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Brief article

Can infants attribute to an agent a disposition to perform a particular action?

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Abstract

The present research investigated whether 13.5-month-old infants would attribute to an actor a disposition to perform a recurring action, and would then use this information to predict which of two new objects—one that could be used to perform the action and one that could not—the actor would grasp next. During familiarization, the infants watched an actor slide various objects forward and backward on an apparatus floor. During test, the infants saw two new identical objects placed side by side: one stood inside a short frame that left little room for sliding; the other stood inside a longer frame that left ample room for sliding. The infants who saw the actor grasp the object inside the short frame looked reliably longer than those who saw the actor grasp the object inside the long frame. This and control results from a lifting condition provide evidence that by 13.5 months, infants can attribute to an actor a disposition to perform a particular action.

Adults are often able, in simple situations at least, to predict others' actions. Some of our predictions are based on *goal* information. If we know, or can infer, that a friend has a particular goal in mind, then we can use this information to predict the kinds of actions she is likely to perform next. For example, if our friend says "Let me get you a glass of water", we might expect her to get a glass and fill it with water: these actions are precisely those needed to achieve her goal. Other predictions are based on *disposition* information. If we know, or can infer, that a friend has a particular disposition—such as a predilection for certain objects, activities, or events—then once again we can use this information to predict her actions. For example, if we know that our friend loves pecan pie, then we might

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predict which dessert she will select at the buffet table. Although at an abstract level goals and dispositions are conceptually distinct—for example, we would not want to say that a fondness for pecan pie is equivalent to a goal of eating pecan pie—at a more concrete level goals and dispositions are clearly intertwined: her fondness for pecan pie should lead our friend, once she reaches the buffet table and notices the pecan pie, to form a goal of obtaining a piece of the pie and to act in a manner consistent with this goal. In this sense, recognizing others' dispositions can thus help us make sense of their goal-directed actions.

Recent research suggests that infants attribute not only goals (e.g., Csibra, Bíró, Koós, & Gergely, 2003; Csibra, Gergely, Bíró, Koós, & Brockbank, 1999; Gergely, Bekkering, & Kiraly, 2002; Gergely, Nadasdy, Csibra, & Biro, 1995; Meltzoff, 1995, 1996; Onishi, Baillargeon, & Woodward, 2005; Shimizu & Johnson, 2004; Song, Baillargeon, & Fisher, 2005; Thoermer & Sodian, 2001; Woodward, 1998, 1999) but also dispositions (e.g., Kuhlmeier, Wynn, & Bloom, 2003; Luo & Baillargeon, 2005, in press; Onishi & Baillargeon, 2002; Premack & Premack, 1997; Song, et al., 2005) to others. In a recent experiment, Kuhlmeier et al. (2003) habituated 12-month-olds to two computer-animated events in which a circle first attempted and failed to climb a hill. In one event, a triangle then helped the circle reach the top of the hill. In the other event, a square pushed the circle down to the bottom of the hill. During test, the hill was removed, and the infants saw the circle approach either the helpful triangle or the unhelpful square. Results suggested that the infants expected the circle (1) to prefer the helpful triangle over the unhelpful square, based on the history of their interactions, and hence (2) to approach the triangle as opposed to the square.

Other experiments suggest that infants may be able to attribute to an agent a preference not only for a particular agent, as we just saw, but also for a particular object (e.g., Luo & Baillargeon, 2005, in press; Song et al., 2005) or kind of object (e.g., Onishi & Baillargeon, 2002). In one experiment, for example, 7.5-month-olds were familiarized to a live event (adapted from Woodward, 1998) in which a human actor reached for and grasped a toy egg, on the left, as opposed to a toy tree, on the right (Song et al., 2005). During test, the toys' positions were reversed, and the actor reached either for the egg (expected event) or the tree (unexpected event). Infants in a control condition saw the same events, except that only the egg was present during familiarization. The infants in the experimental condition looked reliably longer at the unexpected than at the expected event, whereas those in the control condition looked about equally at the two events. Together, these results suggested that the infants in the experimental condition (1) interpreted the actor's actions during familiarization as revealing a preference for the egg over the tree, and hence (2) expected the actor to again reach for the egg when the toys' positions were reversed. Because in the control condition the tree was absent during familiarization, the infants had no information as to which toy, the egg or the tree, the actor would prefer, and hence they could form no prediction as to which toy she would grasp next.

The preceding results suggest that infants can attribute to an agent a positive disposition toward a particular agent or a particular object, and can use this information to predict the agent's actions. The present research built on these findings and asked whether 13.5-month-old infants[1] could also attribute to an agent a disposition involving a particular

[1] Pilot data collected with 9.5-month-olds were negative, so we elected to focus on older, 13.5-month-olds.

action. Specifically, after watching an agent perform the same action on various objects, would infants attribute to the agent an inclination to perform this recurring action, and would they then use this information to predict which of two objects—one that could be used to perform the action and one that could not—the agent would grasp next?

1. The present research

The infants first received three familiarization trials in which they saw an actor grasp an object on an apparatus floor and repeatedly slide it forward and backward (see Fig. 1). Different objects—a toy fish, a box, and a baby shoe—were used in the three trials. Next, the infants received a static pretest display trial in which they saw two identical toy trucks resting side by side on the apparatus floor (see Fig. 2). The truck on the right (from the infants' perspective) stood inside a short frame that was barely longer than the truck, making it impossible for the actor to slide the truck inside the frame. The truck on the left stood inside a longer frame that left sufficient room for the actor to slide the truck. Finally, the infants received a test trial in which they saw the actor grasp the truck inside either the short (short-frame event) or the long frame (long-frame event); the actor then paused until the trial ended.

If the infants (1) interpreted the actor's actions during familiarization as revealing an inclination to slide objects; (2) expected the actor to maintain this disposition during test; and (3) realized that the truck inside the long but not the short frame could be slid forward and backward, then they should be surprised when the actor grasped the truck inside the short frame. The infants who saw the short-frame event should thus look reliably longer than those who saw the long-frame event.

One potential difficulty with our experiment was that the infants might look longer at the short- than at the long-frame event simply because they preferred seeing the actor grasp the truck inside the short as opposed to the long frame. To control for this possibility, infants were tested in a second condition identical to the first, except that during each familiarization trial the actor repeatedly lifted and lowered the object (see Fig. 3). If the infants (1) construed the actor's actions during familiarization as revealing an inclination to lift objects; (2) expected the actor to maintain this disposition during test; and (3) realized that either truck could be lifted inside its frame, then they should find neither test event surprising. The infants who saw the short- and long-frame events should thus look about equally.

We reasoned that finding positive results in the sliding but not the lifting condition would suggest three conclusions about 13.5-month-old infants. First, when watching an agent perform the same action on different objects, infants disentangle the action performed from the objects used to perform it. Second, infants attribute to the agent a disposition to perform the recurring action. Finally, infants use this disposition information to reason about the agent's subsequent actions. When two novel objects are introduced in the situation, infants judge if either, or both, of the objects can be used to perform the action of interest. If only one of the objects can be used, then infants expect the agent to reach for that object and are surprised if she reaches for the other object instead. However, if both of the objects can be used, then infants expect the agent to reach for either object.

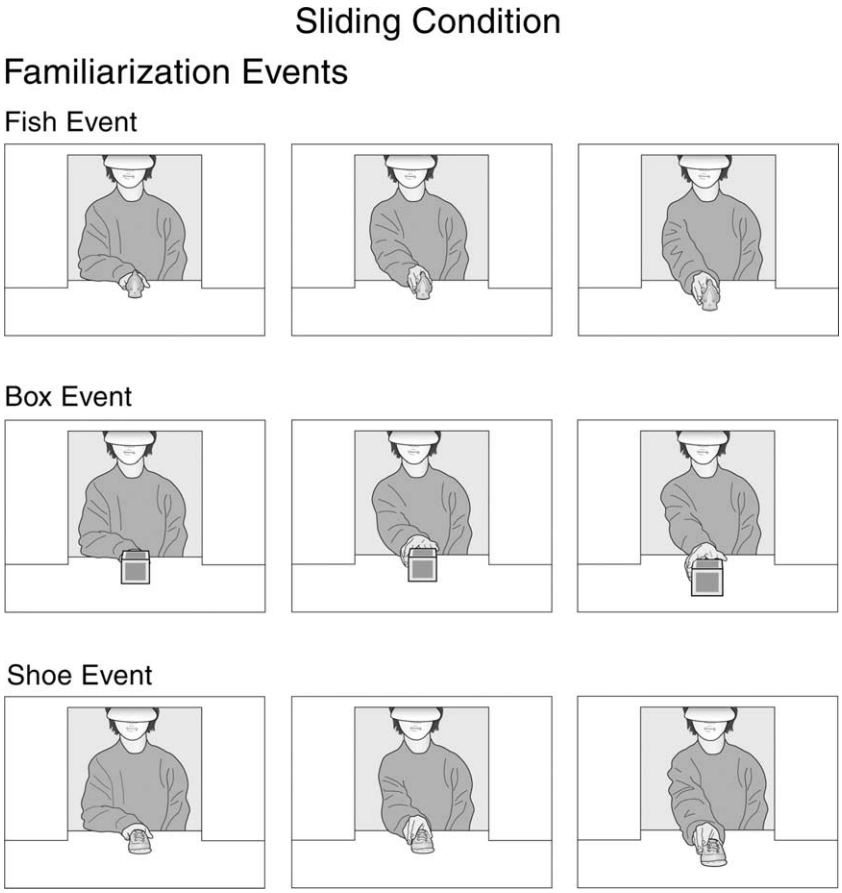

Fig. 1. *Sliding condition: Familiarization events*. At the beginning of each familiarization event, the actor sat on a wooden chair centered behind the window in the apparatus's back wall; she wore a blue shirt and a white visor. A muslin curtain behind the actor hid the test room. In each familiarization event, an object stood on the apparatus floor 10 cm in front of the window; the center of the object was positioned 30.5 cm from the left wall. The object used in the first familiarization event was a plastic toy fish 7.5 cm high, 5 cm wide, and 9.5 cm long; it was bright pink and decorated with black stripes. The object used in the second familiarization event was a cardboard box 6.5 cm high, 8 cm wide, and 14 cm long; it was covered with green contact paper and its edges were outlined with yellow tape. The object used in the third familiarization event was a baby shoe 5 cm high, 6.5 cm wide, and 11.5 cm long; it was made of blue denim fabric and had a white shoelace and a white rubber sole. The actor's bare right hand rested on the apparatus floor with the tip of the middle finger 4 cm behind the object. Each familiarization trial consisted of a 5-s pre-trial followed by a main-trial. During the pre-trial, there was a 4-s pause (to give the infants the opportunity to inspect the object), and then the actor reached for and grasped the object (1 s). During the main-trial, the actor repeated the following sequence of actions until the trial ended: she slid the object forward 15 cm (2 s), paused (1 s), slid the object back to its original position (2 s), and again paused (1 s). To help the actor adhere to the script just described, a metronome beat softly once per second.

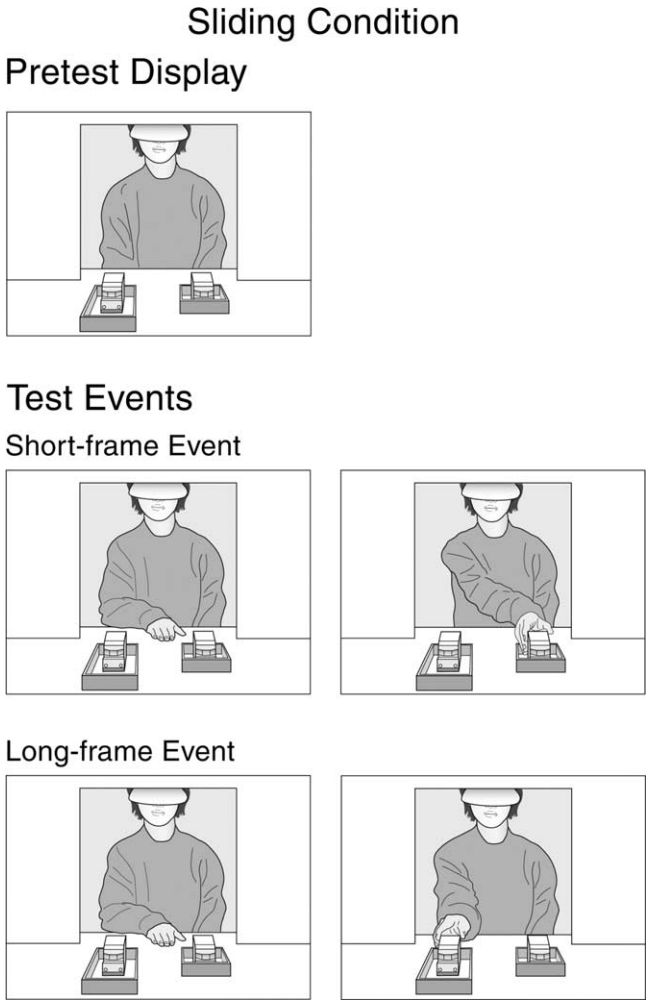

Fig. 2. *Sliding condition: (a). Pretest display*. Prior to the display trial, two identical toy trucks were placed side by side on the apparatus floor. Each truck was 7 cm high, 5 cm wide, and 17.5 cm long; it was made of yellow plastic and had blue windows and black wheels. The trucks stood inside frames positioned 10.5 cm apart, 10 cm in front of the back wall. Both frames were 2.5 cm high, 10.5 wide, made of 0.5 cm-thick Plexiglas, and covered with a wood pattern contact paper. The (short) frame on the right was placed 15 cm from the right wall and was 20 cm long; the gap between the front of the truck and the frame was 1.5 cm. The (long) frame on the left was placed 54.5 cm from left wall and was 31.5 cm long; the gap between the front of the truck and the frame was 13 cm. During the trial, the actor sat at the window, with no hand on the apparatus floor. (b) *Test events*. During the pre-trial at the start of each test trial, there was a 4-s pause, and then the actor reached for and grasped the truck (1 s) inside either the short frame (short-frame event) or the long frame (long-frame event). During the main-trial, the actor paused with her hand on the truck until the trial ended.

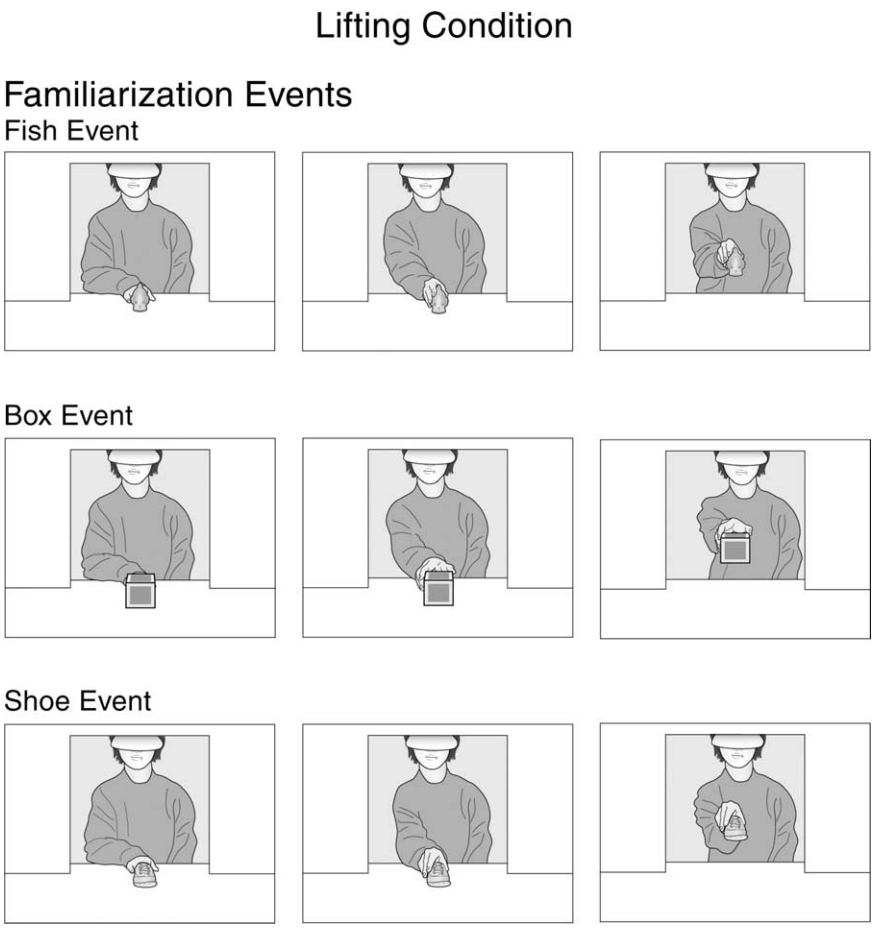

Fig. 3. *Lifting condition: Familiarization events.* The familiarization events shown in the lifting condition were identical to those in the sliding condition except that the actor lifted and lowered the object, instead of sliding it forward and backward. During the main-trial of each familiarization trial, the actor repeated the following sequence of actions until the trial ended: she lifted the object 15 cm above the floor (2 s), paused (1 s), lowered the object to its original position (2 s), and again paused (1 s).

2. Method

2.1. Participants

Participants were 30 healthy term infants, 15 male and 15 female (range = 13 months, 1 day to 14 months, 14 days, $M = 13$ months, 18 days). Another 14 infants were eliminated because they were inattentive (4), distracted (4), or active (2), looked the maximum amount of time allowed on 3 or more of the 5 trials they received (3), or looked over 3 SD above the mean of their condition in the test trial (1). Fifteen infants were randomly

assigned to each action condition; within each condition, 8 infants saw the short-frame event and 7 infants saw the long-frame event.

2.2. Apparatus

The apparatus consisted of a wooden display box 98 cm high, 101 cm wide, and 60 cm deep, mounted 76 cm above the floor. The infant sat on a parent's lap centered in front of the apparatus and faced an opening 42 cm high and 93.5 cm wide. Between trials, a muslin curtain 61 cm high and 99.5 cm wide hid this opening. The side walls of the apparatus were painted white and the floor was covered with pastel patterned contact paper. The back wall was made of white foam core; a window 42 cm high and 42.5 cm wide extended from its lower edge, 11 cm from the right wall.

2.3. Procedure

Two observers monitored each infant's looking behavior through peepholes in cloth-covered frames on either side of the apparatus. The primary observer's responses determined the end of each trial (see below). Interobserver agreement averaged 95% per trial per infant.

The infants first received three *familiarization* trials. In each trial, the actor reached for and grasped the object on the apparatus floor (pre-trial), and then repeatedly slid it forward and backward (sliding condition) or lifted it up and down (lifting condition), until the trial ended (main trial). A toy fish, a box, and a baby shoe were used in the first, second, and third trial, respectively.

Next, the infants received a static *display* trial in which two identical toy trucks rested side by side on the apparatus floor; the truck on the right stood inside a short frame, and the truck on the left inside a long frame.

Finally, the infants received a *test* trial in which the actor grasped the truck inside either the short or the long frame (pre-trial), and then paused until the trial ended (main trial). Each familiarization, display, and test trial ended when the infants (1) looked away for 2 consecutive seconds after having looked for at least 12 (familiarization), 4 (display), or 2 (test) cumulative seconds, or (2) looked for 60 (familiarization) or 30 (display, test) cumulative seconds.

Preliminary analyses of the familiarization, display, and test data revealed no significant interaction involving action condition, event condition, and sex, all Fs$(1, 22) < 0.51$; the data were therefore collapsed across sex in subsequent analyses.

3. Results

Fig. 4 shows the infants' mean looking times during the familiarization, display, and test trials. The infants' looking times during the three *familiarization* trials were averaged and analyzed by means of a 2×2 analysis of variance with action condition (sliding or lifting) and event condition (short- or long-frame) as between-subjects factors. No effect

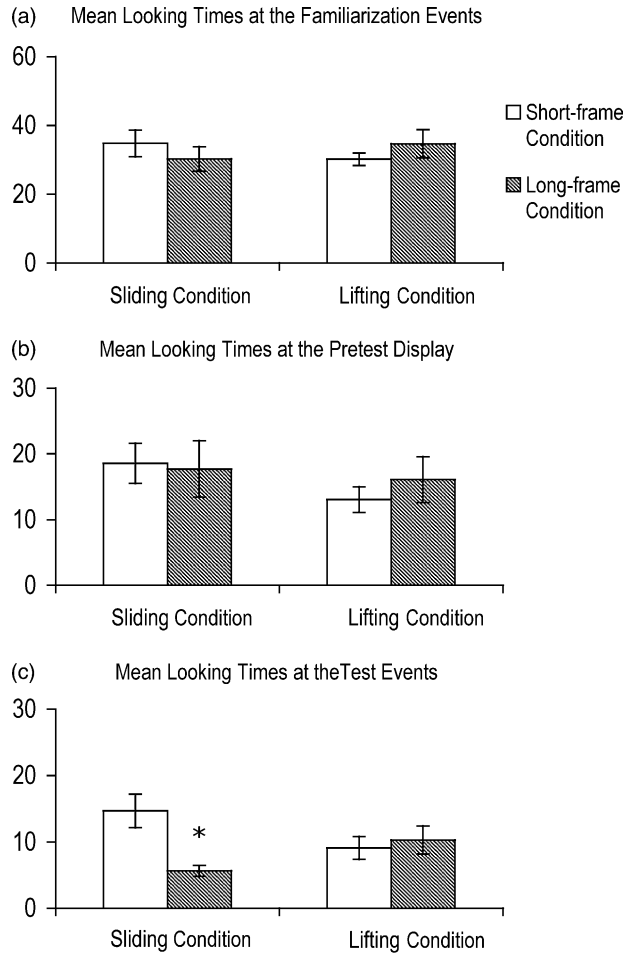

Fig. 4. Mean looking times (sec) of the infants in the two action and the two event conditions during familiarization, display, and test trials.

was significant, all $Fs(1, 26) < 1.89$, $P > .15$, suggesting that the infants in the four experimental groups tended to look equally during the familiarization trials. Analysis of the infants' looking times during the *display* trial produced similar results, all $Fs(1, 26) < 1.30$, $P > .25$, suggesting that the infants also looked about equally during the display trial.

Analysis of the infants' looking times during the *test* trial yielded a significant main effect of event condition, $F(1, 26) = 4.42$, $P < .05$, and a significant action condition $\times$ event condition interaction, $F(1, 26) = 7.59$, $P < .025$. Planned comparisons indicated that (1) in the sliding condition, the infants who saw the short-frame event ($M = 14.7$, $SD = 6.7$) looked reliably longer than those who saw the long-frame event ($M = 5.7$, $SD = 2.2$), $F(1, 26) = 11.79$, $P < .0025$, and (2) in the lifting condition, the infants who saw

the short- ($M=9.1$, SD$=4.6$) and long-frame ($M=10.3$, SD$=5.6$) events looked about equally, $F(1, 26)=0.21$.[2]

Non-parametric Wilcoxon rank-sum tests confirmed the results of the sliding ($W_S=32$, $P<.01$) and lifting ($W_S=60.5$, $P>.20$) conditions.

4. Discussion

When the actor repeatedly slid the various objects before her during familiarization, the infants took her actions to reveal a particular disposition, namely, an inclination to slide objects. During test, the infants (1) expected the actor's disposition to again guide her actions; (2) realized that the truck inside the long frame was "slideable" but that the truck inside the short frame was not; and hence (3) were surprised when the actor reached for the truck inside the short frame.

When the actor repeatedly lifted the various objects before her during familiarization, the infants interpreted her actions as revealing an inclination to lift objects. During test, the infants (1) expected the actor's disposition to continue guiding her actions; (2) realized that the truck inside the short and long frames were equally "liftable"; and thus (3) were not surprised when the actor reached for either truck.

The present results extend three sets of findings in the infancy literature. First, they suggest that, by 13.5 months of age, infants can attribute to agents not only dispositions involving particular agents and objects (e.g., Kuhlmeier et al., 2003; Luo & Baillargeon, 2005, in press; Onishi & Baillargeon, 2002; Premack & Premack, 1997; Song et al., 2005), but also dispositions involving particular actions. The infants in the present research attributed to the actor an inclination to slide or lift objects, and they used this disposition to predict, when new objects were introduced in test, which object the actor would select (and hence which goal-directed actions the actor would perform to obtain that object). These findings, together with those cited above, raise many interesting questions for future research. For example, are these dispositions best understood as primitive mental states or as behavioral tendencies (for discussion, see Kuhlmeier et al., 2003)? What kinds of positive and negative dispositions are infants of different ages able to attribute to agents? At what age do infants become able to assign enduring (as opposed to fleeting, context-bound) dispositions to agents? And finally, at what age do infants become able to attribute to others dispositions inconsistent with their own (e.g., Repacholi & Gopnik, 1997)? Answers to these questions should help us better understand early psychological reasoning.

Second, the present results add to the growing evidence that infants' representations of others' goals or dispositions are sufficiently abstract to allow predictions in relatively new contexts. To date, this evidence has come primarily from experiments exploring

[2] An analysis of covariance using as covariates the infants' looking times during the familiarization trials (averaged across the three trials) and during the display trial again produced a significant main effect of event condition, $F(1, 24)=4.30$, $P<.05$, and a significant action condition $\times$ event condition interaction, $F(1, 24)=5.58$, $P<.05$. Planned comparisons confirmed that the infants who saw the short-frame event looked reliably longer than those who saw the long-frame event in the sliding ($F(1, 24)=10.24$, $P<.005$) but not the lifting ($F(1, 24)=0.07$) condition.

infants' reasoning about events in which two or more non-human agents—computer-animated figures—interact (e.g., Csibra et al., 1999; Gergely et al., 1995; Kuhlmeier et al., 2003; Premack & Premack, 1997). As an example, consider the experiment by Kuhlmeier et al. (2003) that was described in the Introduction. The results of this experiment suggest that the infants' representation of the circle's disposition was sufficiently abstract to allow them to predict whether the circle should approach the helpful triangle or the unhelpful square when the hill was removed in test. Similarly, the infants in the present research represented the actor's disposition in sufficiently abstract terms that they could predict which of the two new objects the actor should select in test.

Finally, the present results extend recent evidence that infants aged 6 months and older can recognize the same action when performed with different objects across trials (e.g., Casasola & Cohen, 2002; Casasola, Cohen, & Chiarello, 2003; McDonough, Choi, & Mandler, 2003). For example, Casasola et al. (2003) habituated 6-month-olds to four different containment events in which an experimenter's hand placed an object inside another object (e.g., a toy monkey inside a basket, or a small toy car inside a larger car). During test, the infants dishabituated to novel support but not containment events, suggesting that they were able to extract the action of containment from the habituation events. The present research shows that by 13.5 months infants can extract, from events with different objects, not only *relational* actions, in which an object is placed in a particular spatial relationship with another object, but also *motion* actions, in which a single object is moved in a particular manner or along a particular path. As such, the present results also have implications for the study of language acquisition and more particularly verb learning. To learn the meaning of a motion-action verb such as "slide", children must map the verb "slide" onto a conceptual structure corresponding to the action of sliding; to form such a conceptual structure, children must be able, when observing appropriate scenes, to extract the action of sliding from the objects being slid (e.g., Fisher & Gleitman, 2002).

In sum, the present results indicate that, by 13.5 months, infants can disentangle a recurring motion action from the objects used to perform it, can attribute to a human actor a disposition to perform this motion action, and can use this disposition to predict, for example, which of two new objects the actor is likely to act on next.

Acknowledgements

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References

Casasola, M., & Cohen, L. (2002). Infant categorization of containment, support, and tight-fit spatial relationships. *Developmental Science*, *5*, 247–264.

Casasola, M., Cohen, L. B., & Chiarello, E. (2003). Six-month-old infants' categorization of containment spatial relations. *Child Development*, *74*, 679–693.

Csibra, G., Bíró, S., Koós, O., & Gergely, G. (2003). One-year-old infants use teleological representations of actions productively. *Cognitive Science*, *27*, 111–133.

Csibra, G., Gergely, G., Bíró, S., Koós, O., & Brockbank, M. (1999). Goal attribution without agency cues: The perception of 'pure reason' in infancy. *Cognition*, *72*, 237–267.

Fisher, C., & Gleitman, L.R. (2002). Language acqusisition. In H.F. Pashler, (Series Ed.) & C.R. Gallistel (Volume Ed.), *Stevens' Handbook of Experimental Psychology, Vol 3*: *Learning and motivation* (pp. 445–496) (3rd ed.) New York: Wiley.

Gergely, G., Bekkering, H., & Kiraly, I. (2002). Rational imitation in preverbal infants. *Nature*, *415*, 6873.

Gergely, G., Nadasdy, Z., Csibra, G., & Biro, S. (1995). Taking the intentional stance at 12 months of age. *Cognition*, *56*, 165–193.

Kuhlmeier, V., Wynn, K., & Bloom, P. (2003). Attribution of dispositional states by 12-month-olds. *Psychological Science*, *14*, 402–408.

Luo, Y., & Baillargeon, R. (2005, April). *Infants' reasoning about agents' goals and perceptions*. Paper presented at the biennial meeting of the Society for Research in Child Development, Atlanta, GA.

Luo, Y., & Baillargeon, R. (in press). Can a self-propelled box have a goal? Psychological reasoning in 5-month-old infants. *Psychological Science*.

McDonough, L., Choi, S., & Mandler, J. (2003). Understanding spatial relations: Flexible infants, lexical adults. *Cognitive Psychology*, *46*, 229–259.

Meltzoff, A. N. (1995). Understanding the intentions of others: Re-enactment of intended acts by 18-month-old children. *Developmental Psychology*, *31*, 838–850.

Meltzoff, A. N. (1996). Understanding the intentions of others: Re-enactment of intended acts by 18-month-old children. *Annual Progress in Child Psychiatry & Child Development*, 67–98.

Onishi, K. H., & Baillargeon, R. (2002, July). *Infants' understanding of others' actions: New directions*. Paper presented at the Workshop on Infant Action Understanding, Munich, Germany.

Onishi, K. H., Baillargeon, R., & Woodward, A. (2005). *There is more than one way to skin a cat: Reasoning about goals in 10.5-month-old infants*. Manuscript in preparation.

Premack, D., & Premack, A. J. (1997). Infants attribute value $\pm$ to the goal-directed actions of self-propelled objects. *Journal of Cognitive Neuroscience*, *9*, 848–856.

Repacholi, B., & Gopnik, A. (1997). Early understanding of desires: Evidence from 14- and 18-month-olds. *Developmental Psychology*, *33*, 12–21.

Shimizu, Y. A., & Johnson, S. C. (2004). Infants' attribution of a goal to a morphologically unfamiliar agent. *Developmental Science*, *7*, 425–430.

Song, H., Baillargeon, R., & Fisher, C. (2005). *The development of infants' use of verbal information when reasoning about others' actions*. Manuscript under review.

Thoermer, C., & Sodian, B. (2001). Preverbal infants' understanding of referential gestures. *First Language*, *21*, 245–264.

Woodward, A. L. (1998). Infants selectively encode the goal object of an actor's reach. *Cognition*, *69*, 1–34.

Woodward, A. L. (1999). Infants' ability to distinguish between purposeful and nonpurposeful behavior. *Infant Behavior and Development*, *22*, 145–160.