Research Article

You Can't Always Get What You Want

Infants Understand Failed Goal-Directed Actions

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ABSTRACT—*At what age 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 not apparent in the actor's movements—is a critical step in answering 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 demonstrated 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 not of unsuccessful attempts. Thus, by the end of the 1st year of life, infants possess an impressive understanding of intentional action, and 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. Thus, an important developmental question is, at what age do children come to perceive the motions of other people 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 not apparent in the actor's movements or the outcome achieved would not be possible without penetrating more deeply than the surface appearance of the action. Thus, appreciation of failed action as goal directed provides firm evidence for an understanding that goals exist independently of the particular actions performed. At what age and how does this understanding develop?

Two sets of findings frame this question. First, infants in their 2nd year clearly appreciate the intentions underlying failed actions. The firmest demonstration of this comes from a study by Meltzoff (1995), in which, 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 intentions underlying the actions. Although the infants never saw the actions modeled successfully, when given a chance to act on the objects themselves, they performed the intended successful goal-directed actions much more than they performed the failed (actually witnessed) actions. Replications of these experiments have shown that 15-month-olds (Carpenter, Akhtar, & Tomasello, 1998), but not 12-month-olds (Bellagamba & Tomasello, 1999), also display this pattern (see also Olineck & Poulin-Dubois, 2005). Thus, by the age of 15 to 18 months, infants appreciate the unfulfilled goals of failed actions.

Second, during their 1st year, infants are sensitive to the intentional structure of actions (Baldwin, Baird, Saylor, & Clark, 2001) and appreciate the goal directedness of successful intentional actions (Csibra, Gergely, Biro, Koos, & Brockbank, 1999; Gergely, Nadasdy, Csibra, & Biro, 1995; Phillips & Wellman 2005; Sodian, Schoeppner, & Metz, 2004; Woodward, 1998). The evidence for this conclusion generally comes from looking-time methods. For example, in one study (Phillips & Wellman, 2005), 12-month-olds were habituated to an actor reaching over a barrier with an arcing motion to successfully retrieve a ball. After habituation, the 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

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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 had encoded the action in terms of its goal (getting the object as directly as possible), then during the test phase they should have looked longer at the event that was inconsistent with that goal—the indirect event. In contrast, if during habituation the infants had encoded the action in terms of its perceptual features (reaching in an arcing motion), then during the test phase they should have looked longer at the event that was inconsistent with those perceptual features—the direct event. Results showed that the infants looked longer at the indirect than at the direct test event. Additional studies have also shown this effect (Sodian et al., 2004), even when the actions were those of computer-generated, abstract agents (Csibra et al., 1999; Gergely et al., 1995). Thus, by the end of the 1st year of life (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, 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 observed action or when the observed action is at odds with the intention. 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, Carpenter, Call, & Tomasello, 2005; Hamlin, Hallinan, & Woodward, 2008). Moreover, it is an important open question whether or not an understanding of failed actions builds upon an understanding of successful ones. Some researchers have proposed developmental accounts according to which a simplified understanding of object connectedness precedes a later, intentional understanding (Phillips & Wellman, 2005; Woodward, 1998) or in which a teleological understanding precedes an intentional, mentalistic one (Gergely & Csibra, 2003). In 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 have attributed to infants a deep, innate understanding of intention that is automatically elicited when infants see animate movements (e.g., Baron-Cohen, 1995; Premack, 1990). According to 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 understanding of failed goal-directed actions in infancy, we devised a visual habituation paradigm suitable for 8-, 10-, and 12-month-olds, and we directly compared infants' understanding of successful and failed intentional actions. Figure 1 illustrates the habituation and test events. Our successful-action condition was identical to the experimental condition of Phillips and Wellman (2005): An actor reached over a barrier with an arcing arm motion and successfully retrieved a ball. In our failed-action condition, infants saw a parallel display in which the actor reached over the barrier with an arcing arm motion; however, crucially, the actor's reach was unsuccessful: The reach fell short of grasping the ball. The test events were identical in the two conditions (and were identical to those in Phillips & Wellman, 2005). In the direct test event, the actor reached directly for the ball and, with no interference from a barrier, 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 (although the barrier was gone) and successfully obtained the ball. The arm movement was identical to that in habituation, and the action was successful, but it was not consistent with attempting to directly reach the goal object.

We predicted that if infants habituated to the failed reaching action could infer its goal, they would look longer at the indirect than at the direct test event, just as infants who are habituated to successful reaches do. Furthermore, we expected that if understanding of successful goal-directed actions precedes understanding of failed actions, we would find an age at which infants in the successful-reaching condition looked longer at the indirect event than at the direct event and infants in the failed-reaching condition did not. In sum, we asked two questions: (a) Do 8-, 10-, and 12-month-olds understand both successful and failed goal-directed actions? (b) When conditions are as comparable as possible, does understanding of failed goal-directed actions emerge later than understanding of successful goal-directed actions?

METHOD

Participants

Participants were 134 infants (66 males, 68 females) in three age groups: 8-month-olds ($n = 46$; mean age = 7.91 months, $SD = 0.28$), 10-month-olds ($n = 44$; mean age = 9.73 months, $SD = 0.48$), and 12-month-olds ($n = 44$; mean age = 11.80 months, $SD = 0.40$).[1] Thirty-seven additional infants were excluded

[1]The data from the 12-month-olds in the successful-reaching condition were reported in Study 2 of Phillips and Wellman (2005).

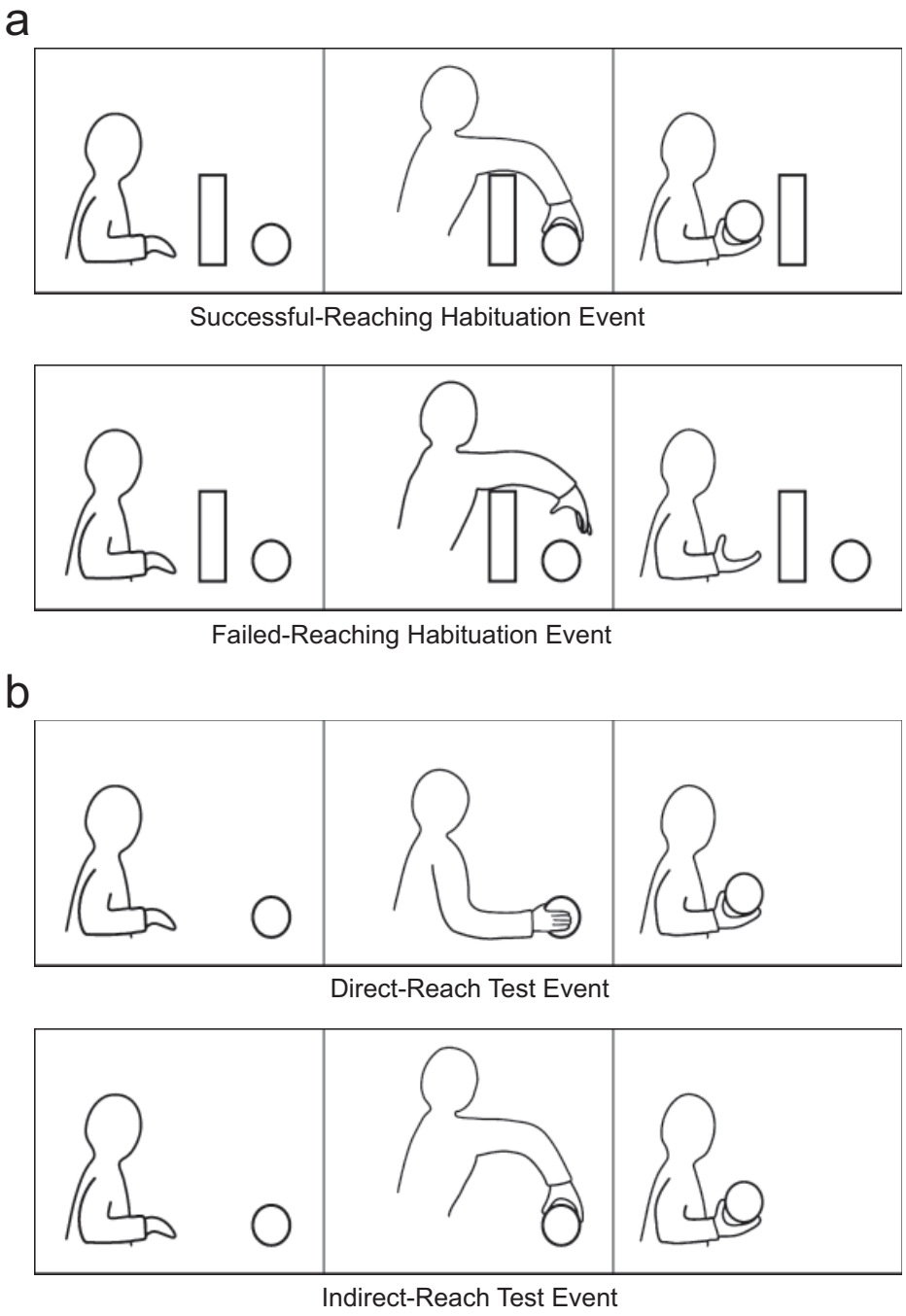

Fig. 1. Depiction of the action events: (a) the successful-reaching and failed-reaching habituation events and (b) the direct-reach and indirect-reach test events. See the text for details.

because of fussiness ($n = 18$), observer error ($n = 14$), interference ($n = 4$), and computer problems ($n = 1$). Infants were assigned to the *successful-reaching condition* (8-months-olds: $n = 23$, mean age = 7.79 months; 10-month-olds: $n = 24$, mean age = 9.55 months; 12-month-olds: $n = 24$, mean age = 11.70 months) or the *failed-reaching condition* (8-month-olds: $n = 23$, mean age = 8.03 months; 10-month-olds: $n = 20$, mean age = 9.94 months; 12-month-olds: $n = 20$, mean age = 11.91 months). Participants were predominantly European American and from middle-income homes.

Procedure

Infants sat before a computer monitor. Videotaped events involving a human actor reaching for a ball were presented on the monitor in an infant-controlled habituation design (Cohen, Atkinson, & Chaput, 2004). Previous work (Phillips & 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 s had elapsed, whichever came first. Infants saw a minimum of 4 and a maximum of 10 habituation trials, followed by 6 test trials. Test trials began once the average looking time across 3 consecutive habituation trials dropped below 50% of the average looking time during the first 3 trials or after 10 habituation trials if this criterion was not met. Looking time on each trial was coded on-line. Test trials for 33% of participants were recoded by a second coder. On 93.7% of the recoded test trials, observers' judgments differed by less than 1 s.

Habituation Events

During habituation, infants saw one of two events (see Fig. 1a). In the *successful-reaching* condition, a man (in profile) was seated at a table in front of a wall-like barrier and ball. He reached over the barrier (with an arcing motion), grasped the ball, and brought the ball back to his torso (tracing the same arcing motion); the video then froze. The habituation event in the *failed-reaching* condition was identical except that the reach was unsuccessful. The actor reached over the barrier with the same arcing motion as in the successful-reaching condition; however, his reach fell short of the ball, and he neither grasped nor occluded it with his hand. He brought his empty hand back to his torso, and the video froze.

Test Events

Following habituation, infants in both conditions were shown two test events (identical to those used by Phillips & Wellman, 2005). In both events, the barrier was absent, and the actor successfully grasped the ball (see Fig. 1b). In the *direct-reach event*, the man reached directly (in a straight line) for the ball and grasped it. He brought it back to his torso (following the same straight path), and the video froze. The arm traced a path that was perceptually different from the arcing path in habituation; however, the action was consistent with the prior goal of directly reaching for the ball. In the *indirect-reach event*, the actor reached for the ball in the same arcing path as in habituation, though the barrier was absent. He grasped the ball and brought it back to his torso, and the video froze. In this case, the path of his arm was perceptually identical to that in habituation; however, the action was inconsistent with the prior goal of directly reaching for the ball. Test events were shown three times each in an alternating sequence, with their order counterbalanced.

RESULTS

Habituation

On average, infants watched 9.06 habituation trials ($SD = 1.56$) and spent 96.77 s ($SD = 42.84$) viewing the habituation events. The number of habituation trials and time spent viewing these events did not differ across conditions or age groups. Many infants did not meet the habituation criterion (63.4% of infants in the successful-reaching condition and 65.1% of infants in the failed-reaching condition), but what is critical is that the 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 analysis of variance (ANOVA) with trial (first, last) as a within-subjects factor and age group (8-, 10-, 12-month-olds) and condition (successful-reaching, failed-reaching) as 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-reaching condition (first trial: $M = 14.76$ s; last trial: $M = 7.56$ s) than in the successful-reaching condition (first trial: $M = 11.63$ s; last trial: $M = 8.22$ s). This decline in looking time did not differ as a function of age group.

Test

Our experiment was intended to determine (a) whether infants would look longer at the indirect test event in the failed-reaching condition, as well as in the successful-reaching condition, and (b) whether infants at some age would look longer at the indirect than at the direct test event 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 an ANOVA to examine the overall pattern of results and, because looking-time data are consistently skewed and nonnormal (in this and other research; e.g., Spelke, Breinlinger, Macomber, & Jacobson, 1992), we confirmed our parametric planned comparisons with nonparametric tests.

In the ANOVA, test event (direct-reach, indirect-reach) was a within-subjects factor, and age group (8-, 10-, 12-months), condition (successful-reaching, failed-reaching), and gender (male, female) were between-subjects factors. This analysis yielded 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, $F(1, 122) = 4.72$, $p = .011$, $p_{rep} = .95$, $\eta_p^2 = .072$. Bonferroni-adjusted pair-wise comparisons revealed that, overall, infants looked significantly longer at the indirect-reach test event ($M = 9.47$ s, $SD = 4.38$) than at the direct-reach test event ($M = 7.62$ s, $SD = 3.41$). Additionally, 10- and 12-month-olds in the failed-reaching condition looked longer during the test phase than did 10- and 12-month-olds in the successful-reaching condition. Eight-month-olds in the two conditions looked equally long.

Our focal planned pair-wise comparisons (Bonferroni-adjusted) showed that in the successful-reaching condition, infants of all ages looked significantly longer at the indirect- than at the direct-reach event (see Fig. 2)—8-month-olds: $F(1, 122) = 5.30$, $p = .023$, $p_{rep} = .92$, $\eta_p^2 = .042$; 10-month-olds: $F(1,$

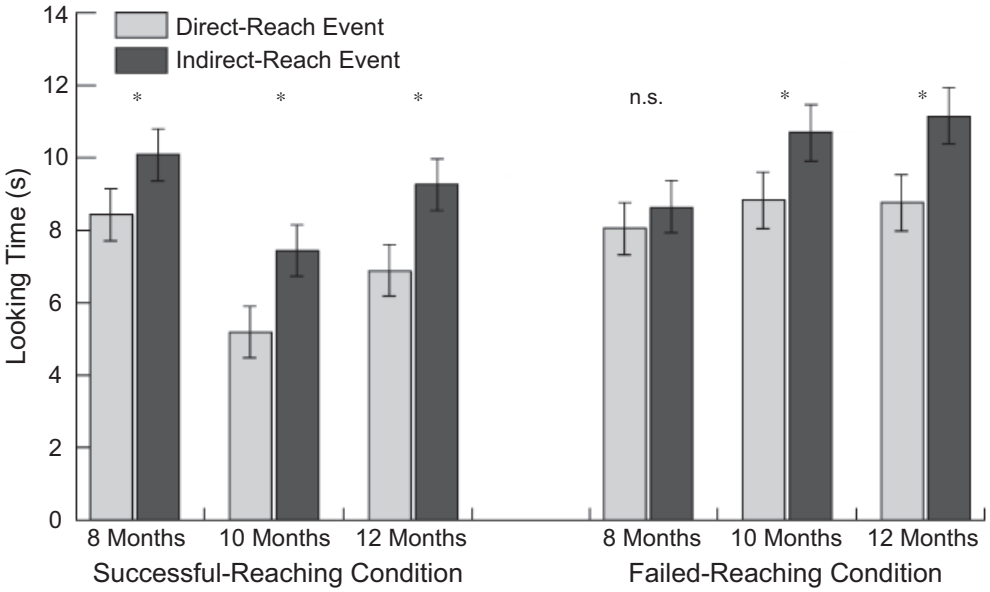

Fig. 2. Average looking time to the direct- and indirect-reach test events as a function of condition and age group. Asterisks indicate a significant difference ($p < .05$) in looking times to the two test events. Error bars indicate standard errors.

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 at the direct-reach event—10-month-olds: $F(1, 122) = 5.81$, $p = .017$, $p_{rep} = .93$, $\eta_p^2 = .045$; 12-month-olds: $F(1, 122) = 9.37$, $p = .003$, $p_{rep} = .97$, $\eta_p^2 = .071$. In this condition, 8-month-olds looked equally long at the two test events, $F(1, 122) = 0.62$, $p = .43$, $p_{rep} = .55$, $\eta_p^2 = .005$.

We confirmed these results with nonparametric, Wilcoxon signed-rank tests. In the successful-reaching condition, 8-month-olds ($Z = 2.07$, $p = .039$, $p_{rep} = .89$), 10-month-olds ($Z = 3.21$, $p = .001$, $p_{rep} = .99$), and 12-month-olds ($Z = 3.51$, $p < .001$, $p_{rep} = .99$) all looked significantly longer at the indirect- than at the direct-reach event. In the failed-reaching condition, 10-month-olds ($Z = 1.98$, $p = .048$, $p_{rep} = .88$) and 12-month-olds ($Z = 2.45$, $p = .014$, $p_{rep} = .94$) looked significantly longer at the indirect- than at the direct-reach event; 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 the failed-reaching actions. Eight-month-olds recognized the goal directedness of the successful but not the failed action.

Could these findings simply reflect a preference for looking at the arcing arm movement regardless of habituation experiences? Such a preference cannot account for the 8-month-olds' data because, although test events were identical across conditions, these infants looked longer at the indirect than at the direct event only in the successful-reaching condition, and not in the failed-reaching condition. For 10- and 12-month-olds, we tested this alternative explanation in a control condition (identical to that in Phillips & Wellman, 2005) in which there was no goal object. An additional twenty-four 10-month-olds and twenty-four 12-month-olds participated. During habituation, the actor reached in an arcing manner over a barrier (same actor and 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-reach test events that were identical to those in the focal conditions, but without a ball. In this control condition, the infants did not dishabituate to either test event and looked equally at the indirect and direct test events (10-month-olds: *M*s = 8.84 s and 7.92 s, respectively; 12-month-olds: *M*s = 6.83 s and 5.70 s, respectively), $Z = 0.67$, $p = .51$, $p_{rep} = .49$, for the 10-month-olds and $Z = 1.17$, $p = .24$, $p_{rep} = .69$, for the 12-month-olds. These results rule out the possibility that infants preferred and thus looked longer at the indirect, curvilinear reach in the focal conditions.

Moreover, these data provide an informative contrast between reaching with and without a goal object. When an action was not directed at a goal object (control condition), infants viewed reaching in a straight line and reaching in an arc as simply different patterns of movement—neither more interesting nor interpretable than the other. In contrast, when the action was directed at a goal object (focal conditions) and infants recognized this goal directedness (10- and 12-month-olds in both focal conditions; 8-month-olds in the successful-reaching condition), they viewed 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 1st 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 our control condition rule out the possibility that infants' performance in the focal conditions was 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 1st 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), our study has shown that even 10-month-olds possess a nascent understanding of the goal directedness of failed actions.

Our findings fit with and extend two other recent studies. Behne et al. (2005) examined infants' reaction to failed actions in the context of a toy-sharing situation. Nine-month-olds responded systematically with greater patience when an experimenter tried but accidentally failed to give them a toy (e.g., accidentally dropped it) than when she willfully refused to give them a toy (e.g., teased them with it in actions and emotional expression). This method did not directly test infants' understanding of the experimenter's goals; however, these data do show that, in the 1st year, infants are sensitive to distinctions among different kinds of failed actions, and they react differentially to those different kinds of failed actions.

Hamlin et al. (2008) 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. The infants were then given an opportunity to interact with the objects themselves. In the incomplete-grasping condition, the infants touched the target object significantly more than the nontarget object; in the pointing condition, the infants were equally likely to touch either object. These findings suggest that infants may understand an actor's failed goal; however, they are open to alternative interpretations. Most critically, it is not clear that the infants were imitating the failed grasp. In the research with older infants, imitation was clear in the infants' repetition of extended, novel, object-directed behaviors; in this study, however, the actor's reaching may simply have triggered a familiar action sequence. That is, it is possible that the infants' touching behavior was not an imitation of the goal of the failed action, but rather was 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 measured not by their own reaching, but rather by their patterns of visual attention. Moreover, in both test events (direct-reach and indirect-reach), the actor successfully retrieved the object, so both test events portrayed a complete, familiar action sequence. Nonetheless, the results of Hamlin et al.—coupled with our own—suggest that young infants may display an understanding of failed action not only in looking-time paradigms, but also in more active or interactive paradigms.

Our data not only demonstrate early understanding of the goals behind failed actions, but also provide a direct comparison between understanding of successful and of failed goal-directed actions. With this comparison, we demonstrated an age at which infants infer the goal of a successful reaching action, but not of a directly comparable failed reaching action. This conclusion depends, in part, on the youngest infants' failure to exhibit a significant difference in looking times to the two test events in the failed-reaching condition, and null findings are always subject to alternative interpretations. For example, the fact that the events were videotaped may have hindered the youngest infants' performance. This seems unlikely, however, because the failed- and successful-reaching events 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 also seems unlikely, though, because these infants successfully completed the same means-end analysis in the successful-reaching condition.

Thus, we favor the interpretation that this pattern of results (earlier success in the successful-reaching condition than in the failed-reaching condition) illustrates a developmental trajectory in which understanding of successful goal-directed actions precedes understanding of failed goal-directed actions. That is, infants are first able to infer an actor's goal while or after observing the actor visibly instantiate that goal 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 it is not instantiated by visible achievement of the goal object. As other researchers 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 were able to construe a familiar, transparently goal-directed human action (reaching) as guided by intentions certainly does not imply that infants of this age 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 (a) whether infants' earliest

understanding of object-directed actions is intentional (Baron-Cohen, 1995; Premack, 1990) or rather more object based (Phillips & Wellman, 2005) or teleological (Gergely & Csibra, 2003), and (b) whether infants' understanding of intentionality is at first specific to or dependent on experience with human actions (Woodward, 1998) or rather more "abstract" (a possibility suggested by studies showing that infants appear to see intention in the actions of nonhuman entities; Csibra et al., 1999; Gergely et al., 1995; Kuhlmeier, Wynn, & Bloom, 2003; Luo & Baillargeon, 2005). Our data shed light on the first question: The progression from first understanding successful intentional actions to only later understanding failed ones supports the view that infants' understanding is initially object based or teleological but then becomes more intentional. Because we have focused only 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. These issues need to be considered in future research, including research with younger infants.

In sum, we have demonstrated an impressive, early understanding of intention that is revealed in 10- and 12-month-olds' appreciation of failed human actions (specifically, failed human reaches). Furthermore, our data indicate that this understanding of action as intentional develops on the heels of an earlier teleological or object-based understanding of action.

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