# Inferring Structural Properties of Objects from Intentional Gestures in Infancy.

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**Abstract**

In this study, we were interested in what 9-month-olds understood about the physical properties of an object after seeing an intentional gesture made toward the object. Specifically, we asked whether infants could make predictions about the presence or absence of a handle from the way a hand manipulated the object. Nine-month-olds were recruited to participate in the study. Infants were familiarized to a box and watched as the box was moved up-and-down by an experimenter. The way the experimenter held the box was either consistent with the presence of a handle or not. The back of the box was hidden from infants during this action sequence. After they had become familiarized to this action, the experimenter then showed infants the back of the box to reveal a handle or not. Infants' looking times were recorded. Infants were predicted to show renewed interest in the box when the experimenter's action during familiarization was inconsistent with what was revealed on the back of the box. However, babies looking time decreased in both cases suggesting that they did not notice this inconsistency.

When we reach for something, such as a book, how do we understand what kind of movement to make to achieve our goal? We would have to have some knowledge about how our hand will ultimately grasp the object as well as what fine motor movements we have to make to produce the gesture. One possibility is that we may use our knowledge of grasping actions as well as our knowledge of the physical properties of an object. In the present study we ask whether this type of knowledge is present in infancy.

Research has grown around the topic of how infants understand intentional gestures within the last decade. This research has revealed that understanding the intentions behind gestures develops between 5 and 13 months (Barrett & Needham, 2008; Gergely et al., 1995; Lou & Baillargeon, 2007; Needham, 1999; Woodward, 1998). During this time period, infants learn about different kinds of gestures. For example, researchers have shown that infants are able to predict the intention of both a reach and a point towards an object (Hamlin, Hallihan, & Woodward, 2008; Sodian & Thoermer, 2004; Woodward & Guajardo, 2002). However, there are still questions about what they actually can predict from these gestures. In this research, I will investigate whether infants can make predictions about the physical properties of objects, such as the presence of a handle, from different kinds of gestures. In the following pages, I will first discuss research that investigated if infants are able to interpret a gesture as goal-directed. Then I will review further evidence which investigates if infants can understand an intended goal. Finally, I will review literature that explores what inferences infants can make about an object from a gesture before describing the current study.

Previous research has shown infants are able to interpret several types of gestures as goal directed. For example, Woodward (1998) showed that 9-month-old infants interpreted reaching

gestures as object-directed. In this study the researcher placed two objects (e.g., a ball and a bear) in front of infants. An experimenter would then reach for one of the two objects (e.g., a bear) several times. After the infant fulfilled the habituation requirement, a screen was raised to occlude the objects from the infant. While the screen was raised, the researcher switched the positions of the objects. The screen was lowered and the experimenter either reached for the bear or the ball. Results indicated that infants paid more attention to when the researcher reached for a new object (e.g., reaching for the ball in the bear's previous location). Results from a replication using 5-month-olds showed that they also showed this pattern, although not as strongly. Thus, the researchers were able to conclude that infants around 5 months begin to interpret reaching gestures as directed at objects.

Other research has shown that this tendency to interpret the object-directedness of gestures may be a more general skill that is not specific to the presence of a human actor. In particular, in Johnson, Shimizu, & Ok (2007) 12-month-old infants watched an agent (e.g. a beeping robot) interact with an unfamiliar toy (e.g. a red plastic cup). Experimenters either interacted with the agent (e.g. a scripted conversation) or did not. After habituating the infant to the agent approaching a toy, the test trials recorded infants' looking time when the agent approached a new toy in the same location (e.g. a ball) or a new location (e.g. where the cup was moved to). Infants looked longer when the agent approached the new toy because they had already encoded the agent's actions as goal-directed based on socially contingent cues.

It has also been found that 6-months-olds make predictions about end goal of the gesture even if it is not completed. In particular, they are more likely to pay attention to a completed, impossible gesture-task than to an unfinished gesture (Daum, Prinz, & Aschersleben, 2008). In

this study, infants watched a video of an experimenter reaching for one of two objects (e.g. a duck or a toy). After the gesture had passed a mid-way point, infants were shown one of two possible outcomes. In the plausible event, the gestured continued along its path towards the original object (e.g. the duck). In the implausible condition, the video would show the experimenter touching the other object (e.g. the toy). Infants looked longer in the implausible conditions, suggesting that they encode an uncompleted gesture as goal directed and are surprised when it is not completed.

Other studies stress the importance of the infant being able to gesture toward the object themselves to understand the gesture as goal-directed (Sommerville, Woodward, & Needham, 2005). In this study, based on Woodward's (1998) findings, 3-month-old infants were give time to interact with objects (e.g. use velcro mittens to pick up the objects) or simply watch them (e.g. no interaction). During habituation trials, infants watched an experimenter reach for and grasp one of the two objects (e.g. a bear or a ball). An occluder was raised and experimenters switched the location of the two objects. After the occluder was raised, the experimenter reached for the new object in the same location, or the old object in a new location. Infants who interacted with the objects looked significantly longer at the new object events. Infants who only watched interactions with the objects did not look significantly longer at either condition. The experimenters suggested that because of their interaction with the objects, infants were able to better understand a gesture as goal-directed.

One question is whether infants can also make predictions about the physical properties of objects based on a gesture that is directed towards it. One study suggests that by 9 months infants can do so (Daum, Vuori, Prinz, & Aschersleben, 2009). This previous research has found

that 9-month-old infants are able to understand that specific properties of gestures (e.g. how wide it is) imply information about the goal object. In this study, infants watched a video of an experimenter make one of two gestures towards an occluded object (e.g. a coffee cup). Half-way through the gesture, experimenters showed one of two completed actions (e.g. holding the side of the coffee cup or the handle of the coffee cup). Infants looked longer in events when the gesture and the completed action did not match (e.g. a handle gesture was made, but infants saw the side of the cup being held). This suggests that infants understand that the physical properties of gestures (e.g. how wide it is), infer certain structural properties of the intended goal object.

In the present study I extend this line of work by discovering if infants are able to predict structural properties of an object (e.g. a box) based on movements caused by an intentional gesture . To answer this question, I presented 9-month-old infants with a series of actions involving a box. Infants watched as the box was moved up-and-down by an experimenter. The way the experimenter held the box was either consistent with the presence of a handle or not, but infants could not see the place the handle would be (on the back of the box). After they had become familiarized to this action, the experimenter then showed the infant the back of the box. The box either had a handle or not and infants' looking times were recorded. Infants were predicted to show renewed interest after familiarization when the features of the box were inconsistent with the experimenter's actions during familiarization.

## Method

*Participants*

Thirty-five 9-month-old infants (18 girls, 17 boys; mean age: 9 months; 22 days; range: 9;0 – 9;30), participated in this study Eight 9-month-old infants were also tested, but were

excluded from the final sample because of technical problems ($n$ = 7), or fussiness ($n$ =1). Infants' information was obtained from the public birth records of a metropolitan area in the southern part of the United States.

*Test Environment*

The study space was a room that was divided in half by a bright, blue curtain that completely hid the experimenters, cameras, table, and equipment used to track infants' gaze. Parents were asked to sit in a chair 3 ft from the curtain. Infants were then placed on their laps for the remainder of the study. The stage where the actions took place was created by cutting a 18 in x 20 in area from this curtain. The cut-out was at the eye-level of the infant. An additional piece of fabric was raised and lowered to occlude and show the events.

*Stimuli*

Two 4 in x 4.5 in x 9.25 in cardboard boxes that were equal in size, shape and color were used as stimuli. One of the boxes also had a different colored piece of cardboard attached to the back of the box that served as a handle (see Figure 1).

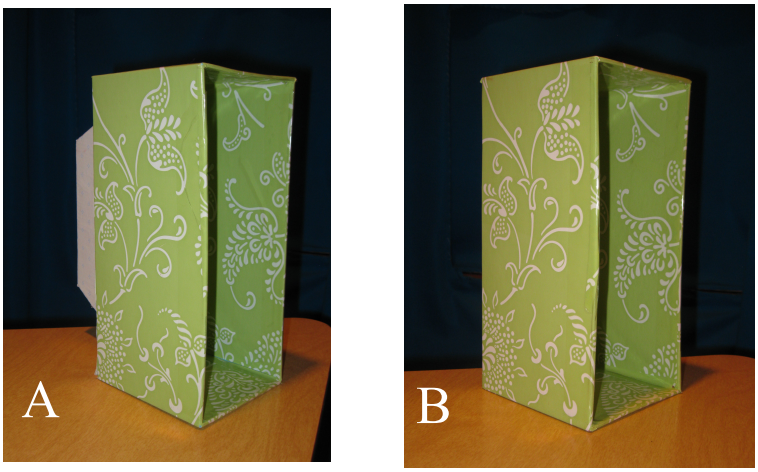


**Fig. 1**. The stimuli with a handle (a) and without a handle (b)

Two cameras and a TV were used to code for the infants' looking time. One camera was placed under the table facing towards the infant's face. A small cut-out in the curtain allowed for everything but the lens to be hidden from the infant. The other camera was placed behind the infant and was used to record the action occurring on the stage. The images from both of the cameras were fed into the TV, placed behind the curtain. An experimenter recorded the infants looking time by depressing a key on a computer keyboard.

*Design and Procedure*

Two experimenters were needed to conduct the study. Experimenter 1 (E1) stood at the side of the table and manipulated the boxes during the study. He was also unable to see the infant or TV throughout the study. Experimenter 2 (E2) was responsible for measuring the amount of time the infant would look at the action on the stage.

The study consisted of three parts, box introduction, familiarization and test trials. The box introduction phase offered infants an opportunity to look at the box prior to seeing it being moved. The familiarization trials (4 total) were used to show infants how the box could be moved. Infants were either shown an up-and-down action that was consistent with the presence of a handle (e.g. the researcher grabbed something on the back of the box and moved it) or inconsistent with the presence of a handle (e.g. the researcher grabbed the back of the box so that his fingers could be seen around the edge before he moved it).

After the familiarization trials infants were shown 4 test trials. During the test trials the back of the box was turned to reveal a handle (in two test trials) or no handle (in the other two test trials). Hence, two of the test trials matched what infants saw during familiarization and two of the test trials did not match.

The order of the match and non-match test trials was counterbalanced (the two trials of each type were blocked). Whether infants were shown an event that was consistent or inconsistent with the presence of a handle during familiarization was between subjects and was determined by random assignment.

To illustrate the procedure I will describe the sequence of events for an infant who was shown a familiarization phase that was consistent with the presence of a handle first. Each familiarization trial began with E1 calling for the infant's attention (e.g., “Susie, look over here”). E1 would then raise the occluder to reveal a box in the center of the stage area. In the box introduction phase, E1 rested his hand on the top of box. The trial would end after the infant had looked for a total of 30 seconds or had looked away for a complete 3 seconds. A small beep from the timing program would indicate the end of the trial. E1 would then lower the occluder, wait 2 seconds, call for the infant's attention, and raise the occluder for the next trial. After the occluder had been raised, E1 grabbed toward the back of the box and raised and lowered the box with a handle (that the infant could not see). A metronome, at the rate of 1 beat per second, was used in order to keep the rate at which E1 moved the box in familiarization trials constant. After the infant had watched the action for 30 seconds or looked away for a total of 2 seconds, a small beep would sound and E1 would lower the box. E1 would then lower the occluder indicating the end of the trial. The four familiarizations trials had an identical procedure.

Test trials began next. Test trials began with a call for attention and the raising of the occluder. E1 would then make a similar gesture as made in the box introduction by resting his hand on the top of the box. He would then turn it counter clockwise so that the infant would have a clear view of the back of the box (e.g., to reveal a handle). After the infant would looked 30

seconds or looked away for a total of 3 seconds, a small beep would indicate the end of a trial. This type of trial was repeated and then the boxes would be switched (when the occluder was lowered) so that the infant would be exposed to the other type of box (e.g., the one with no handle). After the fourth test trial, E1 would lower the occluder and tell the parent that the experiment had ended.

When the familiarization phase was inconsistent with the presence of a handle everything was the same except that E1 would grab the back of the box instead of the handle.

## Results

The prediction was that infants would look longer when the features of the box did not match the familiarization trials. Paired sample t-tests were first used to investigate the effect of seeing a box that matched versus did not match what infants had seen during the familiarization trials. We then investigated each effect separately based on what infants were shown during familiarization (the handle versus no handle condition). Figure 2 shows average looking times across the familiarization trials and the match or no match test trials.

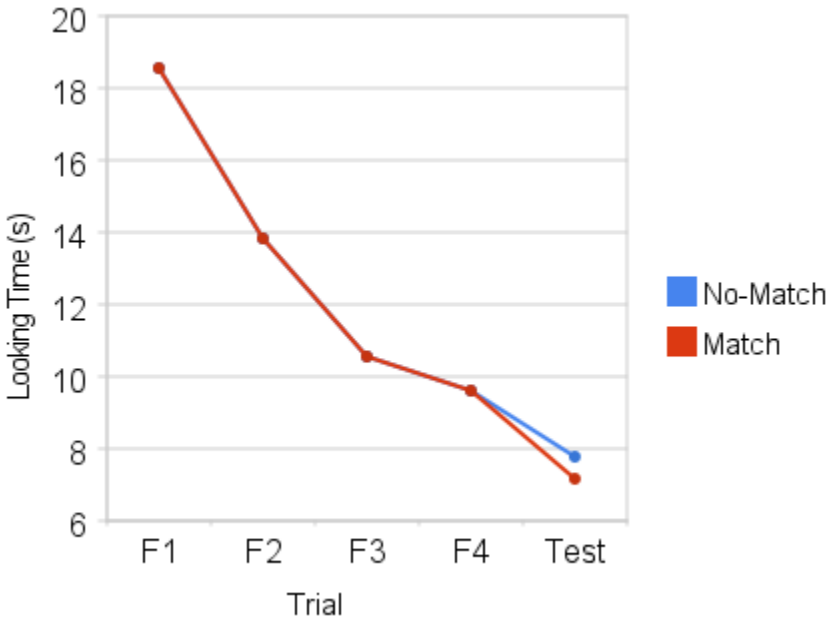


**Fig. 2.** Average looking times across familiarization trials and first test trial in match and no-match conditions.

Infants' looking time, as expected, significantly decreased across familiarization trials from the first (M = 18.54, SD = 7.28) to the fourth (M = 9.61, SD = 5.88) trial, paired t (35) = 6.55, $p < .001$. This was true for both kinds of familiarization trials: handle, paired $t(16) = 4.64$, $p < .001$, and without the handle, paired $t(19) = 4.50$, $p < .001$. This indicates that infants were indeed familiarized to the presented interaction between the box and the gesture.

Compared to the last familiarization trial, infants showed a significant decrease in looking time in the first test trial for the match test trials (M = 7.15, SD = 3.30), $t(35) = 2.45$, $p = .02$. This effect was only significant when babies were shown an action consistent with a handle during familiarization (M = 7.64, SD = 3.61) t (18) = 2.53, $p = .02$. There was no difference when infants were shown a familiarization event that was not consistent with there being a handle on the box (M = 6.71, SD = 3.04), t (16) = .79, p = ns. This would be consistent with infants' recognizing that the box they had been shown during familiarization was the same as the one they saw during test. However, infants also showed a trend in a decrease of their looking time in non-match trials (M = 7.75, SD = 4.32), $t(35) = 1.91$, $p = .07$. This was true in the handle condition (M = 7.45, SD = 4.69), $t(18) = 2.07$, $p = .05$, but not in the no-handle condition (M = 8.09, SD= 3.97), t (16) = .44, p = ns. These findings indicate that infants continued to be bored by the test trials that were supposed to lead to increased looking.

Differences between the looking times in the match (M = 7.75, SD = 4.31) and no-match (M = 7.14, SD = 3.30) conditions were not significant, $t(35) = .84$, p = ns. These findings present the possibility that infants were unable to distinguish a different structural trait based upon a certain gesture.

## Discussion

We were interested if 9-month-old infants were able to infer a physical attribute of an object from its interaction with an intentional gesture. We hypothesized that infants would show renewed interest after familiarization when the physical structure of an object (e.g. a box) did not match the action performed on it by an experimenter. An experimenter familiarized the infant with the box by moving it up and down in a manner that was consistent with a handle or not. During test trials, infants were shown the back of the box that either matched (e.g. had a handle) or did not match (e.g. no handle). Results showed that infants were familiarized, but did not have a significant increase in non-match test trials. There are several explanations for this result, some of which I will discuss in the following paragraphs.

It has been shown that infants are able to use intentional gestures to interpret a specific physical structure of an object (Daum et al., 2009). We predicted that infants should have been able to use this information about the gesture to make inferences about the object. Infants could not have attended to the gesture because of the lack of experience with the gesture. Perhaps orientation to the action could have given infants more experience. Previous research has shown that infants interpret goal directed actions dependent on their point of view (e.g. allocentric or egocentric; Bremner, 1978; Burgess, 2006). Significant amounts of research have shown that infants should be able to infer the gesture as goal directed when situated in an allocentric position (e.g. the view presented in this study) (Woodward, 1998; Guajardo & Woodward, 2004; Lou & Baillargeon, 2007). Perhaps infants could better understand from an egocentric point of view (e.g. as if they were doing the action).

Infants also had a lack of experience with the object. Researchers suggest that infants

must be familiar with the object to interpret a gesture as goal directed (Johnson, Shimizu, & Ok, 2007). Without previous knowledge of the box infants could have been unable to understand the sequence of action occurring. Perhaps allowing infants to play with the boxes prior to the study could help infants' performance on this task.

The experimenters were also out of sight during the experiment. Infants could have needed to see the experimenter make the gesture towards the object to begin to understand its meaning (Guajardo & Woodward, 2004). Infants were not able to see the shape of the hand making the gesture since it was obstructed by the box in the familiarization trials. Perhaps more exposure to the hand when it is making the gesture could help the infants interpret the action (Daum et al., 2009).

From previous research there are many suggestions that could make the experiment easier for infants to understand. What intentional gestures tell us about the object is the frontier of research in this field. The development of this skill has not been thoroughly tested and could be an area of research that gives information about the infant beyond understanding gestures. These areas could include concepts such as theory of mind (Aschersleben, Hofer, & Javanovic, 2008). This is an area of research that is in need of a breadth of findings to begin to fully comprehend what an infant can understand from gestures about the world around us.

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