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Infants' ability to connect gaze and emotional expression to intentional action

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Abstract

Four studies investigated whether and when infants connect information about an actor's affect and perception to their action. Arguably, this may be a crucial way in which infants come to recognize the intentional behaviors of others. In Study 1 an actor grasped one of two objects in a situation where cues from the actor's gaze and expression could serve to determine which object would be grasped, specifically the actor first looked at and emoted positively about one object but not the other. Twelve-month-olds, but not 8-month-olds, recognized that the actor was likely to grasp the object which she had visually regarded with positive affect. Studies 2, 3, and 4 replicated the main finding from Study 1 with 12- and 14-month-olds and included several contrasting conditions and controls. These studies provide evidence that the ability to use information about an adult's direction of gaze and emotional expression to predict action is both present, and developing at the end of the first year of life.

Keywords: Infant cognition; Social cognition; Theory of mind; Intentionality

1. Introduction

How do infants understand the behavior of the people around them? A crucial task involves understanding people in intentional terms as adults do. In the larger sense, adults see people as having intentional mental states, e.g. beliefs *about* the world, desires *for* things. In the narrower, everyday sense they construe actions as purposive and goal-directed. What are the origins of this intentional understanding? Over the last 10 years

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research has demonstrated that preschoolers and toddlers share this "intentional stance" – thus, they employ a variety of intentional mental-state constructs to reason about persons' actions (e.g. Lillard & Flavell, 1990); they conversationally describe and explain human behavior in terms of what the person "wants", "thinks", and "knows" (e.g. Bartsch & Wellman, 1995); and they distinguish intended voluntary actions from unintended biological or physical movements such as a person shaking with fever or being blown down by the wind (e.g. Inagaki & Hatano, 1993; Schult & Wellman, 1997). Recent findings suggest that even 1.5- and 2-year-olds are able to reason about persons' intentions (Baldwin, 1991; Carpenter, Aktar, & Tomasello, 1998; Meltzoff, 1995; Repacholi & Gopnik, 1997). What remains to be investigated are earlier developments, specifically infants' understanding of intentional states and acts.

Our research is guided by a general framework for addressing this question. We acknowledge, as philosophers and psychologists have long pointed out, that action can be described at several contrasting levels, for instance, behavioral motions of the body vs. intentional actions. Behavioral features are not essential to intentions: one can intend to do something but then not do it; an intentional and non-intentional movement can appear behaviorally identical. While not *essential* to intentional action, nonetheless, certain perceivable features (overt movements and expressions) can often help *identify* a behavior as intentional. These features serve to signal a behavior's underlying intentionality – that this behavior is an intentional action – and thus can work to identify intentions, because intentions, when enacted, often (though not always) yield behaviors of a certain form. If so, what features of perceivable behavior, both movements and expressions, might plausibly indicate and manifest intentionality? And of these which might be detected by infants? There are several candidates (see e.g. Baldwin & Baird, 1999) but we concentrate on two: intentional acts are often directed toward certain target objects, and behavioral movements often systematically relate to the actor's gaze, facial expressions, and vocalizations.

Intentional actions, in many simple situations involving actions on objects, can manifest a distinctive directedness to specific objects, reflective of the intention's underlying goal-directedness. We will term this *object-directedness*. Specifically, when an agent acts intentionally toward an object the movement dynamics often result in an approach to (or avoidance of) the object, or contact with, acquisition of, consumption of the object. Thus, in simple action situations at least – a person reaching for an ice cream cone, a hand pulling a cup towards a body, a child grasping a toy – the goal-directedness of intentions can result in a perceptually identifiable object-directedness manifest in behavior.

Beyond object-directed movement itself, an intentional actor often manifests other characteristic movements, expressions, and postures. Consider reaching for and grasping a toy. Typically, such behavior requires perceptual apprehension and then guidance – manifest in head and eye orientations and trajectories. Launching the reach and guiding it might be manifest in a furrowed brow of concentration. If the intention is positive and to approach the object it can be preceded by and manifest in distinctive facial expressions – those associated with interest, pleasure, anticipation. Vocal accompaniments also often co-occur – "There", "yes!", "ahh". If the intention is negative, this can be manifest in fearful, displeased, avoidant expressions and vocalizations. Actually obtaining the target object can result in distinctive facial expressions – those associated with happiness at success, or

surprise at an unexpected result. We will term these various potential connections between target movements and other facial-vocal displays *functional connections*. This term seems apt because, for the actor, the target action is not simply associated with or conjoined with other concomitant behaviors and displays; the connections are indeed more functional. Thus, intentional grasps often require visual apprehension and guidance and hence certain visual orientations by the actor. And intentional actions often result from and result in certain emotional-cognitive reactions in the actor which are, often, manifest in facial or verbal expressions.

In total, we propose that the object-directedness of behavior *and* the functional connections between the target action and other aspects of the person, especially their visual-emotional regard and expressions, can often manifest and potentially identify intentions. Consequently, one way to research infants' initial intentional understandings is to research infants' understanding of the object-directedness and functional connections manifest in human action. In the current research we focus on infants' recognition of connections between actors' actions and their perceptual-emotional displays.

Although there is a long history of inquiry into infant social awareness, recently researchers have developed methods to more precisely examine infants' systematic conceptions of people by extending preferential looking time methods used to investigate infants' understanding of the physical world (e.g. Baillargeon, 1993; Spelke, Breinlinger, Macomber, & Jacobson, 1992) to their understanding of the social world (e.g. Woodward, 1998). Several recent studies of this sort have shown that 6-, 9- and 12-month-olds appreciate important features of how behaviors (e.g. a reach) can be object-directed (Phillips & Wellman, 2002; Sodian & Thoermer, 2001; Woodward, 1998). But these studies do not address whether and when infants also appreciate the telltale connections between the target action and other relevant perceptual and emotional features of the actor.

Of course, much research, such as that on social referencing, indicates that infants at least sometimes pay attention to relevant perceptual-emotional cues in others. For example, infants pay attention to and discriminate emotional expressions in the first year. Newborns may show some discrimination of happy vs. sad living faces (Field & Walden, 1982). Two-month-old infants imitate facial expressions of happiness, sadness, and surprise (Field, Vega-Lahar, Scafidi & Goldstein, 1986). Five-month-old infants generalize from one set of actors portraying happy or sad emotions to new actors portraying these emotions (Caron, Caron, & MacLean, 1988). In these and other ways infants come to discriminate facial expressions of a variety of emotions in the first half year of life (Nelson, 1987). Moreover, 2-month-olds react in systematic and appropriate ways to maternal expressions of joy, sadness, and anger (Haviland & Lelwica, 1987) and throughout the first year infants are upset in "still-face" research when persons do not behave actively and expressively (see review by Muir & Hains, 1993).

In addition, infants can be sensitive to others' direction of gaze. Young infants preferentially attend to faces, particularly eyes, by about 2 months of age (Banks & Salapatek, 1983; Haith, Bergaman, & More, 1977; Johnson & Morton, 1991). There is at least some evidence that by the first half year infants not only attend to eyes but to gaze direction (Hood, Willen, & Driver, 1998; Vicera & Johnson, 1995). By 6 months, infants are beginning to look in the direction of gaze, if it is signaled by both eyes and head turning (Butterworth & Cochran, 1980). Infants' abilities to follow an adult's line of regard

becomes more accurate between 6 and 12 months. For instance, when their mothers sit in front of them and turn their heads by 90 degrees, most 8- to 10-month-olds and almost all 11- to 14-month-olds will turn their heads in the same direction (Butterworth & Grover, 1998; Scaife & Bruner, 1975). Even then, though, the younger infants will stop at the first object in their line of sight, even if the adult is looking farther off. It is not until 12 months that infants are able to extrapolate from their mothers' visual angle and fixate on the same object, thus achieving joint reference (Butterworth & Grover, 1998).

Certainly, by 12 months, infants often are able to achieve joint reference, and they also show effects of social referencing to adults' emotional displays about objects (Bakeman & Adamson, 1984; Hornick, Risenhoover, & Gunnar, 1987; Walden & Ogan, 1988). This competence in and of itself does not, however, tell us how infants are understanding the visual-emotional referential acts of adults. For example, in a social referencing situation the infant sees his mother express a facial emotion of fear toward an object and then tends to play less with that object. The mother's expression clearly controls the baby's behavior, but this does not show that the infant understands the mother's expression as being connected to, or predicting, the *mother's* intentional action. Following the mother's direction of gaze similarly may not involve an understanding of perceptual acts as intentional (as purposely directed toward objects) or as connected to intentional actions. Butterworth (1991), for example, who has conducted many of the studies of infants' ability to accurately follow gaze direction argues that until 18 months or so, infants solve such problems "geometrically", based on simply following line of sight. (See the related arguments in Baldwin and Moses (1996) and Moore and Corkum (1994).) More generally, that infants can attend to gaze direction and emotion does not necessarily mean that they understand emotional-visual regard as connected to object-directed behavior, or that they use information about others' emotion and direction of gaze to assess or predict their action. Our research addresses these issues by exploring infants' recognition that emotional expression and visual regard connect to and thus can predict action.

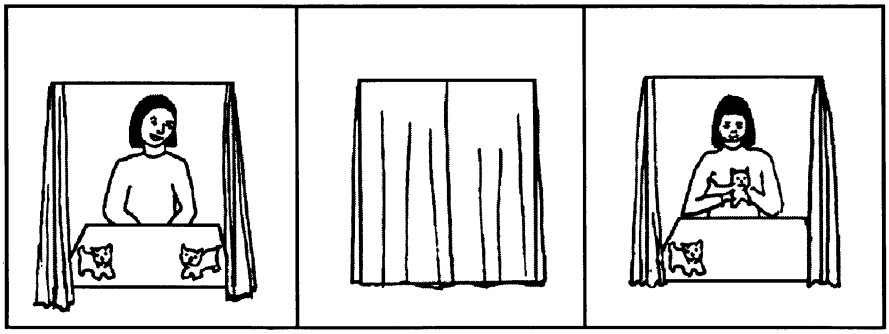
As we noted at the start, the term "intentional" has two related senses. In the everyday sense, actions are intentional in being purposive and goal-directed. In the philosophical sense, mental states, such as beliefs and desires, are intentional in being *about* something – for example, a belief about apples or a desire for apples. Our research includes features that, potentially, relate to both these senses of intentionality. Our displays present purposeful actions to infants. However, the displays also present emotionally valenced visual regard. For adults, such visual regard signals aboutness – the actor's desire for or preferences about the thing regarded.

2. Study 1

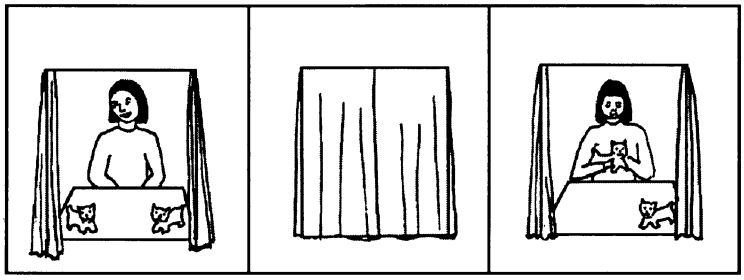
Our question is whether and when infants recognize that a person's perceptual-emotional displays connect to their actions and thus, in certain situations, can predict the direction of their movements. Specifically, if a person looks at and emotes positively about one object, rather than another, then he or she will be likely to grasp that first object rather than the other. In all the research we present below the target person looks at, displays a positive facial expression toward, *and* emits a positively-toned vocalization

about an object. We have assumed that a package of these cues (which we term perceptual-emotional regard) would be a powerful predictor of action, and hence could provide a sensitive test of infants' recognition of functional connections. But we do not test which of these cues, or which package of cues, is most effective at what age. We leave to future research to assess whether and when infants might recognize perceptual regard or emotional expression alone as connected to and predictive of action.

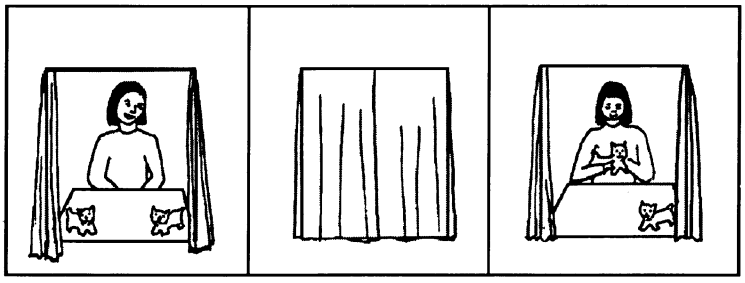
To preview our methods, during habituation trials infants saw a two-phase event as



Habituation



consistent test event



inconsistent test event

Fig. 1. Displays for Study 1.

shown in Fig. 1. First an adult looked to one of two almost identical stuffed animals, kitties, with a facial and vocal expression of interest and joy. Then, a screen was drawn and when the screen opened the adult was shown holding that kitty, kitty A. The infants were then shown two types of test trials. One test event, like habituation, was *consistent* with the principle that emotional expression and visual regard predict the directedness of a subsequent action. In this two-phase event, the adult began by looking at the other kitty, kitty B, the one not regarded and held in habituation, and was then shown holding *that* kitty, kitty B. The other, *inconsistent*, test event began by showing the adult looking at the same kitty she had regarded and held during habituation, kitty A, but then showed her holding the other kitty, kitty B. This event is inconsistent with the principle that emotional and visual regard predict action, because in this test event the adult first looks desiringly at one object but then picks up the other one instead.

Note that in the second phase both test events are physically identical – the adult holds the identical kitty. It is this second phase display to which we measure infant looking. If infants somehow prefer one kitty over another, or if after habituation they prefer to see the person now hold a different kitty than before, and so on, the test displays to which the infants look are equivalent on these features. The only difference in the two test events is where the actor directed her regard earlier in the first phase of the test events – in one case looking to kitty B and in the other kitty A. Because the second phase of the events differs only in terms of the relationship between emotional-visual regard and the subsequent object held, infants should prefer one or the other test event only if they are relating the two phases together – emotional-visual regard *and* subsequent grasping.

2.1. Method

2.1.1. Participants

Twenty-one 8-month-old infants and 25 12-month-old infants from the city of Ithaca, NY participated in Study 1. Five were eliminated due to fussiness, five were eliminated because of presenter error,[2] two were eliminated because of observer error, and two were eliminated because of outside interference. The mean age of the remaining 16 12-month-olds was 11 months, 28 days, or 11-28 (range 11-15 to 12-20). The mean age of the remaining 16 8-month-olds was 8-0 (range 7-17 to 8-15). The infants' names were obtained from birth announcements in the local newspaper. Parents were contacted by letters and follow-up phone calls. They were offered $5 as reimbursement for their travel expenses.

[2] Because the habituation and test events were presented by a live actor to the infant, presentation errors were possible. Therefore, tapes of all presentation events were examined to ensure that all test events were correct in terms of the presenter's emotional-visual regard and in terms of which kitty was picked up. Additionally, we wished to establish that the presenter's expressions were the same when she was looking to a kitty she would later pick up (e.g. the consistent test event) as when she was looking to a kitty she would not later pick up (the inconsistent test event). That is, we wished to be sure that the critical variable was the presenter's visual-emotional direction of regard rather than some other unintended difference in expression, posture, etc. cueing the infant to look longer at the inconsistent test event. Therefore, four observers were asked to judge, based upon looking at tapes of the presenter's face alone, whether she was looking toward the kitty she was going to pick up, or the other one. Observers were at chance in their ability to do this, 58% correct between the two choices.

2.1.2. Procedure

Infants sat in a high chair or their parent's lap, facing a table (120 × 80 cm) 60 cm away. A video camera was placed above the display and recorded the infant through a hole cut in the curtain. A second camera recorded the display. Live observations of the infant's looking times were recorded by a hidden observer through another hole to the side of the camera. The observer determined when the infant was looking at the display, then pressed a button and released when the infant looked away. The button fed to a computer program which kept track of the infants' looks, and determined when trials were finished and when habituation had been accomplished. A second live observer's judgments were also recorded, but did not affect the trial administration or the habituation criterion.

The computer calculated a habituation criterion by summing the total looking times for the first three habituation trials. Habituation trials were terminated (and test trials begun) when the infant had three consecutive trials with looking times 50% or less than this habituation criterion (or when the infant had received ten total trials). Thus, the fewest number of habituation trials any infant was shown was six and the maximum was ten.[3] A trial (either habituation or test) began when the infant looked at the display for at least 0.5 s. If the infant did not initially look at the display for at least that long, the observer made a noise behind the curtain to attract the infant's attention to it. The trial ended when the infant looked away from the display for 2 s. In this way exposure to the trials was controlled by the infant's looks – an infant-controlled procedure.

2.1.3. Habituation event

As shown in Fig. 1, infants were presented with a two-phase display which included a female adult and two stuffed animals, kitties. The two kitties were identical except for color, one pastel orange and one gray. The adult first looked to one of the two kitties (which side counterbalanced across infants) with an expression of interest and joy, while saying in a pleasant voice "Oo-oo, look at the kitty." This first phase always took 5 s. A screen was then drawn to conceal both the adult and the animals; the screen was closed for 2 s. When the screen opened the adult was looking down at, and holding to her chest the same kitty to which she had been looking in the first phase. Looking times were recorded for the infants' attention to this second phase.

2.1.4. Test events

After habituating, infants were shown two types of test events: *consistent* and *inconsistent* events. The infants were shown the two types of test events three times each in alternation, for a total of six test trials (with the test event presented first counterbalanced across infants). Each test event had a two-phase structure exactly parallel to the habituation events. In the *consistent test events*, the adult began by looking at and emoting just as in habituation, but now toward the second kitty, the one not regarded or held during habituation. After the screen opened the second phase showed her holding *that* kitty. This is consistent with the principle that a person will look at and express positive affect

[3] This means that some infants had not reached the habituation criterion when the habituation phase ended at ten trials. However, for the analyses we report, patterns of significance remain the same if these infants are included or excluded (see footnote 3). Thus, our primary analyses include all infants.

toward the object they will subsequently grasp. The *inconsistent test events* showed the adult first looking at and emoting about the same kitty she had regarded and held during habituation, but then showed her holding the other, second kitty. This event is inconsistent with the principle that a person will look at and be positive toward the object they subsequently grasp. As in habituation, infant looking was measured by recording their attention to the second phase of each test event.

2.1.5. Reliability

Reliabilities for observation of infants' looking were calculated by the habituation program which compared the two live observers once every 10 s, continually throughout the testing session. Since the 10 s did not begin anew with each trial, trials which lasted less than 10 s were also sampled. For each comparison the computer tallied whether one or both observers judged the infant as looking at the display or whether one or both observers judged the infant as looking away. Inter-rater reliability averaged 83% (agreements divided by agreements plus disagreements).

2.2. Results

2.2.1. Habituation

Twelve-month-old infants reached the habituation criterion on an average of 7.6 trials. Three 12-month-olds took the maximum of ten trials to reach habituation. On the last habituation trial, 12-month-olds looked for an average of 5.7 s. Eight-month-old infants reached the habituation criterion on an average of 7.8 trials. One 8-month-old infant took the maximum of ten trials to reach habituation, while three received ten trials without reaching the criterion. On the last habituation trial, 8-month-olds looked for an average of 5.1 s.

2.2.2. Test

Our analysis strategy (here and in the subsequent studies) is to focus primarily on the comparison between infants' looking to inconsistent and consistent test events. If infants recognize and appreciate the link between the direction of emotional-visual regard and subsequent action, then they should look longer at the inconsistent test event than at the consistent test event. We assessed this prediction with one-tailed tests of significance because only one direction of possible difference is predicted and interpretable. Our dependent measure for these tests is the infant's looking time summed across the three test trials of any one type. Thus, Fig. 2 presents the mean looking times for the last three habituation trials and for the three test trials for both inconsistent and consistent test events. Collapsing looking times across test trials is a common approach for research of this type (see e.g. Baillargeon, 1986; Spelke et al., 1992) because this tends to stabilize variances (whereas an infant's looking on any single trial can fluctuate for many reasons). Inspection of the trial by trial test data (in this and subsequent studies) showed that differences between inconsistent vs. consistent test events were essentially stable across the three different test trials of a type, although looking times for both types of test events tended to decline from the first to third test trial of a type (presumably as infants gained familiarity with the test events themselves).

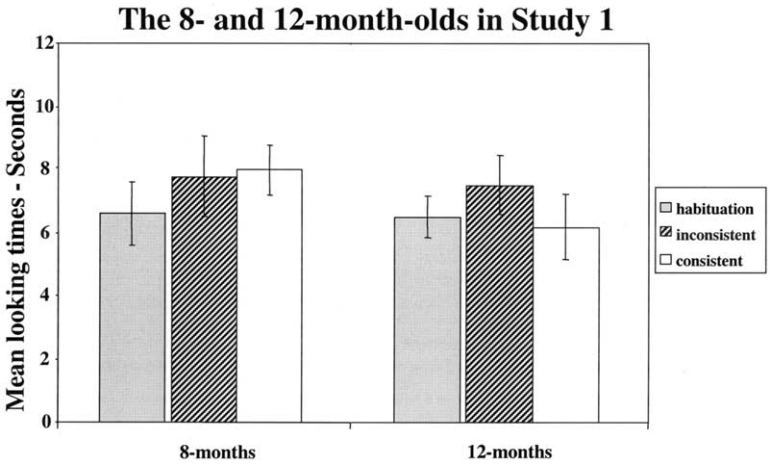


Fig. 2. The 8- and 12-month-olds in Study 1.

Previous research suggests that younger and older infants do not always perform similarly in looking time procedures, and therefore we analyze the data for 8- and 12-month-olds separately. We report 12-month-olds' data first followed by data for 8-month-olds. For both groups an ANOVA showed no effect of sex or presentation order, so these variables were collapsed for further analyses.

As shown in the right-hand portion of Fig. 2, 12-month-olds looked longer at the inconsistent test event ($M = 7.6$) than at the consistent test event ($M = 6.2$) ($t(15) = 3.51$, $P < 0.002$, one-tailed). Consider as well each individual infant's looking preference. Summing across their three trials of each test type an infant could either look longer at the inconsistent or at the consistent test events. Twelve of the 16 12-month-old infants (75%) looked longer at the inconsistent test event (Sign test, $P < 0.04$).

As shown in the left-hand portion of Fig. 2, 8-month-olds looked equally at the inconsistent ($M = 7.8$) and consistent ($M = 8.0$) test events ($t(15) = 0.15$, $P > 0.44$). Individually, only seven 8-month-old infants looked longer at the *inconsistent* test event and nine looked more at the *consistent* event (Sign test, NS).

2.3. Discussion

These results support the conclusion that 12-month-old, but not 8-month-old, infants recognize one common way in which emotional-perceptual regard predicts the direction of an actor's subsequent actions. If so, this requires infants to pay attention to emotional-visual regard in phase-one of these events, to understand the display of emotional-perceptual regard as referential or at least as associated with its target object, and then to use the nature of that regard as indicative of the direction of the person's subsequent action. Therefore, in terms of the framework outlined in Section 1, infants as young as 12 months of age seem to recognize a functional connection between intentional behavior and perceptual-emotional regard, specifically a key connection embodied in something like the

principle that a person who looks at and emotes positively about an object is likely to subsequently grasp that object rather than some other object. Our results provide no evidence that 8-month-olds have an appreciation of this connection; but, of course, null results provide no definitive evidence against such a claim either. The results from the 8-month-olds do contrast with the 12-month-olds, who significantly demonstrated a recognition of this functional connection in our study.

The demonstration that 12-month-olds seem to appreciate that emotional-perceptual regard connects to and thus can predict an actor's behavior is potentially important. However, since this was the first study of its kind, these results deserve replication. Beyond replication, the positive results for 12-month-olds in Study 1 deserve extension and elaboration. Specifically, these results admit of at least two different interpretations. On the one hand, perhaps by 12 months of age infants have developed a general recognition of how perceptual-emotional regard connects to action, or at least of the specific principle that positive perceptual-emotional regard often leads to and predicts approach-like behavior. Such an understanding would be plausible either on the grounds that infants might be innately prepared to attend to coherent connections among human behavior, or on the grounds that after accumulating 12 months of observational and participatory experience with human intentional behavior infants have learned about such consistent co-occurrences. On the other hand, perhaps these infants simply became conditioned, during habituation, to a much more local expectancy. Over the course of six to ten habituation trials, *this* person consistently grasped what she positively regarded, so perhaps infants simply adopted the expectation that she would continue to do so. An important concern, therefore, is whether infants generally recognize something of the connection between perceptual-emotional regard and action vs. whether they merely learned to make this connection, briefly, during habituation itself. One way to address these possibilities, at least in part, would be to present infants with a contrasting control condition.

3. Study 2

Study 2 included an experimental condition that was an exact replication of Study 1 although conducted in a different laboratory at a different university. It also included a control condition where, in habituation, infants saw a contrasting behavioral regularity.

Our reasoning for this control condition is as follows. Suppose infants' looking times in Study 1 reflect merely a simple association built up in habituation, such as: if this actor looks positively at one object, then she will grasp that object. Further suppose that this association is unassisted by background knowledge that more generally persons' perceptual-emotional regard connects to their action. If so, infants easily formed this association during habituation, doing so in six to ten trials. Under these suppositions, presumably infants could equally easily form some other association, for example: if the actor looks positively at one object, then she will grasp the *other* object. If infants' performances reflect only associations formed during habituation, we reasoned, then they could habituate to this contrasting association, and during test, they should now look longer at an event that violates this contrasting association.

On the other hand, suppose infants' dishabituation in Study 1 is, in part, based on the novelty of seeing a display that violates a larger outside-the-laboratory regularity or encoding; namely that, generally, action follows a person's direction of positive perceptual-emotional regard. Under this alternative supposition, differences in looking at the test events would occur in Study 1 but not in the contrasting control condition. That is, suppose infants' background understanding of human action regularities make "looks positively at an object, then grasps that object" familiar and sensible. Such an understanding is made salient in the habituation for Study 1, but goes beyond those habituation trials themselves. And therefore, differential attention during test events to "looks positively at an object, then grasps the other object" reflects violation of this larger regularity. Under this supposition, a preference for looking at the inconsistent test display, evident in Study 1, would not appear in the contrasting control condition.

So, in the control condition used in Study 2, infants saw *habituation* displays where the actor first looked at and emoted positively about one of the two kitties, kitty A, but then was shown grasping the other kitty, kitty B. Then during test, 12-month-olds in both control and experimental conditions saw inconsistent and consistent test events of the same sort as in Study 1. The *consistent* test event was once again consistent with the principle that the direction of a person's action follows the direction of their emotional-perceptual regard (regard kitty A, hold kitty A). Hence, the consistent test event matches the sort of behavioral regularity displayed in the experimental condition habituation trials (and in Study 1) but mismatches the contrasting behavioral regularity displayed in the control condition habituation trials. The second, *inconsistent* test event, is inconsistent with the principle that the direction of a person's action follows from the direction of their perceptual-emotional regard (regard kitty B, hold kitty A). Hence, the inconsistent test event *mismatches* the sort of behavioral regularity displayed in the experimental condition habituation trials. But it *matches* the contrasting behavioral regularity presented in the control condition habituation trials.

3.1. Method

3.1.1. Participants

The infants in this and the subsequent studies were from the city of Ann Arbor, MI. Forty-seven healthy infants participated in Study 2. Two were eliminated due to fussiness, seven were eliminated because of observer error, three were eliminated due to presenter error, and three were eliminated due to outside interference. The mean age of the remaining 16 infants in the experimental condition was 12 months, 9 days, or 12-9 (range 11-16 to 13-16). The mean age of the 16 infants in the control condition was 12-2 (range 11-15 to 13-19). The infants' names were obtained from birth announcements in the local newspaper. Parents were contacted by letters and follow-up phone calls. They were offered $10 as reimbursement for their travel expenses.

3.1.2. Procedure

3.1.2.1. Experimental condition – habituation The procedure for the experimental condition was identical to that in Study 1. To reiterate, as shown in Fig. 1, the adult again looked

to one of the two stuffed animals with an expression of interest and joy. A screen was then drawn to conceal both the adult and the animals. When the screen opened the adult was looking down at, and holding to her chest the same animal at which she had been looking. Thus, infants habituated to the predictable sequence: regard a kitty, then grasp *that* kitty.

3.1.2.2. Control condition – habituation In contrast, in the control condition infants were habituated to a display in which the actor regarded one of two kitties with interest and positive emotion, and then were shown the adult holding the other kitty. Thus, control infants were habituated to the predictable sequence: regard a kitty, then grasp the *other* kitty.

3.1.3. Test events

The test events in *both conditions* were comparable to those in Study 1. Specifically, infants were again shown the two types of test events depicted in Fig. 1. In the *consistent test event*, the adult began by looking at and emoting toward the kitty that had not been picked up during habituation, and was then shown holding *that* kitty. This test event was consistent with the principle that a person's direction of regard predicts the direction of their action. Thus, for the experimental infants, the consistent test event reversed the actual kitties involved, but matched the pattern of events seen in habituation (regard one kitty, pick that one up). In contrast for the control infants, the consistent test event reversed the kitties involved *and* reversed the pattern of events seen in habituation. In the *inconsistent test event* the adult first looked at and emoted about the same kitty she had picked up during habituation, but then held the *other* kitty. Thus, for the control infants, the inconsistent test event reversed the actual kitties involved, but maintained the same pattern of events as seen in habituation (regard a kitty, pick up the other one). For the experimental infants, however, the inconsistent test event reversed the kitties involved *and* reversed the pattern of events seen in habituation.

3.1.4. Reliability

In addition to replicating Study 1 we used a more conservative method for calculating observer reliability. A second set of looking times were calculated from videotapes of the infants recorded during the experiment and compared to those of the live, primary observer. This procedure has the advantage that the secondary observer can be blind to the hypotheses and physical details of the displays (other than their physical dimensions). The secondary observer's looking times were compared in their entirety with the looking times recorded by the live observer (rather than comparing samples every 10 s). The percentage of test trials for which the observer's judgments differed by 2 s or less was 100%. The percentage of test trials for which the observer's judgments differed by 1 s or less was 86%.

3.2. Results

3.2.1. Experimental condition – habituation

Infants in the experimental condition reached the habituation criterion on an average of 8.4 trials. Four infants took the maximum of ten trials to reach the habituation criterion.

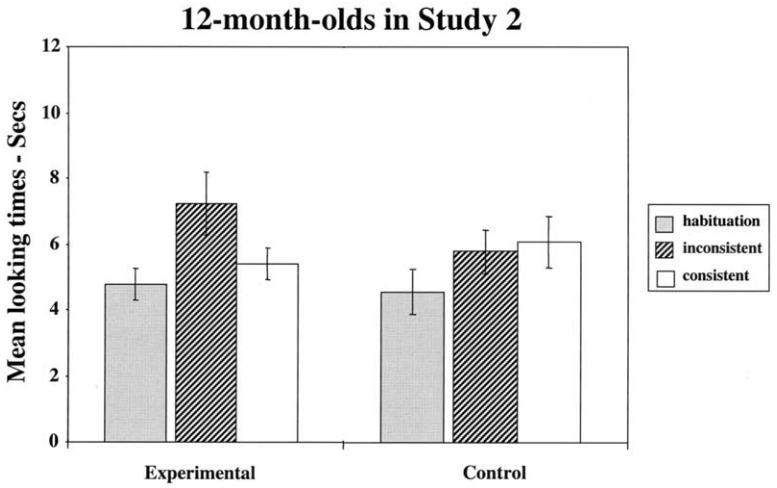


Fig. 3. The 12-month-olds in Study 2.

Four infants received ten trials but did not reach the criterion. On the last habituation trial, the 16 infants looked for an average of 4.3 s.

3.2.2. Experimental condition – test trials

An ANOVA showed no effect of sex or presentation order, so these variables were collapsed for further analyses. As shown in the left-hand portion of Fig. 3, replicating Study 1, 12-month-old infants in the experimental condition looked longer at the inconsistent test event ($M = 7.2$) than they did at the consistent test event ($M = 5.4$) ($t(15) = 1.75$, $P = 0.05$). Individually, nine infants in the experimental condition looked longer at the inconsistent event, six infants looked longer at the consistent event and one infant looked equally at both (Sign test, NS).

3.2.3. Control condition – habituation

Infants in the control condition reached the habituation criterion on an average of 8.8 trials. Seven infants took the maximum of ten trials to reach the habituation criterion. Two received ten trials but did not reach the criterion. On the final habituation trial, the 16 infants looked for an average of 3.9 s.

3.2.4. Control condition – test trials

An ANOVA showed no effect of sex or presentation order, so these variables were collapsed for further analyses. The right-hand portion of Fig. 3 presents the mean looking times for the last three habituation trials and for the three test trials for both test events for the control condition. Infants in the control condition looked equally at the inconsistent ($M = 5.8$) and at the consistent test events ($M = 6.1$) ($t(15) = 0.46$, $P > 0.32$). Only six infants in the control condition looked longer at the inconsistent event, and ten infants looked longer at the consistent event (Sign test, NS).

3.2.5. Studies 1 and 2 combined

Twelve-month-olds in Study 1 and 12-month-olds in the experimental condition of Study 2 looked longer at the inconsistent test event than at the consistent one. Combining these two groups (who received identical displays) increases the power of our comparison so as to provide a more sensitive test. Overall, these 12-month-olds looked longer at the inconsistent test event ($M = 7.4$) than the consistent event ($M = 5.8$) ($t(31) = 3.15$, $P < 0.003$). Individually, 21 of 32 infants looked longer at the inconsistent event, ten infants looked longer at the consistent event and one infant looked equally at both events (Sign test, $P > 0.04$).[4]

Although less informative than comparing looking times to consistent vs. inconsistent events, it is also possible to examine infants' pattern of recovery from habituation, or dishabituation.[5] If, during habituation, infants connect the actor's perceptual-emotional regard and her subsequent behavior, then they could (a) dishabituate to the inconsistent test event because it fails to accord with that pattern, but (b) fail to dishabituate to the consistent test event because it continues that general pattern. Because the predicted difference between habituation and the inconsistent test event goes in one direction, not the other, we again used one-tailed tests to assess these data. Moreover, failure to find significant dishabituation when comparing habituation with the consistent event is more sensitively tested by a one-tailed test as well. Comparing the last three habituation trials to the three test trials of a type, experimental infants showed recovery from habituation for the inconsistent test events ($M = 5.6$ vs. 7.4) ($t(31) = 2.26$, $P < 0.03$) *but* not to the consistent test events ($M = 5.6$ vs. 5.6) ($t(31) = 0.11$, $P > 0.45$).

3.3. Discussion

The results from the experimental infants in Study 2 replicate those for the 12-month-olds in Study 1. Together the findings consistently support the conclusion that 12-month-old infants recognize an important functional connection between an actor's emotional-

[4] Recall that across the two studies six 12-month-olds failed to reach the full habituation criterion after receiving ten habituation trials (as did three 8-month-olds). Any habituation criterion is arbitrary; what is most important for this sort of design is that infants receive sufficient exposure to the habituation displays to lose interest. In our data the looking times for the six 12-month-olds who did not reach the criterion nonetheless declined from an average of 17.8 s looking to their first habituation trial to 5.9 s looking to their tenth trial. Most importantly if these "nonhabituators" are removed the pattern of findings remains the same. Specifically, excluding the 12-month-olds who failed to reach the criterion from the data combined across the two studies, the remaining infants looked significantly more to the inconsistent than consistent test events ($P < 0.005$); they dishabituated to the inconsistent test events ($P < 0.02$) but not to the consistent test events ($P > 0.33$).

[5] Dishabituation patterns provide a less direct test of our hypothesis. Both test events introduce changes from habituation displays; most importantly, in both cases the actor now holds a different kitty from the one held in habituation. Because of this, infants could dishabituate to both displays (yet still look significantly longer at the inconsistent over the consistent test events). On the other hand, at a general level both tests events show perceptual-emotional displays followed by holding a kitty, features also shown in the habituation events. Because of this, infants may not significantly dishabituate to either test display (but still look significantly longer at the inconsistent over the consistent one). Nonetheless, if infants encode the habituation displays as showing a specific direction of perceptual-emotional regard connecting with a specific direction of action, then they might dishabituate to the inconsistent display but not the consistent one, providing further evidence of their recognition of this functional connection.

perceptual regard and their subsequent reaching. Thus, for these infants it was definitely attention-worthy if an actor looked and emoted positively about one of two objects, but then reached for the *other* object.

Is this action regularity something infants were learning de novo during our habituation trials? The results from the control condition in Study 2 speak against that possibility. If the results from Study 1 were due to learning during habituation, infants in the control condition should have shown a similar pattern of results: looking longer at the type of event they had not been shown during habituation. This did not occur. Experimental infants preferred the *inconsistent* test event, but control infants looked equally at both events – they did *not* prefer the consistent event. In fact, control infants not only looked equally to both test events, they dishabituated to both test events.[6] This pattern of dishabituation effects would be expected *if* (a) the consistent event, which infants easily habituate to, represents a type of behavior they have noticed before, while (b) the type of behavior in the inconsistent event is not of a type they usually observe, or have taken note of in the past. This pattern thus gives further indication that 12-month-old infants are sensitive to functional connections between visual-emotional regard and action.

Our results are consistent with findings by Corkum and Moore (1998) who studied infants' ability to follow the gaze direction, or at least the head turning, of an adult. They found that when the mother's head turn was reinforced with the appearance of an interesting object in the corresponding direction, infants of 12 months and younger could easily learn to turn their head in the direction of their mother's gaze. But, for infants whose mother's head turn instead predicted and was reinforced with an interesting event in the *opposite* direction, even 12-month-olds could not learn – after multiple trials they failed to use the mother's head turn as a cue to look in the opposite direction from the mother's gaze. This result indicates that infants must have some sensitivity to a specific directional contingency, before entering the lab, and the sensitivity they had achieved was not easily modifiable over the course of one laboratory session. Similarly, our findings indicate that infants must have some sensitivity to a specific directional contingency linking visual-emotional regard with action, before participation in our laboratory procedure.

4. Study 3

In Study 3 we wanted to provide a more stringent test of the extent to which 12-month-olds recognize that certain sorts of actions will follow from certain sorts of emotional-visual regard. If infants strongly appreciate this connection, then simply showing them a person's visual-emotional regard (e.g. looking positively toward kitty A rather than B) might be sufficient for them to recognize a subsequent action as consistent or inconsistent with that regard. In Study 3, therefore, during habituation, an actor simply looked at and emoted positively toward one kitty (with no attendant actions). Then, during test trials

[6] Both control condition test events differ from habituation (in the same way that both experimental condition test events differ from their habituation) – during test the actor holds the opposite kitty from the one she held during habituation. So infants could dishabituate to both events, if they were processing the habituation events in terms of such specific features. This seems particularly likely in the control condition where a larger, functional connection between regard and action did not characterize the actor's habituation displays.

infants saw consistent or inconsistent actions (i.e. the actor regarded one kitty then picked up and held the corresponding kitty or the other one). This would constitute an additional test that infants connect emotional-visual regard and subsequent action, and has the advantage that in this procedure the actor is never shown grasping a kitty in habituation. Thus, longer looking to the inconsistent test event could not, in this case, reflect an association between regard and actions learned during habituation.

The procedures of Study 3 seem a more stringent test in that no action is presented in habituation and is introduced for the first time in the test events. Yet, at the same time, the new procedure in Study 3 allows us to address one concern about the method used in Studies 1 and 2. In the earlier studies, the infants had a fixed 3 s to see the actor look at and emote positively about the target object, and then the screen was drawn (as in Fig. 1). Perhaps this constrained 12-month-olds' ability to fully process the actor's visual-emotional display. In Study 3, however, where we present only the actor's emotional-visual regard during habituation trials, infants could examine this presentation of emotional-visual regard for as long as they liked. That is, during habituation the actor looked and expressed positive emotion about the kitty and then held that regard until the infant looked away. Thus, examination of the actor's regard was infant-controlled (and as we report below, typically lasted for 7 s or more).

4.1. Method

4.1.1. Participants

Nineteen infants participated in Study 3. Three were eliminated due to presenter error. The mean age of the remaining 16 infants was 11 months, 26 days, or 11-26 (range 11-6 to 12-13). The infants' names were obtained from birth announcements in the local newspaper. Parents were contacted by letters and follow-up phone calls. They were offered $10 as reimbursement for their travel expenses.

4.1.2. Procedure

The procedure for Study 3 was identical to Study 1 and to the experimental condition of Study 2. However, during habituation, infants did not see the actor pick up or hold the kitty. Instead, infants saw the actor turn towards one of two kitties, with an expression of interest and joy, while saying "look at the kitty". The actor then continued to regard the kitty with a smile. This stationary display ended when the infant looked away for 2 s.

After habituation, the infant then saw the two test events, three times each in alternation. The test events were identical to the two-part test events in Study 1.

4.1.3. Reliability

To check observer reliability a second set of looking times were calculated from videotapes of the infants recorded during the display presentations. The secondary observers were blind to the hypotheses and physical details of the displays (other than their physical dimensions). When the secondary observer's judgments were compared with the looking times recorded by the live observer, the percentage of test trials for which the observer's judgments differed by 2 s or less was 97%. The percentage of test trials for which the observer's judgments differed by 1 s or less was 83%.

4.2. Results

4.2.1. Habituation

Infants in this study took an average of 8.8 trials to reach the habituation criterion. Two infants took the maximum of ten trials to reach habituation. Two infants received ten trials but did not reach the criterion. On the final habituation trial, the 16 infants looked for an average of 4.3 s.

4.2.2. Test

An ANOVA showed no effect of sex or presentation order, so these variables were collapsed for further analyses. Fig. 4 presents the mean looking times for the last three habituation trials and for the three test trials for both test events. Infants looked equally at the inconsistent ($M = 9.8$) and consistent ($M = 10.1$) test events ($t(15) = 0.28$, $P > 0.39$). Seven infants looked longer at the inconsistent event, and nine infants looked longer at the consistent event (Sign test, NS). Infants looked significantly longer at the inconsistent test events than to the last habituation trials ($M = 4.8$ vs. 9.8) ($t(15) = 3.76$, $P < 0.001$) and significantly longer at the consistent events as well ($M = 4.8$ vs. 10.1) ($t(15) = 3.96$, $P < 0.001$).

4.3. Discussion

In contrast to Studies 1 and 2, in Study 3, 12-month-olds failed to recognize the functional connection between perceptual-emotional regard and action, in that they failed to prefer the inconsistent over the consistent test events. In comparison to the infants in Studies 1 and 2, their failure seems likely to be due to the fact that in Study 3 the familiarization or habituation displays did not show any action (reaching for or holding an object) on the part of the actor.

The methods of Study 3 can be argued to be a strong test of an understanding of the functional connection between perceptual-emotional regard and action on both methodological and conceptual grounds. Methodologically, during habituation, infants saw only

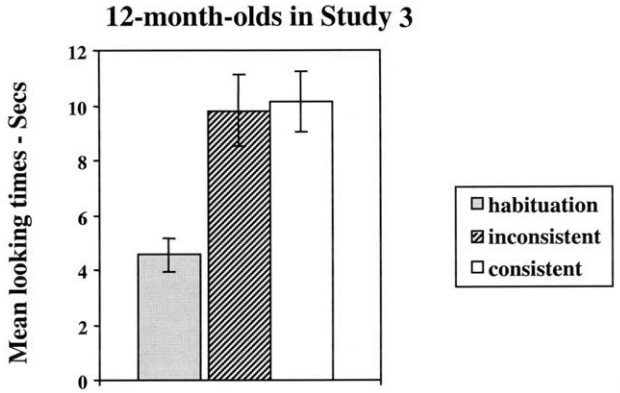


Fig. 4. The 12-month-olds in Study 3.

the actor's visual-emotional regard. Since infants saw action for the first time at test, and did so in *both* test events, the reaching actions may have been so novel that infants gave long looks to both types of test events (masking any difference in appreciation for the two test displays). Consistent with this interpretation, note that 12-month-olds in Study 3 significantly *dishabituated* to both types of test trials. It is also possible, that after watching the actor stare so long at kitty A in habituation, 12-month-olds in both test events were surprised to see her shift attention and action to kitty B.

Conceptually, the methods of Study 3 may also have been demanding. In Studies 1 and 2 during habituation infants see displays of visual-emotional regard *and* of action. Thus, from the beginning infants see action. In a context that includes action infants may be able to recognize that visual-emotional regard connects to action, thereby showing an initial understanding of this functional connection. But it may be significantly more difficult to form action expectations from information about visual-emotional regard alone, where action is not also prominently displayed. The habituation displays in Study 3, of course, show only the actor's visual and emotional regard without any concomitant reaching, grasping, holding, or other action.

5. Study 4

If the methods of Study 3 are more stringent than the methods in Studies 1 and 2, then those methods should nonetheless demonstrate (a firmer, consolidated) understanding in slightly older infants. Fourteen-month-old infants may evidence clear-cut recognition of a connection between regard and action without being first familiarized to *action* sequences, but rather being familiarized to an actor's visual-emotional regard alone.

Since we were testing still older infants in this study, we considered the possibility that the habituation methods we used in Studies 1 and 2 might not be optimal for these older infants. Baillargeon (pers. commun.) has argued that for older infants, or infants who are more secure in their understanding of a certain phenomenon, presentation of the multiple trials needed to reach habituation can, by the final trials, disengage the infant's interest in the displays to such an extent that they become less likely to show strong novelty preferences in test trials. Thus, with older infants she, and others, often present only two to four familiarization trials before presenting the test events (e.g. Needham & Baillargeon, 1997; Xu & Carey, 1996). In Study 4, we present 14-month-old infants with four infant-controlled familiarization trials instead of the six to ten trials needed in our full habituation procedure.

5.1. Method

5.1.1. Participants

Forty-four healthy 14-month-old infants participated in Study 4. Two were eliminated due to fussiness, three were eliminated due to observer error, five were eliminated due to presenter error, and two due to outside interference. The mean age of the remaining 32 infants was 14 months, 0 days, or 14-0 (range 13-15 to 14-14). The infants' names were obtained from birth announcements in the local newspaper. Parents were contacted by

letters and follow-up phone calls. They were offered $10 as reimbursement for their travel expenses.

5.1.2. Procedure

Procedures for Study 4 were identical to those for Study 3, except that instead of exposure to the full habituation trials of the previous studies, infants were only exposed to four, infant-controlled habituation displays, which constituted the familiarization trials. As in Study 3, infants saw the actor regard, but not pick up a kitty during familiarization.

5.1.3. Reliability

Inter-rater reliability was again measured by comparing the live observer's looking time judgments to a second set of looking times which were obtained from secondary observers who were blind to the hypotheses and physical details of the displays (other than their physical dimensions), using videotapes of the infants taped during the display presentations. The percentage of test trials for which the observer's judgments differed by 2 s or less was 100%. The percentage of test trials for which the observer's judgments differed by 1 s or less was 91%.

5.2. Results

5.2.1. Familiarization

Infants looked for an average of 7.0 s on the last familiarization trial.

5.2.2. Test

An ANOVA showed no effect of sex or presentation order, so these variables were collapsed for further analyses. Fig. 5 presents the mean looking times for the last three familiarization trials and for the three test trials for both test events. Overall, infants looked longer at the inconsistent test events ($M = 10.9$) than the consistent test events ($M = 9.0$) ($t(31) = 3.01$, $P < 0.005$). Twenty-four infants looked longer at the inconsistent test event, and eight infants looked longer at the consistent test event (Sign test, $P < 0.05$).[7]

5.3. Discussion

Fourteen-month-olds thus demonstrate a firm recognition that visual-emotional regard links to subsequent action. Even though familiarized to visual-emotional regard with no action, these infants looked significantly longer at the inconsistent event than the consistent event. In contrast to the 12-month-olds in Study 3, therefore, 14-month-olds require significantly less in the way of familiarization trials and familiarization information to demonstrate recognition of this link between the actor's visual-emotional regard and her subsequent action. It is worth reiterating that because the infants were familiarized to the actor's perceptual-emotional regard alone, they received no exposure to a subsequent action within familiarization, and hence no opportunity to learn the focal functional

[7] We tested 32 infants here in order to be comparable to the 32 12-month-olds tested in Studies 1 and 2 combined. Even considering just the first 16 14-month-olds tested, these infants looked significantly longer at the inconsistent test event over the consistent one.

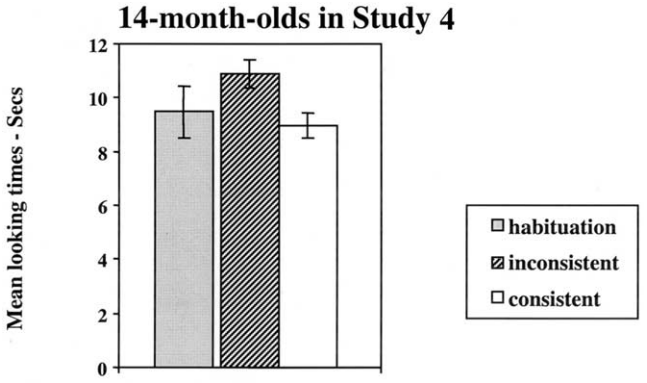


Fig. 5. The 14-month-olds in Study 4.

connection within our procedures. The data thus provide strong evidence that by 14 months infants expect an adult to pick up the object he or she regards positively.

It is also worth reiterating that in Study 4, just as in all our studies, the final displays for both test events (to which we measure infants' looking) are physically identical – the actor holds the identical kitty. Thus, the results cannot be due to an infant preference for one kitty or the other, or to a preference for seeing the person hold one object vs. another, and so on. The test events differ only in the relationship between emotional-visual regard and the subsequent object held.

6. Final discussion

How can we understand human action; how are the complex yet everyday patterns of human movements made sensible, orderly, and ordinary? Given the complexity of human behavior, any answer to this question will be itself complex. But, for adults and older children at least, part of the answer is that we construe action via an intentional stance – by viewing action as purposeful and thus shaped by and manifesting the actor's intentional states such as his or her goals, preferences, attention and knowledge. Indeed, it is now clear that by 2 and 3 years young children routinely and skillfully adopt this intentional stance (Bartsch & Wellman, 1995; Flavell & Miller, 1998; Repacholi & Gopnik, 1997). Their ability to do so must rest on still earlier skills and capacities achieved or expressed in infancy. Just what infant skills and capacities are involved is very much an open question, inspiring a number of contradictory theoretical proposals. For example, Premack (1990) claimed infants are hardwired to interpret as intentional those entities that exhibit self-propelled movements, or, more recently, those entities that exhibit goal-directed, self-propelled movements (Premack & Premack, 1997). Similarly, Baron-Cohen (1995) proposes that young infants, in the first half year of life, possess an intention detection module (ID) that takes as input perceptions of movement and that outputs intentional descriptions of those movements. On the other hand, Moore (e.g. Moore & Corkum, 1994) contends that infants must construct such understanding and only do so after

about 18 months of life based on the sorts of experiences with social partners that infants increasingly participate in from 9 to 18 months of age.

However, only recently is empirical research emerging that attempts to illuminate infants' cognition of action. Sensibly, the research conducted thus far has focused almost exclusively on movements themselves. The most studied movements have been infants' understanding (a) of arm-hand reaches for and grasps of objects (Leslie, 1984; Phillips & Wellman, 2002; Woodward, 1998), or (b) the movements of animated bodies (e.g. computer-generated circles) that approach, contact, or pursue other objects (Gergely, Nadasdy, Csibra, & Biro, 1995; Premack & Premack, 1997; Rochat, Morgan, & Carpenter, 1997). Returning to the distinction we outlined in Section 1, in all this research the focus has been narrowly on object-directed movement. While important, a focus on object-directed movements alone seems decidedly limited from the point of view of our adult construal of intentional action. From an adult construal, focal actions are not only directed toward objects, they are situated within and must be understood within a larger package of connected states (e.g. preferences, knowledge, attention) and acts (e.g. postures, orientations, facial expressions). In our terms, appreciation of these functionally connected states complements and contextualizes an appreciation of object-directed actions per se. The current research addresses infants' recognition of such functional connections.

Of course, we do not address all that infants might know or come to know about the connection of focal actions to larger sets of acts, states, and expressions. We began by investigating a single, simple, yet important manifestation of such functional connections: how visual and emotional regard connect to and thus can predict object-directed action. Specifically, we focused on whether infants recognize that a person who looks at an object with positive regard will grasp that object rather than another. Our results show both recognition of this predictable connection in 12-month-olds coupled with developments from 8 to 14 months.

Consider first 12-month-olds' successes. In Studies 1 and 2, 12-month-olds were habituated to a person positively regarding an object, then holding that object. Then the infant saw two test events. Both test events presented new actions, resulting in the person holding a new, different object. Yet one test event, while physically dissimilar to habituation, was conceptually similar to it. In that event, the consistent event, the actor held an object she had just regarded positively, consistent with the principle that positive visual-emotional regard predicts approach-like actions. The other event, the inconsistent event, contradicted this principle. Twelve-month-old infants looked longer to the inconsistent event, and remained habituated to the consistent event while dishabituating to the other, inconsistent event.

Next consider development. Eight-month-olds did not perform as 12-month-olds. Instead they tended to dishabituate equally to both test events. Eight-month-olds may well have focused on the physical differences in action from habituation to test; as a group they provided no evidence of recognition of the conceptual similarity linking the habituation actions with the consistent test event actions. Fourteen-month-olds succeeded with an alternative method that was more stringent. This alternative method, used in Studies 3 and 4, was demonstrably more difficult because 12-month-olds who appropriately differentiated the inconsistent and consistent test events with the original method failed to show such an appreciation with this alternative method.

These positive results raise the following question. Our presentations purposely present

a variety of cues that infants might or might not connect to the focal action: direction of gaze, facial emotional expression, pleasant vocalization. Which are necessary or sufficient? We believe that a package of visual and emotional regard is important. Conceptually, neither direction of gaze nor emotional expression alone sufficiently predict action: if a person visually regards an object he may like or dislike it; if a person emotes without visual regard it is unclear what he is emoting about. Positive emotional regard linked to a specific object via direction of gaze more tightly predicts approach-like action. Moreover, empirically it seems that infants may well need both cues. Results from Study 1 were briefly reported earlier in a review article (Spelke, Phillips, & Woodward, 1995) leading to at least two other replications.

Sodian and Thoermer (YEAR?) attempted to replicate Study 1 with two groups of 32 infants. Interestingly, they did not, however, include the emotional information, depicting instead visual regard without emotional expression. Results from one group were marginally significant (infants looked longer at the inconsistent test event), while results from the other group were not significant. In our presentations positive emotional cues (vocal and facial expression) are prominent. Their failure to replicate our results may underscore the importance of emotional expression for our findings. But their results should not lead to the conclusion that information about direction of gaze is unimportant. In our displays positive emotions are depicted in each type of test trial, so direction of gaze is necessary to distinguish between the test displays.[8]

Recent research by Heberlein, Fernald, and Birks (a personal communication) replicates our results with 12-month-olds using procedures and displays closely similar to those in Study 1. In addition, they included a condition in which infants are shown a negative emotional expression directed toward one of two objects. In this case, infants look longer when the experimenter picks up the object she had regarded with negative emotion. This indicates that infants are using the emotional valence of the emotional expression to predict the subsequent action, not just predicting that the actor will pick up whatever object the actor has regarded. In total, our preferred interpretation is that 12-month-olds use information about direction of gaze and emotional expression in combination to predict action, but we have not tested this interpretation directly.

Our findings are developmental – 8-month-olds fail to recognize the focal connections, but 12-month-olds, and still more robustly 14-month-olds, do. We believe this pattern takes its place within, and helps clarify other aspects of, infants' developing abilities at the end of the first year of life. In particular we see these results as intimately related to infants' developing gaze-following abilities. First, note that in order to succeed in recognizing a connection between visual-emotional regard and action in our study, but also in everyday life, it is first necessary for the infant to be able to achieve joint attention. It is only by following gaze to the relevant object that the infant can connect visual-emotional regard to

[8] Sodian and Thoermer also included a second condition which further differed from our presentations, by displaying the actor reaching for the object during habituation. In this condition the infants saw the actor look at an object, then reach out and place her hand on that object. The screen then intervened and the actor was again shown holding the object she had regarded and reached out for. Consistent test events showed the actor looking at, reaching for, and then holding the second object. Inconsistent test events showed the actor looking at and reaching for the first object, but then holding the second one instead. With reaching itself depicted in this fashion, Sodian and Thoermer got significant results with two groups of 32 12-month-olds.

the actor's subsequent action toward that object. Considerable research shows that the ability to achieve joint attention is not trivial; in order to locate the same object in space as another person, especially in natural situations where there are multiple objects, the infant must project geometrically from the angle of the eye or head out to an object that is otherwise unconnected to the person. This ability develops gradually between 6 and 12 months of age (Butterworth & Grover, 1998) and it is not until 12 months of age that infants as a group are consistently able to achieve joint attention. From this perspective, that 12-month-olds but not 8-month-olds succeeded at our tasks is reasonable and understandable. But this is not merely a limitation of our task; the ability to achieve this sort of joint reference also limits the infants' ability to observe, encode, and learn about such functional connections in everyday life.

Indeed, drawing on this gaze-following ability, in everyday life year-old infants would increasingly experience witnessing the conjoining of action and visual-emotional regard. Via such experiences year-old infants could be acquiring a more consolidated and complete set of expectations about such functional connections. From this perspective, that 14-month-olds demonstrated a more robust expectancy for such functional connections in our displays is reasonable and understandable. Our data suggest a considerable deepening of infants' recognition of important connections between action and regard in two short months.

The preceding discussion raises an important underlying question: whether our findings manifest a deeper infant understanding of intentional purposiveness or demonstrate less profound behavioral understandings. That is, 12- and 14-month-olds' recognition that the direction of visual-emotional regard connects to the directedness of action is an important piece of social understanding, but one consistent with two quite different developmental accounts. In one account, infants, like older children, construe persons as intentional beings – persons are actors whose internal intentional states such as desire, emotion, and knowledge produce behavior. As noted earlier, several theorists have proposed that infants initially have the disposition to see intentionality in actions which have certain characteristics, such as goal-directedness (Gergely et al., 1995), self-propelled motion (Premack, 1990) or agency (Leslie, 1984). Perhaps, under this sort of account, infants interpret the actor's visual-emotional regard as indicating the actor's desire for and awareness of one object not the other, leading to her actions to obtain that object. If infants construe action intentionally, then the connected, visual-emotional regularities we display would be expected and sensible; when such regularities are contravened this would be puzzling and attention-worthy. Our data show that infants recognize these regularities at 12 months. Since this is just about as soon as could be expected, given their developing gaze-following abilities, this finding could be considered as consistent with the possibility that quite young infants construe persons as intentional beings, although their ability to act on this construal depends on a variety of other developing competences.

Nothing in our data directly supports this rich interpretation, however, and an alternative leaner account is possible: infants may be learning about action in a more behavioral manner. Because people act intentionally, the actions that infants witness demonstrate the observable patterns of intentional behavior, in particular the connections of objected-directed behavior to the actor's visual, emotional displays. On this account it is this behavioral regularity, and nothing more, that 12-month-olds recognize. Our data

demonstrating developments in infants' understanding from 12 to 14 months could be considered as consistent with this alternative possibility, because they demonstrate further learning about action regularities after the point at which infants show an understanding of the focal, functional connection.

On this leaner interpretation, 12-month-olds' recognition of functional connections might be particularly important. Analyses of overt observable action regularities would constitute important data to the infant, crucial to the process of extracting or inferring deeper intentional conceptions. Indeed, not just any observations of human actions would serve this function. Only some sorts of behavioral features would be correlated with and hence informative for deeper intentional construals. Object-directedness and functional connections are the sorts of behavioral features that could do this job.

Indeed, given an understanding that specific behaviors can be object-directed, then coming to appreciate the connections of such actions to visual-emotional expressions might be a particularly important step in developing an understanding of intentionality. That is, consider adults' (and older children's) understanding of humans as intentional. Our sense of a person's intentional states – such as their plans, desires, ideas, hopes – grounds our understanding of and explanation for their actions. But at the same time, we realize that these states need not necessarily connect to action (e.g. we recognize that a person can desire to do something yet never do it). Indeed, an intentional construal of persons depends on conceptions of such states as independent of action itself, as internal mental states distinct from (albeit manifestable in) overt actions. Thus, for adults, intentional states are connected to and predict actions, yet are themselves removed from action in various ways. Twelve- and 14-month-olds' appreciation of functional connections, as we have studied it, may well evidence an important step in this direction – the infant recognizes the connection to action of visual-emotional regard (e.g. recognizes some of the implications for action when a person regards an object positively) even though visual-emotional regard is distinct from (in our displays is distant in space and in time from) action itself.

On several grounds, therefore, infants' appreciation of functional connections between action and visual-emotional regard is an important component of a developing intentional understanding of persons. Our findings show that this appreciation is both in place and developing at 1 year of age.

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