Infants' Understanding of Others' Behaviors: Do Infants Tie Goals to Individuals?

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Abstract

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During the first year of life, infants understand others' simple actions as goal directed, that is, as directed toward particular objects in the world. However, to date, the exact nature of infants' understanding of goals is unknown. As adults, we often see goals as not just outcomes that reliably occur with particular actions, but as being tied to individuals and personal characteristics of individuals. Using a visual habituation paradigm, two experiments examined whether infants are able to understand that others' goal-directed actions are tied to individual identity rather than superficial properties of individuals, such as the particular shirt an actor is wearing.

In both Experiments, 10- and 8-month-old infants were assigned to either the switch actor or the switch shirt condition. During the habituation trials, one actor wearing a yellow shirt (Actor A) and another actor wearing a blue shirt (Actor B) were positioned side-by-side in front of a stage supporting two objects. Actor A repeatedly reached for and grasped one of the two objects while Actor B, positioned next to Actor A, looked down. Following habituation, the locations of the objects were reversed. On the test trials, the actor alternated between pursuing her prior goal object (in a new location; target toy event) and pursuing a new-goal object (non-target toy event). In the switch actor condition, Actor B performed the test trials wearing the same shirt that actor A had worn on habituation trials. In contrast, in the switch shirt condition, Actor A performed the test trials wearing the shirt that Actor B had worn during habituation trials.

The results show that 10-month-olds, but not 8-month-old infants, generalize goals across a change in physical appearance that is not central to personal identity. However, they do not generalize goals across individuals. These results suggest that by at least 10 months of age, infants appear to understand goals as tied to the individual identity. The findings are discussed in terms of infants' understanding of goal-directed action.

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CHAPTER I

INTRODUCTION

People encounter the actions of others everyday and must interpret those actions appropriately for optimal social interaction. A critical part of adults' understanding of the actions of others is that actions are typically driven by internal mental states such as goals and intentions. For example, adults use goal-relevant information in both describing and segmenting a sequence of events (Trabasso, Stein, Rodkin, Munger, & Baugh, 1992; Zacks & Tversky, 2001). Adults also remember goal-relevant information better than other types of event information (Bower, Black, & Turner, 1979). Moreover, adults recognize that goals and intentions can be specific to individuals: Sally's goal of obtaining an apple does not necessarily indicate that Ann will have the goal of obtaining an apple.

Given the centrality of understanding goals and intentions a critical question concerns when infants and children recognize action as goal-directed. Research has demonstrated that the ability to understand behavior as goal-directed emerges early in life: even infants view action as goal-directed (Shimizu & Johnson, 2004; Sommerville & Woodward, 2005; Thoermer & Sodian, 2001; Woodward, 1998, 1999; Woodward & Guajardo, 2002). For example, in one study using a visual habituation paradigm, infants were shown two different objects located on opposite sides of a stage. An agent then reached toward and grasped one of the two objects repeatedly during habituation trials. Subsequently, after the object locations were switched, infants demonstrated longer looking to events in which the actor reached for a new object in the original object location versus those in which the actor reached for the same object in a new location (Woodward, 1998, 2003). These findings

suggest that at least 6-month-old infants pay greater attention to the relation between a person and his or her goal rather than the trajectory of the arm or hand through space.

The ability to understand others' behaviors as goal-directed becomes elaborated over the first year of life. First, infants distinguish between intentional and accidental actions: after seeing an actor drop the back of her hand on an object infants do not selectively encode the actor-object relation (Woodward, 1999). Second, by the end of the first year of life, infants not only recognize simple actions, such as reaching and grasping, as goal directed, but recognize that sequences of action are performed in service of an overarching goal (Sommerville & Woodward, 2005; Woodward & Sommerville, 2000). Third, infants are able to view actions as goal-directed even when these actions do not result in physical contact with a goal object. For example, infants understand the communicative function of the pointing action (Tomasello, Carpenter, & Liszkowski, 2007) and view the points of others as goal-directed (Woodward & Guajardo, 2002).

An important outstanding question concerns how, or at what level, infants represent the goals of others. A variety of recent evidence suggests that by the end of the first year of life, infants view goals as more than objects or outcomes tied to particular actions. Infants flexibly construe actions as directed toward particular goals, depending on the causal context in which these actions occur (Sommerville & Woodward, 2005a; Woodward & Sommerville, 2000). For example, 12-month-old infants view an actor's actions on a cloth as directed toward a toy when the cloth is placed underneath, but not when it sits adjacent to, the toy (Sommerville &Woodward, 2005a). Moreover, at 10 months of age, infants' ability to identify the ultimate goal of the cloth-pulling sequence hinges on whether they receive prior information about an actor's desire for the to-be-pursued toy: infants who are given evidence

that the actor tends to repeatedly pursue a particular object when it is directly available, recognize that the actor's actions on the cloth are directed toward the toy that it supports, not the cloth itself. Infants who are not given such prior information, however, do not recognize the toy as the goal of the sequence (Sommerville & Crane, 2009). These findings suggest that infants view the self-same action differently depending on contextual and historical factors.

Infants also appear to recognize that goals are not just directed toward perceivable objects, by at least 1 year of age. Recent research has found that when infants were shown a person who reached repeatedly for an orange truck versus a black doll, they subsequently expect that the person would choose a red truck instead of a white doll in test trials (Spaepen & Spelke, 2007). This suggests that infants generalize goals along basic-level categories to unseen exemplars. Further research shows that infants can infer the goal of failed attempts and incomplete actions by at least 12 months of age (Brandone & Wellman, 2009; Hamlin, Hallinan, & Woodward, 2008; Sommerville, Blumenthal, Venema, & Sage, 2012). Taken together, these findings support the claim that, for infants, goals are not merely construed as perceptible action outcomes tied to particular actions.

New research suggests that infants may also view goal-directed action as stemming not only from goals but also from enduring personal characteristics, such as preferences and dispositions, in certain contexts. Preferences can be distinguished from goals in at least two ways. First, whereas goals signify attitudes, orientations and actions toward single objects, preferences refer to rankings or likings of one object or event over another object or event (or multiple objects and/or events). That is, preferences are contrastive. Second, whereas goals may be brief and transient, preferences reflect enduring attitudes toward objects and events.

To investigate the conditions under which infants view the actions of others as expressing preferences for particular objects, Luo and Baillargeon (2007) tested 12.5-month-old infants using a paradigm similar to that used by Woodward (1998). In one condition (transparent condition), two objects were placed on a stage, each behind a different transparent occluder. During the familiarization trials, the agent reached for one of the two visible objects. In another condition (opaque condition), two objects were placed on a stage behind occluders, similar to the transparent condition. However, one of the occluders was opaque, giving the actor visual access to only one object. During the familiarization trials, the actor reached for the visible object behind the transparent occluder. Thus, although the actor reliably pursued the same object in the familiarization trials across both conditions, it was only in the transparent condition that the actor knowingly selected the target object over an alternate object.

In the test trials, the occluders were removed and the two objects were placed on the table with their positions reversed. In the old goal event, the actor reached for the same object (now located on the other side of the display) whereas in the new goal event, the actor reached for the alternate object. The authors predicted that the infants would assume the actor possessed a preference for the old goal object over the new goal object, but only in the transparent condition. This would lead infants to look longer when the actor pursued (and, presumably preferred) a new object. In contrast, because the actor in the opaque condition was unaware of the alternate object, infants would have no basis upon which to form an expectation regarding the actor's preference.

The authors found that the results of the study varied as a function of condition: only infants in the transparent condition looked longer when the actor reached for a new goal

object. In the opaque condition, infants looked equally at both test events. The authors argued that infants may construe goal-directed actions as reflecting preferences for particular objects in instances in which an actor has the opportunity to select between two objects.

Preferences are not only relational and contrastive, but also enduring across space and time. To investigate whether infants construe object selections as an expression of enduring preferences, Sommerville, Crane, and Yun (in preparation) tested infants at 10 months of age to determine whether, and under what conditions, infants expect an actor's object choice to generalize across a change in context (e.g., a change in room). During habituation trials, infants were shown two objects on a stage. In one condition (choice condition), the actor reached for and grasped one of the objects. Her actions were accompanied by a general remark ("Look. Wow!"). In the other condition (preference condition), the actor reached for one of the objects and explicitly stated her preference ("I like XXX."). After the infants were habituated, test events were held in a new room using the same objects from the habituation trials. The objects appeared in reverse locations with respect to the actor. During the test events (conducted in a new room), the actor alternated between selecting her prior target object and selecting the new object, in the absence of any utterances about the objects. The question in this study was whether infants would flexibly adjust their interpretation of the same goal-directed action depending on the accompanying linguistic utterance, assuming that whereas the general remark may indicate a fleeting goal or desire for one of two toys, the dispositional statement indicates an enduring preference for one of the two objects.

Sommerville et al (in prep.) found that the results varied according to condition. Infants in the choice condition looked equally at the target and non-target toy events. However, infants in the preference condition looked reliably longer when the actor grasped

the object that was different from the object grasped in habituation trials. Within the preference condition, the infants' longer looking at the non-target toy event over the target toy event was correlated with their reported language comprehension. These findings suggest that infants infer others' object selection as reflecting an enduring preference when given appropriate linguistic evidence, and that their ability to do so is reliant on their own burgeoning language skills.

To ensure that the presence of the preference statement did not merely increase infants' memory for the actor-object relation, leading to greater generalization across contexts, Sommerville et al. (in prep.) conducted a follow-up condition. In this condition, two objects were placed on a stage, but hidden from the actor's view by opaque occluders. During habituation trials, the actor reached around the occluder to retrieve one of the objects and expressed dislike for the object ("Yuck. I hate XXX."). The test trials were identical to those from the preference condition; they were held in a new room with the objects positions switched and the occluders removed. During the test events, the actor alternated between reaching for the target and reaching for the non-target toy without a dislike statement. Infants in this condition showed the reverse pattern to the preference condition; they looked reliably longer when the actor grasped the target object toward which the actor expressed negative attitude during habituation trials. These findings suggest that infants use accompanying verbal statements and contextual cues to determine when and whether object selections reflect enduring preferences for objects. Taken together, these findings suggest that infants may possess the ability to represent actions at two levels: in terms of transient goals, and in terms of enduring preferences.

Although preferences and goals differ along the dimensions mentioned above, they also have common core features. Both goals and preferences are individually specified and need not be shared by others. Consider Tom, who selects an apple over another piece of fruit from the fruit basket every morning. Adults readily think that Tom has a preference for apples over other types of fruit. Indeed, adults might predict that Tom would select an apple over a different piece of fruit in another setting. However, adults do not automatically think that his wife Jenny has the same preference for apples. They understand that goals and preferences are tied to individuals and need not be generalized to others. In the current research, we examined whether infants understand that goals or preferences are tied to individuals and do not necessarily generalize across individuals.

Recent work suggests that by the end of the first year of life, infants may uniquely subscribe goals to individuals. Sootsman-Buresh and Woodward (2007) investigated whether 13-month-old and 9-month-old infants restrict goals to particular individuals. In the first study, infants habituated to an event in which an actor selected one of two toys on a stage. Half of the infants observed a male actor performing the action (single-actor condition) while the other half observed a female actor performing the action (switch-actor condition). After habituation, the locations of the two toys were switched. Infants in both conditions watched the same two test events, in which the male actor reached for either the same toy from the habituation trials on the new side (new-side event) or the other toy on the same side (new-goal event). In the single-actor condition, the actor was the same actor from habituation trials. In the switch-actor condition, the actor was a new individual. If infants represent goals as tied to a particular individual, the authors predicted that infants would look longer at the new-goal event over the new-side event, but only in the single-actor condition. In contrast, if

infants only focus on the relationship between the grasping action and the object without tracking the actor's identity, the authors predicted that infants would look longer at the new-goal event in both single-and switch-actor conditions.

Consistent with the first prediction, Sootsman-Buresh and Woodward (2007) found that 13-month-old infants looked longer when the actor reached for the new goal in the single-actor condition but looked equally at both events in the switch-actor condition. These results suggest that the 13-month-old infants tied goals to individuals and did not generalize goals to a new individual. Similarly, the 9-month-old infants looked equally at both test events in the switch-actor condition. In the single-actor condition, there was a significant difference in looking times between new-goal and new-side events, but this was only present during the first pair of test trials. The weaker findings from the single-actor condition in 9-month-olds suggest that the equal looking time at both test events in the switch-actor condition might not be due to the fact that 9-month-olds attribute goals to the individual and do not generalize goals across others. Rather, the findings from switch-actor condition may have been caused by the fact that the 9-month-old infants were distracted by the change in actors between habituation and test events.

To make sure that the infants' ability to tie goals to individuals in the switch-actor condition is not simply due to the novelty of the second actor, which disrupts infants' understanding of others' actions, Sootsman-Buresh and Woodward (2007) conducted a second study. In this study, they examined whether infants would generalize a conventional linguistic label across individuals. Half of the 13-month-old infants participated in the labeling condition and the other half of the 13-month-olds participated in the no-labeling condition. Both conditions involved nearly the same procedure as the switch-actor condition

in the first study. In the labeling condition, during habituation and test, a female actor labeled the target object while picking it up (e.g. "a modi"). In the no-labeling condition, no such labels were provided during either habituation or test trials. Following habituation, the locations of the two toys were switched and the female actor was replaced by a male actor in the test trials. The male actor then alternated his object choice between the same toy and the other toy, either with the accompanying label ("a modi"; labeling condition) or without the label (no-labeling condition). The authors predicted that if infants restrict goals to individuals but generalize a conventional linguistic label across individuals, they should look longer at the new-goal event over the new-side event in the labeling condition, but not in the no-labeling condition. As predicted, the authors found that 13-month-old infants looked longer at the new-goal event over the new-side event in the labeling condition, suggesting that infants generalized the female actor's conventional label to the male actor and expected the male actor to pick up the same toy as the female actor. However, in the no-labeling condition, 13-month-olds did not generalize the female actor's object selection to the male actor, which suggests that infants tied goals to individuals.

A similar procedure was used for 9-month-olds. However, instead of varying the presence of a label, the authors varied the number of actors: 9-month-olds were assigned to either the single-actor labeling condition or the switch-actor labeling condition. In both conditions, 9-month-olds did not look significantly longer at one test event over the other test event, which suggests that 9-month-olds do not generalize conventional information across people. Since 9-month-olds do not generalize goals or labels across people, these findings raise two possible interpretations: 1) infants understand that goals are specific to individuals, but not that labels generalize across people or 2) the paradigm that was used in Sootsman-

Buresh and Woodward (2007) was not sensitive enough to examine 9-month-olds' abilities to understand others' goal-directed actions. Even in the single-actor condition, the 9-month-old infants did not show a strong understanding that goals are tied to individuals. Moreover, the similar looking times to both events in the labeling conditions were not sufficient enough to rule out the alternative interpretation of a sheer novelty effect in the switch-actor condition. Given that the findings from 9-month-olds are not clear enough to support their generalization ability, infants at 9 months of age may not be able to understand goals as attributes of individual agents, which makes the second interpretation more plausible.

Taken together, the results suggest that infants at 13 months of age restrict goals to particular individuals, but generalize conventional linguistic labels across individuals. In contrast, the findings from the study on 9-month-olds are not clear on whether 9-month-olds attribute goals to individuals, indicating that further work is needed to disambiguate the findings of 9-month-olds' ability to understand person-specific aspects of goals.

CHAPTER II

Purpose of Study

In the present paper, we presented 8-and 10-month-old infants with an event in which an actor selected one of two objects. During test trials we varied either the actor's identity while maintaining superficial similarity to the first actor (a second actor replaced the first, wearing the same t-shirt as the first actor), or the actor's superficial appearance (the first actor changed her shirt), and showed events in which the actor selected either the same object as selected in habituation trials, or a new object. Thus, we asked whether infants appreciate that goals or preferences are sustained across changes in superficial appearance, but may vary according to individuals.

Our study differed from Sootsman-Buresh and Woodward (2007) in several ways. First, we provided infants with clear information that the actor was intentionally selecting one object over another object in habituation trials. Second, we investigated infants' generalization of object selections across two female actors with different ethnicities (versus a male and female actor with the same ethnicity). In our study, one actor was a Caucasian female and the other was an Asian female. Past research has demonstrated that infants can differentiate Asian faces from Caucasian faces (e.g., Anzures et al., 2010); thus, if infants view object selections as unique to individuals, we expect that infants will not generalize the first actor's object selections to the second actor. Moreover, we showed both actors to the infants throughout the experiment rather than showing one actor at a time. By doing so, we sought to familiarize infants with both actors and to ensure that a failure to find differences in

look times to the test events could not be due to novelty effects caused by introducing a new actor on test trials.

We compared the above switch actor condition to a condition we labeled the switch shirt condition, in which the same actor performed habituation and test trials. However, during test trials the actor wore a different colored shirt. Adults assume stability in goals and preferences not only across certain changes in time and space, but also across changes in an individual's perceptual appearance. For example, an adult's prediction of Tom's fruit selection is not tied to the design of his shirt nor his hairstyle for the day. A novel question concerns whether infants share this assumption.

We tested infants at 8 and 10 months of age for several reasons. First, past work suggests that there may be age-related changes in infants' understanding of goal-directed action during this period, broadly construed (e.g., Brandone & Wellman, 2009). Second, initial findings suggest that between 8 and 10 months of age, there may be changes in infants' ability to generalize object selections across a change in context (e.g., a change in room; Sommerville et al, in prep.; Blumenthal, Yun, & Sommerville, 2010).

Critically, our study was designed such that the degree of perceptual change from habituation to test trials in the switch shirt condition was greater than that featured in the switch actor condition.[1] Thus, if infants' generalization of object selections relies solely on

[1] Using a method pioneered by Loucks & Baldwin (2009): we calculated the amount of pixel change from the habituation event to the test events to provide an objective estimate of the degree of change from habituation to test events. To do so, we took the static frame from the habituation and test events that infants' looking was timed to and compared them in terms of degree of pixel change. The amount of pixel change from habituation event to the test events was calculated using the following algorithm (Loucks & Baldwin, 2009):

$$\sum_{i=1}^{h}\sum_{j=1}^{w}\sqrt{(R_{Tij}-R_{Hij})^2+(G_{Tij}-G_{Hij})^2+(B_{Tij}-B_{Hij})^2}$$

the amount of perceptual change from habituation to test events, infants would generalize the actor's object selection in the switch actor condition but not in the switch shirt condition. In contrast, if infants' generalization of object selections is selectively tied to changes in personal identity, we predicted generalization of object selections in the switch shirt condition but not the switch actor condition. Given findings suggesting changes in the understanding of goal-directed behavior broadly, and the understanding of others' object selection specifically, between 8 and 10 months of age, we anticipated that patterns of generalization might vary as a function of age. Specifically, we predicted that 10-month-old infants would generalize across a change in shirt color but not across a change in actor's identity, whereas 8-month-old infants would show the reverse pattern of findings.

Experiment 1

Method

Participants

Twenty-nine infants participated in this experiment: 15 male and 14 female (mean age = 9 months, 25 days, range = 9 months, 15 days to 10 months, 19 days). All infants were full term (at least 37 weeks gestation), typically developing, and from a large metropolitan city. Based on parental report of ethnicity, 19 infants were classified as White, 1 as Hispanc, 2 as Asian/pacific Islander, and 7 as mixed or unlisted ethnicity. Participants were recruited

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In the algorithm, R, G, and B represent the red, green, and blue color values of a pixel. H and T represent habituation event and test event each and h and w represent the height and width of the frames in pixels. For target toy event, the switch shirt condition featured a change of 22,284,794 pixels from the habituation event, whereas the switch actor condition featured a change of 15,597,595 pixels. For the non-target toy event, the switch shirt condition featured a change of 21,208,091 pixels from the habituation event, whereas the switch actor condition featured a change of 14,535,519 pixels. Thus, it was the switch shirt condition, not the switch actor condition that featured an objectively larger perceptual change from habituation events to both of the test events.

from a database maintained by the university at which the research was conducted. Infants were randomly assigned to either the switch actor condition (n =14; mean age = 9 months, 24 days) or the switch shirt condition (n = 15; mean age = 9 months, 26 days). Ten additional infants completed the experiment, but were not included in the final sample because the infants became fussy during the procedure (n = 6), the total looking times during the test trials were longer than 2 standard deviation from the mean (n = 3), or there was an experimental error (n = 1).

Procedure

The habituation booth was rectangular (370 x 130 cm) and fashioned from black curtains. During the experiment, infants sat on a caregiver's lap in the habituation booth approximately 122 cm in front of the display stage. Parents were instructed to look down at the top of their infants' head and to remain silent and neutral during the entire experiment.

A green frog and red car were placed approximately 30 cm apart. Two actors sat behind the stage on the stage (122 x 49 x 62 cm). A video camera on a tripod was positioned behind the actors to record infant eye gaze. An on-line coder, who was unaware of the experimental condition that infants participated in and the order of the test events, monitored infants' looking behavior on a video monitor and pressed a button when infants were looking at the event, activating a computer program (Pinto, 1994). A secondary observer who was unaware of the experimental condition coded infants' eye gaze off-line. Trials in which both observers identified the same look away as ending the trial were considered agreements. The agreement between the primary and secondary observer was 93%.

Infants were shown a preview trial, habituation trials, a pre-test trial, and six test trials. For each of these trial types, infants' looking was timed to the static outcome of the event. Trials lasted until infants looked away from the event for two consecutive seconds or until the maximum trial length (120 seconds) was reached. At the end of each trial, prior to the start of the next trial, the primary experimenter raised a screen that occluded the display from infants' view. The contents of the preview, habituation trials and pre-test trial were identical across conditions, whereas the test trials varied according to condition.

During the preview trial, infants were exposed to a display that supported the frog and car; the actors were absent. This trial was designed to introduce the infant to the objects featured in the experiment.

Infants subsequently viewed habituation trials. During habituation trials two actors sat behind the stage with the two toys positioned in front of them. These two actors were present for the length of each trial. The two actors differed from one another along two dimensions. First, they wore different colored shirts: one actor wore a blue shirt and the other wore a yellow shirt. Second, the actors had different ethnicities: one actor was a Caucasian female whereas the other actor was an Asian female. On each trial, one of the actors (the first actor) said, "Hi," looked toward her target toy, and then the non-target toy. She then said, "Look," picked up the target toy, smiled, and said, "Wow" and held the static pose for the rest of the trial. The other actor (the second actor) positioned next to the first actor always looked down while the first actor performed the event. Infants were shown habituation trials until infants' looking time summed across three consecutive trials fell to half of infants' looking time summed across the first three habituation trials. The maximum

number of habituation trial was 14. Thus, each infant watched between six and fourteen habituation trials.

After the habituation criterion was met, the positions of the two toys were switched while the display was hidden from the infants' view. Before the test trial, infants were shown a pre-test trial, which featured the toys in their new positions, to ensure that infants noticed the toys in their new positions. Since looking time on the first test trial can be affected by both the actors' novel actions and the novel locations of the toys, introducing the new toy locations in advance minimizes the possibility of infants' enhanced attention during the first test trial due to the change in toy location.

Following habituation trials and the pre-test trial, the actors switched shirts while the display was hidden from view. During test trials, the conditions diverged. Infants in the switch shirt condition (SS) were shown the original actor from the habituation trials performing the actions in test trials. Thus, in this condition, although the shirt worn by the primary actor differed from the shirt worn during habituation trials, the actor remained the same. During the non-target toy trials, the actor reached towards the same side of the display that she had reached towards in habituation trials and grasped a toy that was different from the toy that she grasped in habituation trials. In the target toy trials, the actor reached to a different side of the display for the same toy that she had selected during habituation trials. Across both sets of trials, after reaching for and picking up the toy, the actor said, "Look. Wow," and held her static pose.

In the switch actor (SA) condition, the actors also switched shirts prior to test trials. However, in this condition, the second actor performed the actions during test trials. Thus,

although the shirt worn by the actor who performed the actions remained consistent across habituation and test trials, the actor who produced the actions changed. The target and non-target test trials were otherwise identical across conditions.

Infants in both conditions received six test trials in alternation. Infants' looking time was measured starting from the completion of the actor's utterance to the moment when the infant looked away for two consecutive seconds, terminating a trial. The primary experimenter raised a screen that occluded the display from view to end test trials.

The sequential order of actor, the actors' sitting location, the shirt colors, the side of habituation reach, toy on the actor's right and test event shown first were counterbalanced. Thus, half of the infants saw the actor grasp the frog during habituation trials, whereas half saw her grasp the car during habituation trials.

Results

Attention during habituation. Infants in both the switch actor and the switch shirt conditions habituated in an average of 7 trials (range = 6 to 14 for both groups). All but two infants (both in the switch actor condition) reached habituation criterion in 14 trials or less. Analysis of looking times in the first three and last three habituation trials demonstrated a significant decline in attention over habituation, $F(5, 135) = 22.84$, $p < .0005$, $\eta_p^2 = .45$. There was no significant difference in overall attention between infants in the switch actor and switch shirt conditions, $F(1, 27) = .09$, $p = .76$, *ns*.

Responses to test events. If infants demonstrate an adult-like understanding of the intrinsic properties of goals, then they should demonstrate an expectation that the same actor will pursue the same goal object and an expectation that this goal would not affect a different

actor's choice. Therefore, we expected that infants would look longer to the non-target toy event in the switch shirt condition, and demonstrate equal looking to both the non-target toy and target toy events in the switch actor condition. An ANOVA with condition (switch actor vs. switch shirt), infant sex (female vs. male), first actor (Caucasian vs. Asian), goal object (car vs. frog), and test first (non-target toy vs. target toy) as between subjects measures, and looking time to the three new-goal and the three new-side test events as a within subjects measure, yielded an effect of test pair, $F(2, 12) = 29.48$, $p < .001$, $\eta_p^2 = .83$, indicative that infants' overall looking time declined with each successive test pair. However, this decline in overall looking times was consistent across both the switch actor and switch shirt conditions, $F(1,26)=1.27$, $p =.27$, *ns*. Critically, the analysis also revealed a significant interaction between test event and condition, $F(1, 6)=7.89$, $p<.05$, $\eta_p^2=.57$. Infants in the switch shirt condition looked longer to non-target toy events than to target toy events (see Table 1), $t(14)=3.15$, $p<.01$. In contrast, infants in the switch actor condition looked equally to both the new-goal and new-side events, $t(13)=0.35$, $p =.73$, *ns*. These results are consistent with the hypothesis that infants expected an actor to maintain a consistent goal across a change in physical appearance (i.e. a change in shirt), but did not expect a different actor to preserve the first actor's goal.

Table 1

Summed mean (SE) looking times for habituation and test trials (Experiment 1)

Condition	First 3 Hab	Last 3 Hab	Non-target Toy	Target Toy
Experiment 1				
Switch Actor	71.01 (8.85)	21.86 (3.30)	26.21 (3.47)	24.57 (3.42)
Switch Shirt	67.56 (5.26)	21.85 (2.16)	35.66 (3.63)	25.06 (1.78)

CHAPTER III

Experiment 2

The results of Experiment 1 suggest that at 10 months of age, infants generalize the object selection across a change in an actor's superficial appearance, but not across different individuals. As discussed earlier, if infants' ability to generalize others' goals or preferences depends on the amount of perceptual change from the habituation event to the test event, infants would be strictly expected to generalize the object in switch shirt condition, which has a greater perceptual change than the switch actor condition. However, 10-month-old infants generalized the actor's object selection across a change in shirt color but not across personal identity, suggesting that infants interpret preferences are tied to personal identity but not to perceptual appearance in individuals.

Previous research also suggests that there may be developmental changes in ability to infer others' goals or preferences between 8 and 10 months of age. In Experiment 2, we examined whether 8-month-old infants understand that goals are linked to personal identity, not superficial perceptual appearance. If infants at 8 months of age have similar understanding of goals or preference as 10-month-old infants, their looking time patterns should mirror those of 10-month-old infants. In contrast, if younger infants' ability to generalize object selections is more heavily reliant on the degree of perceptual similarity between habituation and test events, then they would be expected to generalize the object selection in the switch actor condition, but not the switch shirt condition. To examine this question, in Experiment 2, we randomly assigned 8-month-old infants to the switch shirt condition or the switch actor condition, using identical procedures to that of Experiment 1.

Method

Participants

Thirty infants participated in this experiment: 14 male and 16 female (mean age = 7 months, 28 days, range = 7 months, 11 days to 8 months, 14 days). All infants were full term (at least 37 weeks gestation), typically developing, and from a large metropolitan city. Based on parental report of ethnicity, 22 infants were classified as White, 3 as Asian/pacific Islander, and 5 as mixed or unlisted ethnicity. Participants were recruited from a database maintained by the university where the research was conducted. Infants were randomly assigned to either the switch actor condition (n =16; mean age = 8 months, 1 day), or the switch shirt condition (n = 14; mean age = 7 months, 25 days). Seventeen additional infants completed the experiment, but were not included in the final sample because the infants became fussy or cried during the procedure (n = 5), their total looking times during the test trials were longer than 2 standard deviation from the mean (n = 2), the parents interfered in the experiments (n = 3), or there was an experimental error (n = 7).

Procedure

The procedure was identical to Experiment 1. [2]

Results

Attention during habituation. Infants in both the switch actor and the switch shirt conditions habituated in an average of 7 trials (range = 6 to 12 for the switch actor condition;

[2] A secondary observer coded infants' eye gaze off-line. Due to the bad quality of recorded file, the secondary observer could not code one infants' eye-gaze. Overall, the agreement between the primary and secondary observer was 90%.

range = 6 to 10 for the switch shirt condition). Analysis of looking times in the first three and last three habituation trials demonstrated a significant decline in attention over habituation, $F(5, 140)=30.47$, $p<.0005$, $\eta_p^2= .52$) There was no significant difference in overall attention between infants in the switch actor and switch shirt conditions, $F(1, 28)=1.05$, $p=.31$, *ns*.

Responses to test events. Looking time data were analyzed in the same manner as in Experiment 1. A repeated-measures ANOVA revealed a significant effect of test pair, $F(2, 12)=12.85$, $p<.001$, $\eta_p^2=.68$. Overall looking declined from the first to the third pair of test trials, however, this decline was equal across both conditions, $F(2, 12)=0.25$, $p=.78$, *ns*. Additionally, there was a significant test pair by gender interaction, $F(2,12)=4.16$, $p<.05$ $\eta_p^2 = .41$. In all, females looked longer on the first test pair ($M=32.66$, $SE=4.64$) than males did ($M=20.46$, $SE=2.80$), $t(28)=2.17$, $p < .05$. This effect of gender was consistent across both the switch actor and the switch shirt conditions. Additionally, there was a significant effect of test event: overall, infants looked longer to non-target toy than target toy events (see Table 2), $F(1,6) = 6.69$, $p < .05$, $\eta_p^2=.53$. There was no significant interaction between test event and experimental condition for the sample as a whole. However, follow-up analyses revealed an effect of age. Infants younger than 8-months ($n = 17$, $M = 7$ months 23 days; 10 females) looked longer to non-target toy than target toy events in the switch actor condition, $t(6)=2.43$, $p=.05$, and equally to both types of test events in the switch shirt condition, $t(9)=0.61$, *ns*. In contrast, the older infants ($n=13$, M age=8 months 5 days, 6 females) looked equally to both types of test events in both the switch actor – $t(8)=0.79$, *ns* -- and switch shirt – $t(3)=.58$, *ns* -- conditions (see Table 2).

Comparison of 8- and 10-Month-Old Looking Times. A repeated measures ANOVA with condition (switch actor vs. switch shirt), age (7 months vs. 8 months vs. 10 months), and

infant sex (female vs. male) as between subjects factors and looking time on the three non-target toy and three target toy events as a within subjects factor confirmed a three-way interaction, $F(2, 47)=4.05$, $p<.05$, $\eta_p^2=.15$. Tests of simple effects confirmed a main effect of test type for the 10-month-olds in the switch shirt condition, $F(1, 14)=9.91$, $p<.01$ $\eta_p^2=.42$, and a main effect of test type for the younger 8-month-olds in the switch actor condition, $F(1,6)=5.92$, $p<.05$, $\eta_p^2=.50$.

Table 2

Summed mean (SE) looking times for habituation and test trials (Experiment 2)

Condition	First 3 Hab	Last 3 Hab	Non-target Toy	Target Toy
Experiment 2				
Switch Actor				
Overall	82.92 (11.61)	26.42 (4.09)	33.54 (5.46)	25.27 (2.83)
7-month-olds	96.43 (21.19)	30.23 (7.33)	35.37 (9.24)	22.49 (4.49)
8-month-olds	72.40 (12.48)	23.46 (4.69)	32.12 (7.01)	27.34 (3.70)
Switch Shirt				
Overall	65.55 (6.39)	25.08 (2.63)	32.48 (4.07)	28.37 (4.54)
7-month-olds	63.93 (8.80)	24.54 (3.37)	31.24 (4.60)	28.03 (5.36)
8-month-olds	69.61 (5.59)	26.43 (4.38)	35.59 (9.35)	29.23 (9.79)

Together, these results suggest a developmental transition from an early understanding of goals as tied to superficial appearance before 8-months, to a conceptualization of goals as restricted to individuals but generalizable across changes in that person's perceptual appearance, by 10-months-old.

CHAPTER IV

GENERAL DISCUSSION

The present study investigated whether infants understand that goals or preferences are maintained across changes in superficial appearance but vary according to individuals. In Experiment 1, the findings suggest that 10-month-old infants generalize one person's object selection across perceptual changes in individuals but not across individuals. In Experiment 2, however, younger 8-month-old infants generalized one person's object selection to another person but not across perceptual changes within an individual, showing the opposite pattern of results as the 10-month-olds in Experiment 1. Taken together, infants at 10 months of age understand that the object selections are intimately tied to personal identity, while 8-month-olds do not attribute one's object selections to individual identity. Rather, younger 8-month-old infants focus more on perceptual changes, such as a change in shirt color. These findings have important implications for infants' understanding of goals and preferences between 8 and 10 months of age.

The present findings with 10-month-old infants contribute to the current literature on infants' understanding of others goals by extending previous research in several ways. First, our results suggest that 10-month-old infants are capable of understanding goals as attributes of individuals. Previous research by Sootsman-Buresh and Woodward (2007) found that 9-month-old infants show a fragile understanding that goals are tied to individuals. Although they found that 9-month-olds did not generalize goals across individuals, they also found that 9-month-olds did not show a strong understanding that the same individual would pursue the same goal, making the findings unclear. We could interpret this to be a broader problem with 9-month-old

infant's understanding of others' goals. However, such a conclusion is unlikely, as previous research has shown that that even 6-month-olds understand that a person maintains the same goal regardless of the location of the goal (Woodward, 1998). Alternatively, it could be a problem with the paradigm. For example, the presence of the second person might have increased the task difficulty and impaired 9-month-old infants' performance.

In our study, we tested slightly older infants using a paradigm in which both actors were present on both habituation and test trials. We found that 10-month-old infants are do not generalize object selection from one individual to another. In contrast, 10-month-old infants readily generalize goals or preferences across a superficial change in an individual's appearance (i.e., the actor's shirt color). These findings allow us to rule out an important alternate interpretation of infants' lack of generalization of goals or preferences across individuals: namely, they suggest that the results do not stem from a domain general limitation in infants ability to generalize information at 10 months of age. Rather, infants at this age can selectively generalize goals or preferences along similar dimensions to those used by older children and adults.

The current study also suggests that infants at least 10 months of age are able to use proper information to generalize or restrict goals or preferences of others. In order to understand that goals or preferences are tied to individuals, infants need to attend to the identity of the actors to track the performing actor. The previous study by Sootsman-Buresh and Woodward (2007), which contrasted the genders of the two actors to represent two distinct individuals, showed that 13-month-olds do not generalize a woman's goals to a man. In the present study, we expand on the previous research by varying the actors' ethnicities. Indeed, there are some similarities in terms of processing gender and race information in face perception: (a) infants capture gender

and race information in face perception processing from early on in their lives (Quinn et al., 2008) and (b) infants develop a preference for one type of gender or race based on early experiences (Kelly et al., 2005). Based on the previous research, which shows infants' ability to process race information in face perception, our study confirms that infants at 10 months of age are capable of using race information in individuating others and tracking the identity of the actor. To conclude, our research enriches previous literature of infants' understanding of others' goal-directed action by showing that infants use not only gender information but ethnicity information as well to properly restrict goals to individuals.

Another piece of information that infants might attend to is the degree of perceptual change from habituation to test events. In the current study, the identity of the actors is crucial for tracking the individual actor, while the superficial appearance of the individual (i.e. shirt color) is less relevant in inferring the actor's object selection. One might argue that infants simply attend to the degree of perceptual change rather than the relevant information in generalizing others' goals. To rule out this possibility, we intentionally designed conditions considering the degree of perceptual change between habituation and test trials. We evaluated the degree of change in a static scene for each condition and found that the switch shirt condition featured a bigger perceptual change from the habituation event than the switch actor condition. Thus, our results suggest that 10-month-old infants selectively considered the identity of the actor rather than other physically salient information (shirt color) when making goal attributions. Although it is not clear whether infants selectively attend to and encode certain types of information and subsequently use the information in understanding others' goals or preferences or whether infants encode all types of information equivalently but only consider some relevant

information when inferring others' goals or preferences, our study at least suggests that infants are able to use the proper information to attribute the goals of other individuals.

The findings from the current study that infants pay less attention to the superficial appearance change in inferring others' object selection is supported by recent research. Newman, Herrmann, Wynn, & Keil (2008) has shown that when reasoning about self-propelled objects, infants prioritize internal features over external features. In the study, infants were familiarized to two self-propelled cat-shaped-objects, each of which generated different types of motion. In the test trials, a novel object which shared an internal feature (stomach color) with one object (object A) and an external feature (hat color) with another object (object B) was presented. Infants expected the novel object to generate the same type of motion as that of object A, which had the similar internal feature as that of the novel object. That is, by manipulating internal and external features of objects, Newman and colleagues found that infants understand that objects with self-generated motion are categorized together with objects that are congruent in terms of internal features opposed to objects that are congruent in terms of external features. These findings suggest that infants are sensitive to the distinction between internal versus external features and show biases towards the internal features to infer the object's movement. Although our study did not directly manipulate internal versus external features of the actors, our findings are consistent with the Newman and colleagues' study in that infants at least 10 months of age rely on an individual's identity, not the individual's outward appearance, in inferring a person's goal.

Our findings from 8-month-olds suggest that there may be a conceptual change between 8 and 10 months of age in understanding goal-directed action. In contrast to our findings from10-month-olds, we found that younger 8-month-old infants generalize one's object selection across

other people, but do not generalize the selection across perceptual changes in individuals. Our results indicate that younger 8-month-olds do not simply lack the generalization ability. Rather, they generalize along one dimension that is not necessarily related to goal generalization. Three additional pieces of evidence support the conceptual change in understanding others' actions between 8-and 10-month-olds: 1) understanding of failed actions, 2) distinguishing preferences from goals in certain contexts, and 3) using eye-gaze direction and emotional expression in goal understanding.

The first piece of evidence that supports infants' conceptual changes in goal-directed action understanding is that infants develop the ability to understand the underlying intentions of others' failed actions during this period. Brandone and Wellman (2009) tested 8, 10, and 12-month-old infants to examine whether they understand failed intentional actions. Infants were shown an actor trying to reach for a ball over a barrier that was located in front of the ball. Half of the infants were shown a successful-reaching action and the other half was shown a failed-reaching action. During the test trials, the barrier was removed and actor reached for the ball successfully either directly (direct-reach event) or indirectly (indirect-reach event). Researchers found that 10-and 12-month-olds looked reliably longer at indirect-reach event regardless of what they saw during the habituation trials but 8-month-olds looked significantly longer at the indirect-reach action only when they were shown the successful-reaching action. These suggest that both 10-and 12-month-olds encode the intention of actions in both successful and failed actions. In contrast, 8-month-olds recognized the intention in only successful-reaching action, not in failed-reaching action. These findings support that the understanding of intention of failed action may emerge between 8 to 10 months of age.

Another conceptual change that happens during this time is ability to understand the difference between goals and preferences. Recent research by Sommerville, Crane, and Yun (in prep.) found that infants at 10 months of age infer others' object selections as enduring preferences toward the object rather than transient goals given preference statements that accompany object selection. Thus, 10-month-old infants expect the actor to continue to choose the same object across a change in physical locations. Recent research found that 8-month-old infants, however, do not expect actor to maintain object selection across change in physical location or temporal delays (Blumenthal, Yun, & Sommerville, 2010). These suggest that there might be a transition period in terms of infants' concept of goal-directed action: a shift from understanding goals as transient action outcomes at 8-months, to a richer understanding of goals as enduring psychological states at 10 months.

A third piece of evidence that there is a conceptual shift from 8 to 10 months of age is the ability to use eye-gaze direction and emotional expression as a cue of inferring others' subsequent goal-directed actions. Phillps, Wellman, and Spelke (2002) examined whether infants at 8 and 12 months of age predict others' actions based on eye gaze and positive emotional expressions toward objects. Infants were shown an actor looking at and expressing positive emotion toward one of the two identical objects except colors (object A) and then picking up the object in habituation trials. During the test trials, the actor looked down and expressed positive emotional expression toward the other object (object B) from the habituation trials before grasping either the object A (inconsistent event) or object B (consistent event). Researchers found that 12-month-old infants looked significantly longer at the inconsistent event, suggesting that they expected the actor to grasp the object that the actor's eye-gaze and emotional expression was directed toward in the test trials (consistent event). In contrast, 8-month-old

looked equally at both events suggesting there is a transition period in terms of understanding the connection between goal-directed action and emotional-perceptual regard. Taken all together, these results support the there may be a transition period in terms of infants' understanding of other's goal-directed action.

Our findings suggest several directions for future research. In the current research, two actors were present for the length of each trial, but only one actor performed while the other remained silent with her eyes directed downward. Since we aimed to examine whether infants transfer one actor's object selection to another person, we wanted to provide the presence of two actors without any communication between the actors. However, it is possible that two actors can share an object choice in context of communication. In social contexts, people sometimes share object selection under some forms of social consensus. Communication is crucial tool for reaching a social consensus. If infants understand that communication is a way to interact with others and create social norms or rules that are shared by other individuals, infants might generalize one person's object choice across other people under the communicative context. Future studies could explore these questions by manipulating the communication cues between actors.

Another direction of possible research includes shared preference among group members. Previous research showed that adults use various pieces of information, such as gender, ethnicity, age, and language in categorizing social groups (Fiske, 1998; Gluszek & Dovidio, 2010; Shutts, Banaji, & Spelke, 2010). Moreover, adults readily categorize social groups using given information and sometimes infer that group members share preferences. One interesting question is whether infants also infer the shared preferences towards certain objects among group members. Recent research found that at least 2-year-olds understand group membership using

shared preference towards the object and readily rely on the information in their future object selection (Fawcett & Markson, 2010). The present study can be extended to examine whether infants transfer the same goal or object preference to other members of that group, but not to members from different groups. Those are empirical questions that need to be tested as future studies.

To conclude, the current study demonstrates that infants of at least 10 months of age infants appear to understand goals as tied to the individual identity but not as to the perceptual appearance of the individual. Our findings further suggest that there may be a transition period in infants' understanding of others' goals between 8-and 10-month of age. The current studies enrich the literature of infants understanding of others' actions and indicate that, by 10 months, infants selectively generalize others' object selections across changes in superficial perceptual appearance but not changes in individual identity.

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