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Discussion

Do 5-month-old infants see humans as material objects?

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Abstract

Infants expect objects to be solid and cohesive, and to move on continuous paths through space. In this study, we examine whether infants understand that human beings are material objects, subject to these same principles. We report that 5-month-old infants apply the constraint of continuous motion to inanimate blocks, but not to people. This suggests that young infants have two separate modes of construal: one for inanimate objects and another for humans.

Keywords: Inanimate objects; Animates; Constraints

Infants have appropriate expectations regarding the nature of objects (Aguiar & Baillargeon, 1999; Baillargeon, Spelke, & Wasserman, 1985; Leslie, 1982). As early as 4 months of age, infants are sensitive to violations of the constraints of object physics such as cohesion (objects move as bounded wholes) (Spelke & Van de Walle, 1993), solidity (two objects do not occupy the same space at the same time) (Baillargeon, Needham, & DeVos, 1992; Spelke, Breinlinger, Macomber, & Jacobson, 1992), and continuity (objects move on connected paths) (Spelke, Kestenbaum, Simons, & Wein, 1995). It is also the case that infants distinguish between inanimate objects and animates, namely humans, in important ways. For example, they recognize that humans are self-propelled while inanimate objects move only after contact with another object (Poulin-Dubois, Lapage, & Ferland, 1996; Rakison & Poulin-Dubois, 2001; Spelke, Phillips, & Woodward, 1995).

However, do infants recognize that, in some cases, the principles they readily apply to inanimate objects also apply to humans? In other words, do they understand that people are

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objects that are subject to physical laws such as cohesion, solidity, and continuity? If they do, it would imply an understanding of the duality of humans: animate objects engaging in self-initiated action, yet fundamentally material objects. Here, we examine this question by using the test case of the continuity principle.

We tested 5-month-olds' application of this principle to inanimate objects and humans, using a procedure modeled after Spelke, Kestenbaum, et al. (1995). In that study, infants were familiarized to an object moving across a stage that contained two occluding screens. Infants who saw the object slide behind the first screen, then "reappear" from behind the second screen *without having traversed the intermediary space*, looked longer at a subsequent test display of one object than at a display of two identical objects, implying that the former was more novel or surprising than the latter. That is, the infants recognized the discontinuity of motion in the original presentation and, since a single object cannot move in such a manner, inferred the presence of two objects. Consistent with this interpretation is the fact that infants in the same study who were familiarized to an object moving in a continuous manner (behind one screen, through the intermediary space, then behind the second screen and out again) showed preferential looking to the test display of two objects (Spelke, Kestenbaum, et al.). In the present two experiments, we test infants in a similar manner using analogous, videotaped scenes depicting either inanimate objects (Experiment 1) or human actresses (Experiment 2).

1. Experiment 1

1.1. Method

Participants. In Experiment 1, we tested 20 infants (mean age 4 months 29 days; range 4 months 16 days to 5 months 20 days). Infants were recruited from the greater New Haven area. Five additional infants were tested, but not included in analysis due to general fussiness and/or failure to complete at least two test trial pairs.

Procedure and stimuli. Procedures were closely modeled after Spelke, Kestenbaum, et al. (1995). For both experiments, infants sat in a baby seat positioned 45 cm from a computer monitor that displayed video movies. Half of the infants were repeatedly shown the "Continuous Motion" movie depicted in Fig. 1 until a predetermined looking time criterion was met.[1] In this movie, an inanimate object (a white cardboard box) was initially located on the right side of a 3.65 m stage that also contained two, large, red screens separated by 1.21 m. The box silently slid back and forth across the stage in a continuous manner, moving behind, and momentarily occluded by, each red screen. The second half of infants was shown a "Discontinuous Motion" movie (Fig. 1). Here, the staging was similar; however, after being occluded by the first red screen, the box did not emerge and travel in the space separating the two screens. Instead, a box reappeared from behind

[1] The movies played continuously until habituation criterion was met. 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. Habituation criterion was defined as three consecutive trials with summed looking time less than or equal to 50% of the sum of the looking times on the first 3 trials.

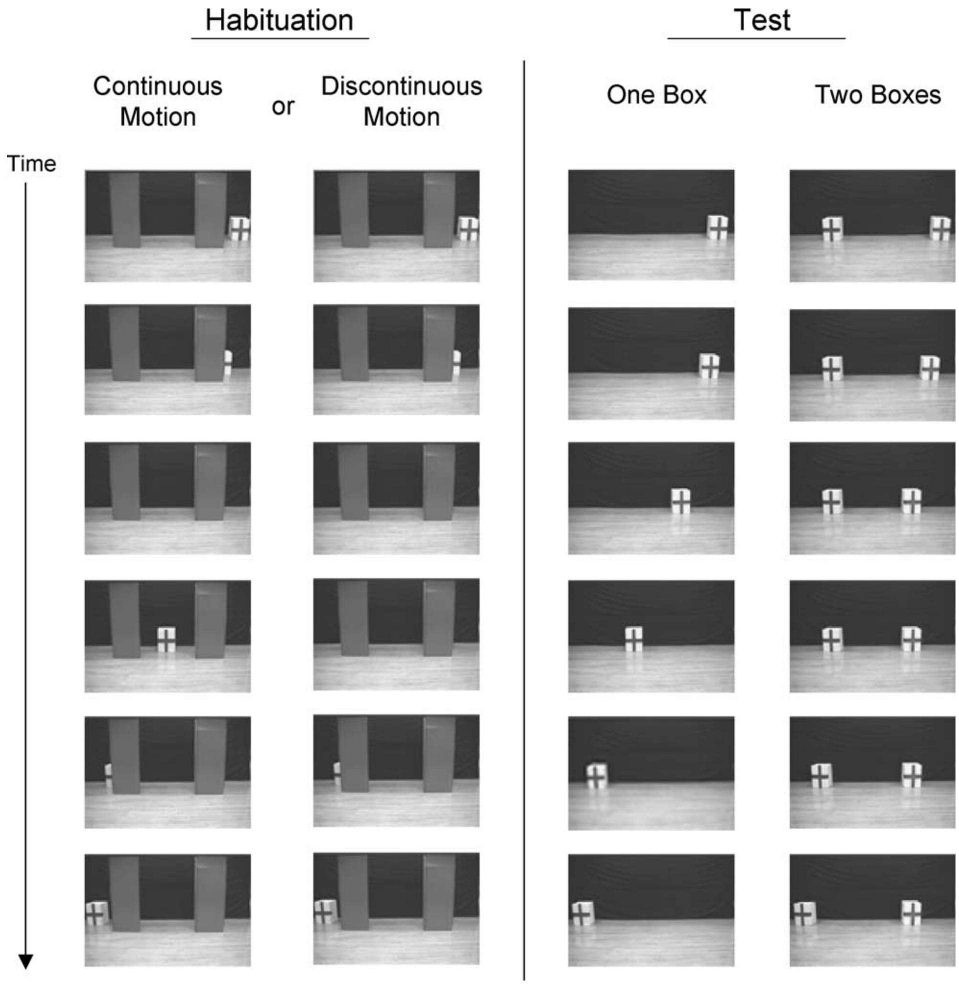

Fig. 1. Movie stimuli used in Experiment 1 (inanimate objects), presented as a sequence of static frames, with time decreasing downward. See text for details.

the second screen at a time appropriate had the box traveled the entire path across the stage. If an observer of these movies is sensitive to the principle of continuous motion, the Continuous Motion display gives the impression of one box sliding across the stage, whereas the Discontinuous Motion display implies the presence of two boxes where one box stays behind the first screen and an identical second box emerges from the second screen.

To test infants' sensitivity to this principle, we presented them with two types of test movies (Fig. 1), each presented three times, after habituation to either the Continuous Motion or the Discontinuous Motion movies. The two types of test movies were presented in pairs, with order counterbalanced across subjects. In each test movie, the stage no longer contained the red screens. In the "One Box" test movie, a single white box slid back and forth for the length of the stage. In the "Two Boxes" test movie, a box slid until reaching the location where the first red screen had stood in the habituation movies, and then an identical box, located in the previous position of the second red screen, began to move to the other edge of the stage. The speed of object motion was equal for each test movie, and corresponded to the motion speed in the habituation movies (8 s/slide across stage). If infants apply the principle of continuity of motion to inanimate objects, those habituated to the Continuous Motion movies should find the Two Boxes test movie unexpected as compared to the One Box test movie, and look longer at the former. However, infants habituated to the Discontinuous Motion movies should find the One Box test movie unexpected, and thus show the opposite looking time preference. In contrast, if infants do not apply the continuity principle to the objects in these movies, no looking time difference should obtain.

Data analyses. All but one infant completed three test pairs, and for this infant, the missing pair was replaced by the mean values for her habituation group. Thus, the analyses reported incorporate three test pairs from each subject. An experimenter naïve to the subjects' habituation group reviewed video footage of all test trials and measured the infants' looking times to the test movies. These times were found to correspond well with the online timing ($r = 0.90$).

Preliminary ANOVAs revealed no main effect of habituation group or trial order. There was a significant Test Trial Type ("One Box" or "Two Boxes") × Habituation Group ("Continuous Motion" or "Discontinuous Motion") × Sex interaction ($F(1, 19) = 11.21$, $p = 0.004$; effect size (eta-squared) = 0.41. Sex differences were not found in a similar previous study (Spelke, Kestenbaum, et al., 1995), and are not of theoretical interest in the present paper.

1.2. Results and discussion

A repeated measures ANOVA on infants' looking times in test demonstrated a significant Test Trial Type ("One Box" or "Two Boxes") × Habituation Group ("Continuous Motion" or "Discontinuous Motion") interaction, $F(1, 19) = 6.77$, $p = 0.019$; effect size (eta-squared) = 0.30. That is, infants who saw a depiction of continuous motion during habituation looked longer at test movies with two objects than test movies with one object, while infants who saw discontinuous motion during habituation looked longer at one object than two objects (Table 1). Non-parametric analyses revealed the same pattern. A chi-squared contingency test (Habituation Group × Test Trial Type) on frequencies of infants showing a mean looking time preference for either type of test movie was significant ($\chi^2(1) = 5.50$, $p = 0.020$) (Table 1).

The results of Experiment 1 replicated previous work by Spelke, Kestenbaum, et al. (1995), demonstrating that by 5 months infants apply the continuity of motion principle to inanimate objects. In Experiment 2, we examined whether infants would apply this principle to the motion of humans.

Table 1
Mean looking time (standard deviation) to test movies depicting one and two inanimate objects and the number of subjects preferring each

Test movie	Habituation group	
	Continuous	Discontinuous
*Looking time**		
One box	5.53 s (3.80)	6.40 s (3.91)
Two boxes	7.23 s (4.19)	5.61 s (3.73)
*Number of subjects**		
One box	1	6
Two boxes	9	4

Asterisk indicates statistical significance at $p < 0.05$.

2. Experiment 2

2.1. Method

Participants. Twenty infants were tested (mean age 4 months 29 days; range 4 months 15 days to 5 months 16 days), recruited in the same process as Experiment 1. Seven additional infants were tested, but not included in analysis due to general fussiness and/or failure to complete at least two test trial pairs.

Procedure and stimuli. The procedure and stimuli were similar to Experiment 1, except that now, adult women walked across the stage (Fig. 2) during the habituation and test movies. For movies in which two women were needed (Discontinuous Motion habituation movie and Two Humans test movie), identical twin sisters wearing identical clothing were filmed. The Continuous Motion and One Human movies depicted one of the twins. If infants apply the continuity principle to animate motion, a looking time pattern similar to Experiment 1 should obtain in test trials here. However, if infants do not apply the continuity principle with animate objects, no looking time preferences should obtain.

Data analyses. Data were analyzed in a manner identical to Experiment 1. Similarly to Experiment 1, online and offline timing of infants' looking time were strongly correlated ($r = 0.92$). Preliminary ANOVAs revealed no main effect of habituation group or trial order.

2.2. Results and discussion

A repeated measures ANOVA on infants' looking times in test did not produce a significant Test Trial Type ("One Human" or "Two Humans") × Habituation Group ("Continuous Motion" or "Discontinuous Motion") interaction ($F(1, 19) = 0.644$, $p = 0.445$; effect size (eta-squared) = 0.04). Infants in both habituation groups did not look longer at one type of test movie over the other (Table 2). Consistent with this result, there was no difference in the number of subjects preferring either type of test movie (Table 2). Thus, in marked contrast to Experiment 1, infants in Experiment 2 did not look preferentially at one type of movie over the other. The present

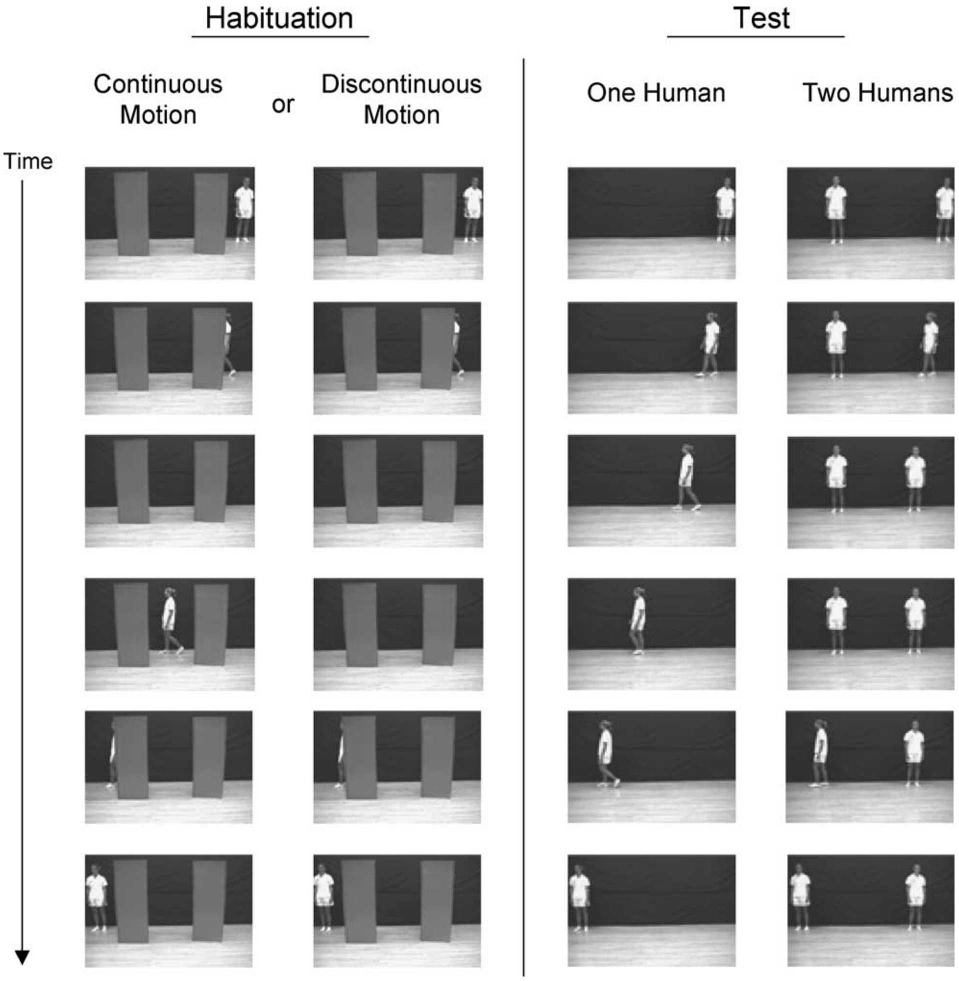

Fig. 2. Movie stimuli used in Experiment 2 (humans), presented as a sequence of static frames, with time decreasing downward. See text for details.

results suggest that infants do not recognize that humans are subject to a fundamental principle of object motion, namely continuity.

Additional analyses of the infants' behavior were made. There was no difference in the mean number of trials to reach habituation criterion between Experiments 1 and 2 (Experiment 1: M = 8.65 trials, SD = 2.74; Experiment 2: M = 8.35 trials, SD = 2.74); $t(38) = 0.35$, $p = 0.73$) and no difference in the overall looking time to the first three and last three habituation trials (Experiment 1: M = 12.61 s, SD = 1.31; Experiment 2: M = 11.38 s, SD = 1.31; $F(1, 38) = 0.44$, $p = 0.51$). Furthermore, there was no difference in mean overall looking time during test (Experiment 1: M = 6.19 s, SD = 3.60; Experiment 2: M = 7.57 s, SD = 4.87; $t(38) = 1.02$, $p = 0.31$). Thus, it is unlikely that

Table 2
Mean looking time (standard deviation) to test movies depicting one and two humans and the number of subjects preferring each

Test movie	Habituation group	
	Continuous	Discontinuous
Looking time (N.S.)		
One human	6.57 s (6.62)	8.62 s (5.19)
Two humans	7.50 s (5.42)	7.58 s (3.94)
Number of subjects (N.S.)		
One human	5	5
Two humans	5	5

N.S., statistically non-significant.

the test movie preferences that were found in Experiment 1, but not Experiment 2, were due to any difference in attention to movies containing boxes versus movies containing humans.

3. General discussion

The present results suggest that while 5-month-old infants apply the principle of continuous motion to inanimate objects, they do not readily apply it to humans. There is evidence from prior studies that infants differentiate between animate and inanimate objects in appropriate ways (Poulin-Dubois et al., 1996; Spelke, Phillips, et al., 1995). However, the present study represents a situation in which they *mistakenly* differentiate between the two, suggesting that at 5 months, infants do not readily view humans as material objects.

The precise nature of the distinction here is an open question. It might be best characterized as humans versus everything else, but there is also good reason to think that the category of "humans" might be too narrow. After all, infants treat a wide variety of animals, including humans, as similar to each other but different from inanimate objects (Mandler & McDonough, 1993). In fact, they will even regard non-animals such as geometrical figures as goal-directed agents, akin to humans, so long as they are imbued with multiple animate characteristics (e.g. behavioral adjustment and contingent reactivity) (Gergely, Nadasdy, Csibra, & Biro, 1995; Johnson, Slaughter, & Carey, 1998; Kuhlmeier, Wynn, & Bloom, 2003). On the other hand, recent research has also suggested that, in some cases, infants treat humans as separate not only from inanimate objects, but other animate entities (Bonatti, Frot, Zangl, & Mehler, 2002). It thus remains an open question whether the results of the present study are due to a distinction between animates versus inanimates, intentional agents versus non-intentional objects, or humans versus other entities.[2]

[2] One might note that the boxes in the present study did have one cue to animacy, namely self-propelled motion. The infants may have seen the boxes as animate, yet still expected continuous motion, suggesting the failure to apply the continuity principle is specific to human stimuli. However, it is also possible that infants did not see the boxes as animate. Self-propulsion is the only animacy cue exhibited by these objects as they moved on their straight-line trajectory, and recent research has indicated that while this cue may used, it is often not necessary or sufficient to denote animacy (infants: Csibra, Gergely, Biro, Koos, & Brockbank, 1999; children/adults: Gelman, Durgin, & Kaufman, 1995; Opfer, 2002; monkeys: Hauser, 1998).

Regardless of whether the current results apply specifically to humans or to all animate/animated entities, the present study still suggests that, early in development, infants are mistaken about the physical constraints that apply to humans. Of course, one must be cautious when interpreting a null result such as that found in Experiment 2. Yet, the combined data from Experiments 1 and 2 are consistent with the current interpretation: the expectations that infants have of inanimate objects are not readily applied to humans in analogous situations in which the application is appropriate.

Infants *do* have certain expectations about humans—and these expectations are often (correctly) not applied to inanimate objects. For example, infants interpret humans—but not inanimates—as social, goal-directed entities (Baldwin, Baird, Saylor, & Clark, 2001; Carpenter, Aktar, & Tomasello, 1998; D'Etremont, Hains, & Muir, 1997; Meltzoff, 1995; Phillips, Wellman, & Spelke, 2002). To illustrate, after witnessing a human arm repeatedly reach and grasp one of two toys, 6-month-old infants expect the arm to continue to reach for that particular goal toy, even if its location has been moved. In contrast, infants do not have such expectations of an inanimate rod engaging in the same motion patterns (Woodward, 1998), implying that the rod's motion was not interpreted as goal-directed. Additionally, while infants will imitate the intentional actions of a human, they will not imitate the motions of an inanimate object (Meltzoff).

It is possible that the dissociation between objects and humans found in the present study forms the complement to the distinction between humans and inanimate objects in terms of social, goal-directed behavior. Together, this double dissociation suggests that young infants may have different modes of construal for humans versus inanimate objects: humans are construed in terms of social and intentional actions, while inanimate objects are interpreted via a system sensitive to object physics (see Bloom (2004) for further discussion). The existence of this human/inanimate distinction, and the differential application of principles to each, may help infants to define these areas of knowledge early in development. The appreciation that these construals overlap—that in certain regards, people *are* just objects—may be a developmental accomplishment.

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