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Infant Behavior & Development 27 (2004) 181–194
Infant Behavior & Development

Nine-month-olds' shared visual attention as a function of gesture and object location

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Received 2 June 2003; received in revised form 10 September 2003; accepted 22 September 2003

Abstract

Two factors hypothesized to affect shared visual attention in 9-month-olds were investigated in two experiments. In Experiment 1, we examined the effects of different attention-directing actions (looking, looking and pointing, and looking, pointing and verbalizing) on 9-month-olds' engagement in shared visual attention. In Experiment 1 we also varied target object locations (i.e., in front, behind, or peripheral to the infant) to test whether 9-month-olds can follow an adult's gesture past a nearby object to a more distal target. Infants followed more elaborate parental gestures to targets within their visual field. They also ignored nearby objects to follow adults' attention to a peripheral target, but not to targets behind them. In Experiment 2, we rotated the parent 90° from the infant's midline to equate the size of the parents' head turns to targets within as well as outside the infants' visual field. This manipulation significantly increased infants' looking to target objects behind them, however, the frequency of such looks did not exceed chance. The results of these two experiments are consistent with perceptual and social experience accounts of shared visual attention.
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Keywords: Joint attention; Gaze-following; Communication

Infants' participation in shared visual attention typically emerges and improves between 6 and 12 months of age (Adamson & Bakeman, 1991; Butterworth & Cochran, 1980; Butterworth & Itakura, 2000; Butterworth & Jarrett, 1991; Corkum & Moore, 1998; D'Entremont, 2000; D'Entremont, Hains, & Muir, 1997). However, previous studies have not uniformly agreed on when infants become able to establish shared visual attention or the nature of its development during the latter half of the first year. Lack of consensus is probably due, in part, to differences across studies in the types of gesture used by

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doi:10.1016/j.infbeh.2003.09.007

adults, criteria for scoring instances of shared visual attention, locations of target object relative to the infant, and the presence or absence of distractor objects.

Some studies, for example, have found that 6–12-month-old infants can follow an adult's gaze, with or without finger point, to a visual target if that target is within the infant's visual field and it is the first object along the infant's scan path (e.g., Butterworth & Cochran, 1980; Butterworth & Jarrett, 1991; D'Entremont, 2000; Morales, Mundy, & Rojas, 1998). However, other studies indicate that infants younger than 12 months are not capable of shared visual attention, because they are no more likely to follow an adult's gesture to the correct target object than to look toward a distractor (Corkum & Moore, 1998; Moore & Corkum, 1994). Thus, some researchers suggest that before 14 or 15 months of age infants cannot follow adults' attention-directing actions to more peripherally located visual targets (Carpenter, Nagell, & Tomasello, 1998; Corkum & Moore, 1998; Moore & Corkum, 1994). While differences in experimental and analytic factors probably contribute to this developmental discrepancy, it is clear that the ability to participate in shared visual attention significantly improves between 6 and 14 months of age. The current study was designed to examine various factors associated with the development of shared visual attention in 9-month-olds.

One commonly described developmental change that occurs between 6 and 12 months of age is the ability to spatially infer the object of another's attention while ignoring intermediate objects or distractors (Butterworth, 1995; Butterworth & Jarrett, 1991). For example, Butterworth and Jarrett (1991) found that 6-month-olds follow an adult's gaze or finger point in the appropriate direction (i.e., left or right), but often fixate on the first object seen while scanning towards the target location. By 12 months of age, however, infants ignore proximal distractors to look at the correct target, but only if it is within their visual field. Butterworth (1995, p. 32) attributed this developmental shift to the emergence of a "geometric mechanism" that allows the infant to extrapolate an invisible line between the mother's direction of gaze (or outstretched hand) and the object of her attention. While evidence is available that is consistent with the proposed geometric mechanism (e.g., Butterworth & Cochran, 1980; Butterworth & Grover, 1988; Butterworth & Jarrett, 1991), factors other than a specialized capacity to extrapolate imaginary lines may also explain 6–12-month-olds increasing ability to establish shared visual attention.

One alternative is that younger infants may be less prone than older infants to perceive and make use of perceptual information that specifies the adult's focus of attention. For instance Deák, Flom, & Pick (2000) found that both 12- and 18-month-olds more frequently looked at their parents' focus of attention when the parent looked and pointed at the target than when the parent simply looked at it, suggesting that these infants did not always make use of their parent's less redundant attention direction actions. In a follow-up experiment (Deák et al., 2000, Experiment 2), parents were seated perpendicular to their infant's right or left side, so parents' head turns were of the same magnitude (i.e., degrees of deviation from midline) when turning toward a target object within or outside the infant's visual field. In this case, both 12- and 18-month-olds followed parents' large head turns more than small head turns. Importantly, even the 12-month-olds followed parents' large gaze shifts, when reinforced by redundant pointing gestures, toward targets behind them. In other words, by providing 12-month-olds with a more noticeable gesture they established shared visual attention to targets outside their visual field, contrary to Butterworth's claim that this ability develops around 18 months of age as a result of the infant's capacity for representation.

The perceptually based account of Deák et al. (2000) makes at least one prediction that diverges from Butterworth's account (1995) and provides a developmental explanation that does not rely on the emergence of a series of mechanisms. Specifically, if redundant information is available that specifies an adult's focus of attention, perhaps infants younger than 12 months can use this information and establish shared visual attention, even if the adult's visual target is not within the infant's central visual field.

A difficulty, however, in assessing infants' ability to follow adults' attention-directing gestures is that this ability will only be expressed when infants are motivated or compelled to do so. Related to this issue Deák et al. (2000) found that 12- and 18-month-olds followed into adults' focus of attention more frequently when the target objects were distinctive and complex (e.g., multi-colored and uniquely shaped) than when they were identical (e.g., all blue squares). These authors reasoned that infants are less likely to follow another's gaze toward a target object outside their own visual field if an identical object is readily apparent within their visual field. Moreover, a split-half analysis of their data suggested that infants' frequency of gaze-following across multiple trials is maintained by complex, distinctive targets compared to simple, identical targets. Together, these findings suggest that interesting (i.e., distinctive, complex) visual targets provide one context or circumstance for revealing emerging joint attention skills in younger infants. Moreover, this context, in combination with redundant gesture combinations (i.e., gaze plus pointing), establishes, what we believe is a reasonable test of infants' ability to follow adults' visual attention to target objects within as well as outside their visual field.

The current study examined whether the effects shown by Deák et al. (2000) could be extended to 9-month-olds. Specifically we examined the effects of three different gestures (looking, looking and pointing, and looking, pointing, and verbalizing) on shared visual attention. Also examined was the type of target object, i.e., identical and simple versus distinctive and complex, to determine whether 9-month-olds, like older infants, more frequently follow adults' gaze cues and points when such cues specify reasonably interesting sights. Finally, target location relative to the infant (in front, behind, or peripheral), was varied to determine whether 9-month-olds can ignore intermediate or distractor target objects, and if 9-month-olds will turn to look toward out-of-sight targets in establishing shared visual attention.

1. Experiment 1

1.1. Method

1.1.1. Participants

Seventy-two 9-month-olds (37 males, 35 females; $M = 281$ days, S.D. $= 5$) and their parents participated. Another 17 infants were excluded from the final analyses, $n = 10$ due to fussiness, $n = 3$ due to experimenter error, and $n = 4$ due to parents' failure to follow instructions. Infants were recruited from a database maintained at an urban, midwestern University, and were primarily Caucasian and middle class. Parents were initially contacted by telephone by the experimenter.

1.1.2. Apparatus and target objects

The experiment was conducted in a quiet room (4.4 m × 3.2 m) with white sheets hanging from ceiling to floor around its perimeter. Incidental objects and features were eliminated from the testing area. The infant was seated in booster chair in the center of the testing area. The parent's chair faced the infant. Seat heights were adjusted so that infants' and parents' eyes were at the same height.

Two sets of objects were used. The first consisted of four identical blue squares (15 cm × 15 cm). The second consisted of 14 distinctive and irregularly shaped objects, approximately the same size as the identical objects, covered in varying patterns of multicolored construction paper and shiny decorations. During each trial four objects were mounted on movable, white stands placed in front of the sheets and oriented so that the objects faced the infant seat. A video camera mounted in the ceiling directly above the infant's head recorded a "bird's-eye" view of the infant and parent. Objects were not visible on the video tape. A digital stopwatch was imprinted onto the videotape for coding. A hand-held stopwatch was used by the experimenter to monitor trial length.

1.1.3. Design

Infants were randomly assigned to one of two target type conditions (Identical or Distinctive) and one of three parental gesture conditions (Look; Look and Point; or Look, Point, and Verbalize). In the *Look* condition parents silently turned and gazed toward the target without pointing or producing other gestures. In the *Look and Point* condition parents simultaneously turned to look and pointed at the target. Finally, in the *Look, Point, and Verbalize* condition, parents turned to look and point toward the target, while verbally encouraging their infant to look at it. In this last condition parents were instructed to say whatever they would normally say to encourage their child to look at an object or event. Target type and gesture were between subjects factors. Parents produced their assigned gesture on every trial.

Target object location was varied within subjects. Ten locations were paired, one on each side of the room, in five "object latitudes" ranging from the front to the back of the room (see Fig. 1). Two location pairs (1 and 2 in Fig. 1) were in front of the infant (i.e., within the visual field), two (4 and 5) were behind the infant (i.e., outside the visual field), and one (location 3) was in the infants' periphery (i.e., 75° from midline).

These five object latitudes were paired in three object location configurations. In each configuration and each trial, four target objects were placed in two parallel right–left pairs. In the *Front-and-Peripheral* (F & P) configuration, two targets were within the infants' visual field and two were in the infants' periphery (i.e., Pairs 1 and 3). In the *Front-and-Back* (F & B) configuration, two targets were in front of the infants and two were behind the infants (i.e., Pairs 2 and 4). In the Peripheral-and-Back (P & B) configuration, two targets were in the infants' periphery and two were behind the infants (i.e., Pairs 3 and 5). In all configurations, the first and second target objects on one side were separated by 60°. If a peripheral target was paired with front objects (i.e., F & P), then it was considered a "second target" because it was the object further from midline along the infants' scan path on that side. If, however, it was paired with back objects (i.e., P & B), then it was considered the "first target" along the infants' scan path. By varying the locations of distractors accompanying peripheral targets, we tested Butterworth and Jarrett's (1991) claim that infants younger than 12 months fixate on the first object they see when they turn in the direction of an adult's gaze, and thus fail to reliably establish joint attention to targets in their periphery.

Infants completed 12 trials, four with each configuration (F & P, P & B, F & B). Across trials the designated target occurred at each of the 10 locations once, except for each location 3, where the target was located twice (once each in the F & P and the P & B configuration). Within each gesture and target condition, each infant received a different random order of configurations and target object locations, with the constraint that each parent gestured toward a different target object on the first trial, and no more than two successive trials occurred in the same configuration.

1.1.4. Procedure

The procedure was identical to Deák et al. (2000, Experiment 1). Upon arrival at the laboratory the purpose and procedure were explained to the parent. The parent was instructed on the particular gestures

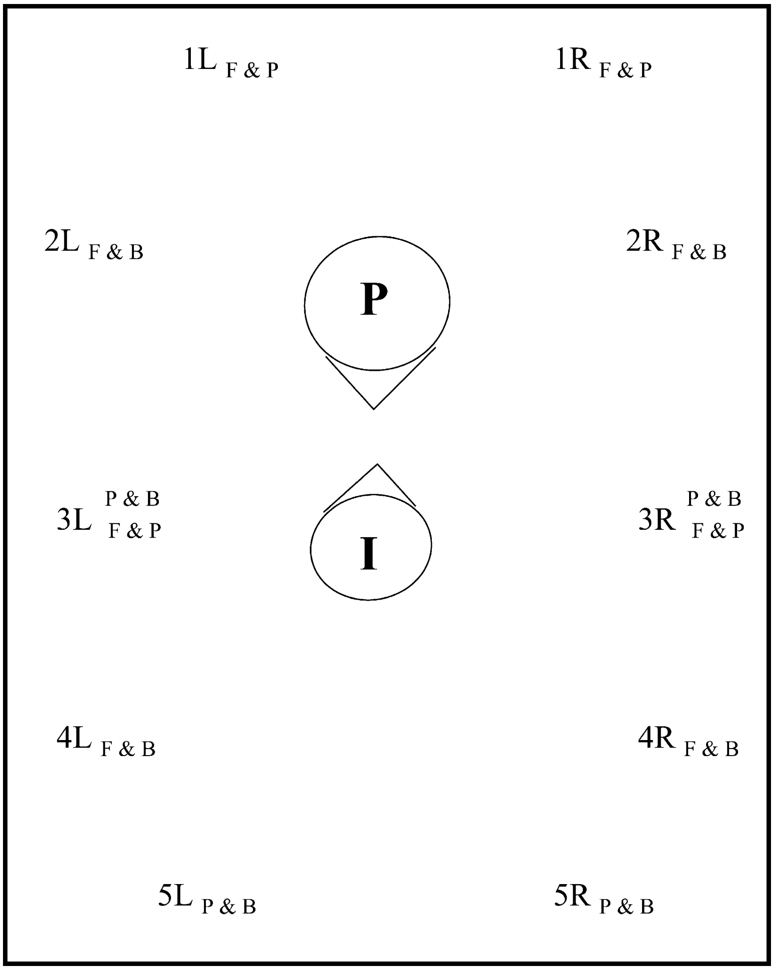

Fig. 1. Schematic diagram of the room showing location of infant, parent, and targets in Experiment 1. P: parent; I: infant; F & P: Front-and-Peripheral configuration; F & B: Front-and-Back configuration. Distance from infant's midline, and side of the room are specified by location codes (e.g., 2L).

to use. Parents were told to play with and distract their infant between trials, but not to touch the infant after a trial began (pilot testing showed that parents sometimes touch infants to encourage them to look at target objects). Before each trial, the experimenter told the parent which object was the target, then left the test area. The parent then elicited the infant's attention by calling his or her name until the infant looked at her. The experimenter then signaled the parent to begin the trial. The experimenter terminated each trial after fifteen seconds. Between trials the experimenter rearranged objects for the next trial.

1.1.5. Coding

Coding procedures were identical to Deák et al.'s (2000). A coder recorded the direction of every visual fixation made by an infant. A fixation was defined as absence of head movement (i.e., scanning or turning) for at least 0.5 s. The direction of each fixation was measured by a transparent disc, marked with 10° increments and mounted on the video monitor. The center of the disc was placed over the image of the infant's head and adjusted so that 0° was aligned with the infant's midline. During the trial, any fixation within 25° of the target object was coded as a "hit." Any fixation within 25° of a distractor was coded as a "miss." The average difference of recorded hit locations from target locations was, however, only 9.4° (S.D. = 6.7°). Though we cannot know how much of this difference reflects measurement error, given that the closest object was ±60° from the target, hits and misses were not confusable. All coders were blind to target type and exact target object locations; however, they were not blind to parents' actions, because they had to see parents to determine precisely when each trial began and ended. A second observer, blind to experimental hypotheses, recoded 30% of the final sample (i.e., 22 infants) to assess observer reliability. A Cohen's (1960) kappa was used to assess inter-observer reliability. Kappa for infants' looking toward the correct target was 0.94.

1.2. Results and discussion

Nine-month-olds' participation in shared visual attention was assessed using difference scores for each infant: total number of correct looks (i.e., hits) toward specified target(s) minus total number of misses (i.e., looks at distractors). In order to make infants number of "hits" and "misses" comparable we computed an average number of misses by dividing the total number of looks to the three distractors by 3. This was done to account for the fact that on every trial there were three times as many distractors as there were correct targets. In most previous experiments of shared visual attention there is one correct and one incorrect target where such a correction is not necessary. However, one reviewer pointed out that this procedure may potentially inflate the difference score because an infant may be less likely to look at a distractor outside their field of view and thus inflate the difference score in favor of hits. In order to control for this possibility all target and distractor locations were perfectly counterbalanced for each infant. By counterbalancing the location of the target object, and as result the location of the distractor objects, we feel some confidence in using infants' average looks to the distractors. That is for some target locations the difference score could be inflated, i.e., when the target object is located within the infants visual field. However in an equal number of situations, i.e., when the target object is located outside the infants' visual field, infants' difference score could be artificially reduced.

A positive difference score indicates the infant looked more often at the target than at distractor objects; a negative difference score indicates more looks to one or more distractor objects than to the target object. A score of zero indicates chance, or undifferentiated, looking between distractor and target objects. Fig. 2 presents infants' shared visual attention difference scores as function of gesture, target type, and location.

For each gesture condition and target object location, the mean difference score was compared to chance (i.e., zero) using a single-sample t-test (two-tailed). Across all gesture conditions, 9-month-olds' difference scores reliably differed from chance, indicating more correct than incorrect looks, $P < 0.01$. However, for target objects outside infants' visual field, difference scores were not statistically significant, $P > 0.10$.

One question is whether 9-month-olds' frequency of attention following increases as adults' attention-directing actions become more compelling. To test this, infants' difference scores were entered into a 3 (gesture) × 2 (target type) × 2 (position[1]) mixed-model analysis of variance (ANOVA). The between

[1] Front hits were the number of correct hits in all trials in which the target object was at Locations 1 and 2, and Location 3 in P & B trials. Back hits were the number of hits when the target object was at Locations 4 and 5, and Location 3 in F & P trials.

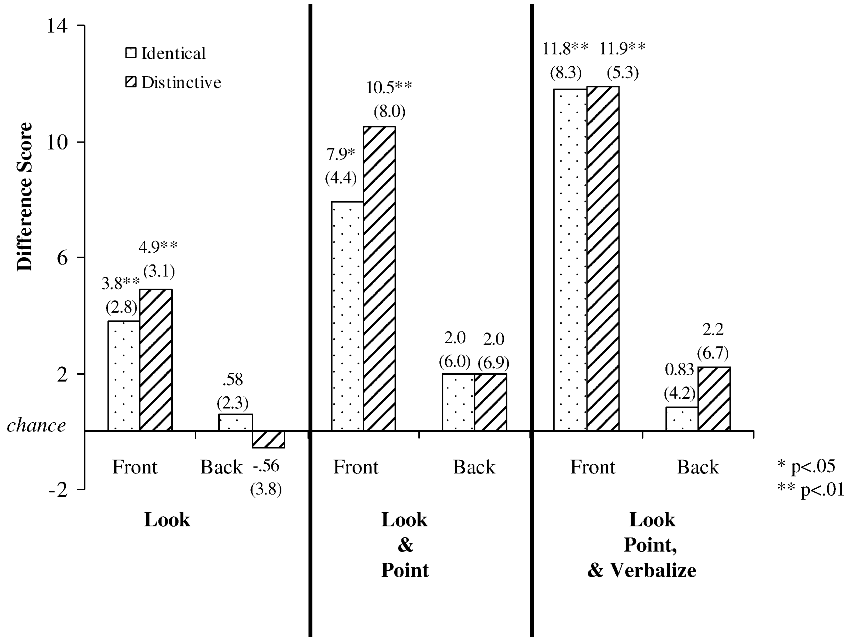

Fig. 2. Mean (S.D.) difference score for front and back targets as a function of attention direction action and target type in Experiment 1.

subjects gesture effect was significant. Nine-month-olds produced more correct looks if their parent looked and pointed ($M = 11.2$; S.D. $= 10.7$) or looked, pointed, and verbalized ($M = 13.4$; S.D. $= 9.8$), than if the parent simply looked at the target ($M = 4.4$; S.D. $= 3.6$), $F(2, 66) = 6.8$, $P = 0.002$. Number of hits in the Look and Point condition and Look, Point, and Verbalize conditions did not significantly differ from one another, $P > 0.1$. Thus, infants followed parents' attention-directing actions more often when pointing and gaze were redundant than when gaze alone specified parents' focus of attention, but when parents also added verbalizations there was no further reliable increase in infants' attention following.

There was a significant within subjects effect of target position, $F(1, 66) = 87.6$, $P < 0.01$. Infants established more shared visual attention to targets within their visual field ($M = 8.5$, S.D. $= 6.4$) than targets outside their visual field ($M = 1.2$, S.D. $= 5.2$). There also was a significant interaction between gesture and target location, $F(2, 66) = 4.93$, $P = 0.01$. That is the gesture effect was significant for target locations within but not outside infants' visual field. The effect of target type (identical versus distinctive) did not reach significance, $P > 0.1$, nor was any other interaction.

These results replicate, in 9-month-olds, previously reported effects of gesture and target object location on 1-year-olds' shared visual attention (Deák et al., 2000). The current results do not show that 9-month-olds more often, or more persistently, follow adults' attention to distinct, complex target objects than to identical, simple ones. The mean difference was in the correct direction, however, so it is possible that a more pronounced difference in target distinctiveness and complexity would have elicited such an effect. The current results also replicate previous findings (e.g., Butterworth & Cochran, 1980; Butterworth & Jarrett, 1991; D'Entremont, 2000; Morales et al., 1998) that 9-month-olds establish shared visual attention to targets within their visual field but not to targets outside their visual field.

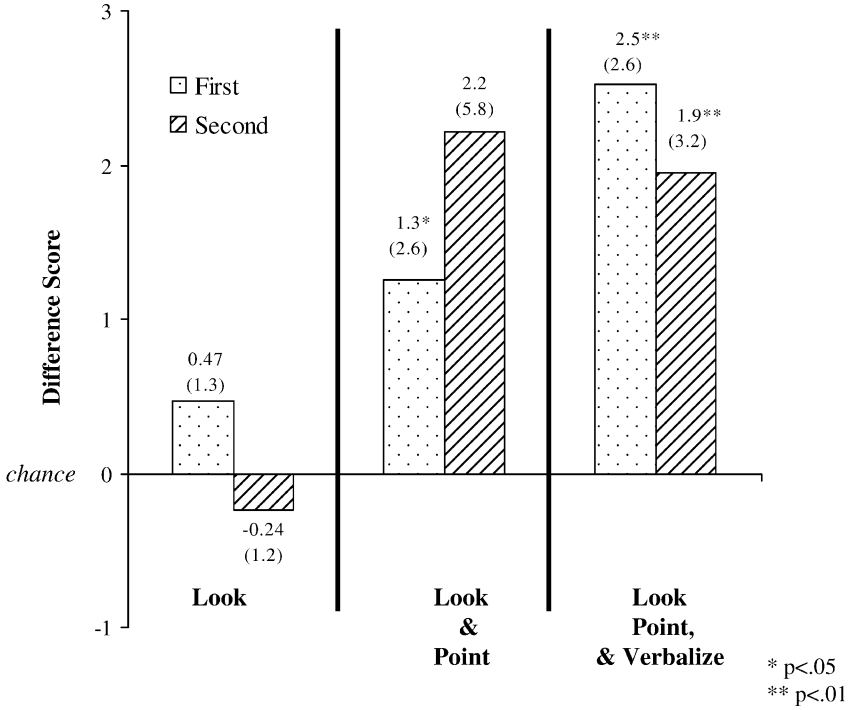

Fig. 3. Mean (S.D.) difference score for peripheral targets when it is the first or second along infants' scan path as a function of attention direction action in Experiment 1.

Another question was whether 9-month-olds can ignore distractor objects when the indicated target is not the one closest to midline along the infant's scan path. To answer this we compared infants' difference scores for peripheral targets (Location 3) in the P & B configuration (i.e., target is first in the scan path) to those scores in the F & P configuration (i.e., target is second in the scan path). Fig. 3 presents these mean difference scores, compared to chance (i.e., zero), as a function of gesture.

When the peripheral target was first along infants' scan path, frequency of shared visual attention exceeded chance when the parent looked and pointed, $t(23) = 2.33$, $P = 0.029$, or looked, pointed and verbally encouraged their infant, $t(23) = 4.8$, $P = 0.001$. When the parent only looked toward a peripheral target, however, infants did not exceed chance, $t(23) = 1.8$, $P = 0.084$. When the peripheral target was second in the infant's scan path, 9-month-olds' frequency of attention following only exceeded chance when the parent looked, pointed, and verbally encouraged them, $t(23) = 2.98$, $P = 0.007$.

These results show that redundant gesture combinations, such as looking, pointing, and verbalizing, increased 9-month-olds' frequency of gaze-following toward peripheral targets, even when this meant ignoring an object closer to midline. The results did not, however, show that 9-months can establish shared visual attention to targets outside their visual fields.

There are at least two alternative explanations of this target location effect. Deák et al. (2000) observed that when infants and parents face one another, as in most tests of shared visual attention, the parent need only produce a slight shift of the head and eyes to fixate on an object behind the infant, but she must turn

90–180° to look at a target within the infant's visual field. They hypothesized that infants seem to not follow adults' gaze to unseen targets because gaze shifts in this context are less noticeable. This implies a "cue detection account" of phenomena for which Butterworth inferred multiple, developing mechanisms (e.g., a developmental shift from ignoring to following gaze to peripheral and then out-of-sight targets). To test this, Deák et al. (2000, Experiment 2) rotated parents 90° to the infant's right or left, to roughly equate the size of parents' head turns toward targets in front of and behind the infants. As a result of rotating the parent relative to the infant, 12-month-olds reliably followed parent's gaze and points to targets behind them, and the effect of gesture size (i.e., small versus large head turns) was significant. Perhaps 9-month-olds also seem unable to follow gaze to back targets because parents have made smaller gestures to targets behind infants than targets in front of them. To test this, in Experiment 2 parents were rotated to the infant's right or left so that target location and head turn magnitude were unconfounded. We predicted that 9-month-olds would, in this situation, follow parents' larger gestures, but not smaller gestures, toward targets behind them.

2. Experiment 2

2.1. Method

2.1.1. Participants

Thirty-six 9-month-olds (20 males, 16 females; $M = 265$ days, S.D. $= 4.4$) and parents participated. Another six infants participated but were excluded from the final analyses, $n = 5$ due to fussiness and $n = 1$ due to experimenter error. Infants were recruited in the same way, and from the same population, as in Experiment 1.

2.2. Apparatus and target objects

The setting, apparatus, and distinctive objects of Experiment 1 were used.

2.2.1. Design

Infants were randomly assigned to one of the three gesture conditions (Look; Look and Point; Look, Point, and Verbalize). In all 12 trials, objects were located as in F & B trials of Experiment 1: one pair of objects was within infants' visual field and the other was behind infants. Two objects were on infants' left and two on infants' right; these pairs were separated by 60°. This configuration is shown in Fig. 4. Each infant completed three trials with the designated target in each of the four locations. Trials were in three blocks of four, with one per target location. Target locations were randomized within each block. Parents were randomly assigned to sit either on the infant's left or right (half on each side), rotated 90° so that the parent's midline gaze direction was orthogonal to the infant's midline gaze direction. From midline, parents made a *small* head turn to look at one object in front of the infant (F/S) and one object behind the infant (B/S). Similarly, they made a *larger* head turn to look at another front object (F/L) and another back object (B/L). Therefore each parent produced a "large" gesture toward one front and one back location, and a "small" gesture toward another front and another back target location. A different distinctive target was used for each trial. Trials lasted 15 s.

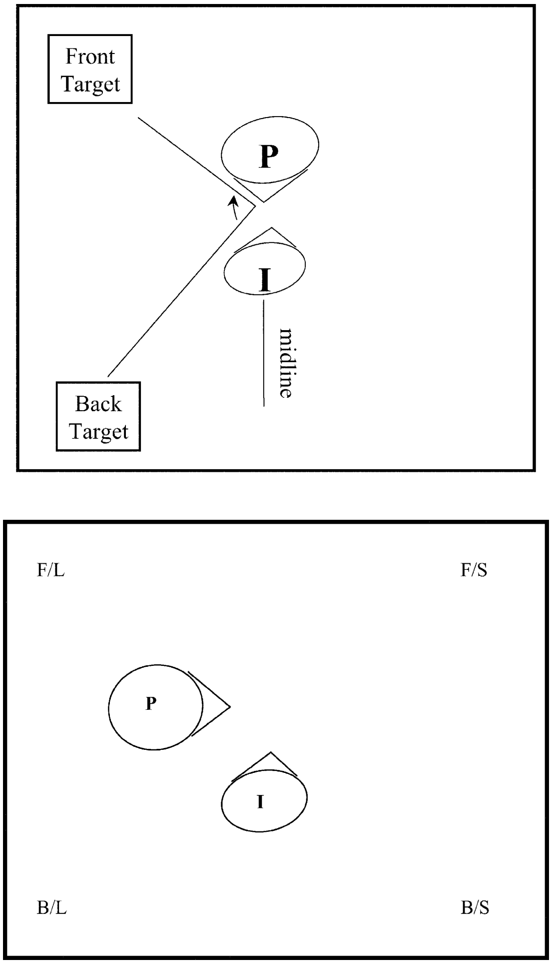

Fig. 4. Schematic diagram of the typical joint visual attention paradigm and the modified seating arrangement used in Experiment 2 with infant (I) and parent (P). Note the parent produces a small head turn to look at the target in front of the infant.

2.2.2. Procedure

The procedure was similar to Experiment 1, except (i) only one configuration was used, (ii) only distinctive targets were used, and (iii) parents were seated perpendicular to their infant. As in Experiment 1, parents verbally recruited infants' attention before attempting to redirect their attention. As a consequence, infants were looking at their parent, slightly to one side of midline, when the trial began.

2.2.3. Coding

The coding procedure and criteria were identical to Experiment 1.

2.3. Results and discussion

The dependent variable was again infants' participation in shared visual attention, coded as a difference score. The primary question was whether situating the parent perpendicular to the infant, to equate the size

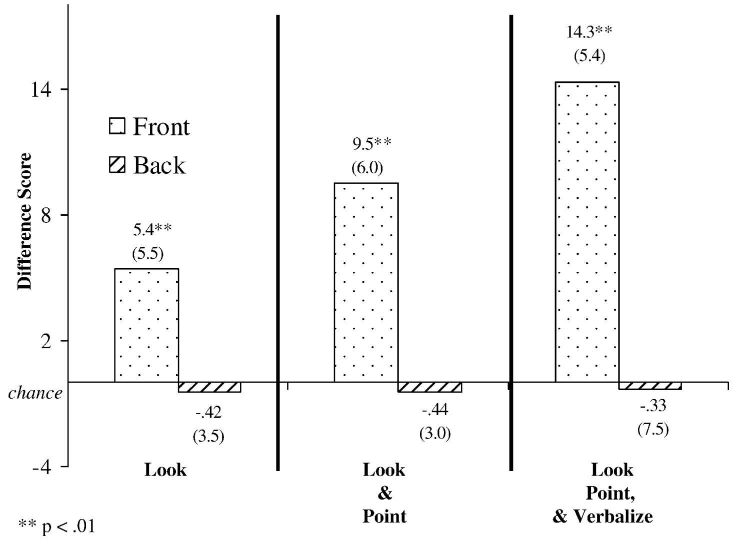

Fig. 5. Mean (S.D.) difference score of looking toward front and back targets as a function of attention direction action combination in Experiment 2.

of head turns to front and back targets, would promote 9-month-olds' frequency of following parents' attention to back targets. Average difference scores as a function of gesture and target positions are presented in Fig. 5. Preliminary analyses found no effects of gender or parents' location (i.e., to the infant's right or left), or interactions involving these factors, so these were not considered in further analyses.

Infants' frequency of shared visual attention reliably exceeded chance when the target was in front of them, across all the gesture combinations. However, it did not when the target was behind them. This effect of target location was significant; infants followed parents' gestures more to front ($M = 9.7$; S.D. $= 6.6$) than back targets ($M = -0.40$; S.D, $= 5.0$), $F(1, 33) = 58.5$, $P < 0.001$. There was also a significant gesture effect; infants followed parents' visual attention more when specified by looking, pointing, and verbal cues, than when specified by looking alone, $F(2, 33) = 4.7$, $P = 0.017$. The interaction between gesture and target location also was significant: redundant gestures compelled infants more powerfully to follow adults' attention to front targets; however, type of gesture did not affect infants' tendency to follow adults' attention to back targets, $F(2, 33) = 3.74$, $P = 0.034$. In short, 9-month-olds did not reliably follow adults' attention-directing gestures to targets outside their visual field. More compelling gestures did, however, promote more attention to targets within 9-month-olds' visual field.

In Experiment 2, parents were rotated 90° to 9-month-olds' right or left, to test the effect of "size" of the parent's gesture on infants' tendency to follow attention to targets both within and outside their visual field. Infants followed parents' larger turns ($M = 8.0$; S.D. $= 7.9$) more often than smaller turns ($M = 1.3$; S.D. $= 5.5$), $t(35) = 3.7$, $P = 0.001$. Importantly, 9-month-olds followed large gestures more often than small gestures to objects behind them (i.e., $M = 0.82$; S.D. $= 5.0$ versus $M = -1.2$; S.D. $= 3.2$), $t(35) = 2.083$, $P < 0.05$. Thus, though 9-month-olds did not reliably look more at target objects behind them than distractor objects, they more often turned in the direction of larger, more compelling gestures to out-of-sight regions, even if these turns were not completed by finding the target. Finally, for targets within infants' visual field, infants followed large head turns ($M = 7.2$; S.D. $= 4.9$) more than small ones ($M = 2.5$; S.D. $= 4.2$), $t(35) = 4.5$, $P < 0.01$.

The results replicate the finding (Experiment 1) that redundant gestures (e.g., looking, pointing, and verbalizing) promote more frequent and reliable gaze shifts to adults' target locations than do simpler gestures (e.g., simple gaze shifts). The results also demonstrate that infants more frequently follow larger than smaller gestures, even if the intended target object is not immediately visible.

3. General discussion

The results show that the frequency with which 9-month-old infants follow and share adults' visual attention is affected by the salience and redundancy of the gesture, and the location of the visual target. Experiment 1 extends the results of Deák et al. (2000) by showing that 9-month-olds can follow gesture combinations that redundantly specify where an adult is looking (i.e., that include pointing, with or without verbalizations, in coordination with gaze). This is true even if the target is in the infant's periphery, and another object, closer to the infant's midfield, must be ignored. Experiment 2 replicates the effects of gesture and target location, and shows that when "noticeability" of an adult's gesture is equated for objects in front of and behind the infant, 9-month-olds more often follow "larger" gaze shifts, with or without more sweeping points, than smaller shifts. The gesture size effect held for targets behind infants, though even large gestures to back targets did not reliably elicit attention following. Thus, in contrast to findings from 12-month-olds (Deák et al., 2000, Experiment 2), the current investigation did not find that 9-month-olds can follow adults' gaze or points to targets outside their current visual field.

These results underscore the importance for attention following in terms of infants' ability to perceive and discriminate gestures or actions that specify where an adult is attending. These studies and others (e.g., Butterworth & Cochran, 1980; Butterworth & Jarrett, 1991; Deák et al., 2000; Flom & Pick, 2003) show that elaborate or redundant gesture combinations promote episodes of following attention. However, this ability depends on target location, as previously noted. At 9 months, though infants do not reliably follow adults' gestures to targets behind them, they will follow relatively compelling or redundant gesture combinations to peripherally located targets. We argue that these results belie any simplistic story about discrete perceptual mechanisms associated with infants' participation in shared visual attention. Rather, the evidence about 9-month-olds' responses to other people's attention cues, along with data from other studies on 12–18-month-olds, indicate that multiple factors determine the probability that an infant will establish shared attention. Some of these factors, it seems, reduce to how easily the infant can detect a shift in the adult's attention-specifying behavior, and how much information is available to specify the adult's current focus of attention.

Given that factors like type and combination of gesture, gesture size, and target placement interact to determine how responsive infants are in following adults' gaze and points, why do 9-month-olds not follow even redundant, large gestures towards targets behind them? One possibility is that before 12 months of age infants do not comprehend the communicative intent of others' attention-directing actions, and their shared attention "repertoire" is closely tied to their history of social interactions. That is, infants might learn to follow gaze or points to visually accessible locations because most triadic interactions in the first year involve nearby, visible targets, and it is plausible that relatively simple learning systems can acquire discriminant responses to parental cues (e.g., head poses; hand positions) directed at different locations (Fasel, Deák, Triesch, & Movellan, 2002). Yet parents of 9-month-olds might avoid "referring" to out-of-sight objects. Instead they might or generally restrict joint play to objects close at hand (Bakeman & Adamson, 1984; Bruner, 1983; Ruff & Lawson, 1990). Restricting triadic interactions in this way would slow infants' capacity to learn the cues that specify an adult attending to something behind them. Peripheral objects, in the presence of more proximal distractors, would bear only modest similarity to triadic social interactions in the first 9 months, and thus permit attention following only when social cues are redundant and salient.

Another possible explanation involves infants' changing locomotor experience. Around 9–12 months of age, infant's capacity for locomotion dramatically increases. Perhaps 12-month-olds can follow adults' gaze and points to out-of-sight targets (Deák et al., 2000), but 9-month-olds cannot, because the former have accumulated a critical mass of experience exploring larger scale spaces (e.g., rooms). Such experience might facilitate the ability to generate and utilize more elaborate spatial knowledge. For example, in exploring rooms, infants must remember where out-of-sight locations and objects are, relative to what they see from their current position. Related studies (Campos, Kermoian, Witherington, Chen, & Dong, 1997; Kermoian & Campos, 1988) compared the referential attention of infants who were crawling to infants who were not yet crawling, some of whom were placed in walkers. Independently locomoting infants, as well as infants using a walker, more readily looked at the object of the experimenter's attention, and less time looking at the experimenter. It seems reasonable that the onset of locomotion creates new opportunities for social interactions across larger spaces, and thus increases infants' familiarity with nonverbal communicative exchanges that incorporate reference over larger distances (also see Gustafson, 1984). While the present data do not speak to effects of locomotor experience, it is possible that critical changes in triadic social experience between 9 and 12 months might promote infants' ability to follow an adult's attention to targets outside their immediate visual field.

The fact that multiple explanations can be offered as to why infants younger than 12-months fail to follow another's attention-directing actions to objects that are not immediately visible, in our opinion, reaffirms our position that it is unlikely that any one factor or mechanism will adequately explain the development of this behavior. Moreover, we believe, as our data suggest, that infant's participation in shared visual attention involves the interaction of multiple variables including, but not limited to the location of the target object, and the nature of the adult's attention-directing action.

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