Infants' understanding of the point gesture as an object-directed action

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Abstract

There have been many studies of infants' propensity to orient in response to a point. However, little is known about infants' understanding of the relation between a person who points and the referent object. In Study 1, a habituation paradigm was used to assess this understanding in 9- and 12-month-old infants. Infants saw an actor point to one of two toys during habituation, and then saw test events in which either the referent object or path of motion taken by the actor's arm had changed. Twelve-month-olds looked longer at the former test event than the latter, indicating that they had encoded the relation between the actor and the referent. Nine-month-olds, in contrast, looked equally long at the two test events. Coding of infants' attentional responses to the points indicated that these results did not derive from the "spotlighting" effects of points. These findings suggest that between 9 and 12 months, infants come to understand pointing as an object-directed action. The results of Study 2 suggest that between these ages, infants' own use of object-directed points is related to their understanding of the points of others as object-directed.
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1. Introduction

One of the most critical tasks facing infants and young children is interpreting the actions of other people. The set of actions that is involved in communication is particularly important because communicative interactions provide children with

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a great deal of information about people, objects and events. To glean this information, infants must learn not only the appropriate response to the behaviors of an interaction partner, but also how to interpret the actor's behavior in terms of his or her likely intentions in acting. In studying infants' understanding of communicative actions such as looking and pointing, researchers have focused on infants' overt orienting responses to these actions, that is, the tendency to follow gaze and points to some object in the environment. This approach has yielded important insights about the development of social responsiveness, but it does not directly tap infants' understanding of these actions as involving intentions or attention on the part of the person who performs them. The current studies were designed to begin to address this issue.

In its mature form, understanding the point gesture involves several interrelated components. First, the point is a signal that highlights an object. In responding to it, one should follow it to the referent rather than focusing on the pointing hand. Second, this gesture, like many other intentional actions, is object-directed. The actor's point is evidence of a relation between the person who points and the referent, specifically, that the actor is attending to the referent object. Understanding the object-directed nature of pointing provides the basis for a third component, understanding the communicative nature of the gesture. By using it, the pointer intends to bring another person into shared attention on the referent object. In this paper, we focus on infants' understanding of the second aspect of points — their object-directedness.

At a general level, object-directedness is an important aspect of mature folk psychological understanding of many intentional actions (Barresi & Moore, 1996; Wellman & Phillips, 2001; Woodward, 1998; Woodward, Sommerville, & Guajardo, 2001). For adults, many actions seem to be organized around the relation between the agent and some object. This is true for goal-directed actions such as grasping, as well as for attentional behaviors such as looking and pointing. Adults know a great deal about the particular relation between a person who points and the referent object. For example, adults can infer that a person who points at an object has certain psychological states (e.g., awareness of the referent, desire to make others aware of it), as well as certain behavioral propensities (e.g., concurrent and future behaviors, utterances, emotional expressions are likely to be directed at the referent). An important first step in development would be the realization that points instantiate a relation between a person and the object at which he or she points. This insight would set the stage for further discoveries about the particular intentions and behavioral propensities expressed by the point gesture. In this paper, we investigate infants' understanding of this basic aspect of points.

The existing evidence suggests that the end of the first year of life is an important period in the development of the point gesture. Between 9 and 12 months, infants begin to produce points that are clearly directed at objects (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Desrochers, Morissette, & Ricard, 1995; Lempers, 1979; Leung & Rheingold, 1981; Morissette, Ricard, & Decarie,

1995; Murphy & Messer, 1977; Schaffer, 1984).[1] A common conclusion is that these observations reflect infants' understanding pointing as an intentional, object-directed action (Bretherton, 1991; Carpenter, Nagell, & Tomasello, 1998; Tomasello, 1995, 1999). However, several theorists have noted that these observations are at best ambiguous indicators of infants' underlying understanding of the point gesture. For one, there is debate about the intentionality of infants' own points. Some researchers have reported that infants' earliest points do not appear to be produced with the intention of manipulating another person's attention, but may, instead be something like an egocentric expression of interest (Bates et al., 1979; Werner & Kaplan, 1963), and others have noted that the putative behavioral indicators of communicative intent which accompany the points of 1-year-olds are open to several interpretations (Baldwin & Moses, 1996; Moore & Corkum, 1994). With respect to infants' responses to points produced by others, several researchers have proposed that infants initially follow other people's points based only on understanding the signal value of the action, only later coming to understand the intentions of the person who produces the gesture (Barresi & Moore, 1996; Butterworth & Jarrett, 1991; Moore, 1999; Moore & Corkum, 1994). For example, Moore and Corkum (1994) argue the latter view in their discussion of the development of joint visual attention. They propose that infants learn about the signal value of adult behaviors such as gaze and pointing because these behaviors predict the locations of interesting objects and events.

These considerations indicate that an alternative research strategy is needed to illuminate infants' understanding of pointing as an object-directed action. Recent studies of infants' understanding of another object-directed action, grasping, suggest such a strategy (Guajardo & Woodward, under review; Woodward, 1998, 1999; Woodward & Sommerville, 2000; Woodward et al., 2001). On seeing a person reach toward and grasp a toy, adults would probably construe this event in terms of the relation between actor and object (e.g., "She grabbed the ball"), rather than in terms of the many other observable attributes of the event (e.g., "She moved her hand 10 in. to the left and then stopped with her arm fully extended, closing her fingers around the ball"). The question was whether infants, like adults, focus on the relation between actor and object for the familiar action grasping. To address this question, infants were habituated to an event in which an actor moved her arm through a distinctive path and grasped one of two toys that sat side by side on a stage. Following habituation, the positions of the toys were

[1] A few researchers have documented that pointing hands draw attention to objects for infants as young as 9 months under very supportive conditions, for example, when the hand is quite close to the referent (Lempers, 1979; Murphy & Messer, 1977). However, other researchers have failed to find this in 9-month-olds in similar contexts (Butterworth & Grover, 1988; Morissette et al., 1995), and even the researchers who do find it argue that it is more primitive than the abilities of 12- to 14-month-olds. Lempers (1979) labelled this early ability "prereferential" and Murphy and Messer (1977) suggested that it might be due to infants' first looking at the hand itself and then happening to notice the nearby toy (see also Butterworth & Grover, 1988; Morissette et al., 1995; Schaffer, 1984).

reversed, and infants saw two test events in alternation. In one (the new toy event), the actor reached to the same location as during the habituation phase, this time grasping a different toy. In the other (the new path event), the actor reached to the other location, grasping the same toy as during the habituation phase. If infants represented the habituation event mainly in terms of the relation between actor and object, then they would be expected to look longer on new toy trials, on which this dimension was altered. Alternatively, if infants represented the habituation event mainly in terms of the surface properties of the reach, they would be expected to look longer on new path trials. The results were that 6- and 9-month-olds looked longer on new toy trials than on new path trials, suggesting that at these ages, infants understand grasping as an object-directed action (Woodward, 1998, 1999, in press).

Comparison conditions revealed that infants did not construe the motions of inanimate objects as being object-directed (Woodward, 1998). When they saw an inanimate object, such as a rod or mechanical claw, move toward and grasp a toy, infants did not respond selectively to a change in the "actor"–object relation. If anything, they recovered slightly more when the inanimate actor moved through a new path. Moreover, infants did not construe all manual actions as object-directed. When infants saw an actor contact a toy with the back of her inert hand, they did not represent this event as object-directed, but they did represent a grasping event, designed to match the back-of-hand event on several perceptual dimensions, as object-directed (Woodward, 1999). By 6 months of age, therefore, infants seem to represent some, but not all, actions in terms of the relation between actor and object.

These findings suggest a strategy for assessing infants' understanding of pointing: If babies represent the relation between the pointer and the referent object as being central to the action, then, following habituation to a pointing event, an alteration in this dimension should lead to a greater novelty response than alterations in other aspects of the event. Recently, Moore (1999) reported findings from studies taking this approach with 13-month-old infants. Infants saw an experimenter point toward and look at one of two toys in habituation. Then, the positions of the toys were reversed and infants saw test events in which the experimenter pointed to the same toy as during habituation (moving through a new path in order to do so), or to the other toy (moving through the same path as during habituation). Moore found that infants responded more strongly to the change in relation between actor and object than to the change in the surface properties of the actor's motions — infants looked longer on the former test events than the latter ones. This finding might suggest that by 13 months, infants understand pointing as object-directed. However, Moore points out that a potential problem with this research strategy is that it may fail to distinguish between infants' propensity to respond to the signal value of points and their understanding of pointing as an object-directed action. It is possible that infants look longer when there is a change in the relation between actor and object not because they encode this relation in memory, but because the pointing hand leads them

to look longer at the referent object, acting as an "attentional spotlight." When this spotlight shifts to a new object during test, infants might look longer only because they are being led to look at a new object. In fact, Moore (1999) takes a lean interpretation of his findings, arguing that they reduce to just this kind of spotlighting.

However, based only on infants' overall looking times on test trials, it is not possible to determine whether this interpretation is correct. Clearer evidence would involve a direct measure of the pointing hand's effectiveness as a spotlight. The studies of infants' encoding of grasping (Woodward, 1998, 1999) provided evidence that spotlighting effects can be measured directly and that these effects can be distinguished from the infant's encoding of an action as object-directed. As was the case in Moore's (1999) studies, it was also possible that infants' response to a change in the relation between actor and the object of her grasp derived from spotlighting effects. Specifically, if grasping hands served as effective attentional spotlights, but inanimate objects and inert human hands did not, then this could account for the finding that infants responded to the change in relation between actor and object for human grasps but not the other events. To evaluate this possibility, infants' looking to each of the two toys was coded from the videotape of the session. Attentional spotlighting would be indicated by their looking longer at the toy that was contacted by the hand than at the other toy. This coding revealed that the grasping hand, inert hand, and inanimate objects were all strong attentional spotlights, and that they were equally effective in this regard. Regardless of which of these contacted the object, infants spent most of the time staring at the contacted object. Therefore, attentional spotlighting could not account for infants' differential representation of the events that involved human graspers as compared to inert hands, rods, and claws. Although infants responded to hands, claws and rods alike by focusing attention on the object they contacted, it was only the human grasps that infants represented as object-directed.

In the current studies, we used the procedure developed by Woodward (1998, 1999) and Moore (1999) to investigate 9- and 12-month-old infants' understanding of pointing as an object-directed action. Specifically, we habituated infants to an event in which an actor pointed to one of two toys, and then measured their novelty responses to test events in which either the relation between actor and object or the spatial properties of the point were altered. With the concerns just discussed in mind, we also coded infants' allocation of visual attention to the two toys during the procedure, and used this coding to determine whether attentional spotlighting could account for infants' novelty responses to the two kinds of test events. We began by testing 9- and 12-month-old infants based on the findings, reviewed earlier, which suggest that there may be important changes in infants' understanding of pointing between these two ages. Finally, we also investigated the relation between infants' understanding of pointing as object-directed, and their own use of object-directed points. In Study 1, we were able to gather preliminary evidence on this relation. In Study 2, we pursued this issue more thoroughly.

2. Study 1

In Study 1, we tested infants at two ages, 9 and 12 months. We attempted to configure the experimental events to be as sensitive as possible to these infants' abilities. First, we were concerned that difficulties with following points could interfere with infants' encoding of the relation between the actor and the referent. Most researchers fail to find that infants younger than 12 months follow points to distant objects in laboratory settings. If infants did not succeed in following the point to the referent in the context of this experiment, then they would have no chance to further encode the relation between actor and object. With this in mind, we eliminated the spatial demands of following the point by having the actor touch the referent object with her index finger as she pointed. Second, there was the question of whether or not to include in the event behaviors that often accompany points in natural contexts. When a person points, he or she also usually provides other cues to his or her attentional state such as postural shifts, direction of gaze and vocalization. On the one hand, these cues might bolster infants' ability to encode the actor's point as object-directed. On the other hand, including additional behaviors, especially those involving social interaction and the actor's face, might create visual distractions that would pull infants' attention away from the pointing hand. With these issues in mind, we included two presentation conditions in the study. One group of infants at each age saw only a pointing hand (the *hand-only* condition). Infants in a second group saw events in which the actor was visible from the waist up and interacted with the baby (the *face-and-hand* condition). The actor greeted the baby at the start of each trial and said "Look" as she turned to point at the toy. She turned her head and body as she pointed, and looked at the referent toy.

3. Method

3.1. Participants

Eighty infants from the city of Chicago and its near suburbs took part in the study. The infants were all full-term (at least 37 weeks gestation). Their parents had been contacted by advertisements or mailings, and were given $10 to reimburse their travel expenses. There were 40 infants in each of two age groups, 9 and 12 months. Within each of these two age groups, 20 infants were assigned to the *hand-only* condition and 20 were assigned to the *face-and-hand* condition. The 18 males and 22 females in the 9-month group had a mean age of 9 months 5 days (range = 8 months 1 day to 10 months 11 days). The 21 males and 19 females in the 12-month group had a mean age of 11 months 25 days (range = 10 months 24 days to 12 months 18 days). The infants in the two conditions did not differ in age (mean (9 month face-and-hand) = 9 months 7 days, mean (9 month hand-only) = 9 months 2 days, mean (12 month

face-and-hand) = 11 months 28 days, mean (12 month hand-only) = 11 months 22 days). An additional 27 infants visited the laboratory but were not included in the final sample because they did not complete all trials due to fussiness (9), because they moved off camera during a test trial (10), or because of an error in the experimental procedure (8).

3.2. Procedure

Infants saw events that took place on a curtained stage at a distance of 30 in. They sat in a tabletop seat or on a parent's lap. If the infant was seated on the parent's lap, the parent was asked to look down at the infant rather than at the experimental events. If the infant sat in the table top seat, the parent stood just behind the table and the infant. There were two toys on the stage, a white teddy bear and a multicolored ball. The toys were mounted on pedestals that stood 10 in. apart from one another. Just above and between the toys, a video camera was mounted so that its lens protruded through the rear curtain. The curtains surrounding the stage, the stage floor and the pedestals were black. Between trials, a white screen was raised from below the stage to hide the toys from view.

During the experimental events, an actor reached into the stage area from the right side and pointed to one of the toys, touching it with her outstretched index finger. She wore a long sleeved magenta sweater. Her hand was bare. In the hand-only condition, the actor remained hidden behind the side curtain (see Fig. 1). Only her arm was visible to the infant. When she pointed to the toy on the far side of the stage, the actor's arm passed below the near toy, leaving it in full view. To allow for this reach, the toys stood on pedestals that were 10 in. high. In the face-and-hand condition, the toys were mounted on lower pedestals, 3 in. high, and the actor leaned into the stage area from above so that her face and the top half of her body were visible to the infant and she pointed to the toys from above rather than from below (see Fig. 2). In this condition, at the beginning of each trial, the experimenter made eye contact with the baby and said "hi". She then said "look" as she turned to look and point toward and touch one of the toys. In both conditions, once the actor's hand was in contact with the toy, she remained still for the duration of the trial, while pointing to (and looking at) the object.

An observer watched the infant over video and coded looking times online using a custom software package (Pinto, 1994). The observer could not see the stage area, the toys, or the actor's arm. Observers had been trained to be able to discern, based on the direction of the infant's gaze, whether the infant was looking at the area containing the toys and the actor. The observer was blind to the order of the test trials.

Each trial began when the screen was lowered to reveal the two toys. After the observer confirmed that the baby was attentive, the actor pointed at and touched one of the toys, as described earlier. The infants' looking was coded beginning

Habituation Event

New Side Test Event   New Referent Test Event
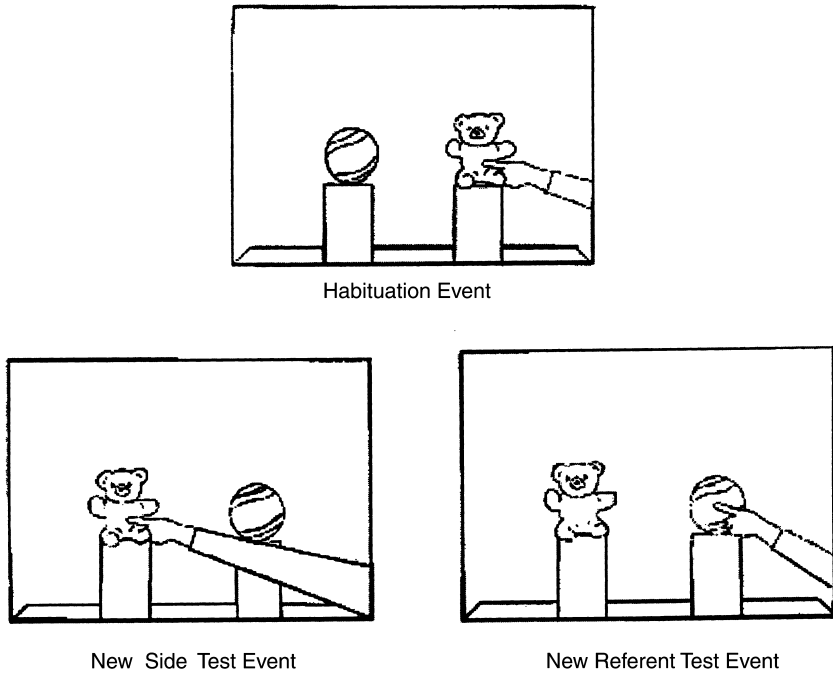
Fig. 1. Sample habituation and test events for the hand-only condition.

when the actor's hand made contact with the toy. That is, looking was timed to
the static portion of the event. This was achieved by having a third experimenter
click the computer mouse to begin the timing process once the actor's hand was
in place. The trial ended when the infant had looked away for two consecutive
seconds or when 120 s had elapsed.

During the habituation phase, the actor always pointed to the same toy. At each
age and in each condition, equal numbers of infants were habituated to a point to the
toy on the left and a point to the toy on the right, and equal numbers were habituated
to a point to the teddy bear and a point to the ball. The habituation criterion was
computed based on the first three trials that totaled to 12 s or more. The criterion
for habituation was met when the infant had three consecutive trials that totaled
less than half of the sum of these trials. Thus, each infant had a minimum of six
trials in habituation. If an infant did not meet this criterion, this phase was ended
after 14 trials and test trials were begun.

After the last habituation trial, the positions of the toys were switched while
the screen hid the stage from view. Then, the infant received one trial to famil-
iarize him or her with the new toy positions. The actor did not reach into the
stage area during this trial. After this, each infant was given six test trials, three
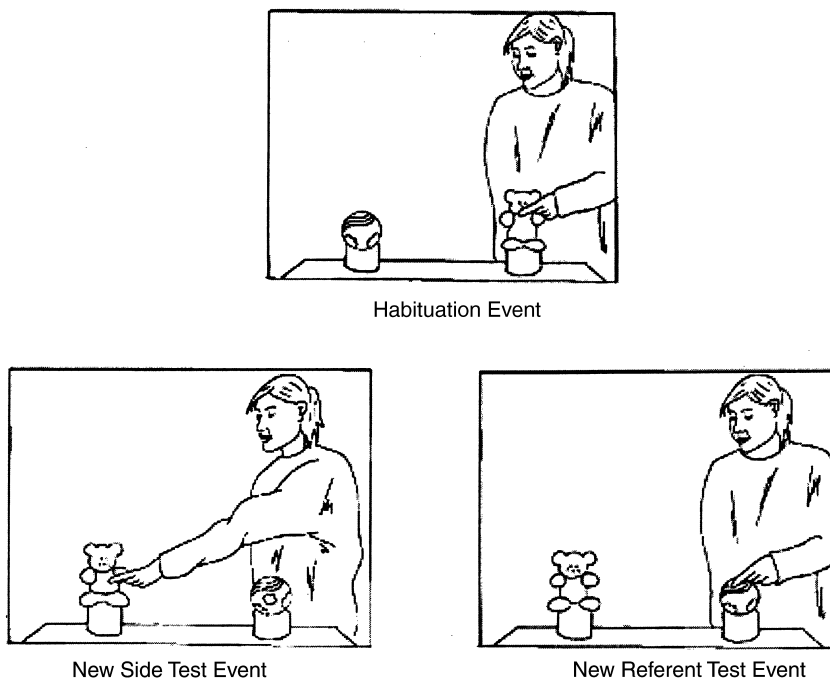in which the path of motion taken by the actor's arm had changed (*new side*

Fig. 2. Sample habituation and test events for the face-and-hand condition.

trials), and three in which the object that she pointed to had changed (*new referent trials*) (see Figs. 1 and 2). The two kinds of test trials were given in alternation. The type of test trial given first was counterbalanced within each age and condition.

3.3. After the fact video coding

3.3.1. Reliability coding of looking times

To assess the reliability of the online coding, a second observer coded the test trials of each videotaped session. The tape from one infant, a 9-month-old, was lost and could not be coded. Coders were counted as agreeing if the tone signaling the end of the trial on the videotape was indistinguishable from the tone signaling the end of the trial for the reliability coder. On this measure, the two coders agreed on the trial endings for 86, 87, 86, and 84% of trials for the 12-month hand-only and face-and-hand and 9-month hand-only and face-and-hand groups. Next, at each age and condition, the disagreements were categorized into two groups, those for which potential bias on the part of the live observer would have biased the results in favor of the hypothesis (i.e., longer judged looking times for new referent trials, and shorter times for new path trials), and those for which bias on the part of

the live observer would be biased against the hypothesis. The disagreements were randomly distributed between these categories for infants at each age and condition (two-tailed sign test, all P's $> .2$).

3.3.2. Coding of looks to each side during the test phase

In a second pass of the tapes, infants' looks to each of the two toys were coded during the test trials. Coders watched the tape in slow motion, using a custom computer program to calculate the amount of time that babies spent looking at each of the two toys. Coders were not informed of the condition to which an infant had been assigned. They could not see the toys or the actor's arm on the videotape. The tape from two infants, one 9- and one 12-month-old, could not be coded due to loss of the tape or problems with the quality of the tape. Two independent coders overlapped for 20 infants, 10 at each age. Their judgments of infants' distribution of looking time to each of the two toys were strongly correlated, $r = .83$.

3.3.3. Coding of infants' production of points during the habituation procedure

In a third pass of the tapes, infants' production of pointing was coded. For each trial, the coders noted whether the infant's hands were visible and empty. If so, they watched the trial in real time, pausing each time the infant extended one of his or her index fingers. Each index finger extension was tallied. The coders then noted whether the index finger extension was part of a well-formed (remaining fingers curled back) point directed at an identifiable object (e.g., the experimental toys). Two independent coders overlapped for 16 infants, 8 in each age group. For these infants, the coders agreed 100% of the time as to whether or not the infant produced any object-directed points, and their judgments of the number of points produced were strongly correlated, $r = .93$.

4. Results and discussion

4.1. Looking times during habituation and test

The first analysis tested whether infants in the two age groups and conditions differed in their levels of attention during the habituation phase. An analysis of variance with age group (9 months versus 12 months) and condition (hand-only versus face-and-hand) as between subjects factors was carried out on the looking times for the first and last three habituation trials for each infant. To reduce positive skew, the data were subjected to a log transformation before the analysis of variance was conducted. This analysis revealed only a main effect of trial, indicating a decline in attention across trials, $F(5, 380) = 35.43$, $P < .0001$.[2] There were no

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[2] *Post hoc* tests comparing the first three habituation trials with the last three habituation trials confirmed that this decline in attention was present at both ages. Nine-month-olds showed a significant decrease in looking, $t(39) = 3.97$, $P < .001$, as did the 12-month-olds, $t(39) = 7.46$, $P < .001$.

Table 1
Mean (S.E.M.) total looking time (across three trials of each type) on test trials in Study 1

Age group and condition	Test Trial Type	
	New referent	New side
9 months overall	27.8 (4.0)	27.8 (4.8)
Hand-only condition	27.9 (7.0)	29.0 (9.1)
Face-and-hand condition	27.6 (3.9)	26.6 (3.3)
12 months overall	30.0 (3.2)	24.4 (2.3)
Hand-only condition	29.3 (5.8)	24.4 (4.0)
Face-and-hand condition	30.7 (2.9)	24.4 (2.4)

reliable effects of age group or condition. A second analysis of variance confirmed that infants did not differ in the number of habituation trials taken to reach criterion as a function of age or condition (the mean number of trials taken to reach the habituation criterion was 9 in both conditions for 12-month-olds and 10 in both conditions for 9-month-olds). Thirteen 9-month-olds and six 12-month-olds reached 14 trials without meeting the habituation criterion.[3]

The principal analyses concerned infants' looking times during the test trials (see Table 1). The looking times on the three new referent and new side trials were summed for each infant, and then subjected to a log transformation to reduce positive skew. These data were entered into an analysis of variance with age group (9 versus 12 months), condition (hand-only versus face-and-hand), and test trial given first (new referent first versus new side first) as the between subjects factors and trial type (new referent versus new side) as the within subjects factor. This analysis revealed a reliable main effect of Test Trial Type, $F(1, 72) = 4.83$, $P < .05$, indicating an overall trend for infants to look longer on new referent trials than on new side trials. This main effect was qualified by two interactions, a Trial Type × Type First interaction, $F(1, 72) = 4.52$, $P < .05$, and a Trial Type × Type First × Age Group interaction, $F(1, 72) = 4.06$, $P < .05$. There were no other reliable effects. Notably, infants' looking times did not vary reliably as a function of whether they saw only the actor's hand or her face-and-hand.

To further explore the two interactions, separate analyses of variance were conducted at each age with Type First as the between subjects factor and Trial Type as the within subjects factor. At 12 months, there was a reliable main effect for Trial Type, $F(1, 38) = 6.18$, $P < .05$, reflecting longer looking on new referent trials than on new side trials, and no other reliable effects (all other F's < 1). At 9 months, there was not a reliable effect of trial type, $F(1, 38) = 0.16$, $P > .6$, indicating that as a group, 9-month-olds did not look longer on new referent trials

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[3] These infants were evenly distributed between the two conditions. At 12 months, 3 were in the hand-only condition and 3 were in the face-and-hand condition. At 9 months, 6 were in the hand-only condition and 7 were in the face-and-hand condition. When these infants were excluded from the analyses, the principle findings were unchanged.

than on new side trials. The only reliable effect was a Trial Type $\times$ Type First interaction $F(1, 38) = 10.78$, $P < .005$. Follow-up comparisons revealed that those 9-month-olds who began with new referent trials looked longer on these trials, mean (new referent trials) = 33.4 (S.E. = 8.7), mean (new side trials) = 28.4 (S.E. = 7.0), $t(19) = 2.62$, $P < .05$; whereas those 9-month-olds who began with new side trials looked marginally longer on these trials, mean (new referent trials) = 22.2 (S.E. = 3.8), mean (new side trials) = 27.1 (S.E. = 3.8), $t(19) = 2.03$, $P < .06$. Thus, infants at the two ages responded differently on test trials. Twelve-month-olds looked longer when the relation between actor and referent changed than when the surface properties of the actor's movements changed. Nine-month-olds, in contrast, did not respond differentially to the change in relation between actor and referent, instead looking longer at whichever kind of test event they saw first.

Examination of individual performance patterns also indicated that infants at the two ages responded differently to the test events. Infants were categorized as to whether they had longer overall looking times on new referent trials or on new side trials. Out of the 40, 12-month-olds, 27 had longer overall looking times on new referent trials, $P < .05$ by sign test, whereas of 40, 9-month-olds, 17 showed this pattern, $P > .4$. The difference in the distribution of infants at the two ages was significant $\chi^2(\text{d.f.} = 1) = 5.50$, $P < .05$.

To summarize, 12-month-olds responded selectively to the change in the relation between the actor and the referent object — looking longer when this dimension was altered than when the surface properties of the actor's motion were altered. Nine-month-olds, in contrast, showed no evidence of selective responding to the change in the relation between actor and object. Because infants at the two ages did not differ in the total length of time they watched the test events, nor in their looking times during habituation, it seems unlikely that these findings were due to floor effects or boredom on the part of 9-month-olds.

As noted above, the analysis of variance did not reveal reliable effects of presentation condition — that is, the findings did not differ as a function of whether the infant saw only a pointing hand or saw the actor greet the baby and accompany the point with gaze and postural cues. Thus, the absence of converging behavioral cues did not seem to make the habituation event less clear for 12-month-olds, and the addition of these cues did not seem to make the event more clear for 9-month-olds. It is possible that additional behavioral cues would be useful to infants in other situations, for example, when there are additional processing demands or for infants between 9 and 12 months, who may be just beginning to attend to the relation between pointer and referent. Further research is needed to test this possibility.

4.2. Looks to each side

The next question was whether the presence of the pointing hand drew babies' attention to the referent object, and whether spotlighting of this kind could account for infants' patterns of attention during test trials. As described above, the
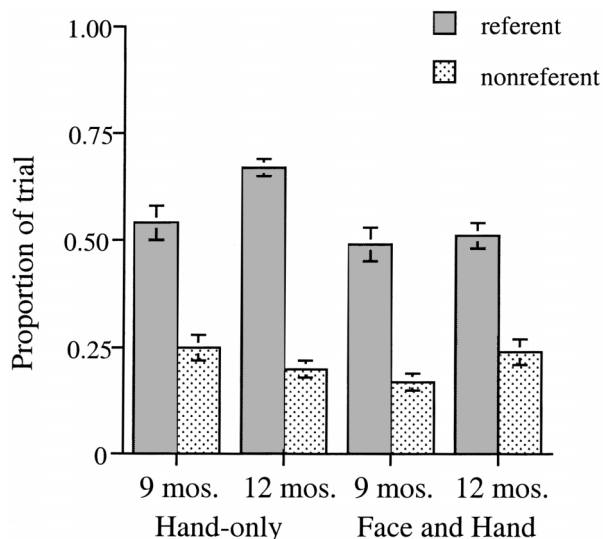
Fig. 3. Mean (S.E.M.) proportion of the trial that infants spent looking at the referent and nonreferent objects in Study 1.

videotaped test trials for each infant were coded after the fact to determine how long the infant looked at each of the two toys. The proportion of each trial that the infant spent looking at the referent object versus the other object was calculated. Since the infant could look at parts of the display other than the two toys (e.g., at the entry point of the actor's arm or the pedestals), these scores did not always sum to 100%. Fig. 3 summarizes these scores. As a measure of the pointing hand's effectiveness as a spotlight, the difference between the proportion of looking to the referent object and the proportion of looking to the other object was calculated. For both age groups and in both conditions, this difference was reliably greater than 0, indicating that the hand was a highly effective spotlight, $t(19) = 5.57$, $P < .0001$ and $t(18) = 7.16$, $P < .0001$ for the 9-month-olds in the hand-only and face-and-hand conditions, and $t(18) = 12.19$, $P < .0001$ and $t(19) = 5.15$, $P < .0001$ for the 12-month-olds in the hand-only and face-and-hand conditions. Out of the 39 codeable 12- and 9-month-olds, 36 and 37 babies looked longer at the referent object than at the nonreferent object on average, respectively (for both $P < .0001$ by sign test). Thus, the actor's pointing hand strongly directed 9-month-old infants' attention to the referent object, just as it did for 12-month-olds. Nevertheless, as described above, infants at these two ages differed as to whether they responded systematically to the change in relation between actor and object. Therefore, it seems unlikely that the 12-month-olds' novelty response to the change in relation between actor and object was only the result of attentional spotlighting. If this were the case, then infants at both ages should have looked longer on new referent trials than on new side trials.

As a further test of the possibility that spotlighting effects contributed to the principle findings, at each age group the spotlighting score for each infant was entered into a Spearman rank correlation with the difference in total looking time on new referent versus new side trials. Neither of these correlations was reliable, $\rho(12\,\text{months}) = .07$, $z = .41$, $P > .6$; $\rho(9\,\text{months}) = -.02$, $z = .11$, $P > .9$. Thus, the fact that the pointing hand was an effective attentional spotlight seems not to account for infants' patterns of looking on test trials. Instead, 12-month-olds' longer looking on new referent trials than new side trials seems to reflect their representation of the pointing action rather than simply an attentional response to this action. Specifically, infants at this age seem to have encoded the pointing action in terms of the relation between actor and object.

4.3. Infants' production of points during the procedure

The final analyses explored infants' production of object-directed points during the procedure. The tapes for nine 9-month-olds and five 12-month-olds could not be coded because the infants' hands were not visible or because of other problems with the tape. Table 2 summarizes the pointing behavior of the remaining 31 of 9-month-olds and 35 of 12-month-olds. Most 9- and 12-month-olds produced index finger extensions, and the two age groups did not differ on this dimension, $\chi^2(\text{d.f.} = 1) = 0.07$, $P > .70$. Twelve-month-olds were somewhat more likely than 9-month-olds to produce object-directed points, $\chi^2(\text{d.f.} = 1) = 3.04$, $P < .10$. At a global level, this finding concurs with the findings of other researchers in suggesting that object-directed pointing begins to emerge toward the end of the first year of life, and, taken together with the findings from the habituation procedure, they suggest that this emergence overlaps in time with the development of the understanding of points as object-directed.

The next analyses tested whether there was a more specific relation between infants' production of object-directed points and their comprehension of points as object-directed. Infants at each age were identified as "pointers" if they produced at least one object-directed point during the habituation procedure. On this criterion, seven 9-month-olds and fifteen 12-month-olds were scored as pointers. To test whether pointing status was related to infants' responses during the habituation procedure, an analysis of variance with age group (9 versus 12 months) and Test Trial Type given first (new referent versus new side) was conducted for the log

Table 2
Number (and proportion) of infants in Study 1 who produced finger extensions and points during the habituation procedure

Age group	Proportion of infants who produced at least one	
	Index finger extension	Object-directed point
9 months ($n = 31$)	.77	.23
12 months ($n = 35$)	.80	.43

transformed difference score, total looking on new referent trials — total looking on new side trials, for each infant.[4] This analysis revealed a significant Test First × Age Group interaction, $F(1, 58) = 4.14$, $P < .05$, analogous to the interaction reported above, and no other reliable effects. In particular, there was no indication that pointing status was related to infants' preference for the new referent test event; neither the main effect of pointing status nor any of the interactions involving this factor approached significance, all F's < 1. In keeping with these results, at an individual level there was no indication that pointing status was related to infants' patterns of looking during the habituation procedure: At 9 months, approximately half of the infants in both the pointer and nonpointer groups, looked longer on new referent trials than new side trials (4 of 7 pointers and 11 of 24 nonpointers). At 12 months, the group level preference for new referent test events was preserved for the nonpointers, 15 of 20 nonpointers overall looked longer on new referent trials, $P < .05$ by sign test. However, the pointers did not show this pattern as strongly, 9 of 15 pointers looked longer on new referent trials, $P > .6$ by sign test.

One possible conclusion from these results is that there is not a specific relation between infants' ability to produce object-directed points and their understanding of the points of others as object-directed. However, it is also possible that the approach taken in Study 1 was not sufficiently sensitive to yield evidence of this relation. For one, relying only on the infants' production of points during the habituation procedure probably underestimated the number of infants at each age who were able to produce object-directed points. In addition, by testing infants at 9 and 12 months, we may have missed the age range at which this relation would be most evident — if most 9-month-olds do not produce points, and most 12-month-olds do, there may not have been enough variation in pointing status at either age for the relation to be evident.

With these concerns in mind, Study 2 was designed to provide a more sensitive test of whether infants' developing understanding of pointing as object-directed is related to their own ability to produce object-directed points. We tested 48 infants between 8.5 and 11 months, gathering two sources of evidence about their production of points in addition to testing each infant in the habituation procedure. Because there were no effects of presentation condition in Study 1, we chose to use only the face-and-hand presentation condition in Study 2.

5. Study 2

5.1. Participants

As recruited in Study 1, 48 infants participated in the second study. The 24 males and 24 females had a mean age of 9 months 19 days (range = 8 months 10

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[4] The unequal n's in each group, and the small number of pointers at 9 months precluded a within subjects analysis of variance with test trial type as a factor.

days to 11 months 5 days). Nine additional infants began the procedure but were not included in the final sample due to failure to complete all trials due to distress (1), experimental error (3), or moving off camera during a test trial (5).

5.2. Procedure

For all of the infants in Study 2, the procedure was identical to that used in the face-and-hand condition in Study 1 (see Fig. 2). Infants were approximately evenly distributed in the assignment of the side to which the actor pointed during habituation (right versus left) and the identity of the toy to which she pointed (bear versus ball). Following habituation, the positions of the toys were reversed, and infants saw three new referent and three new side test trials in alternation. Out of 48, 24 infants began with a new referent test trial.

5.3. After the fact video coding

As in Study 1, the videotaped procedure for each infant was coded in three separate passes in order to (1) assess interobserver agreement for the online judgments of looking time; (2) determine how long the infant spent attending to the referent toy versus the other toy for each test trial; and (3) to code for infants' production of points. The online and video coders agreed on the endpoint of the trial for 86% of test trials. The direction of their disagreements was randomly distributed with respect to the trial type, $P > .6$, by sign test. For the coding of infants' looks to each of the two toys, two independent coders overlapped for seven infants. Their judgments of infants' distribution of looking time to the two toys were highly correlated, $r = .90$. For the coding of infants' point production, two independent coders overlapped for 34 infants. The coders were in agreement 94% of the time as to whether or not the infant produced any object-directed points, and their judgments of the number of object-directed points each infant produced were strongly correlated, $r = .87$.

5.4. Questionnaire

In addition to the coding of the infants' point production in the lab, we also interviewed parents about their infants' point production at home. This was done *via* a short questionnaire, which was administered verbally by the experimenter before the habituation procedure began. Parents were asked whether their infant ever produced the point handshape (the experimenter produced a point to illustrate), and whether the infant directed this gesture at objects.

6. Results

The goal of Study 2 was to test whether infants who produce object-directed points are more likely to encode the relation between a person who points and the

Table 3
Proportion of infants in Study 2 who produced index finger extensions and points

Source of evidence	Proportion of infants who produced at least one	
	Index finger extension	Object-directed point
Video	.55	.19
Questionnaire	.38	.30
Combined video and questionnaire	.60	.38

referent than infants who do not produce object-directed points. With this question in mind, we first identified those infants for whom there was evidence of the production of object-directed points either from their videotaped behavior during the habituation procedure or from the parental interview. Table 3 summarizes the findings from the video coding and interview. Infants were classified as "pointers" if they produced at least one object-directed point during the habituation procedure or if their parents answered "yes" when asked whether the infant pointed to objects at home. On these criteria, 18 of the 48 infants were identified as pointers; 4 of these were identified based on the videotape alone, 10 based on parental report alone, and 4 based on both the videotape and parental report. The pointers did not differ from the nonpointers in age (mean (pointers) = 9 months 21 days, mean (nonpointers) = 9 months 18 days, $t(46) = 0.53$).

The next analysis compared the levels of attention during habituation for the pointers and nonpointers. For each infant, the log transformed looking times on the first three and last three habituation trials were entered into an analysis of variance with pointing status (pointer versus nonpointer) as the between subjects factor. This analysis revealed an effect of trial, $F(5, 230) = 32.44$, $P < .0001$, indicating a decline in looking across trials, and no other reliable effects (all other F's < 1). Infants in each group reached the habituation criterion in 8 trials on average. Three infants, one pointer and two nonpointers reached 14 trials without meeting the habituation criterion. Thus, pointers and nonpointers did not show any differences in their attentiveness during the habituation phase.[5]

The next analyses tested whether pointers and nonpointers differed in their responses on new referent and new side test trials. For each infant, the total looking times on the three test trials of each type were calculated (see Table 4), and then subject to a log transformation to reduce positive skew. Because preliminary analyses revealed no significant effects (for the group as a whole or for pointers and nonpointers separately) of the type of test trial given first, the placement of the toys or the side pointed to during habituation, these dimensions were collapsed in subsequent analyses. Infants' looking times on the two kinds of test trials were entered into an analysis of variance with pointing status (pointer versus nonpointer)

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[5] *Post hoc* tests comparing the first three habituation trials with the last three habituation trials confirmed that this decline in attention was present at both ages. Pointers showed a significant decrease in looking, $t(17) = 7.62$, $P < .001$, as did the nonpointers, $t(29) = 12.09$, $P < .001$.

Table 4
Mean (S.E.M.) total looking time during the three test trials of each type for pointers and nonpointers in Study 2

Group	Test Trial Type	
	New referent	New side
Pointers ($n = 18$)	29.6 (2.5)	18.6 (1.6)
Nonpointers ($n = 30$)	28.4 (4.0)	27.2 (4.1)

as the between subjects factor and Test Trial Type (new referent versus new side) as the within subjects factor. This analysis revealed a main effect of Test Trial Type, $F(1, 46) = 11.73$, $P < .005$ which was qualified by a Test Trial Type × Pointing Status interaction, $F(1, 46) = 6.99$, $P < .05$. Planned comparisons revealed that pointers looked reliably longer on new referent trials than on new side trials, $t(17) = 4.98$, $P < .0005$, but that nonpointers did not, $t(29) = 1.01$, $P > .32$. Infants in the two groups did not differ in their overall attentiveness during test trials, as indicated by the lack of a significant main effect for Pointing Status, $F(1, 46) = 0.003$. Thus, although they did not differ in age, rate of habituation or overall levels of attentiveness during the habituation and test phases, infants who produced object-directed points and those who did not differed in their responses to the test events. Infants who pointed, like the 12-month-olds in Study 1, looked longer when the relation between actor and referent changed than when the surface properties of the actor's movements changed. Infants who did not point did not differentiate between these two kinds of alterations.

Examination of individual performance patterns also provided support for the conclusion that the pointers responded more strongly to the change in relation between actor and referent than did the nonpointers. Within each group, infants were categorized as to whether they had longer overall looking times on new referent trials or on new side trials. Of the 18 pointers, 16 looked longer on new referent trials than on new side trials, $P < .005$ by sign test. Of the 30 nonpointers, 20 showed this pattern, $P > .09$ by sign test. The difference in the distribution of infants in the two groups was marginally significant, $\chi^2(\text{d.f.} = 1) = 2.96$, $P < .10$.

6.1. Looks to each side

The proportion of time spent looking at the referent object and at the nonreferent object during test trials was calculated as in Study 1. Fig. 4 summarizes these scores. As was the case in Study 1, the pointing hand was a strong attentional spotlight for infants in Study 2. For both the pointers and the nonpointers, the difference in the proportion of looking to the referent versus the nonreferent object was reliably greater than 0, $t(17) = 8.46$, $P < .0001$ and $t(29) = 7.39$, $P < .0001$, for the pointers and nonpointers, respectively. Of the 18 pointers, 17 looked longer
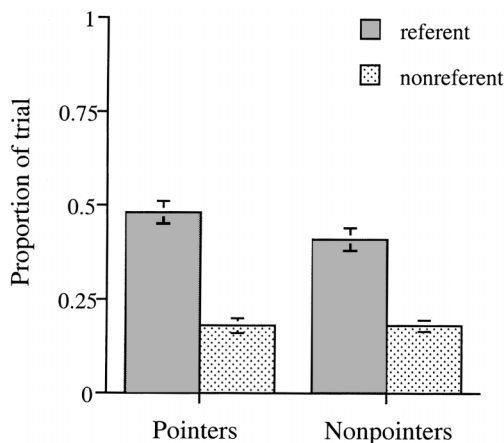
Fig. 4. Mean (S.E.M.) proportion of the trial that infants spent looking at the referent and nonreferent objects in Study 2.

overall at the referent object, and of the 30 nonpointers, 28 did this, both $P < .0001$ by sign test. Thus, even though the two groups of infants responded differently to the change in relation between actor and referent, both groups responded very strongly to the pointing hand as an attentional spotlight. This makes it seem unlikely that spotlighting effects can account for the differing response of the pointers and nonpointers to new side and new referent test trials. Further support for this conclusion is provided by Spearman rank correlation analyses testing for a relation between the size of infants' preference for the new referent test event (looking time on new referent trials — looking time on new side trials) and the strength of the spotlighting effect. This correlation was reliable for neither group, $\rho(\text{pointers}) = .09$, $z = .36$, $P > .7$, $\rho(\text{nonpointers}) = .14$, $z = .75$, $P > .4$.

7. General discussion

The aim of these studies was to investigate the development of infants' understanding of the relation between a person who points and the referent object, that is, their understanding of pointing as an object-directed action. The findings of Study 1 support the conclusion that 12-month-old infants, but not 9-month-olds, focus on the relation between actor and referent when they see a person point. Regardless of whether or not the point was accompanied by supportive behavioral cues, 12-month-olds looked longer when, following habituation to one pointing event, the actor pointed to a new object than when she moved through a new path in order to point to the object she had pointed toward earlier. This finding suggests that 12-month-olds attended specifically to the relation between the actor and the object of her point.

In neither the pared down hand-only condition nor the richer face-and-hand condition did 9-month-olds show any tendency toward this pattern, even though the actor touched the toy with her index finger, thus eliminating the need to follow the point through space. This lack of differentiation on the part of the 9-month-olds did not result from boredom or inattentiveness. Nine-month-olds watched the experimental events during habituation and test for as long, on average, as did the 12-month-olds. Moreover, like 12-month-olds, 9-month-olds showed a strong orienting response to the pointing hand — looking most of the time at the hand and the object to which it pointed. This indicates that 9-month-olds were attentive to the experimental events. Nevertheless, they differed from 12-month-olds in terms of the features they weighted in their memorial representations of the pointing action. These findings suggest that between 9 and 12 months, infants begin to understand the object-directed nature of the point gesture.

In Study 1 we found, in keeping with several other researchers, that object-directed pointing had begun to emerge in 9-month-olds and was more prevalent in 12-month-olds. However, we had limited information about infants' point production. Therefore, in Study 2, we gathered more comprehensive data in order to ask whether there was a relation between this development and the development of point production. We found that between 8.5 and 11 months, those infants who produced object-directed points encoded the habituation events as object-directed. In contrast, those infants who did not produce object-directed points did not attend selectively to the actor–object relation. These two groups, the pointers and non-pointers, did not differ in age or overall levels of attention during the habituation procedure. Moreover, both groups responded strongly to the pointing hand by orienting to the referent toy. Thus these findings seem not to be due to inattention on the part of those infants who did not point. Instead, these findings suggest that the production and comprehension of object-directed points are linked in development.

In both studies, there existed a potential alternative explanation for infants' longer attention to the test events in which the actor pointed to a new object. This response might have derived from a general propensity to orient toward objects which are pointed at rather than attention to the actor–object relation *per se*. This spotlighting effect of the pointing hand could account for the findings of Study 1 if the pointing hand were an effective spotlight for 12-month-olds but not for 9-month-olds, and could account for the findings of Study 2 if the pointing hand were an effective spotlight for infants who produce points but not for those who do not. To investigate this possibility, we analyzed infants' allocation of attention to each of the two objects during the test trials. In both studies all babies allocated their visual attention in similar ways, looking most of the time at the pointing hand and the object which it touched. In fact, nearly every baby tested looked longer at the referent object than at the other object regardless of age (in Study 1) and Pointing Status (in Study 2). If spotlighting were contributing to infants' preference for the new referent test event, the same preference should have been observed across the board. However, it was only 12-month-olds in Study 1, and the infants who pointed in Study 2 who looked longer on new referent test events.

Moreover, the strength of the spotlighting effect was not correlated with infants' preference for the new referent test event in either study. Thus, infants' encoding of the pointing event as object-directed can be distinguished from the more general propensity to look at a pointing hand that makes contact with an object.

It is possible that the spotlighting effects seen in these two studies reflected infants' understanding of the signal value of the point gesture. However, infants may not have been responding to the point gesture *per se*. The fact that the actor's hand moved toward the toy and stopped in contact with it may have been sufficient to lead infants to look longer at that location. In fact, in other studies, hands in several postures, rods, and mechanical claws were all effective spotlights of attention when they moved toward and made contact with an object (Woodward, 1998, 1999, in press). We did not assess infants' propensity to orient in response to points at a distance and we did not assess their understanding of the object-directed nature of distant points. Further research is needed to investigate whether and how the current findings relate to points that occur at a distance.

The failure of 9-month-olds in Study 1, and the nonpointers in Study 2 to discriminate between the test events in the habituation task is interesting in light of the findings from prior studies of infants' encoding of grasping (Guajardo & Woodward, under review; Woodward, 1998, 1999, in press; Woodward et al., 2001). In those studies, infants at 6, 7 and 9 months attended selectively to the actor–object relation for similar events in which the actor grasped the toy rather than pointing to it. In other ways, the experimental events for grasping were very similar to those used for pointing in the current studies. In some studies, only the actor's arm was visible (Woodward, 1998, 1999), and in others the actor's face was also visible (Guajardo & Woodward, under review; Woodward et al., 2001; Woodward, in press). In both cases, young infants showed a strong novelty response when the relation between actor and object changed from habituation, but no such response when this relation was preserved and other features of the action changed. Taken together these findings suggest that infants' understanding of object-directed action is based in their knowledge about particular actions, rather than stemming from a general propensity to treat all human actions as object-directed.

The findings of Study 2 indicate that infants' developing understanding of the object-directed nature of points is related to their own use of this gesture. This finding raises many questions for future investigations to explore. Most critically, there are several possible ways in which the production and comprehension of points might be related, and the current findings do not distinguish between these possibilities. One possibility is that some third factor constrains both abilities. The fact that the pointing and nonpointing infants were the same age on average, and did not differ in their overall levels of attention during the habituation procedure suggests that these factors did not drive the correlation. It is possible, however, that the growth of a general cognitive ability, such as short-term memory or attention regulation, contributes simultaneously to the development of the production and comprehension of object-directed points.

A second possibility is that there is a specific and causal relation between infants' propensity to encode points as object-directed and their ability to produce object-directed points. If this were true, then the relation could run in two directions. On the one hand, infants might begin to use object-directed points after they have discovered the object-directed nature of other people's points. That is, infants may learn to produce object-directed points by first understanding the purpose of this action in other people. Alternatively, infants' own point production might contribute to their developing understanding of the points of others as object-directed. A number of observers have reported that infants' first object-directed points appear not to be communicative in nature, but rather seem to be an expression of the infant's own attention and interest (Bates et al., 1979; Desrochers et al., 1995; Schaffer, 1984; Werner & Kaplan, 1963). Infants might draw on their own experience of pointing as an expression of interest to infer that the points of others reflect a similar internal state. That is, infants may seek to relate their own internal experiences and actions to the observable actions of other people, and thereby gain an understanding of the attentional link between a person who points and the object of her point. This possibility is in keeping with several current proposals that understanding intentional action in others is rooted in noting the correspondence between self and other (Meltzoff & Gopnik, 1993; Tomasello, 1999; cf. Rizzolatti & Arbib, 1998). Of course, the existence of a correlation does not provide evidence as to the direction of causality. Until further evidence is gathered, this hypothesis remains a speculation.

There are important aspects of point comprehension that the current studies did not investigate. For one, we did not explore infants' understanding of the communicative function of points, that is, that points not only indicate the actor's attention but are also used in order to influence the attention of others. It seems logical to expect that this aspect of point comprehension would require the prior understanding of the object-directedness of points, and would therefore come later. Clear evidence for infants' comprehension of the communicative function of points has been difficult to obtain. Sometimes young 1-year-olds accompany their points with a turn toward their interlocutor. It has been argued that by pointing and then checking back to the parent's face, infants are showing that they understand and produce acts of intentional communication (Bretherton, 1991). However, as Moore and Corkum (1994) have pointed out, this behavior can be interpreted in other ways, for example, as an anticipation of an interesting response on the part of parents. More evidence is needed on this question.

Finally, although the current findings indicate that 12-month-olds and younger infants who produce points focus on the relation between a person who points and the referent object, these findings do not specify the nature of this relation from the infant's point of view. As discussed earlier, adults understand the relation between a person who points and the referent object both in terms of the psychological underpinnings of the action (attention to the referent, intention to communicate about the referent) and in terms of the behavioral regularities associated with this action (the actor's concurrent and future behaviors, utterances, emotional expressions are

likely to be directed at the referent). Infants may understand the pointer-object link in something like psychological terms, especially if they seek to relate their own internal states and actions to those of other people. Alternatively, at the earliest stages of point comprehension, infants may be limited to understanding only the behavioral link between pointer and object. These are critical issues for future investigations to explore. Nevertheless, our findings suggest that by 12 months and perhaps earlier, infants have an important component of an intentional understanding of pointing in place in that they structure their representations of pointing events around the relation between actor and object. This structuring reflects a basic property of intentional actions, their object-directedness, and it could serve as the basis for later discoveries about the particular intentions expressed by the point gesture.

Acknowledgments

References

Baldwin, D. A., & Moses, L. M. (1996). The ontogeny of social information gathering. *Child Development*, *67*, 1915–1939.

Barresi, J., & Moore, C. (1996). Intentional relations and social understanding. *Behavioral and Brain Sciences*, *19*, 107–154.

Bates, E, Benigni, L., Bretherton, I., Camaioni, L., & Volterra, V. (1979). *The emergence of symbols: Cognition and communication in infancy*. New York: Academic Press.

Bretherton, I. (1991). Intentional communication and the development of an understanding of mind. In D. Frye, & C. Moore (Eds.), *Children's theories of mind* (pp. 49–75). Hillsdale, NJ: Erlbaum.

Butterworth, G., & Grover, L. (1988). The origins of referential communication in human infancy. In L. Weiskrantz (Ed.), *Thought without language* (pp. 5–24). Oxford: Clarendon Press.

Butterworth, G., & Jarrett, N. (1991). What minds have in common is space: Spatial mechanisms serving joint visual attention in infancy. *British Journal of Developmental Psychology*, *9*, 55–72.

Carpenter, M., Nagell, K., & Tomasello, M. (1998). Social cognition, joint attention and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development, 63*(4).

Desrochers, S., Morissette, P., & Ricard, M. (1995). Two perspectives on pointing in infancy. In C. Moore, & P. J. Dunham (Eds.), *Joint attention: Its origins and role in development* (pp. 85–102). Hillsdale, NJ: Erlbaum.

Guajardo, J. J., & Woodward, A. L. (under review, 2001). *Is agency skin-deep? Infants use surface cues to identify goal-directed actions*.

Lempers, J. D. (1979). Young children's production and comprehension of nonverbal deictic behaviors. *Journal of Genetic Psychology*, *135*, 95–102.

Leung, E. H. L., & Rheingold, H. L. (1981). Development of pointing as a social gesture. *Developmental Psychology*, *17*, 215–220.

Meltzoff, A., & Gopnik, A. (1993). The role of imitation in understanding persons and developing a theory of mind. In S. Baron-Cohen, H. Tager-Flusberg & D. Cohen (Eds.), *Understanding other minds: Perspectives from Autism*. New York, NY: Oxford University Press.

Moore, C. (1999). Intentional relations and triadic relations. In P. D. Zelazo, J. W. Astington, & D. R. Olson (Eds.), *Developing theories of intention.* Mahwah, NJ: Lawrence Erlbaum Associates.

Moore, C., & Corkum, V. (1994). Social understanding at the end of the first year of life. *Developmental Review*, *14*, 349–372.

Morissette, P., Ricard, M., & Decarie, T. G. (1995). Joint visual attention and pointing in infancy: A longitudinal study of comprehension. *British Journal of Developmental Psychology*, *13*, 163–175.

Murphy, C. M., & Messer, D. J. (1977). Mothers, infants and pointing: A study of a gesture. In H. R. Schaffer (Ed.), *Studies in mother–infant interaction*. London: Academic Press.

Pinto, J. (1994). MacXhab. Stanford, CA.

Rizzolatti, G., & Arbib, M. A. (1998). Language within our grasp. *Trends in Neurosciences*, *21*, 188–194.

Schaffer, H. R. (1984). *The child's entry into a social world*. London: Academic Press.

Tomasello, M. (1995). Joint attention as social cognition. In C. Moore, & P. J. Dunham (Eds.), *Joint attention: Its origins and role in development* (pp. 103–130). Hillsdale, NJ: Erlbaum.

Tomasello, M. (1999). Having intentions, understanding intentions, and understanding communicative intentions. In P. D. Zelazo, J. W. Astington, & D. R. Olson (Eds.), *Developing theories of intention.* Mahwah, NJ: Lawrence Erlbaum Associates.

Wellman, H. M., & Phillips, A. T. (2001). Developing intentional understandings. In B. Malle, L. Moses, & D. Baldwin (Eds.), *Intentions and intentionality: Foundations of social cognition*. Cambridge, MA: MIT Press

Werner, H., & Kaplan, B. (1963). *Symbol formation*. New York: John Wiley and Sons, Inc.

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

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

Woodward, A. L. (in press). *Infants' developing understanding of the link between looker and object. Developmental Science*.

Woodward, A. L., & Sommerville, J. A. (2000). Twelve-month-old infants interpret action in context. *Psychological Science*, *11*(1), 73–77.

Woodward, A. L., Sommerville, J. A., & Guajardo, J. J. (2001). How infants make sense of intentional action. In B. Malle, L. Moses, & D. Baldwin (Eds.), *Intentions and intentionality: Foundations of social cognition*. Cambridge, MA: MIT Press.