^2 = .071$); 8-month-olds looked equally long at both test events, $F(1, 122) = 0.62, p = .43, p_{rep} = .55, \eta_p^2 = .005$.

We confirmed these results with non-parametric, Wilcoxon Signed Ranks tests. In the *successful-reaching* condition, 8- ($Z = 2.07, p = .039, p_{rep} = .89$), 10- ($Z = 3.21, p = .001, p_{rep} = .99$), and 12-month-olds ($Z = 3.51, p < .001, p_{rep} = .99$) all looked significantly longer at the indirect than the direct events. In the *failed-reaching* condition, 10- ($Z = 1.98, p = .048, p_{rep} = .88$) and 12-month-olds ($Z = 2.45, p = .014, p_{rep} = .94$) looked significantly longer at the indirect- than the direct-reach events; 8-month-olds, however, did not ($Z = 0.70, p = .48, p_{rep} = .51$). In sum, 10- and 12-month-olds recognized the goal-directedness of both the successful- and failed-reaching actions. Eight-month-olds recognized the goal-directedness of successful but not failed actions.

Could these findings simply reflect a preference for looking at the arcing arm movement regardless of habituation experiences? This cannot account for the 8-month-olds' data because, although test events were identical across conditions, infants preferred the indirect event only in the successful-reaching and not in the failed-reaching condition. For 10- and 12-month-olds, we tested this alternative in a control condition (identical to that in Phillips & Wellman, 2005) where there was no goal-object. An additional 24 10- and 24 12-month-olds participated. During habituation, the actor reached in an arcing manner over a barrier (same actor, same barrier as in the focal conditions) but there was no goal-object (no ball). During test, the barrier was removed and infants saw direct- and indirect-test events that were identical to those in the focal conditions, but without a ball. In the control condition, 10- and 12-month-olds did not dishabituate to either test event and looked equally at the indirect and direct test events (10- month-olds: $Z = .67, p = .51, p_{rep} = .49, Ms = 8.84$ and 7.92 , respectively; 12-month-olds: $Z = 1.17, p = .24, p_{rep} = .69, Ms = 6.83$ and 5.70 , respectively). Performance in this control condition rules out the possibility that infants prefer and thus look longer at the indirect, curvilinear reach. Moreover, these data provide an informative contrast between reaching with and without a goal-object. When an action is not directed at a goal-object (control condition), infants view reaching in a straight line or an arc as simply different patterns of movement—neither more interesting nor interpretable than the other. In contrast, when the action is directed at a goal-object (focal conditions) and infants recognize this goal-directedness (10-, 12-month-olds in both conditions; 8-month-olds in successful-reaching condition), infants view the manner of reaching in terms of its consistency with the actor's goal (directly reaching for the ball).

Discussion

We examined how infants in the first year of life interpret both successful and failed reaching actions. Eight-, 10-, and 12-month-olds encoded *successful* reaching actions in terms of their goals and not simply in terms of their surface perceptual features. Ten- and 12-month-olds (but not 8-month-olds) also encoded *failed* reaching actions in terms of their goals and not simply in terms of their perceptual features. Additional data from a control condition rule out the possibility that infants' performance in the focal conditions is based solely on a visual preference for curvilinear arm movements.

These data extend prior work (e.g., Meltzoff, 1995) by revealing infants' understanding of failed actions during the first year of life. Through the use of a minimally demanding looking-time procedure and a simple, familiar, human action that infants themselves can perform (reaching), these data show that even 10-month-olds possess a nascent understanding of the goal-directedness of failed actions.

Our findings fit with but extend two other recent studies. Behne and colleagues (2005) examined infants' reaction to failed actions in the context of a toy-sharing situation. Nine-month-olds responded systematically differently (i.e., with greater patience) when an experimenter tried but accidentally failed to give them a toy (e.g., accidentally dropped it) versus when she willfully refused to do so (e.g., teased them with it in actions and emotional expression). This method does not directly test infants' understanding of the experimenter's goals, but these data do show that, in the first year, infants are not oblivious to and do not react identically to all sorts of "failed" acts.

More directly, Hamlin and colleagues (in press) extended earlier imitation studies to 7-month-olds using a simplified imitation design. In the critical comparison, infants viewed an actor either (a) reach for but fail to grasp or (b) point to one of two objects. Infants were then given an opportunity to interact with the objects themselves. In the incomplete-grasping condition, infants touched the target object significantly more than the nontarget object; in the pointing condition, infants were equally likely to touch either object. These findings suggest that infants may understand the actor's failed goal; however, they are open to alternative interpretations. Most critically, it is not clear that infants were *imitating* the failed grasp. Unlike the research with older infants (where imitation was clear in infants' repetition of extended, novel, object-directed behaviors), here the actor's reaching may simply have triggered for infants a familiar action sequence. That is, it is possible that infants' own touching behavior was not an imitation of the goal of the failed action but rather a continuation of the next step in a familiar behavioral sequence—reaching for and grasping an object.

Our data are not subject to this alternative interpretation because in our study infants' reaction to reaching was not measured by their own reaching but rather by their patterns of visual attention. Moreover, in both test events (direct and indirect) the actor successfully retrieved the object, so both test events portrayed a complete, familiar, action sequence. Nonetheless, Hamlin and colleagues' results—coupled with our own—suggest that young infants may display an understanding of failed action not only in looking-time but also in more active-interactive paradigms. Our data not only demonstrate early understanding of the goals behind failed actions, but also directly compare understanding of successful and failed goal-directed actions. With this comparison, we demonstrate an age where infants infer the goal of a successful-reaching action, but fail to do so for a directly comparable failed-reaching action. This conclusion depends, in part, on the youngest infants' failure to produce a significant difference in the failed-reaching condition and null findings are always subject to alternative interpretations. For example, the videotaped nature of the events may have

hindered the youngest infants' performance. This seems unlikely, however, because the failed- and successful-reaching presentations were both videotaped and the youngest infants succeeded in the successful-reaching condition. Alternatively, the youngest infants may have had special difficulty completing the means-end-analysis required to understand the process of reaching around a barrier. This seems unlikely to account for our findings because infants successfully completed the same means-end-analysis in the successful-reaching condition.

Thus, the alternative we favor is that this pattern of results (succeeding in the successful-prior to the failed-reaching condition) illustrates a developmental trajectory where understanding successful goal-directed actions precedes understanding failed goal-directed actions. That is, infants are first able to infer an actor's goal while or after observing the actor visibly instantiate it in action (e.g., successfully grasping and retrieving the goal-object). At this early age, infants need outcome information to determine the goal of an action. In contrast, somewhat older infants are able to infer the goal of an action even when that goal is unrealized and no visible achievement of the goal-object is available to instantiate the goal. As others have argued (e.g., Meltzoff, 1995), because an appreciation of behavior as goal-directed in the absence of overt goal-fulfillment seems impossible without a rudimentary understanding of goals as distinct from the actions that achieve them, this ability to infer the goal of a failed action marks an important step toward understanding actions as *intentional*. That 10- and 12-month-olds in our experiment are able to construe a familiar, transparently goal-directed human action, such as reaching, as guided by intentions certainly does not imply that at this age infants apply a sophisticated, intentional or mentalistic framework broadly to all human actions. Nevertheless, these data illustrate the early emergence of an intentional framework in at least one key instance of human action. Moreover, they show that this early intentional understanding of action appears later than, and potentially builds upon, a prior, action- and object-based understanding.

Two important questions in contemporary research on infants' understanding of intentionality are (1) whether infants' early understanding of object-directed actions is intentional (Baron-Cohen, 1995; Premack, 1990) or at first more object-based (Phillips & Wellman, 2005) or teleological (Gergely & Csibra, 2003), and (2) the extent to which infants' understanding of intentionality is at first specific to and/or dependent upon experience with human actions (Woodward, 1998) or rather more "abstract" in that it is invoked by and revealed in infants' reaction to nonhuman entities (Csibra et al., 1999; Gergely et al., 1995; Kuhlmeier et al., 2003; Luo & Baillargeon, 2005). Our data shed light on the first question: the progression from first understanding successful to only later understanding failed intentional actions supports the view that infants' understanding becomes more intentional after an earlier more object-based or teleological understanding. Because we have focused on human action, however, our data do not address the second question. A related issue is whether the more complex intentional-action analysis required for understanding failed actions in particular may first be specific to human action. Future research and research with younger infants should consider these issues.

In sum, we demonstrate one case of an important, early, intentional understanding that is revealed in 10- and 12-month-olds' understanding of failed human reaches and that develops on the heels of an earlier understanding of successful goal-directed actions.

Acknowledgments

This research was supported by NSF Graduate Research Fellowship to Brandone and NICHD grant HD-22149 to Wellman. We thank Betsy Hamilton, Shelley Housey, and our participants.

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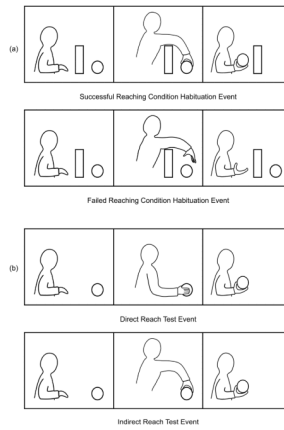


Figure 1. Depiction of the action events: (a) Successful-reaching and failed-reaching habituation events; (b) Direct-reach and indirect-reach test events.

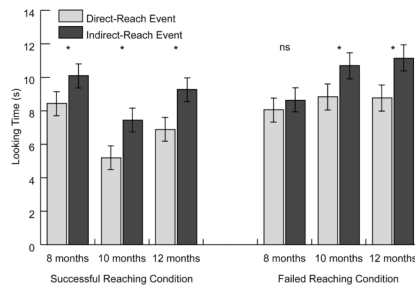


Figure 2. Average looking time to the direct- and indirect-reach test events by condition and age group.