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# Infants track action goals within and across agents ☆,☆☆

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**Abstract**

The ability to understand that goals and other intentional relations are attributes of individual people is of fundamental importance to social life. It enables us to predict and interpret actions on-line by relating a person's prior and current behaviors, and distinguishing them from the behaviors of other persons. In this paper, we consider the origins of the ability to mark goals as attributes of individual people. Using a visual habituation paradigm to assess infants' tracking of goals, we tested whether infants represented goals are specific to particular agents. Thirteen-month-old infants restricted reaching goals to particular agents, but generalized a conventional linguistic action, labeling, across agents. Nine-month-old showed the former pattern but not the latter. We discuss these findings in the context of developing understandings of person specific and person general action knowledge.


*Keywords:* Infant cognition; Intention; Convention

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## 1. Introduction

To adult eyes, human behavior is organized in two critical ways. First, human actions are seen as organized by underlying goals or intentions, rather than as random movements through space. Second, goals and intentions are conceived of as residing in the individual person. The idea that individuals carry with them consistent goals and behavioral propensities is fundamental to our conceptions of both intentions and persons. Adults readily attribute to others enduring personality traits, emotional states, and behavioral propensities based on only "thin slices" of observed behavior (Ambady & Rosenthal, 1992). This ability yields the perception of coherent persons, and underlies our ability to interpret and predict others' actions over various timescales. Conceptions of persons vary across cultures; nevertheless, people across the globe infer stable intentional states in others, and use them to predict and explain behavior (Callaghan et al., 2005; Knowles, Morris, Chiu, & Hong, 2001; Lieberman, Jarcho, & Obayashi, 2005; Lillard, 1998; Norenzayan & Nisbett, 2000).

In this paper, we consider the origins of the ability to mark goals as attributes of individual people. Previous findings have shown that by 18–24 months of age, children are able to track the goals of individuals. Other studies have revealed that younger infants seem to understand some actions as goal directed. Taken together, these findings raise the question of whether infants understand the individual nature of goals.

### *1.1. Infants' understanding of goal-directed action*

A prerequisite to associating intentions with individuals is representing the particular action an actor performs in terms of its intentional structure. Results from a growing number of studies indicate that infants represent purposeful actions in terms of the agent's goals (Gergely & Csibra, 2003; Johnson, 2000; Tomasello, 1999; Woodward, 2005). This evidence comes from studies of infants' social responses and social learning (Behne, Carpenter, Call, & Tomasello, 2005; Gergely, Bekkering, & Kiraly, 2002; Meltzoff, 1995; Repacholi & Gopnik, 1997; Tomasello & Haberl, 2003), and infants' visual responses to observed events (Csibra, Gergely, Biro, Koos, & Brockbank, 1999; Gergely, Nasady, Csibra, & Biro, 1995; Phillips, Wellman, & Spelke, 2002; Kuhlmeier, Wynn, & Bloom, 2003; Luo & Baillargeon, 2005; Shimizu & Johnson, 2004; Sodian & Thoermer, 2004; Sommerville & Woodward, 2005; Woodward, 1998, 1999, 2003; Woodward & Guajardo, 2002; Woodward & Sommerville, 2000).

To illustrate the latter kind of evidence, Woodward (2003) showed infants an event in which a person grasped one of two objects mounted on a stage (see Fig. 1). There are at least two aspects of this event that infants could attend to and remember—the relation between the actor and his goal, and the spatial properties of the actor's motion. Adults most readily describe the grasping event in terms of the relation between the agent and his goal, (e.g., "He grasped the bear.") rather than in terms of the perceptual properties of the person's motion, (e.g., "Moving


Fig. 1. Sample habituation and test events for the single-actor condition.

his arm to the right''). After infants had habituated to the first event, they then viewed two types of test events. One test event disrupted the spatial properties of the reach while maintaining the relation between the actor and the goal of his reach (*new-side trials*). The other test event maintained the spatial properties of the reach while disrupting the relation between the actor and the goal (*new-goal trials*). Infants showed stronger novelty responses (i.e. longer looking) on new-goal trials than on new-side trials, indicating that they represented the goal-directed structure of the actions and responded when this structure has been disrupted. Other studies have obtained similar results in infants ranging from 5 to 12 months of age (Guajardo & Woodward, 2004; Jovanovic et al., 2003; Kiraly, Jovanovic, Prinz, Aschersleben, & Gergely, 2003; O'Hearn & Johnson, 2002; Wellman & Phillips, 2001; Woodward, 1998, 1999; Woodward & Guajardo, 2002).

Do infants represent goals as belonging to particular agents? They could, in principle, encode motions as being goal-directed (''Grasping the ball'') without yet taking into account the identity of the person who acts (''**She's** grasping the ball''). They may, for example, understand that a hand that grasps an object is directed at the object, without yet considering whose hand it is, or the relation between the hand's motions and the rest of the agent's actions.

Early in the first year of life, infants are able to perceive the differences between individual faces (see Bahrick, Gogate, & Ruiz, 2002; Slater & Quinn, 2001) and voices (DeCasper & Fifer, 1980), and they are able to learn about novel face-voice relations (Brookes et al., 2001). These acts of perceptual learning and discrimination provide the basis for, but are critically distinct from the ability to conceptualize a person with enduring goals and propensities. Do infants link perceptual representations of agents with their analysis of the agent's goal?

### 1.2. Children's ability to track individual intentions

Recent evidence indicates that by 18 months, children have begun to link goal representations with particular individuals. For one, by these ages, children distinguish their own desires (Repacholi & Gopnik, 1997), attentional states (Baldwin & Moses, 2001) and means-ends relations (Gergely et al., 2002) from those of other people. To illustrate, Repacholi and Gopnik (1997) found that 18-month-olds attended to an adult's expressed preference for one of two food items, and they gave her the item she preferred even when it was not the item they themselves preferred. Fourteen-month-old infants tested in the same paradigm did not seem to represent the experimenter's preference as different from their own.

Tomasello and Haberl (2003) investigated children's ability to distinguish their own perceptual experiences from those of others. An experimenter first familiarized the child with several objects. Then the experimenter left the room and the child was given an additional object. When the experimenter returned to the room, she expressed interest towards all the toys, and then asked the child to give her one. Although all the objects were equally familiar to the children, they responded by giving the experimenter the toy that she had not seen before. Twelve-month-old infants showed similar, though less consistent, responses.

Two studies have investigated infants' tracking of individual goals for events in which they observe two or more agents in action. In one, Moore (1999) showed 12-month-old infants habituation events like the ones described for Woodward's (2003) study. Infants saw a person looked at and pointed to one of two toys. Following habituation to one event, they were shown new-object and new-side test events. Infants who saw the same actor throughout the procedure looked longer on new-object than new-side trials, indicating that they represented the event in terms of the relation between agent and goal. Infants who saw one actor in habituation and a new actor in test showed exactly the same pattern of response. Thus infants either attributed the same goal to the two actors or they failed to encode the actor's identity as relevant to her goal.

However, in a different paradigm, Kuhlmeier and colleagues (2003) found that 12-month-old infants tracked the behavior of agents over time, and attributed dispositions to particular agents. Infants viewed three animated geometric shapes that moved as if they were animate agents. One of the agents (A), attempted to climb a steep hill. A's progress was helped by B and hindered by C. In the test trials, 12-month-old infants looked longer when A spontaneously approached B than when A approached C. These findings suggest that infants recalled the behaviors of each of the agents, inferred A's disposition toward the other two agents (liking B and disliking C), and used this information to evaluate A's actions when it later approached B and C. Thus, in contrast to the Moore (1999) study, infants in this study seemed to track the actions of individuals. However, in this case, the individuals were not people, but rather geometric shapes.

In our first study, we sought clearer evidence as to whether 12- to 14-month-olds track goals based on the individual identity of the agent. To address this question, we tested 13-month-olds in a modified version of the procedure used in Woodward (2003) and Moore (1999). Infants viewed a person, visible from the chest up, who looked at and grasped one of two toys. To test whether infants represented this event in terms of the person's relation to the goal, following habituation, the toys' positions were reversed and infants were shown new-object events (which disrupted the relation between the agent and her goal) and new-side events (which preserved this relation while varying the physical motions involved).

We showed infants events with a single actor throughout the procedure (single-actor condition), or one actor in the habituation phase and a different, distinctive-looking, actor in the test phase (switch-actor condition). If infants represent goals as belonging to particular people, then the results of the two conditions should differ. Based on prior findings, infants in the single-actor condition are predicted to look longer at new-goal than new-side events. The question of interest is whether infants in the switch-actor condition would also respond in this way. If infants understand that one person's goals do not necessarily generalize to another person, then infants would have no basis for distinguishing between the test trials in this condition. However, if infants do not represent goals as attributes of individuals, then they should respond identically in the two conditions, because each presents them with a change in the goal of the action.

One concern with this design is the possibility that the sheer novelty of the second actor could lead to indiscriminate responding in the switch-actor condition. Infants might show a ceiling effect in this condition, looking for much longer than in the single-actor condition. In addition, the presence of a new face might lead infants to attend less to the object at which the actor directed her actions, thereby limiting infants' ability to detect the change in goal. To evaluate these possibilities, we assessed whether infants in the two conditions differed in their overall levels of attention on test trials and whether they differed in their allocation of attention to the actor and toys.

In Study 2, we introduced a second control for the possibility that the novelty of the second actor might have overwhelmed infants' ability to respond selectively on test trials. The experimental events were identical to those in the switch condition of Study 1 except that they included a behavior that is reliably the same across people, that is, the use of a linguistic label for the goal object. When labeling was part of the action, infants were predicted to respond systematically on test trials despite the switch in actor. This manipulation provided a control comparison for the first study, and it also provided an initial exploration of infants' understanding of the conventional versus individual aspects of action. We consider this distinction at length in the general discussion.

Based on the findings of the first two studies, in Studies 3 and 4 we investigated younger infants' ability to represent goals as attributes of individuals, and their responses to labeling events.

## 2. Study 1

### 2.1. Method

#### 2.1.1. Participants

Thirty-two full-term 13-month-old infants participated in Study 1. Parents were contacted through mailings and advertisements and were offered a $10.00 travel reimbursement for their participation. One additional infant participated in the study but was not included in the final sample due to crying. Sixteen infants saw one actor in both the habituation and the test phases produce positive affect toward the objects while picking them up (single-actor condition),[1] and 16 infants saw one actor in the habituation phase and a different actor in the test phase perform these actions (switch-actor condition). The final sample consisted of 8 females and 8 males in the single-actor condition (mean age 12 months, 28 days), and 8 females and 8 males in the switch-actor condition (mean age 12 months, 25 days). Infants were from mainly middle-class families from a large city in the United States. The sample of infants was 47% Caucasian, 31% African-American, 19% Hispanic, and 3% Asian.

#### 2.1.2. Procedure

Infants in both conditions were first familiarized with the two actors who would appear in the switch-actor condition. Infants sat on their parent's lap at a table. The two actors hid under the table approximately 70 cm away from the infant. One of the actors was a fair-haired female wearing a lavender shirt. The other actor was a dark-haired male wearing a red shirt. The actors took turns popping up to smile at and talk to the infant for approximately 6 s. Each actor appeared twice alone, and then the two appeared side by side twice.

The infant and parent were then ushered into the habituation room. The infant sat in a highchair or on the parent's lap, 75 cm away from a stage. A $20 \times 8$ cm multi-colored plastic toy rocket and a $15 \times 10$ cm multi-colored plush animal sat on the stage approximately 50 cm apart, with the actor sitting behind and between them. During habituation, the animal appeared on the infant's left. The three closed sides of the stage were draped in black curtains. Infants were filmed by a hidden video camera mounted above the actor. Between trials, a white screen was raised to block the stage from view. Parents were instructed to look down at the infant rather than at the experimental display.

Infants in the single actor condition saw the male actor in habituation while infants in the switch actor condition saw the female actor. At the start of each trial, the actor made eye contact with the baby, saying "Hi." Then, the actor looked at and grasped one of the toys, picking it up while saying "Ooh, hmm" in a mildly positive tone of voice. Then the actor held the toy silently to the side approximately

[1] To ensure that in the single-actor condition the test actor did not inadvertently bias infants' attention, the experimental events were coded off-line. The coder, who was unaware of the trial type, watched the video of the test actor in the single-actor condition and attempted to guess whether the test actor was performing a new-goal or a new-side event. The coder's responses did not differ significantly from chance.

10 cm above the table, maintaining this pose until the end of the trial (see Fig. 2). The goal (rocket or animal) was counterbalanced across infants in each condition.

A trained observer coded the infant's looking online from a video monitor. The camera and monitor were placed so he could not see any part of the experimental event, and he was not informed of the condition to which the infant had been assigned. He pressed a key when the infant looked at the event and a computer program calculated looking times and habituation criteria from this input (Pinto, 1994). The infant's looking was timed starting when the actor had picked up the toy and had finished saying "Hmm". To achieve this, the observer began coding as soon as the screen was lowered, and a second experimenter began the timing process by clicking the mouse at the appropriate time.

Each trial ended when the infant looked away for 2 s or when 120s had elapsed. The habituation criterion was calculated using the first three trials that summed to 12 s or more. When the infant had three additional consecutive trials that summed to less than 50% of this criterion, the habituation phase was ended. If the infant had not met the habituation criterion after 14 trials, the habituation phase was ended and test trials were begun.

After the habituation phase, infants saw one additional trial of the habituation event to provide an unbiased baseline measure of post habituation levels of attention. The screen was then raised to hide the stage and the positions of the toys were switched. In the single-actor condition the male actor remained in the booth for the

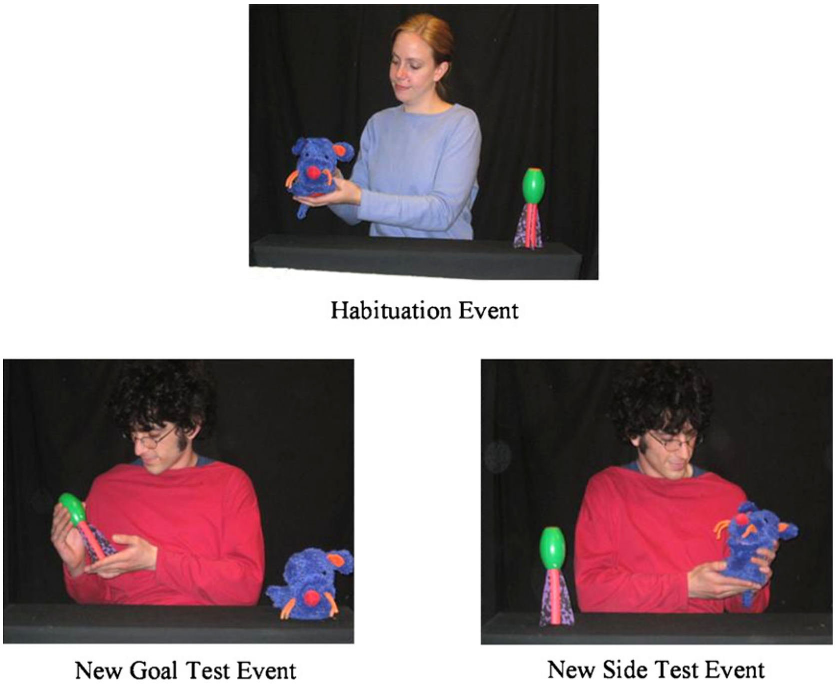


Fig. 2. Sample habituation and test events for the switch-actor condition.

remainder of the experiment. In the switch-actor condition, the female actor left the booth and the male actor took his place. Next, infants watched one trial in which the test actor sat between the toys (in their new locations). This trial served two purposes: (a) to familiarize infants with the test actor and the toy locations before the test trials began, and (b) to determine whether infants would respond to a question by looking at the object that had been the habituation actor's goal. For this *where is it* trial, the screen was lowered and the test actor said, "Hi, Where is it? Did they switch? Where did it go?" After the sentences were uttered, the actor looked down to the infant's chest in order to break eye contact. Infants' looking during this trial was timed beginning after the actor said "Hi" and continued until the infant looked away for 2 consecutive seconds. The infant then saw three new-object and three new-side test trials in alternation. On new-goal events the actor reached to the same side as habituation, this time picking up the other toy. On new-side events the actor picked up the same toy as in habituation, which now sat on the other side of the stage. The actor accompanied his actions on the toy with the same vocalizations as during the habituation events. The order of the test events (new-goal or new-side first) was counterbalanced across infants in each condition.

#### 2.1.3. Reliability coding

A secondary observer, who was unaware of the trial type, coded each infants' session from videotape. The primary and secondary observers were counted as agreeing if they identified the same look away as ending the trial. The observers agreed on 94% of the test trials in the single-actor condition and 92% of test trials in the switch-actor condition. To ensure that disagreements did not occur systematically in favor of the hypothesis the disagreements were categorized into two groups: those that would have contributed to the hypothesized pattern of findings and those that would have worked against the hypothesized pattern of findings. The disagreements were distributed randomly across these categories for each condition (Fisher's exact tests: $p > .99$ for both conditions).

### 2.2. Results

#### 2.2.1. Attention during habituation

Infants in the single-actor condition habituated in 8 trials on average and infants in the switch-actor condition habituated in 7 trials. All infants reached habituation criterion in 14 trials or fewer except 2 infants in the single-actor condition and 1 infant in the switch-actor condition. Table 1 summarizes infants' attention during habituation and test trials. Analyses of looking time during the first three and last three habituation trials revealed that although infants in both conditions showed significant declines in attention during habituation, infants in the single-actor condition looked for longer overall ($F(1,30) = 5.02$, $p < .05$, $\eta_p^2 = .14$). However, the two groups of infants did not differ in their decrease in looking over the last three habituation trials ($F(2,60) = .87$, $p = .43$, $\eta_p^2 = .03$). Recall that the design of the experiment was such that infants in the two groups saw different actors in the habituation trials. This may have contributed to the initial baseline difference in

Table 1
Mean (SE) looking times for habituation and test trials

| Condition | First 3 Hab | Last 3 Hab | New-goal | New-side |
|---|---|---|---|---|
| *Study 1* | | | | |
| Single-actor | 21.7 (3.5) | 8.1 (1.3) | 9.9 (1.3) | 6.9 (.9) |
| Switch-actor | 12.8 (1.7) | 5.2 (.7) | 9.8 (1.5) | 9.5 (1.4) |
| *Study 2* | | | | |
| No-labeling | 13.1 (1.6) | 4.4 (.5) | 9.3 (.9) | 9.6 (1.5) |
| Labeling | 12.6 (1.7) | 5.4 (.7) | 12.5 (2.2) | 8.6 (1.4) |
| *Study 3* | | | | |
| Single-actor | 15.1 (1.1) | 5.0 (.5) | 8.7 (.7) | 6.6 (.6) |
| Switch-actor | 13.8 (1.3) | 5.3 (.6) | 10.1 (1.3) | 11.2 (2.5) |
| *Study 3 Pair 1* | | | | |
| Single-actor | | | 13.4 (1.8) | 7.0 (1.1) |
| Switch-actor | | | 13.5 (2.7) | 18.1 (5.1) |
| *Study 4* | | | | |
| Single-actor-labeling | 13.5 (2.8) | 4.9 (.6) | 9.2 (1.5) | 6.1 (.7) |
| Switch-actor-labeling | 16.5 (2.9) | 5.9 (1.3) | 8.5 (1.2) | 8.7 (2.0) |

looking times. In subsequent studies we changed the design so that in the single actor condition half of the infants saw the male presenter throughout the experiment and the other half of the infants saw the female presenter.

### *2.2.2. Responses to new-goal versus new-side test events*

Based on prior work, we predicted that infants would look longer on new-goal than new-side trials when they viewed the same actor throughout the procedure. The focal question was whether a change in actor would affect this response. Preliminary analyses revealed no effects of infant sex, habituation goal, or test trial order (new-goal trials or new-side trials first). Subsequent analyses collapsed across these measures. To address the focal question, a repeated measures analysis of variance was conducted with test type (new-goal, new-side) and test pair (first, second, or third) as the within subjects variables and condition (single-actor or switch-actor) as the between subjects variable. We found a main effect of test pair $F(2,60) = 4.36$, $p < .05$, $\eta_p^2 = .37$; indicating that infants' looking time decreased over the test trials, but trial pair did not interact with any other variable. There was a main of test type $F(1,30) = 9.68$, $p < .005$, $\eta_p^2 = .24$; and a test type by condition interaction $F(1,30) = 5.93$, $p < .05$, $\eta_p^2 = .17$. There were no other main effects or interactions. Planned comparisons on infants' total looking time across the three trials of each type revealed that infants in the single-actor condition looked longer on the new-goal trials ($M$ ($SE$) = 29.62 (3.92) s) than on new-side trials ($M$ ($SE$) = 20.84 (2.78) s), $t(15) = 4.94$, $p < .0001$, while infants in the switch-actor condition looked equally at the new-goal trials ($M$ ($SE$) = 29.44 (4.49) s) and the new-side trials ($M$ ($SE$) = 28.38 (4.11) s), $t(15) = .41$, $p = .69$. A paired sign test revealed that a significant number of infants in the single-actor condition (14 of the 16 infants) looked at

Table 2
Mean (*SE*) proportion looking to the locations in the display during the test trials

| Condition | Goal object | Actor's face | Non-goal object |
|---|---|---|---|
| *Study 1* | | | |
| Single-actor | .47 (.05) | .24 (.06) | .29 (.02) |
| Switch-actor | .44 (.06) | .33 (.06) | .23 (.04) |
| *Study 2* | | | |
| Labeling | .46 (.03) | .30 (.06) | .24 (.04) |
| No-labeling | .44 (.04) | .38 (.04) | .18 (.02) |
| *Study 3* | | | |
| Single-actor | .48 (.04) | .26 (.04) | .25 (.03) |
| Switch-actor | .36 (.04) | .42 (.05) | .22 (.04) |
| *Study 3 Pair 1* | | | |
| Single-actor | .55 (.04) | .20 (.05) | .25 (.03) |
| Switch-actor | .33 (.05) | .50 (.06) | .16 (.04) |
| *Study 4* | | | |
| Single-actor-labeling | .45 (.03) | .30 (.04) | .25 (.03) |
| Switch-actor-labeling | .45 (.04) | .38 (.05) | .17 (.02) |

the new-goal trials longer than the new-side trials, $p < .005$. In the switch-actor condition, this number (10 of the 16 infants) was not significant, $p = .45$.

### 2.2.3. Attention during test events

Infants in the two groups were equally attentive in the test trials. However, it is possible that infants in the two conditions might differ in their following of the actor's reach. To evaluate this possibility, an observer who was unaware of the trial type and condition coded the infants' attention to the three relevant areas of the display (goal of the actor's reach, non-goal object, and actor's face) during the test trials (see Table 2).[2] We then tested whether infants in the two conditions differed in the proportion of attention they allocated to the goal of the actor's reach. Analyses of the proportion of attention infants allocated to this area revealed no differences between the two conditions, $t(19) = .43$, $p = .67$. There was also no difference in the extent to which infants watched the goal of the actor's reach more than the other (non-goal) toy $F(1,19) = 1.43$, $p = .25$, $\eta_p^2 = .20$. Infants in both the single-actor condition $t(9) = 3.53$, $p < .01$, and the switch-actor condition $t(10) = 2.52$, $p < .05$ looked longer at the goal of the actor's reach than the other toy. The switch in actor did not disrupt infants' attention to the goal of the actor's reach.

### 2.2.4. Attention during the where is it trial

Infants' attention to the two toys during "where is it" trials served as a secondary source of information about their tracking of the agents' goals. If infants link goals to individuals, then we predict that they would look longer at the prior goal on this

[2] In Study 1, this coding was done for 10 infants in the single-actor condition and 11 infants in the switch-actor condition.

trial in the single-actor condition, but that they would not show this response in the switch- actor condition. To test this prediction, we conducted planned comparisons for each condition evaluating whether infants looked longer at the prior goal than at the other toy. Ten infants in the single-actor condition and 11 infants in the switch-actor condition had videotapes that could be coded for the location of the infants' gaze during this trial. One additional infant was excluded because his looking to the habituation goal during this trial exceeded 3 standard deviations from the mean. As predicted, infants in the single-actor condition looked reliably longer at the prior goal, $t(9) = 2.53$, $p < .05$. Infants in the switch-actor condition did not differ reliably in their attention to the two toys, $t(9) = 1.36$, $p = .21$. However, infants in the two conditions did not differ in their relative attention to the prior goal (as indexed by the difference in looking times to the two toys), $t(18) = .78$, $p = .45$. Thus, we cannot conclude with certainty that the two conditions differed in their responses.

### 2.3. Discussion

The results of Study 1 indicate that 13-month-old infants who see a single actor interpret these actions as goal-directed, replicating Woodward (2003) in a slightly modified paradigm. Infants in the single-actor condition looked longer during test events in which the actor picked up a new goal then when he reached to the old goal on a new side. If infants had not attended to the identity of the particular actor who performed the action, or if they attributed the same goal to the second actor, we would expect to infants in the switch-actor condition to show the same result. However, infants who saw one actor in habituation and a different actor in the test phase looked equally at the two test events. This suggests that by 13 months of age infants know that the individual person who performs an action is important for representing action goals.

These results, while consistent with the findings from Kuhlmeier et al. (2003) suggesting that infants track the behavior of individual agents over time, are not consistent with the findings of Moore (1999). While Moore (1999) used a similar paradigm, there are several important differences between his study and ours. One interesting difference is while the current study showed infants events involving actors who reached and picked up objects, Moore (1999) showed infants events involving actors who attended to objects but did not act on them. One possibility is that infants track the agents of instrumental goals more readily than agents who attend. A second possible explanation is that because the two actors in the Moore (1999) study were similar in appearance (Moore, personal communication, October, 2003), and because there was no actor familiarization, infants may not have noticed the switch in actor.

Our results suggest that infants track action goals over time by linking them to the individual person who performs them. When infants see events involving a person reaching for objects, they take into account whether or not they have seen that person previously performing that action. If they have seen the person performing the action earlier, they use that previous information to reason about his current actions (i.e., "**He** reached for the animal before, and **now** he's reaching for the rocket. That's novel"). If they have not seen the person performing the action earlier, they do not use another person's actions to reason about the current actions (i.e., "**She** reached for the animal before. **He's** reaching for the animal, and **he's** reaching for the rocket. Both are equally novel"). By 13 months of age infants seem to know that goals are associated with particular agents.

Several controls from additional coding ruled out alternative explanations. One preliminary concern was that the switch in actor manipulation would prove to be distracting or overwhelming for the infants. Perhaps because of the familiarization phase, we found no differences in the overall levels of test trial attention, indicating that the switch in actor did not affect the total amount of infants' attention during the test trials. A second concern was that although infants in the two conditions did not differ in the overall amount of time they looked at the test events, perhaps infants might differ in the extent to which they followed the actor's reach to the goal object. However, we found no differences in the proportion of time infants spent looking at the actor's goal object. These two explanations cannot explain why infants in the two conditions differed in the extent to which they looked at the new-goal versus the new-side events.

A further control would test whether infants can extend information across the two dissimilar agents under conditions in which it would be appropriate to do so. If they can, then this argues against the possibility that low-level perceptual factors drove the findings, suggesting instead that infants have begun to delimit the aspects of actions that do and do not travel with individuals. In Study 2, we designed this kind of control by introducing a conventional element into the experimental events.

By definition, conventional actions are consistent across different agents. We chose to employ a type of convention that is evident in children's behavior from quite early in life, namely, linguistic convention (Clark, 1993). Recent work suggests that by 2 years of age children understand that the name for an object is information that would likely be shared between people, while a preference for an object would not (Henderson & Graham, 2005). By the end of the first year of life children have already begun to acquire words, thus raising the possibility that they understand the conventional nature of linguistic forms.

All infants in Study 2 were tested in the switch-actor procedure. What varied in Study 2 were the utterances that accompanied the actions. For one group of infants (no-labeling condition) the actor produced positive vocal expressions ("Ooh, hmm") as she looked toward and grasped the toy, just as in Study 1. These expressions conveyed information about her interest in the object, but they were not conventional referential terms. A second group of infants, (labeling condition) saw the actor produce a novel label for the object ("A modi, a modi"). Then, in test, infants saw the second actor direct these behaviors at either the same object or the other object. Based on the findings of Study 1, we predict that infants in the no-labeling condition will not distinguish between the test events. If this failure to discriminate were due to perceptual disruption, then the same result would occur in the labeling condition. If, in contrast, infants distinguish between actions that do versus do not transcend individuals, the presence of the linguistic label in the labeling condition should lead infants to respond systematically, looking longer on new-toy than new-side trials.

# 3. Study 2

## 3.1. Method

### 3.1.1. Participants

Thirty-two full-term infants, recruited as in Study 1, participated in Study 2. One additional infant participated in the study but was not included in the final sample due to a computer malfunction. Sixteen infants saw one actor in the habituation phase and a different actor in the test phase produce positive affect toward the objects while picking them up (no-labeling condition), and 16 saw one actor in the habituation phase and a different actor in the test phase produce labels for the objects while picking them up (labeling condition). The final sample consisted of 8 females and 8 males in the no-labeling condition (mean age 12 months, 29 days), and 8 females and 8 males in the labeling condition (mean age 12 months, 29 days). The sample of infants was 47% Caucasian, 31% African-American, 15% Hispanic, 3% Asian, and 4% other.

### 3.1.2. Procedure

All infants engaged in the familiarization phase with the two distinctive experimenters. In the no-labeling condition, the procedure was identical to that of the switch condition in Study 1. In the labeling condition, the actor labeled the toy twice with a novel word while picking up the object. That is, the actor looked at the infant and said "Hi", looked at the goal toy said "A modi", then picked it up and repeated "A modi". During the *where is it* trial in the labeling condition the second actor said "Hi, Where's the modi? Look at the modi! Do you see the modi?" Then the actor looked down at the infant's chest to break eye contact, just as in the no-labeling condition.

Then, infants in both conditions saw six alternating new-goal and new-side test trials. During the test trials, the second actor uttered the same positive affect ("Ooh, hmm") or word ("A modi, a modi") as the habituation actor, while performing an action that disrupted the goal-actor relation (new-goal trials), or disrupted the perceptual characteristics of the action (new-side trials).

### 3.1.3. Reliability

Reliability was assessed as in Study 1. The primary and secondary observer agreed on 92% of test trials in the no-labeling condition and 93% of test trials in the labeling condition. The disagreements were distributed randomly across those that would have contributed to the hypothesized finding and those that would have worked against it (Fisher's exact tests: $p > .99$ for both conditions).

## 3.2. Results

### 3.2.1. Attention during habituation

Infants in the labeling condition habituated in 9 trials on average and infants in the no-labeling condition habituated in 8 trials. All infants reached habituation criterion in 14 trials or fewer except 2 infants in the labeling condition. Table 1 summarizes infants' attention during habituation and test trials. Analyses of looking during the first three and last three habituation trials revealed no group differences in the overall amount of looking during habituation, $F(1,30) = .03$, $p = .86$, $\eta_p^2 = .001$.

### 3.2.2. Responses to new-goal versus new-side events

The focal question was whether the presence of the label would lead infants to relate information from the first actor to the actions of the second. Preliminary analyses revealed no effects of infant sex, habituation goal or test order. Therefore, subsequent analyses collapsed across these measures. Looking times were analyzed in a repeated measures analysis of variance with test type (new-goal, new-side) and test pair (first, second, or third) as the within subjects variables and condition (labeling or no-labeling) as the between subjects variable. There was a main effect of test pair $F(2,60) = 10.51$, $p < .001$, $\eta_p^2 = .26$, indicating that infants' looking decreased across the test pairs. There was also a significant Test type × Condition interaction $F(1,30) = 4.62$, $p < .05$, $\eta_p^2 = .13$, suggesting that infants in the two conditions differed in their patterns of looking on the new-goal and new-side trials. There were no other main effects or interactions. Planned comparisons revealed that infants in the labeling condition looked longer on the new-goal trials ($M$ ($SE$) = 37.49 (3.68) s) than on new-side trials ($M$ ($SE$) = 25.92 (4.27) s), $t(15) = 3.49$, $p < .005$, whereas infants in the no-labeling condition looked equally on the new-goal trials ($M$ ($SE$) = 27.95 (2.83) s) and the new-side trials ($M$ ($SE$) = 28.70 (4.34) s), $t(15) = -.16$, $p = .88$. A paired sign test revealed that a significant number of infants in the labeling condition (14 of the 16 infants) looked at the new-goal trials longer than the new-side trials, $p < .005$. In the no-labeling condition, this number (11 of the 16 infants) was not significant, $p = .21$.

### 3.2.3. Attention during test events

Infants in the two conditions were equally attentive during the test trials. However, it is possible that infants in the two conditions might differ in their following of the actor's reach. As in Study 1, videotapes were coded for infants' attention to the three relevant areas of the display (goal of the actor's reach, non-goal object, and actor's face) during the test trials (see Table 2).[3] Infants in the two conditions did not differ in the proportion of attention to the goal of the actor's reach, $t(19) = .43$, $p = .67$. There was also no difference in the extent to which infants watched the goal of the actor's reach more than the other (non-goal) toy $F(1,23) = .63$, $p = .44$, $\eta_p^2 = .11$. Infants in both the no labeling condition $t(11) = 4.31$, $p < .005$, and the labeling condition $t(12) = 6.51$, $p < .0001$ looked longer at the goal of the actor's reach than the other toy. The switch in actor did not disrupt infants' attention to the goal of the actor's reach.

### 3.2.4. Attention during the where is it trial

If infants track linguistic goals across agents, then we predict that they would look longer at the prior goal on this trial in the labeling condition, but that they would not show this response in the no-labeling condition. To test this prediction,

[3] In Study 2, this coding was done for 12 infants in the no-labeling condition and 13 infants in the switch-actor condition.

we conducted planned comparisons for each condition to evaluate whether infants looked longer at the prior goal than at the other toy. Thirteen infants in the labeling condition and fourteen infants in the no labeling condition had videotapes that could be coded off-line for the location of infants' gaze during the *where is it* trial. As predicted, infants in the labeling condition looked reliably longer at the prior goal, $t(12) = 3.62$, $p < .005$. Infants in the no-labeling condition did not differ reliably in their attention to the two toys, $t(13) = -.17$, $p = .87$. The two conditions also differed in their relative attention to the prior goal (as indexed by the difference in looking times to the two toys), $t(25) = 2.15$, $p < .05$. Thus, infants in the labeling condition looked at the habituation goal (i.e. the previously labeled object) when the test actor asked, "Where is the modi?" while infants in the no-labeling condition did not respond systematically when the test actor asked, "Where is it?"

#### 3.2.5. Actor discrimination

The main findings suggest that infants restrict nonverbal goals to individual agents, but generalize conventional linguistic labels across agents. However, there is an alternative explanation for the findings. It is possible that the inclusion of labeling increased the complexity of the events and therefore compromised infants' ability to distinguish between the two agents. If this were the case, then infants may have generalized not because they understand labels as conventional, but because they were unable to keep track of the distinct actors. To evaluate this possibility, we conducted a follow-up experiment, testing whether infants watching the labeling events were able to detect the change in actor. If infants notice the change in actor in this study, we can infer that infants in the labeling condition of Study 2 generalized information across actors rather than failing to notice the switch in actor. A group of 8 infants (4 males, 4 females, mean age 13 months, 0 days) first participated in the actor familiarization phase, and then watched habituation events identical to the labeling condition described earlier. After infants habituated, the objects remained in the same locations the same labeling event was performed. Infants saw two test trials in counterbalanced order. The new-actor trial was performed by the new actor and the old-actor trial was performed by the actor who performed the habituation event. Infants looked longer on new-actor (M (SE) = 25.57 (5.88) s) than on old-actor trials ($M$ ($SE$) = 8.59 (1.81) s), $t(7) = 2.67$, $p < .05$. A one-tailed paired sign test revealed that a significant number of infants (7 of 8 infants) looked longer at the new-actor trials, $p < .05$. This suggests that infants attend to the actor in the context of a labeling event and that infants in the previous condition generalized linguistic information across discriminable actors.

### 3.3. Discussion

Together, the results of these two studies suggest that by 13 months of age infants can appropriately both restrict and extend information about goal directed action. When infants saw one actor in habituation and a distinctive-looking actor in the test phase they restricted the goal of the habituation action to the original individual that performed the action. The results from Study 2 suggest that given nearly identical events, infants can also appropriately extend conventional information across individual agents. Study 2 served two purposes. For one, it provided a control for Study 1 because it demonstrates that infants can relate the behavior of two distinctive-looking actors under at least one circumstance where it is appropriate to do so. The results of Study 2 further suggest that infants understand that labeling is a conventional action. The fact that infants showed a novelty response for the mismatch test trials (i.e., when the test actor said “a modi, a modi”, while picking up the new goal), demonstrates that infants related the actions of the first agent to those of the second agent.

When do these abilities to associate action goals with a single individual or multiple individuals emerge in development? Previous studies have shown that infants as young as 5–7 months of age interpret grasping events as goal-directed (Guajardo & Woodward, 2004; Woodward, 1998; see also Sommerville, Woodward, & Needham, 2005). No studies have yet investigated whether infants younger than one year of age attach action goals to individual agents, or if they extend conventional actions across agents.

In Study 3, we assessed younger infants’ abilities to associate goals with individual agents. Two groups of 9-month-old infants saw either the single-actor or switch-actor events from Study 1. If infants represent goals as belonging to particular people, then infants in the single-actor condition should look longer at the new-goal than the new-side test events, while infants in the switch-actor condition should not. If 9-month-old infants do not represent goals as attributes of individuals, then in both conditions they should look longer at the new-goal event, because each presents them with a change in action goal.

## 4. Study 3

### 4.1. Method

#### 4.1.1. Participants

Thirty-two full-term 9-month-old infants, recruited as in the previous studies, participated in Study 3. Two additional infants participated in the study but were not included in the final sample due to crying (1) and a coding error (1). Sixteen infants saw one actor in both the habituation and the test phases produce positive affect toward the objects while picking them up (single-actor condition), and 16 infants saw one actor in the habituation phase and a different actor in the test phase perform these actions (switch-actor condition). The final sample consisted of 8 females and 8 males in the single-actor condition (mean age 9 months, 2 days), and 8 females and 8 males in the switch-actor condition (mean age 9 months, 2 days). The sample of infants was 38% Caucasian, 28% African-American, 28% Hispanic, and 6% Asian.

#### 4.1.2. Procedure

The single-actor and switch-actor conditions were identical in procedure to the single-actor and switch-actor conditions in Study 1.

#### 4.1.3. Reliability coding

The primary and secondary observers agreed on 92% of the test trials in the single-actor condition and 90% of test trials in the switch-actor condition. The disagreements were distributed randomly across those that would have contributed to the hypothesized finding and those that would have worked against it (Fisher's exact tests: $p > .99$ for both conditions).

### 4.2. Results

#### 4.2.1. Attention during habituation

Infants in both conditions habituated in 8 trials on average. All infants reached habituation criterion in 14 trials or fewer. Table 1 summarizes infants' attention during habituation and test trials. Analyses of looking during the first three and last three habituation trials revealed no group differences in the overall amount of looking during habituation, $F(1,30) = .12$, $p = .73$, $\eta_p^2 = .004$.

#### 4.2.2. Responses to new-goal versus new-side test events

Preliminary analyses revealed no effects of infant sex, habituation goal or test trial order (new-goal trials or new-side trials first). Subsequent analyses collapsed across these measures. A repeated measures analysis of variance was conducted with test type (new-goal, new-side) and test pair (first, second, or third) as the within subjects variables and condition (single-actor or switch-actor) as the between subjects variables. We found a main effect of test pair $F(2,60) = 13.74$, $p < .005$, $\eta_p^2 = .31$; indicating that infants' looking time decreased over the test trials. There was a three-way Condition × Test Type × Test Pair interaction, $F(2,60) = 3.74$, $p < .05$, $\eta_p^2 = .11$, revealing that the two conditions differed on their looking to the two types of test trials, but this difference was not uniform across the test pairs. There were no other main effects or interactions. Planned comparisons indicated that in the first pair of test trials, infants in the single-actor condition looked longer on the new-goal trial (M (SE) = 13.4 (1.75) s) than on new-side trial ($M$ ($SE$) = 7.00 (1.07) s), $t(15) = 3.63$, $p < .005$, while infants in the switch-actor condition did not, $t(15) = -1.02$, $p = .32$, (new goal trial: $M$ ($SE$) = 13.49 (2.71) s, new-side trial: $M$ ($SE$) = 18.07 (5.13) s). In the second test pair, infants did not differentiate the test trials in either the single-actor ($t(15) = -.92$, $p = .37$), or the switch-actor ($t(15) = -.31$, $p = .76$) conditions. Similarly, in the third test pair infants also did not differentiate the test trials in either the single-actor ($t(15) = 1.22$, $p = .24$), or the switch-actor ($t(15) = 1.18$, $p = .26$) conditions. A paired sign test revealed that in the first test pair, a significant number of infants in the single-actor condition (14 of the 16 infants) looked at the new-goal trial longer than the new-side trial, $p < .005$. In the switch-actor condition, this number (6 of the 16 infants) was not significant, $p = .45$.

#### 4.2.3. Attention during test events

As in previous studies, infants in the two conditions were equally attentive during the test trials. However, it is possible that infants in the two conditions might differ in their following of the actor's reach. As in previous studies, videotapes were coded for infants' attention to the three relevant areas of the display (goal of the actor's reach, non-goal object, and actor's face) during the test trials (see Table 2).[4] Analyses of looking during all test trials indicated that infants in the two conditions did not differ in the raw amount of looking to the goal of the actor's reach, $t(28) = -.01$, $p = .99$; but the two conditions did differ in the proportion of looking to the goal of the actor's reach, $t(28) = 2.40$, $p < .05$. This difference in the proportion of attention allocated to the actor's hand and goal also emerged during the first test pair, $t(28) = 2.79$, $p < .01$, with infants in the single-actor condition allocating more looking time to the hand and goal than infants in the switch-actor condition. Infants in the two conditions also differed in the proportion of attention allocated to the actor's face during the first test trial, $t(28) = 3.92$, $p < .01$, with infants in the switch-actor condition allocating more time to the actor's face than infants in the single-actor condition. However, there was no difference in the extent to which infants watched the goal of the actor's reach more than the other (non-goal) toy $F(1,28) = 2.43$, $p = .13$, $\eta_p^2 = .08$. Infants in both the single-actor condition $t(14) = 5.19$, $p < .001$, and the switch-actor condition $t(14) = 2.92$, $p < .05$, looked longer at the goal of the actor's reach than the other toy.

These findings, in contrast to those with the 13-month-olds, suggest that differences in attention to the novel versus familiar face might have contributed to the findings for younger infants. Perhaps these younger infants were distracted from the grasping action by the new actor's face, and thus were less able to notice the change in goal on new-goal trials in the switch-actor condition. As a further test of the possibility, we assessed the correlation between infants' relative attention to new goal test events over new-side events during the first pair of test trials and their attention to the goal of the actor's reach. These factors were not reliably correlated, $r = .003$.

As a further analysis, we next considered a subsample of infants who were matched across the two conditions in their attention to the goal of the actor's reach, $t(23) = 1.80$, $p = .08$. If the findings were driven only by the infants with the most extreme levels of attention (i.e., those infants with high attention to the actor's hand in the single actor condition and low attention to this area in the switch actor condition), this subset should not show the same pattern of results. However, the condition difference in the new-goal versus new-side trials still emerged, $F(1,25) = 14.44$, $p < .001$, $\eta_p^2 = .97$. Infants in the single actor condition watched the new-goal test event longer than the old-goal test event, $t(13) = 5.49$, $p < .001$, while infants in the switch-actor condition did not, $t(12) = -.74$, $p = .47$. In summary, although the control coding raised the concern that the findings in the switch condition resulted from distraction, follow up analyses showed no evidence that this was the case.

### *4.2.4. Attention during the where is it trial*

As in the first two studies, we conducted secondary analyses to evaluate whether infants looked longer at the prior goal than at the other toy in each condition. Fifteen infants in the single-actor condition and 16 infants in the switch-actor

[4] In Study 3, this coding was done for 15 infants in each of the two conditions.

condition had videotapes that could be coded for the location of the infants' gaze during the *where is it* trial. As predicted, infants in the single-actor condition looked reliably longer at the prior goal, $t(14) = 2.37$, $p < .05$. In the switch-actor condition this difference in attention to the toys did not reach significance, $t(15) = 1.91$, $p = .08$. However, infants in the two conditions did not differ in their relative attention to the prior goal (as indexed by the difference in looking times to the two toys), $t(29) = .69$, $p = .50$. Thus, we cannot conclude with certainty that the two conditions differed in their responses.

### 4.3. Discussion

Just as in previous studies (Woodward, 2003, 1998), infants in the single-actor condition looked longer during test events in which the actor picked up a new goal then when he reached to the old goal on a new side. In this case, the effect was limited to the first pair of test trials, perhaps because infants' attention declined during test trials. We would expect infants in the switch-actor condition to also show the novelty preference for new-goal trials if they had either (a) not attended to the identity of the particular actor who performed the action, or (b) if they attributed the same goal to the second actor. However, infants in the switch-actor condition looked equally at the two events. This may suggest that infants as young as 9 months of age of link the goal of an action to the actor who performs it.

Our control analyses identified a potential alternative explanation for the results in the switch actor condition. Infants in this condition spent less time looking at the actor's hand and more time looking at the actor's face than did infants in the same actor condition. Thus, it is possible that infants failed to respond on new goal trials because they were distracted from the relevant aspect of the test events, i.e. the actor's hand and the goal. Follow-up analyses provided no support for this possibility. Infants' attention to the actor's hand was uncorrelated with their relative preference for new goal events, and analyses of a subsample matched for attention to the actor's hand revealed no evidence that the findings in the switch condition resulted from distraction. Thus, distraction cannot account for the results at 9 months. Infants at this age, like older infants, link action goals with the individual agent who performs them.

In the final study, we extended the logic of Study 2 to ask whether 9-month-old infants could generalize information across two dissimilar agents when the agents perform a conventional action. We showed one group of infants labeling events with two dissimilar agents, just as in the labeling condition in Study 2. If infants understand that labeling actions are conventional and thus generalize to a second actor, infants in the switch-actor labeling condition should also look longer at the new-goal trials than the new-side trials.

If 9-month-olds fail to respond systematically in the switch-actor labeling condition, this might indicate that they do not yet understand the conventional nature of labels. Alternatively, they might be confused by the sheer presence of the label and not be able to encode the goal of the actor's reach. To assess this possibility, we tested a second group of 9-month-old infants with labeling events involving a single actor throughout the procedure.

## 5. Study 4

### 5.1. Method

#### 5.1.1. Participants

Thirty-two full-term 9-month-old infants, recruited as in the previous studies, participated in Study 4. Two additional infants participated in the study but were not included in the final sample because of crying. Sixteen infants saw the same actor in both the habituation and test phases label objects (single–actor-labeling condition), and 16 infants saw one actor in the habituation phase and a different actor in the test phase label objects (switch-actor-labeling condition). The final sample consisted of 8 females and 8 males in the single-actor-labeling condition (mean age 9 months, 3 days), and 8 females and 8 males in the switch-actor-labeling condition (mean age 9 months, 5 days). The sample of infants was 53% Caucasian, 23% African-American, 17% Hispanic, and 7% Asian.

#### 5.1.2. Procedure

The procedure was identical to the labeling condition of Study 2 except one group of infants saw a single actor throughout the procedure (single-actor-labeling condition).[1] Eight infants saw only the female actor and 8 infants saw only the male actor perform these actions. A second group of infants saw the male actor in the habituation phase and the female actor in the test phase (switch-actor-labeling condition). All other elements of the procedure were identical to previous studies.

#### 5.1.3. Reliability coding

The primary and secondary observers agreed on 95% of the test trials in the single-actor-labeling condition and 96% of test trials in the switch-actor-labeling condition. The disagreements were distributed randomly across those that would have contributed to the hypothesized finding and those that would have worked against it (Fisher's exact tests: $p > .99$ for both conditions).

### 5.2. Results

#### 5.2.1. Attention during habituation

Infants in the both conditions habituated in 8 trials on average. All infants reached habituation criterion in 14 trials or fewer except 1 infant in the single-actor labeling condition and 1 infant in the switch-actor labeling condition. Table 1 summarizes infants' attention during habituation and test trials. Analyses of looking during the first three and last three habituation trials revealed no group differences in the overall amount of looking during habituation, $F(1,30) = .60$, $p = .45$, $\eta_p^2 = .02$.

#### 5.2.2. Responses to new-goal versus new-side test events

We were primarily interested in whether infants in the two conditions would show a novelty response for the new-goal (mislabeling) trial. Preliminary analyses revealed no effects of infant sex or habituation goal. Subsequent analyses collapsed across these measures. To address the primary question of whether infants in the two conditions would differ in their looking to the new-goal and new-side test events, infants' looking times were entered in a repeated measures analysis of variance with test type (new-goal, new-side) and test pair (first, second, or third) as the within subjects variables and condition (single-actor-labeling, switch-actor-labeling) and test order (new-goal trial or new-side trial first) as the between subjects variables. We found a main effect of test pair $F(2,56) = 15.68$, $p < .001$, $\eta_p^2 = .54$; indicating that infants' looking time decreased over the test trials. There was a 3-way Condition × Test Type × Test Trial Order interaction $F(1,28) = 5.08$, $p < .05$, $\eta_p^2 = .15$. This indicates that infants in the two groups differed in their looking during the test trials, but this difference was not the same for infants in the new-goal first condition and infants the new-side first condition.

To interpret this interaction, we next conducted separate analyses of variance for the single-actor-labeling and switch-actor-labeling conditions. In the single-actor-labeling condition there were effects of test pair, $F(2,13) = 6.18$, $p < .05$, $\eta_p^2 = .49$, indicating that infants' looking decreased over the test trials; and test type, $F(1,14) = 14.30$, $p < .005$, $\eta_p^2 = .51$, indicating that infants differed in their attention to the test events. Planned comparisons on infants' total looking time across the three trials of each type revealed that infants looked longer on the new-goal trials than on new-side trials, $t(15) = 3.10$, $p < .01$. Thus infants in the single-actor-labeling condition showed the group-level predicted difference in test trial looking. However, this effect was qualified by a Test type × Test order interaction, $F(1,14) = 8.28$, $p < .05$, $\eta_p^2 = .37$, indicating that the difference in looking to the test events differed depending on which test trial order infants saw (new-goal first or new-side first). Further analyses revealed a main effect of test type in the new-side first condition $F(1,7) = 22.99$, $p < .01$, $\eta_p^2 = .77$, but not in the new-goal first condition $F(1,7) = .39$, $p = .55$, $\eta_p^2 = .05$. Thus infants who saw the new-side first test order were more likely to show the group level pattern of response.

In the switch-actor-labeling condition there was an effect of test pair, $F(2,13) = 13.02$, $p < .001$, $\eta_p^2 = .67$, indicating that infants' attention decreased over the test trials. However, there was no main effect of test trial type, $F(1,14) = .01$, $p = .92$, $\eta_p^2 = .001$, nor were there any other significant interactions, indicating that infants did not differ in their attention to the two test events.

### 5.2.3. Attention during test events

As in previous studies, infants in the two groups were equally attentive during the test trials. However, it is possible that infants in the two conditions might differ in their following of the actor's reach. As in previous studies, videotapes were coded for infants' attention to the three relevant areas of the display (goal of the actor's reach, non-goal object, and actor's face) during the test trials (see Table 2).[5] Analyses revealed that infants in the two conditions did not differ in the proportion of atten-

[5] In Study 4, this coding was done for 15 infants in the single-actor-labeling condition and 14 infants in the switch-actor-labeling condition.

tion to the goal of the actor's reach, $t(27) = .01$, $p = .99$. There was also no difference in the extent to which infants watched the goal of the actor's reach more than the other (non-goal) toy $F(1,27) = 1.45$, $p = .24$, $\eta_p^2 = .05$. Infants in both the single-actor-labeling condition $t(14) = 4.19$, $p < .001$, and the switch-actor-labeling condition $t(13) = 5.47$, $p < .001$ looked longer at the goal of the actor's reach than the other toy. The switch in actor did not disrupt infants' attention to the goal of the actor's reach.

### 5.2.4. Attention during the where is it trial

If 9-month-old infants track linguistic goals over time but fail to generalize those goals across individuals, then we predict that they would look longer at the prior goal on this trial in the single-actor-labeling condition but not in the switch-actor-labeling condition. To test this prediction, we conducted planned comparisons for each condition evaluating whether infants looked longer at the prior goal than at the other toy. Fifteen infants in the single-actor-labeling condition and 14 infants in the switch-actor-labeling condition had videotapes that could be coded for the location of the infants' gaze during the *where is it* trial. Infants in the single-actor labeling condition looked reliably longer at the prior goal, $t(14) = 2.35$, $p < .05$. Infants in the switch-actor labeling condition did not differ in their attention to the toys, $t(13) = 1.14$, $p = .28$. However, infants in the two conditions did not differ in their relative attention to the prior goal (as indexed by the difference in looking times to the two toys), $t(27) = 1.19$, $p = .24$. Thus, we cannot conclude with certainty that the two conditions differed in their responses.

## 5.3. Discussion

The results of Study 4 suggest that when infants see a single actor perform labeling events, they show a novelty preference for test events in which his goal has changed (when he utters the label while picking up the new goal). This effect was modulated by the order in which infants saw the test trials, such that infants whose first test event was a new side test trial were more likely to notice that his goal had changed in the subsequent new-goal test events. This interaction is the opposite of what we might expect when the findings are weak, that is, infants usually look longer at the test type that they see first, not second. The pattern we observed, more systematic responding when new-object trials came second, might derive from fragility in 9-month-olds' understanding of labeling actions. Although 9-month-olds understand grasping events as goal-directed, the addition of labeling to the event may have made it more difficult for infants to interpret. Seeing the new-side (old object) test trial first may have reinforced infants' understanding that the labeling action was directed at that object, thereby supporting infants' response to the novelty in the subsequent new goal test trials. Further research is required to investigate this possibility.

When infants saw one actor perform labeling events in habituation and then a second actor perform labeling events in the test trials, infants did not discriminate between the test events. Thus, unlike the 13-month-olds in Study 2, the 9-month-old infants in Study 4 did not extend conventional linguistic information across individuals. At nine months, infants' word knowledge is by all accounts quite limited. Most infants at this age do not produce any words yet, though they seem to understand some (Fenson et al., 1994). Thus, it is possible that 9-month-old infants have not yet discovered the conventional nature of linguistic actions. Alternatively, it is possible that 9-month-olds would have showed sensitivity to the person-general nature of labels under more supportive testing conditions. Given their difficulty in processing labeling events even when they were performed by a single actor, it is possible that 9-month-olds might benefit from seeing more repetitions of the habituation labeling events. Further research is required to investigate this possibility.

## 6. General discussion

In this paper, we considered the origins of the infants' abilities to mark goals as attributes of individuals, and to generalize one conventional action (labeling) across individuals. Earlier findings that infants interpret actions as goal-directed, and that older babies can differentiate between the goals of different individuals suggested to us that younger infants might link goals with individual agents. Further, findings that older infants understand certain aspects of conventional action raised the question of whether younger infants would not only restrict generic action goals but also generalize the conventional aspects of actions across individual agents.

The findings of Studies 1 and 2 indicate that by 13 months of age, infants associate certain goals with individual agents and generalize conventional elements across agents. When infants at this age viewed one actor during habituation and a second during test, they did not relate information about the first actor's goal to the actions of the second actor. However, when the events included a conventional act, the use of a linguistic label, then 13-month-olds extended information from the first actor's actions to events involving the second actor.

In Studies 3 and 4 we investigated younger infants' abilities to restrict and extend goals within and across agents. Evidence from Study 3 suggests that 9-month-old infants associate the goals of reaching actions with the individual who performs them. However, the results from Study 4 suggest that unlike older infants, 9-month-olds did not extend linguistic labels across agents. Infants who saw one actor perform the habituation events and a second actor perform the test events did not show evidence of generalization. This suggests that 9-month-olds might not understand that labeling is conventional. Infants who saw a single actor perform linguistic actions throughout the procedure did respond to the change in the actor's goal in the test trials. However, only infants who saw the actor perform the consistent labeling event *first* were able to show this group level pattern of response. This suggests some fragility in 9-month-olds' understanding of labeling events, even when they involve only a single actor. Because of difficulty in processing, infants in both the single-actor and switch-actor labeling conditions might require additional repetitions of the labeling event in order to fully process the event and later respond to the change in goal during the test trials.

It is an open question whether infants even younger than 9 months of age would associate person-specific goals with individuals. Is this ability a product of development, or is it present from the very beginning of infants' discrimination of individuals? One possibility is that infants represent goals as attributes of individuals as soon as they represent the goal-directed structure of events. Another possibility is that infants represent events as goal directed before they can integrate this information with their representation of individual agents. In this second possibility, we might expect that very young infants would respond to changes in the goal of an action regardless of the agent's identity. Recent findings from our laboratory provide support for this possibility. In these studies, infants at 8 months of age showed a novelty preference for new-goal test events in both single-actor and switch-actor conditions (Buresh & Woodward, 2005).

In mature folk psychology, actions are understood as the expression of underlying mental states, including goals, and these mental states are seen as residing in individual minds. By the preschool years, children evidence knowledge of this aspect of folk psychology (Wellman, 1990). It is an open question whether infants understand individual goals as mental states. As noted earlier, a great deal of recent evidence indicates that infants represent the goal structure of certain events. However, there is disagreement as to whether infants represent goals as mental entities (see Woodward, 2005 for a discussion). Gergely and Csibra (2003) have proposed that infants represent goals in purely behavioral terms, and that this behavioral analysis provides a basis for the subsequent emergence of mental state concepts. In contrast, Onishi and Baillargeon (2005) conclude that infants (at least by 15 months of age) infer mental states in others.

Several researchers have suggested that if infants attribute to goals to individuals, then this would constitute evidence that they understand goals as mental (Moore & Corkum, 1994; Kuhlmeier et al., 2003). Our findings indicate that by 9 months, infants attribute goals to individuals. However, we remain open-minded about the question of infants' conceptions of mental life. It is possible that infants, like older individuals, understand goals as internal mental states of individuals. It is also possible that infants understand goals as person-specific behavioral tendencies, and that it is not until later in development that children infer the existence of private mental states.

This question aside, our findings show that infants have begun to delimit the person-general and person-specific components of goal-directed action by the end of the first year of life. This ability likely provides a foundation for social reasoning by enabling infants to predict and interpret actions on-line by relating a person's prior and current behaviors, and distinguishing those behaviors from those of other persons. More generally, the ability to unite actions at the individual person level would play a critical role in the acquisition and generalization of infants' action knowledge.

### *6.1. Discovery of person general and person specific actions*

Our findings raise the question of how infants discover whether or not particular kinds of actions are best tracked within agents or across agents. In everyday life, the problem is hard: conventional and individual aspects of action live cheek by jowl.

Imagine the following scene: an infant watches as her mother reaches for a fork and then uses it to put food in her mouth. As adults, we know that the mother's choice of food expresses her individual preferences, and these may not be shared by others. But we also know that when the mother uses the fork to eat she is also acting in a conventional manner. She is using this utensil to eat because she is a member of a larger community of individuals who also use forks to eat. How does the infant discover when the mother is acting as an individual (choosing one food over another), and when she is acting as a member of a larger community (using fork to eat rather than her hands)?

One possible solution could be the observation of multiple people engaged in similar versus different actions. The infant might come to understand that some actions are person-specific with evidence that multiple individuals have different goals (e.g., Mom prefers to eat pasta while Dad prefers to eat salad). Likewise, the infant might come to understand that some actions are person-general with evidence that multiple individuals perform the same actions (e.g., Mom uses a fork to eat lunch and so does Dad; Mom says "Dog" while referring to dogs, and so does Dad). To test whether infants use this kind of distributional evidence, we could systematically vary whether infants see one actor or multiple actors engaging in an action that is ambiguously person-specific or person-general. Infants who see only a single actor perform the action might interpret it as person-specific and subsequently associate it only with that actor, while infants who see multiple actors perform the action should interpret it as person-general and subsequently generalize it to new actors.

In addition to drawing on distributional evidence, infants might infer the existence of conventions or individual goals based on an analysis of the functions of certain kinds of actions. As Clark (1993) has described, linguistic conventions exist because of their role in communication. If words were not shared, they would not function as communicative tools. It is an open question how much infants understand about the function of conventional actions. Knowing that people engage in conventional actions for the purposes of communication and cultural transmission most likely emerges later in development. Our current results suggest that by 13-months of age infants seem to understand that when multiple people engage in conventional linguistic behavior, the actions of one individual can generalize to a second individual. By this age infants have begun to track patterns in conventional action that could provide a pre-requisite for later developments in cultural knowledge. There is evidence that infants know the conventional use of objects from their nonfunctional "recognitory gestures", for example, holding an empty cup to the lips (Bates, Beningni, Bretherton, Camaioni, & Volterra, 1979). This suggests that infants might understand that these actions are conventional as well.

Conventionalized communicative forms might be negotiated in the course of communicative interactions between child and parent (Bates et al., 1979; Bruner, 1975, 1983). In addition, infants might acquire other conventional actions through understanding and imitating adults' intentional actions (Tomasello, 1999). Based on these interactions, children may come to a more general understanding that some kinds of actions are conventional.

These possibilities are not mutually exclusive. The use of distributional evidence might initially help infants sort the actions that others perform into person-specific and person-general categories. This initial categorization may contribute to the insight that conventions are not coincidences — we all do it the same way for a reason. It is possible that early in development infants understand only particular person-specific and person-general actions, and as the infants' action repertoire increases so does the ability to group particular actions together into the categories of actions according to their person-specific and person-general goal structure.

The current findings raise a number of questions for future investigation. These include the range of actions that infants understand as conventional, the origins of person-general and person-specific action representations, and later steps in understanding individual goals and conventional actions. These questions aside, our findings indicate that by the end of the first year of life, infants have begun to map out the person-specific and person-general aspects of goal-directed action.

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