Research Article

ATTRIBUTION OF DISPOSITIONAL STATES BY 12-MONTH-OLDS

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Abstract—*The ability to interpret the behavior of other individuals is essential for effective social functioning. Many investigators now believe that even young infants can recognize that agents act toward goals. Here we report three experiments suggesting that 12-month-old infants not only can recognize goal-related action, but also can interpret future actions of an actor on the basis of previously witnessed behavior in another context. The possibility that this inference is made through the attribution of mental states is discussed.*

The ability to interpret the behavior of other individuals is essential for social functioning. Without the ability to infer emotions, desires, and beliefs—for instance, that John is angry, Mary wants to leave, or Betty thinks that it is cold outside—it would be impossible to predict or understand the behavior of other people. Although the ability to reason about certain mental states such as beliefs and false beliefs might emerge between the ages of 3 and 5 years (Gopnik, 1993; Wellman, 1990; Wellman, Cross, & Watson, 2001), there is growing interest in infants' reasoning about the behavior of others (e.g., Gergely, Nadasdy, Csibra, & Biro, 1995; Meltzoff, 1995; Woodward, 1998).

Recent studies have shown that infants do have some understanding of goal-related behavior. For example, in one study, 9- and 12-month-old infants were shown a computer-animated ball repeatedly jumping over a barrier to reach another object. When subsequently shown a modified display with the barrier removed, the infants expected the ball to move straight to the object to satisfy its goal, rather than repeat the jumping behavior (Csibra, Gergely, Biro, Koos, & Brockbank, 1999; Gergely et al., 1995). Twelve-month-old infants can also recognize the underlying positive or negative "valence" of an action; the helping actions of one computer-animated actor toward another are seen as similar to caressing actions, whereas a hindering act is seen as similar to a hitting act (Premack & Premack, 1997a). However, many researchers have noted that such sensitivity to goal-related behavior need not imply that infants are attributing mental states to the actors (Gergely et al., 1995; Premack & Premack, 1997b; Woodward, 1998). Identifying a goal state that an actor tends to act toward does not require understanding how the actor mentally construes the situation (e.g., that the actor *wants* to reach the goal). For example, in the aforementioned studies, infants may have identified the specific, physical goal of an actor in a scene—that is, recognized simply that there was a tendency or disposition for the actor to act toward a given physical state.

In the present studies, we sought to elaborate upon the type of attributions infants make when viewing goal-oriented behavior. Previous studies (e.g., Gergely et al., 1995; Woodward, 1998) have shown that after witnessing an actor engage in a specific goal behavior (e.g., approaching an object), infants recognize that the same goal behavior will occur in a subsequent situation with an altered spatial arrangement (e.g., the goal object has moved or an obstacle has been removed). However, what will infants attribute if the second situation is a completely different context from, yet is socially related to, the first? That is, will infants interpret an actor's new behavior in this new situation on the basis of the history of that actor's behavior in a different situation? Such a pattern of results would indicate that the infant's ability to recognize an agent's dispositions is more complex than previously shown. Furthermore, such a sophisticated ability might indicate that infants are actually attributing to the actor a mental-state mediator underlying the new behavior.

The present experiments tested infants using movies consisting of animated geometric figures, a type of stimulus commonly used in the study of psychological reasoning in infants (Gergely et al., 1995; Wagner & Carey, 2002) and adults (Heider & Simmel, 1944; Thayer & Schiff, 1969). In Experiments 1 and 2, 5- and 12-month-old infants were habituated to computer-animated movies depicting two objects (a square and a triangle), one engaging in helping behavior and one engaging in hindering behavior toward a third object (a ball) that attempted to climb a hill. The infants were then shown two new test movies in which all three objects were present in a new context in which the original goal state did not apply (no hill was present). In one test movie, the ball approached and settled next to its helper, and in the other movie, the ball approached and settled next to its hinderer.

Pilot testing demonstrated that adults tended to see the ball as "liking" or "preferring" the helper object, because the ball completed its goal in concert with the actions of the helper in the habituation movies. Because of this interpretation, they differentiated between the test movies: When asked to choose between two interpretations, 9 of 10 adults reported that the test movie in which the helper object was approached was a coherent continuation of the previous habituation movies, whereas the test movie in which the hindering object was approached was not. We predicted that if infants interpreted the ball's likely new disposition in the test-movie context on the basis of the previous actions in the habituation movies, they would also differentiate between the test movies, and looking times to the two movies would differ. Experiments 1 and 2 tested this hypothesis. Experiment 3 served to control for an alternative, associationist explanation for looking-time patterns.

EXPERIMENT 1

Method

Participants

Participants were twenty 5-month-old infants with a mean age of 4 months 28 days (range: 4 months 17 days–5 months 14 days) and twenty-one 12-month-old infants with a mean age of 12 months 1 day (range: 11 months 14 days–12 months 17 days). An additional six 12-month-olds and nine 5-month-olds were tested but excluded because

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of fussiness, disinterest, parental interference, or failure to reach the minimum looking criterion for the movies (see the next section).

Materials and procedure

Infants sat in a high chair positioned 45 cm from a computer monitor and were repeatedly shown the two computer-animated movies depicted in Figure 1. In both movies, a small, red, ball-like object sitting at the bottom of the first of two hills started to climb the short hill in front of it. Upon reaching the top of the first hill, the ball stopped, then expanded and contracted. The ball then began to climb the second, larger hill, but slid to the base of this hill after climbing only halfway to the top. At this point, the two movies differed. In the *Help* movie, the ball began a second climb attempt, and once it was halfway up (and again having difficulty), a green triangle-shaped object moved down from its original position at the top of the screen, landed on the hill behind the ball, and pushed the ball to the top of the hill. The triangle then returned to its original position and the ball expanded and contracted once more, ending the movie. In the *Hinder* movie, the ball began the second climb attempt, and once it was halfway up, a yellow, square-shaped object moved down from its original position, landed in front of the ball, and pushed the ball down the hill. Still sliding from the momentum of the pushes, the ball fell down the first hill, returning to its original position, while the square returned to its original position.

Half of the infants saw the movies just described, and half saw movies identical to these except that the initial positions and the actions of the triangle and square were reversed (the square helped and the triangle hindered). (The movies can be viewed on the Web at http://pantheon.yale.edu/~kw77/minds.html.)

The Help and Hinder movies were equated for total length, length of contact time and number of contacts between the ball and the helping or hindering object, and speed and extent of motion of all objects. Half of the infants were shown the Help movie followed by the Hinder movie, and the second half were shown the movies in the opposite order. These movies played continuously in alternating sequence until a habituation criterion was met. The infants were presented with a minimum of 6 and a maximum of 14 habituation trials. A given trial ended if the infant looked away from the monitor for 2 consecutive seconds or if 30 s elapsed. The habituation criterion was defined as 3 consecutive trials with summed looking time less than or equal to 50% of the sum of the looking times on the first 3 trials. Additionally, to ensure an equivalent minimum exposure to the two movie types, we included in the study only infants who saw at least 2 complete Help and 2 complete Hinder examples.

After infants in both groups viewed the Help and Hinder movies, they were presented with two new test movies in which all three objects were present in a new physical context, without any hill present. The triangle was located at the upper left of the screen, the square was

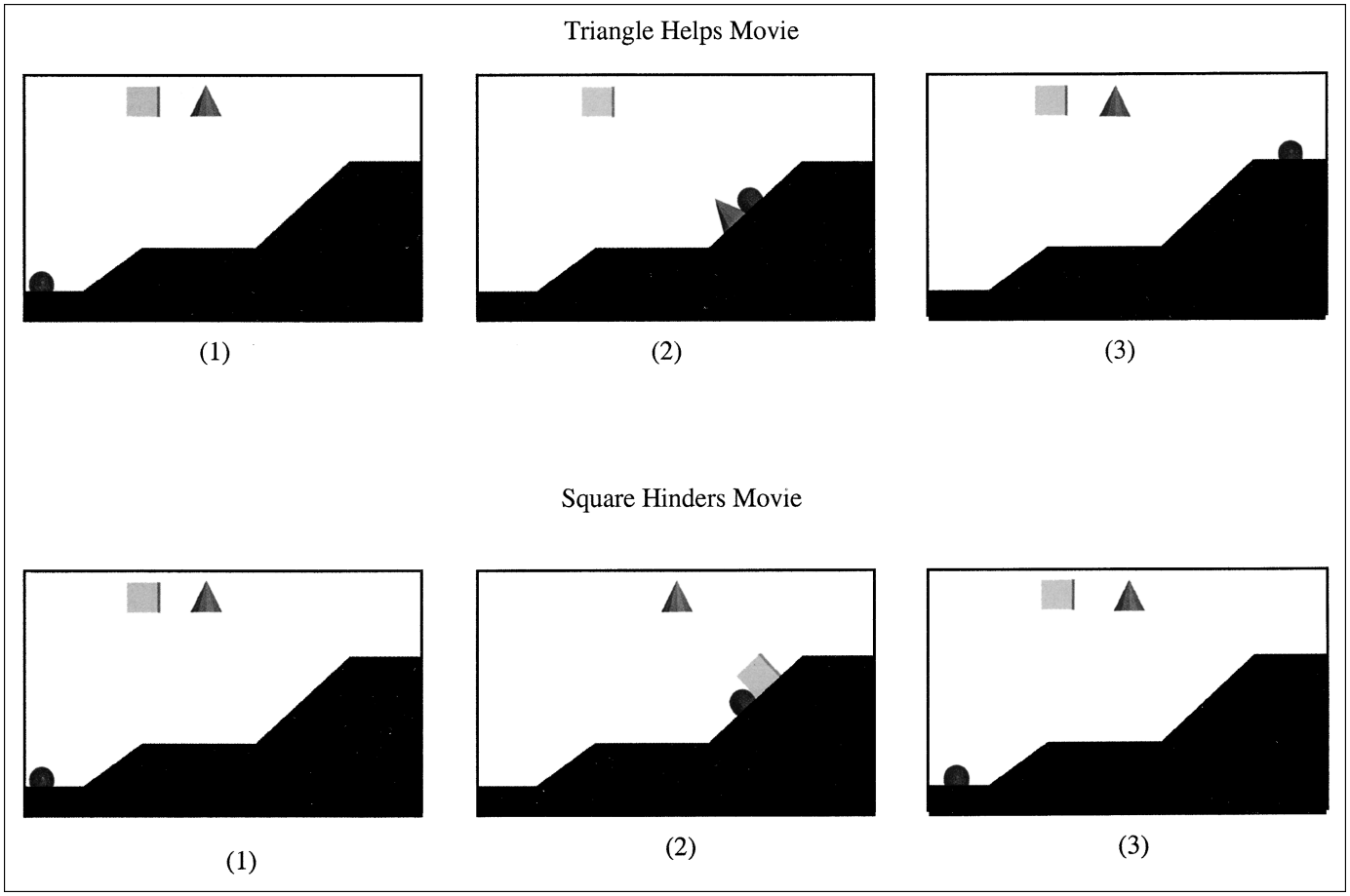

Fig. 1. Illustration of the habituation movies used in Experiments 1, 2, and 3.

in the upper right, and the ball was centered at the bottom of the screen. The ball rose to the middle of the screen, paused and wiggled side to side (as if perhaps deciding which direction to move in), and then moved adjacent to either the triangle (*Approach Triangle* movie) or the square (*Approach Square* movie) (Fig. 2). The test movies were equated along the same parameters as the Help and Hinder movies, and were presented in pairs, with order counterbalanced. The ball's two possible directions of movement in the test movies ensured that looking-time preferences could not be due to simple perceptual preferences for movement direction. For example, a looking-time preference for movies in which the ball approached the object that previously helped it would result in greater looking times for a movement in the upward-right direction for one group of infants (the *square-helps, triangle-hinders* habituation group), but a movement in the upward-left direction for the other group of infants (the *triangle-helps, square-hinders* habituation group).

It is important to note that the present experiments differ from *violation-of-expectation* studies, in which infants are exposed to unexpected and expected outcomes of an event and a looking preference to the unexpected outcome is hypothesized. Here, the test movies portrayed the actors in an entirely new context; infants viewed a new scene consisting of new actions in a new environment. Therefore, there was no a priori expected movement or action; any of the objects might have manifested some new goal or goals. The two test movies differed such that one (the ball approaching the helper) made a coherent continuation of the habituation movies, whereas the other did not. For these reasons, and because it is not always clear under what circumstances infants will show looking-time preference to coherent or matching stimuli versus stimuli that mismatch previous stimuli (Gibson & Walker, 1984; Meltzoff & Borton, 1979; Streri & Spelke, 1988), we made no predictions about the direction of infants' preferences in the present study.

Data analysis

To be included in analyses, subjects had to see not only at least two Help and two Hinder examples during habituation, but also at least one pair of test trials, out of a possible three pairs. A given test trial was considered to be completed if the infant watched for at least 2.5 s (the length of time it took for the small ball to direct itself toward one of the two other objects). Looking time on each trial was measured by an observer who was hidden behind a curtain and was unaware of the infant's habituation group. A second experimenter, also naive to the subjects' habituation groups, reviewed video footage of all test trials and measured the infants' looking times to the test movies. For all three experiments, these times were found to correspond well to the on-line timing (r = .90), and thus all data analyses were performed using results from the on-line timing.

Because of the low attention spans of infants (and as in previous experiments using computer-animated stimuli; see Gergely et al.,

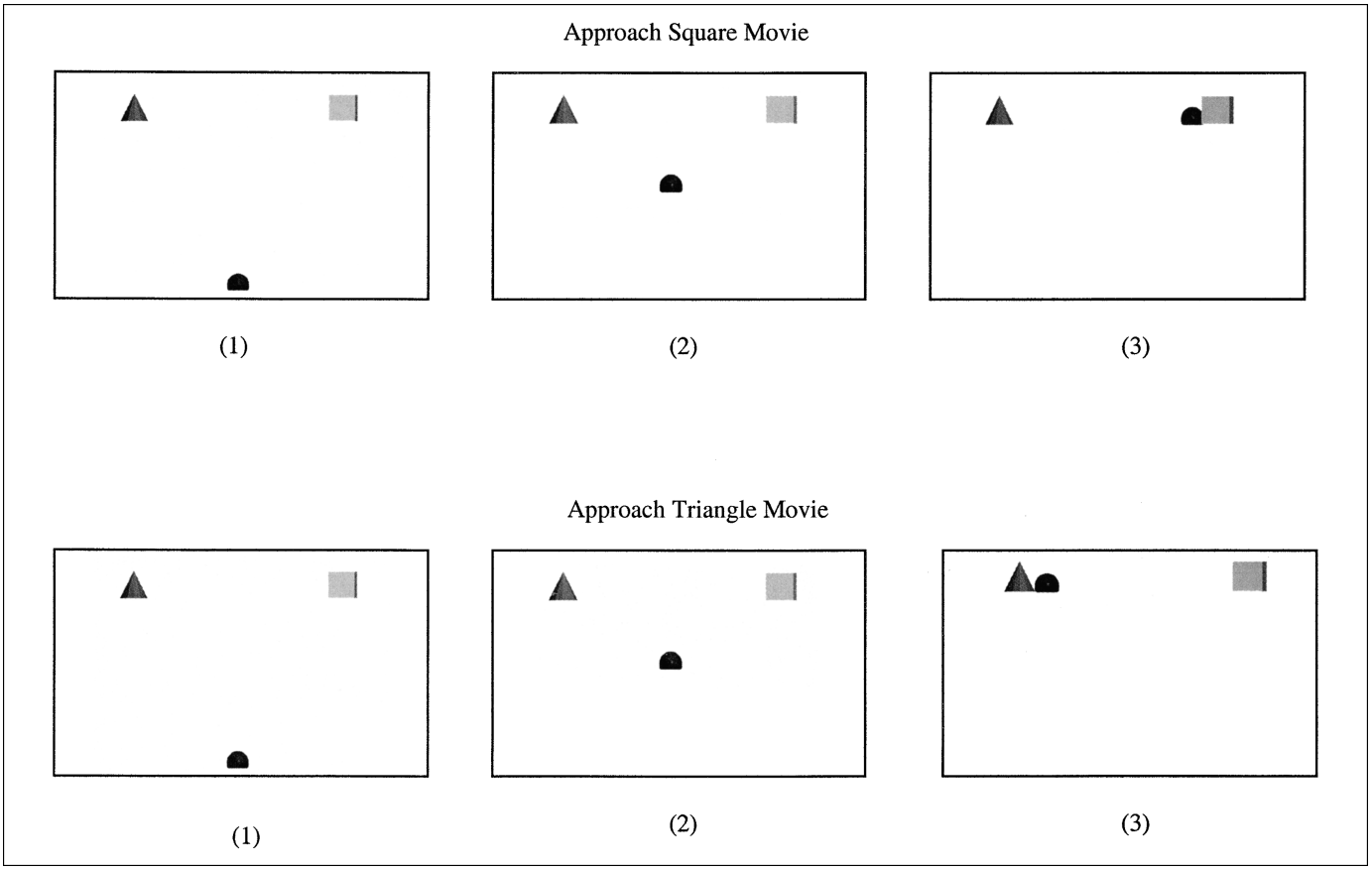

Fig. 2. Illustration of the test movies used in Experiment 1.

1995), many subjects completed only one test pair. Thus, following procedures of Gergely et al. (1995), we based our analyses on data from infants' first completed pair of trials. Separate analyses were completed on all available data for those infants who completed two or three test pairs, and the effects were identical to those reported here.

The patterns of looking during habituation did not differ across the three experiments or across habituation groups. The average number of habituation trials was similar for the three experiments (Experiment 1: 9.7 trials for 12-month-olds and 8.56 for 5-month-olds; Experiment 2: 10.4; Experiment 3: 8.5). The average number of habituation trials was also similar for the two habituation groups, both within an experiment and combined across experiments (triangle helps, square hinders: 9.15 trials; square helps, triangle hinders: 9.44 trials). Also, in all analyses reported for the three experiments, repeated measures analyses of variance (ANOVAs; completed separately for each age group and each experiment) on looking time revealed no main effects of habituation group (triangle helps, square hinders vs. triangle hinders, square helps), habituation-movie order, test-movie order, or gender, and no significant interactions between these variables.

Results

For the 12-month-olds in Experiment 1, the repeated measures ANOVA on infants' looking times in test demonstrated a significant Test Trial (Approach Triangle vs. Approach Square) × Habituation Group (triangle helps, square hinders vs. triangle hinders, square helps) interaction, $F(1, 19) = 4.651$, $p < .05$. Twelve-month-old infants who saw habituation movies depicting the triangle helping and the square hindering looked longer at the test movie depicting the ball approaching the triangle (looking-time difference = 1.85 s), whereas infants who saw the square help and the triangle hinder looked longer at the ball approaching the square (looking-time difference = 2.23 s). Thus, in both habituation groups, infants preferred the test movie in which the ball approached the object that had previously helped it reach the top of the hill (effect size, Cohen's $d = .48$; see Fig. 3). However, the ANOVA on the 5-month-olds' test looking times showed that they had no preference for either test movie (Fig. 3). The data from this age group are consistent with results from previous studies demonstrating a difficulty in understanding goal-related behavior in 6-month-old infants (Csibra et al., 1999). If infants of this age do not

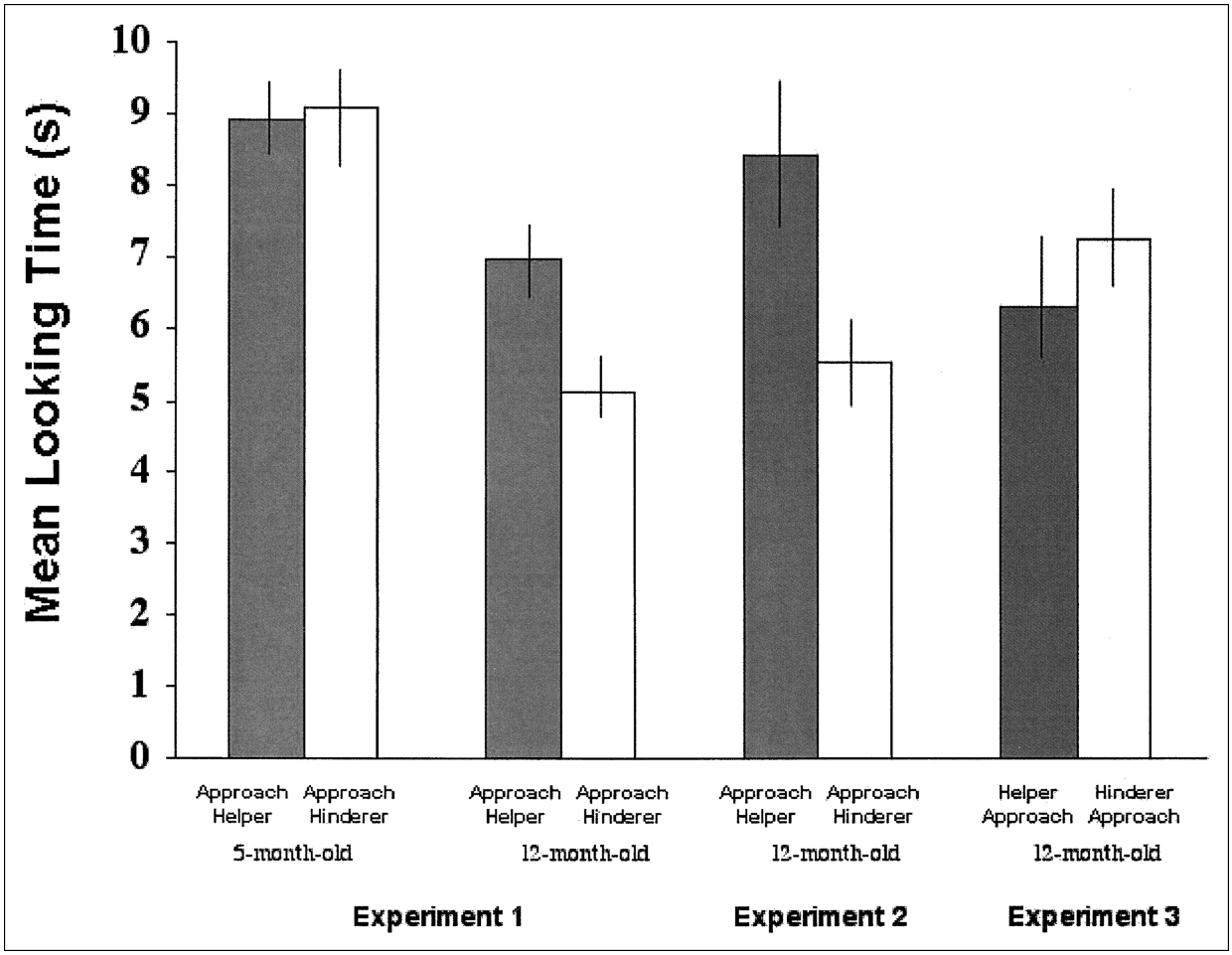

Fig. 3. Mean looking times (with standard error bars) to the test movies in Experiments 1, 2, and 3. Results are grouped with regard to the helper and hinderer, across habituation groups.

yet possess the ability to interpret a computer-animated agent's behavior in terms of its goals when the context remains stable between habituation and test, it would be unlikely for them to have differentiated between the test movies in the present study.

EXPERIMENT 2

A group of 12-month-old infants was tested using the same habituation movies as in Experiment 1, but the test movies were modified slightly by reversing the positions of the square and triangle. With this modification, Experiment 2 served to replicate the 12-month-olds' results from Experiment 1 using different test movies.

Method

Participants

Fourteen infants with a mean age of 12 months 3 days (range: 11 months 15 days–12 months 18 days) were tested. An additional 6 infants were tested but excluded because of fussiness, disinterest, parental interference, or failure to reach the minimum looking criterion for the habituation movies.

Materials and procedure

The infants were tested under the same procedures as in Experiment 1. However, the test movies were slightly modified. In the Experiment 1 test movies, the triangle and square were positioned in the upper left and right corners of the screen, respectively. For Experiment 2, these positions were reversed.

Results and Discussion

A repeated measures ANOVA performed in the same manner as in Experiment 1 yielded similar results. There was a significant Test Trial (Approach Triangle vs. Approach Square) × Habituation Group (triangle helps, square hinders vs. triangle hinders, square helps) interaction, $F(1, 12) = 7.25$, $p < .05$. Again, infants who saw movies depicting the triangle helping and the square hindering looked longer at the test movie depicting the ball approaching the triangle (looking-time difference = 1.3 s), whereas those who saw the square help and the triangle hinder looked longer at the ball approaching the square (looking-time difference = 4.5 s). That is, the infants preferred the test movie in which the ball approached the object that had previously enabled it to reach the top of the hill (effect size, Cohen's $d = .69$; see Fig. 3). These results support those of Experiment 1, extending the findings to slightly altered test stimuli.

EXPERIMENT 3

Although the results for 12-month-olds in Experiments 1 and 2 suggest that the infants differentiated between the test movies in terms of the ball's likely dispositions, an alternative associationist account must be addressed. One possible explanation for the looking preferences in Experiments 1 and 2 is that the 12-month-olds formed simple associations between the ball and the triangle and square. The infants may have observed that the ball had the goal of reaching the top of the hill and that whenever the "helping" object was next to the ball, this state was achieved, and whenever the "hindering" object was next to the ball, this state was not achieved. Through this observation, infants may have simply formed a positive association between the helper object and the ball, or a negative association between the hinderer object and the ball. The infants' looking pattern for the test movies might therefore simply reflect a preference to look at the movie that depicts actions between positively associated objects, not an attribution of a particular disposition.

Experiment 3 was designed to test this explanation for the looking-time preferences. We presented the same Help and Hinder movies from Experiment 1. The subsequent test movies were modified from those in Experiment 1; in this case, on alternate trials, either the helper or the hinderer approached the ball, rather than the other way around. In one test movie, the square moved toward the center of the screen, then moved down to the ball. In the second test movie, the triangle moved toward the center of the screen, then moved down to the ball (Fig. 4). If a simple positive association between the helper object and the ball drove infants' looking preference in Experiments 1 and 2, a similar preference would be expected in Experiment 3. That is, the infants would look longer at the movie depicting the helper object approaching and settling next to the ball than at the movie depicting the hindering object approaching and settling next to the ball. If, however, infants had attributed a particular disposition to the ball, this preference pattern would not be expected.

Method

Participants

Participants were 20 infants with a mean age of 12 months 2 days (range: 11 months 15 days–12 months 19 days). An additional 11 infants were tested but excluded because of fussiness, disinterest, parental and sibling interference, or failure to reach the minimum looking criterion for the habituation or test movies.

Materials and procedure

The procedure remained unchanged from that of Experiment 1. The habituation movies from Experiment 1 were used; however, the test movies were modified as we have already described and as shown in Figure 4.

Results and Discussion

Unlike in Experiments 1 and 2, there was no Test Trial (Approach Triangle vs. Approach Square) × Habituation Group (triangle helps, square hinders vs. triangle hinders, square helps) interaction, $F(1, 18) = 2.68$, $p > .05$. Neither habituation group looked longer at one movie over the other (Fig. 3). The results of Experiment 3 indicate that the looking-time patterns in Experiments 1 and 2 were not driven by simple positive or negative associations between characters.

GENERAL DISCUSSION

On what basis did the 12-month-old infants discriminate between the two test movies in Experiments 1 and 2? In one movie, the ball approached the helping object; in the other movie, the ball approached the hindering object. The looking preference observed for one type of movie over the other suggests that the 12-month-olds differentiated the helper and the hinderer with respect to the ball's new goal in the new context. This study expands on previous studies (e.g., Gergely et al., 1995; Woodward, 1998) by demonstrating that infants will interpret an actor's new behavior in a new physical context on the basis of

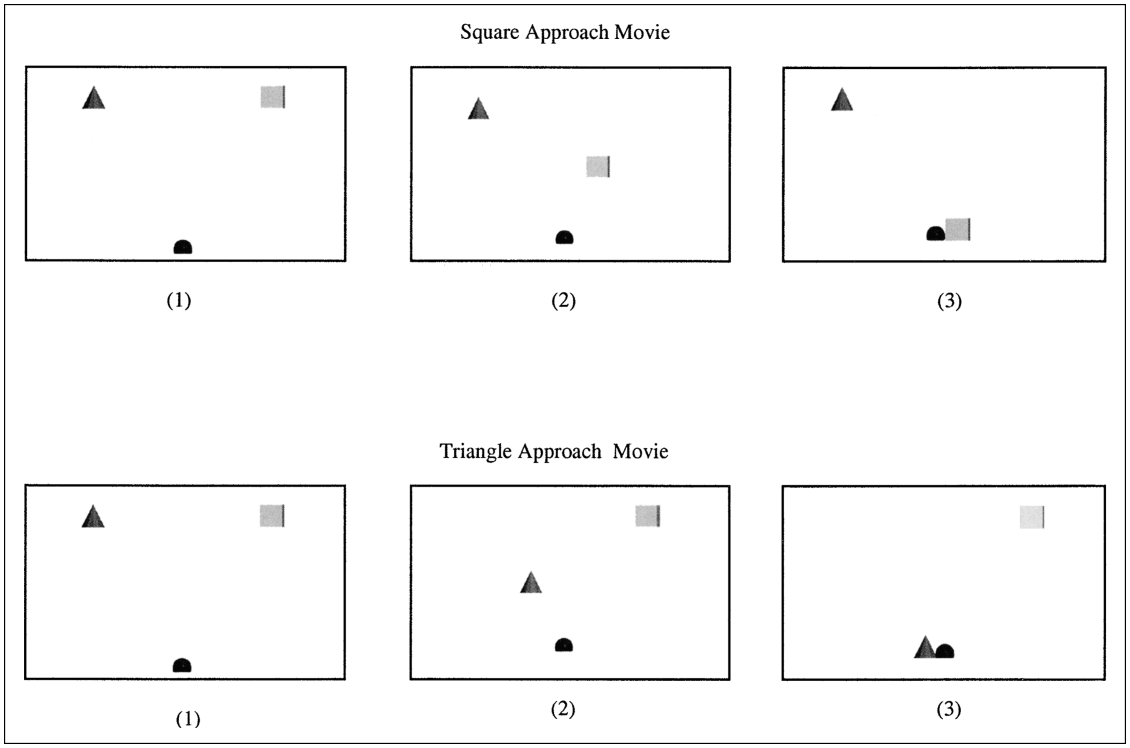

Fig. 4. Illustration of the test movies used in Experiment 3.

that actor's previous experience in a different context. That is, interpretation of the new action is made even without previously witnessing that goal action or situation.

The question remains as to how one approach event might be judged as preferable to the other. Two interpretations are possible. Under one interpretation, the infants find the act of approaching the helper more coherent than the act of approaching the hinderer because they have posited a mentalistic mediator for the ball's actions. The infants recognize that there is a goal of climbing the hill during the habituation scenes and that the goal is completed in concert with the helper, but not completed in the presence of the hinderer. Given this history, the ball is seen as preferring (or "liking"), or "wanting to be with," the helper object. At this mentalistic level of analysis, the Approach Helper movie makes a better, more coherent continuation of the habituation movies than does the Approach Hinderer movie.

Under the alternative, nonmentalistic interpretation, the infants make a purely behavioral analysis of the ball's actions (i.e., "the ball has the tendency to approach the helper object"). The judgment that this action constitutes a more coherent continuation of the habituation movies may fall out of an assumption such as "agents are more likely to approach objects that are positively associated with previous goal completion than to approach objects that are not positively associated with previous goal completion." That is, the infants would expect a goal-directed agent like the ball to move toward an object that would more likely be involved in accomplishing ends than hindering ends. This assumption could take the form of a psychological principle similar to the principle of rational action (proposed by Csibra et al., 1999; Gergely et al., 1995), according to which infants predict behavior regarding a specific goal in a single context by using a system that relates the goal, the action, and the constraints of the physical world and posits that the most efficient means to goal completion will be produced.

Although the present study does not distinguish between these two interpretations, there is reason to prefer the mentalistic interpretation. If infants make a nonmentalistic analysis of the ball's behavior, an assumption or psychological principle regarding goal behavior would be necessary to mediate the interpretation of the new goal action in the new context. We proposed earlier that such an assumption would be in the form of "agents are more likely to approach objects that are positively associated with previous goal completion than to approach objects that are not positively associated with previous goal completion." However, this assumption would require that 12-month-old infants possess an abstract, nonmentalistic concept of "goal," in which agents are seen to have the overall goal (nonmentalistic) of achieving all future goals. Moreover, this abstract notion would have to be attributed to the agents themselves. This type of psychological principle has not been previously specified and is far more complex than the rationality principle proposed by Gergely et al. (1995), which applies over behavior toward a concrete, previously defined goal.

In sum, the present studies suggest that by 12 months of age (but not by 5 months), infants are able to interpret actions of an actor on the basis of the actor's previous actions and interactions, even when these occurred in different physical contexts with different goal states. Thus, infants of this age are able not only to recognize a goal event, but also to later infer a new disposition in a new situation. This finding raises the possibility that infants of this age make such interpretations on the basis of the attribution of mental states to actors. It will be informative to discover the extents and limits of this ability in infants, and the developmental trajectory for such capacities.

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