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# Gaze following at 12 and 14 months: Do the eyes matter?

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Two questions were addressed: (1) Is the gaze following of infants under 18 months sensitive to eye status? (2) Do they construe looking as referential behaviour? Corkum and Moore (1995) concluded that, prior to 18 months, gaze following is responsive to the head turn alone (H), because infants followed such turns as frequently as conjoint head and eye turns (H/E). Since their results may have been compromised by an absence of targets and a relatively lengthy response time, we retested a 12- and 14-month group with H/E, H and eyes closed (H/Ecl) cues in the presence of targets and with reduced response time. To examine comprehension of referentiality, two more H/E cues were shown—(1) saying 'oh wow' while turning and (2) actively scanning the targets—each intended to increase gaze following if infants regard looking as seeing something. Fourteen-month-olds, but not 12-month-olds, responded significantly more to the standard H/E cue than to the H and H/Ecl cues, indicating the importance of eyes for gaze following at this age. Neither age group, however, responded more to the two 'enhanced' H/E cues than to the standard. In a second experiment, a new 14-month group was tested without targets, and again, responding was significantly greater to H/E than to H and H/Ecl. It was concluded that by 14 months, the eyes are co-equal with the head in controlling gaze following, but whether such head/eye turns are understood as object-directed is problematic.

The search for early precursors of theory of mind has prompted an examination of infant comprehension of the intentional/referential nature of visual behaviour, namely, that it is object-directed and involves the mental experience of seeing something (Moore, 1996; Moore & Dunham, 1995). Much of the research in this regard has focused on the phenomenon of *gaze following* or 'looking where someone else is looking' (Butterworth, 1991), which has been subject to both mentalist and non-mentalist interpretations.

Even prior to 6 months, infants show some ability to follow the gaze of others to

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targets within their visual field (D'Entremont, Hains, & Muir, 1997), but gaze following to targets outside the immediate visual field does not typically appear until the end of the first year (Butterworth & Jarrett, 1991; Corkum & Moore, 1995, 1998). The prevailing mentalist interpretation of this behaviour holds that the infant turns to see what the other is seeing (Baron-Cohen, 1994; Bretherton, 1991; Tomasello, Kruger, & Ratner, 1993), which implies that the infant understands: (1) that the other individual has made visual contact with a target, (2) that the eyes play a role in establishing contact, and (3) that self and other share this visual capacity. As intuitively compelling as this view may seem, it has been faulted for attributing too much sophistication to infants in the earliest stages of gaze following.

The strongest challenge to the mentalist conception has come from Moore and his colleagues (Corkum & Moore, 1995; Moore, 1999; Moore & Corkum, 1998), who have offered an 'attentional' account of gaze following. On this view, the adult head turn, as a consequence of interactive experience with caretakers, has come to serve as a predictive cue directing the child's attention to the location of interesting events, and not until at least 18 months do infants have any appreciation of the object-directed nature of looking or of the role of eyes therein. Thus, in its earliest stages, infants do not gaze follow to see what the other is seeing but rather look in the direction others are looking in the expectation of encountering something interesting.

Moore's position is based on a series of experiments (Corkum and Moore, 1995; Moore, Angelopoulos, & Bennet, 1997; Moore & Corkum, 1998) that sought to pinpoint the particular adult cues (head turns, eye turns, or both) that guide infant gaze following. It was reasoned that if infants do not respond to eye turns, one could hardly attribute their gaze following to 'wanting to see what the other is seeing'. In an initial study (Corkum & Moore, 1995), groups of infants 6–19 months old were each shown a number of head/eye cue combinations: (1) congruent head and eye turn (H+E); (2) head turn only—eyes remaining frontal (H); (3) eye turns only—head remaining frontal (E); and (4) head and eyes turning in opposite directions (H–E). The most relevant findings were (a) that gaze-following did not significantly exceed chance until 12 months, (b) that not until 18 months did significantly more turns occur to the H+E cue than to the H cue (suggesting that prior to 18 months, infants are guided primarily by direction of head turn, exclusive of eyes), and (c) that at no age did infants turn significantly to the eye turn alone (E). Even when explicitly trained to use adult eye turns to predict target location, only 18-month-olds succeeded (Moore & Corkum, 1998).

Despite this negative evidence, there is room for scepticism regarding the non-responsiveness of infants under 18 months to eye orientation. First, in a recent habituation study (Brooks, Caron, & Butler, 1998), 14-month-old infants who were exposed to an adult who turned to stare at one of two targets were found on a subsequent test involving a reversal of target position to look longer at change in the object of attention than to change in the direction of attention. The important point, however, is that when the adult's eyes were closed during initial turning, a change in direction of looking recruited longer fixation at test than a change in object. Second, although Corkum and Moore (1995) found no significant difference favouring the congruent H+E cue over the H cue at 12 or 15 months, it is noteworthy that the difference was in the right direction at both ages, which suggests that any factor that might have diminished responding to the congruent cue and/or increased responding to the non-congruent cue could have obscured sensitivity to eye status in their study.

Indeed, there are two factors that might have played such an obscuring role. The first is the absence of targets on the side walls (targets had been eliminated in order to reduce the occurrence of false positive, i.e. elicited, turns). This could have biased against finding greater responding to the H+E cue, because if infants turn to see something, and there is nothing to see, they should refrain from further turning altogether, thus effectively reducing any advantage of the congruent cue. In recent studies, Moore and Corkum did employ targets (Corkum & Moore, 1998; Moore, Angelopoulos, & Bennet, 1997; Moore & Corkum, 1998), but these were training studies involving dynamic targets serving as contingent reinforcers.

The second methodological factor that may have obscured greater gaze following to the congruent cue is the relatively lengthy time allotted for responding (7 s). If there were indeed a stronger tendency to respond to the congruent than the non-congruent cue, it might be reflected in latency of responding rather than amount of responding. Corkum and Moore did not provide latency data for their infant turns, but if turns to the H+E cue were indeed emitted more rapidly than those to the H cue, reducing response times might reveal a difference in total responding in favour of the congruent cue. However, if latency is not a factor, a reduction in response time should have no effect on responding to the congruent and non-congruent cues; both scores might be reduced, but the absence of a difference (as reported by Corkum and Moore) should persist.

The present study had two specific objectives: (1) to provide an additional test of sensitivity to eye status in infants between 12 and 15 months, using Corkum and Moore's (1995) paradigm but with the addition of side targets and a reduction in allotted response time; and (2) to provide an indirect test of referential understanding at these ages. Probing referential understanding in these relatively young infants was prompted in the first instance by the previously noted finding that looking is encoded as target-directed activity at 14 months and possibly younger (Brooks *et al.*, 1998; Woodward, 2001). Additionally, recent evidence from the social referencing and verbal learning literature suggests that referential comprehension may exist as early as 12–14 months. Repacholi (1998), for example, demonstrated that infants of 14 months regard emotional signals emitted by an adult as referring to specifically fixated objects and that non-referential mechanisms could not have been responsible for the subsequent approach or avoidant behaviour to these items. Likewise, Baldwin, Bill, and Ontai (1997) found that 12–13-month-olds, when confronted with ambiguous referential intentions by an adult who uttered a novel label in the presence of two novel objects (one the target of the child's attention, the other the target of the adult's attention), carefully checked the adult's direction of gaze to determine the correct referent of the label.

To test for sensitivity to eye orientation, we compared gaze following to an H+E cue (hereafter, H/E) with that to an H cue as well as to a head turn with closed eyes (H/Ecl). To assess referential comprehension, two further cues were presented that were intended to enhance the impression that the adult had made visual contact with an external target. Thus, the regular H/E turn was accompanied, in one instance, by a verbal exclamation ('oh wow') and, in the other, by peering intently at the target while scanning back and forth across it. The reasoning here was that if infants construe looking as involving the sight of a target, overt suggestions to that effect should induce heightened gaze following relative to the standard silent H/E turn. However, if infant gaze following is simply a topographical response to adult head direction, suggestions of visual contact should fall on deaf ears as it were (have little significance for the infant) and hence have no facilitative effect on gaze following. Some support for these assumptions comes from a recent study by Butler, Caron, and Brooks (2000), where 18-month-olds were found to turn significantly more to an H/E 'wow' cue than to a silent H/E cue, whereas 14-month-olds turned only marginally more. Given the inconclusiveness of the 14-month data, we sought to retest the visual 'enhancement' hypothesis with that age group as well as 12-month-olds. The use of 14-month-olds by Brooks *et al.* (1998) and Repacholi (1998), and 12-month-olds by Baldwin *et al.* (1997), also dictated the selection of 12- and 14-month-olds here.

In an initial experiment, 12- and 14-month-olds were each exposed to all five cues (H/E, H, H/Ecl, H/Ewow, H/Escan) in the presence of targets and using a 5-s response time. Generally, it was expected that if infants appreciate the role of eyes in vision, significantly more gaze following should occur to the standard congruent cue (H/E) than to each of the non-congruent cues (H and H/Ecl). In addition, if looking is understood to involve visual contact with a target, the two contact-enhancing cues ('wow' and 'scan') were expected to elicit more gaze following than the standard congruent cue. The purpose of a second experiment was to determine whether the presence of targets had contributed significantly to the congruent–non-congruent differential found in Expt. 1. Consequently, another group of 14-month-olds was exposed to the same cues under the same conditions as in Expt. 1, except now *without* targets.

## EXPERIMENT — Gaze following with targets

### Design and method

#### *Participants*

Participants were 32 infants (16 at 12 months and 16 at 14 months). All were full-term (> 37 weeks gestation), of normal birth weight (> 2.5 kg), with 5-min Apgars of at least 7, and had experienced no birth complications or major health problems. Five additional infants (1 at 12 months, 4 at 14 months) were excluded from the study because of fussiness ($N = 3$) and experimental error ($N = 2$). The 7 females and 9 males at 12 months had a mean age of 12–11 (range = 11–23 to 12–25), and the 8 females and 8 males at 14 months had a mean age of 14–15 (range = 14–0 to 15–10). All infants were recruited through birth records collected from suburban town halls and flyers posted in the immediate university area.

#### *Setting*

Experimental sessions were conducted in a 2.44 × 1.83 m cubicle, uniformly lined with light blue curtains on 3 sides to a height of 2.44 m. The wall behind the mother and infant contained a two-way mirror for observation. The mother sat in a chair facing the experimenter with the infant on her lap, approximately 0.92 m from the experimenter. The experimenter was seated so that infant and experimenter were at eye level. Two identical, colourful pictorial targets, 21.6 × 27.9 cm, were hung at the infant's eye level on both sides of the room, 65° from the infant's forward line of sight and 45° from the experimenter's forward line of sight. The targets were not visible to the infant from the forward position (Fig. 1).

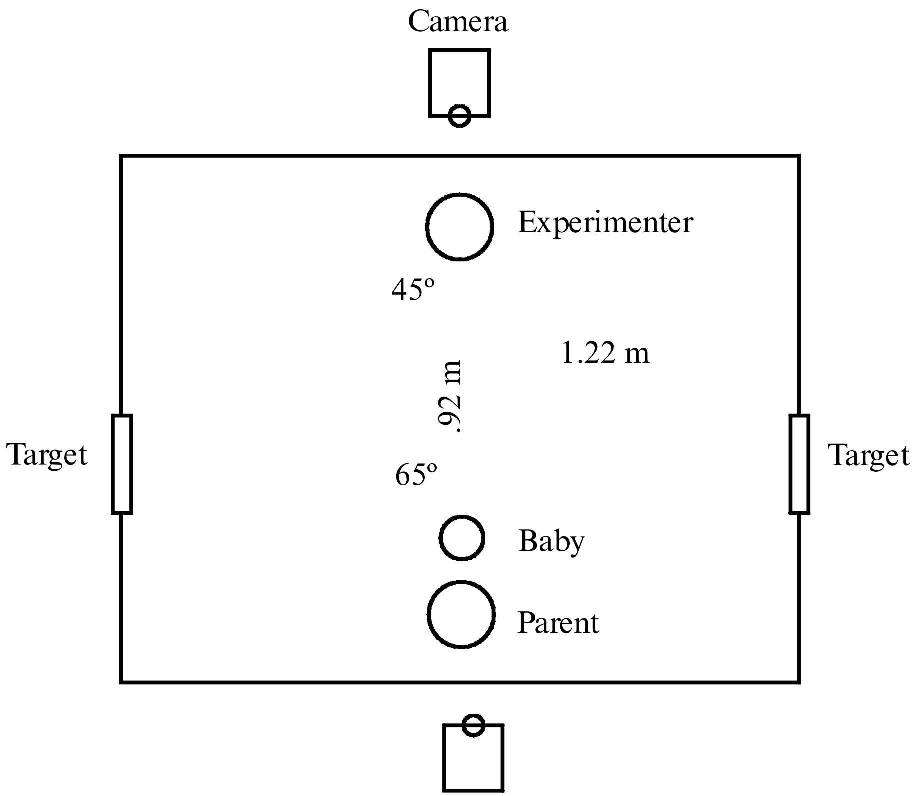


**Figure 1.** Aerial view of the experimental layout.

A small hole in the curtain directly above the experimenter permitted unobserved video recording of the infant's actions. The experimenter was cued as to which turn to perform through an earpiece connected to an audio recorder hidden in the experimenter's hand. Four different cue orders were pre-recorded on the audio tape. Coincident with the start of each experimenter turn, a brief audio signal was sounded, and a terminal signal was activated after 5 s. A second camera behind the mother recorded the experimental turns, and the outputs of both cameras were fed to a video mixer.

### *Procedure*

All infants were tested in an alert state, and throughout the course of the session, the experimenter monitored changes in state. If the infant became fussy, wiggly, or too distracted, the session was terminated. Parents were asked to look down and not to move their bodies or interact with their infant in order to prevent unintended cueing. At the start of each trial, the experimenter recaptured the attention of the infant (by speaking, singing, or calling her name) to ensure the child's perception of impending turns. Once eye contact was established, the experimenter shifted her orientation towards one the of the targets, and held the new orientation for 5 s. During trials, she did not talk to the infant or move her body (other than the head). On the H/E, H, H/Exl, and Scan trials, her facial expression remained neutral. On the Wow trials, her face registered mild surprise. The intertrial interval ranged from 10 to 60 s.

Each infant participated in a single experimental condition consisting of two blocks of 10 trials each (20 trials in all). The time interval between blocks was about 2 min. All five cues were presented in each block: (1) the standard conjoint head and eye turn (H/E), (2) the standard turn accompanied by the 'oh wow' exclamation (H/E wow), (3) the standard turn accompanied by peripharel target scanning (H/E scan), (4) a head turn with eyes remaining frontally fixed on the infant (H), and (5) a head turn with closed eyes (H/Ecl). Each cue was presented twice in succession (to the left or right) within each block. Directional order (1–r, r–1) was randomized across cues within blocks, and this order was reversed for each cue in the second block. Four cue orders were used (4 subjects randomly assigned to each in each age group). The entire experimental session ranged from 15 to 20 min.

### *Scoring*

Two naïve observers, blind to condition, cue, and age, scored the videotapes of infant turns on each trial. Only the *first* head and/or eye turn to target was scored on each trial. Glances that did not make visual contact with the target did not count as turns, nor did turns that followed the first turn. Determining whether the infant had fixated the target was not difficult, since there was nothing else to look at on the periphery, and the child's degree of turn could be rather accurately matched to the angular location of the target. Reliability of scoring for the first turn (to the referenced target, to the target opposite the referenced target, and no turn) was determined by calculating Cohen's kappa coefficient for 50%of the data (8 per age group). These values were $k = .94$ (12 months) and $k = .92$ (14 months).

### *Data analysis*

A match or correct turn consisted of the infant turning in the same direction as the experimenter, and a mismatch or incorrect turn consisted of the infant turning in the opposite direction of the experimenter. To control for random turning, a difference score was calculated for each infant by adding the number of correct turns or matches per cue and subtracting the number of incorrect turns or mismatches (a common practice in current joint attention research—Corkum & Moore, 1995; Morisette *et al.*, 1995). Failure to turn was scored as zero or not counted (also in accord with present practice). Thus, the difference scores for each cue could range from $-4$ to $+4$ per session.

Also measured were the latencies of the first turn. This was done to check on whether reponses to the congruent cues were indeed more rapid than those to the non-congruent cues.

## Results

### *Gaze following*

A preliminary mixed-model ANOVA of the difference scores was conducted with age, sex, and trial order as between-subjects variables and direction of head turn (right or left), type of cue (H/E wow, H/E scan, H/E, H, and H/Ecl), and trial block as within-subjects variables. Since the analysis yielded no significant main or interaction effects

**Table 1.** Mean (SD) frequency of matched and mismatched turns in each age × cue subgroup

| Age (months) | Type of turns | H/E wow | H/E scan | H/E | H eyes closed | H |
|---|---|---|---|---|---|---|
| 12 | Matched | 1.63 (0.86) | 1.19 (0.92) | 1.25 (0.86) | 0.69 (0.63) | 0.69 (1.43) |
| 12 | Mismatched | 0.19 (0.40) | 0.31 (0.48) | 0.25 (0.45) | 0.25 (0.45) | 0.13 (0.34) |
| 12 | Difference score | 1.44 (1.31) | 0.88 (1.36) | 1.00 (1.26) | 0.44 (0.81) | 0.56 (1.09) |
| 14 | Matched | 2.76 (1.23) | 2.13 (1.12) | 2.63 (1.18) | 0.82 (1.05) | 1.13 (1.06) |
| 14 | Mismatched | 0.38 (1.09) | 0.44 (1.03) | 0.25 (1.0) | 0.69 (1.14) | 0.63 (1.09) |
| 14 | Difference score | 2.38 (1.36) | 1.69 (1.20) | 2.38 (1.38) | 0.13 (0.96) | 0.50 (1.03) |
| 14 | Matched no target | 1.22 (1.18) | 1.21 (1.15) | 1.79 (1.32) | 1.29 (1.24) | 0.72 (0.85) |
| 14 | Mismatched no target | 0.29 (1.07) | 0.50 (1.29) | 0.29 (1.07) | 1.36 (1.65) | 0.36 (1.08) |
| 14 | Difference scores no targets | 0.93 (1.27) | 0.71 (1.27) | 1.50 (1.56) | −0.07 (0.83) | 0.36 (.63) |

involving sex, trial order, block, or direction of turn, the data were collapsed on these dimensions for all subsequent analyses.

The top six rows of Table 1 provide a summary of the mean number of matched responses, mismatched responses, and difference scores for the various age × cue subgroups of Expt. 1. Although the amount of mismatched turning to the H/E cue (11.4% of all turns) is less than that reported by Corkum and Moore (1995) for their comparable cue with similar age range (about 24%), the amount of mismatched turning to the H cue (29% of all turns) is equivalent to that reported by Corkum and Moore for their H cue (about 34%). Interestingly, the proportion of mismatched turns to the three congruent cues combined was 13.6%, and to the two non-congruent cues combined, 33.8%. Finally, there was no difference overall in the proportion of mismatched turning between 12- and 14-month-olds (18.0% vs. 22.5%, respectively).

The two left-hand portions of Fig. 2 present in graphic form the mean difference scores for the five cues at 12 and 14 months. Two separate analyses were conducted: (1) comparison of the three congruent cues (H/E wow, H/E scan, H/E) to test for the effects of referential enhancement, and (2) comparison of the three 'unenhanced' cues (H/E, H/Ecl, H) to test for the contribution of eye turns. The data for the three congruent cues were entered into a mixed-model ANOVA with cue type as the within-subjects variable and age (12 vs. 14 months) as the between-subjects variable. The analysis yielded only one significant effect, that for Age ($F(1,30) = 11.76, p < .01$), with 14-month-olds turning much more overall than 12-month-olds (2.15 vs. 1.11, respectively). There were no significant effects for Cue or for the Cue × Age interaction indicating that referential enhancement ('wow' and 'scan') had no facilitative effect on gaze following at either age. Responding to all three congruent cues at each age significantly exceeded chance.

The data for the three unenhanced cues were also entered into a mixed-model ANOVA with cue type as the within variable and age as the between variable. The analysis yielded a highly significant effect for Cue ($F(2,30) = 18.41, p < .0001$), the two non-congruent cues each eliciting much *less* turning overall than the congruent (H/E) cue (H/E = 1.69, H = .53, H/Ecl = .28), $p < .01$ by Tukey test, in each instance. The analysis also yielded a significant Age × Cue interaction ($F(2,30) = 6.78, p < .002$) such that the congruent–non-congruent differential was much steeper at 14 months than at 12 months. Indeed, at 12 months, the three measures were not significantly different from one another, whereas at 14 months, the H/E group significantly outperformed the

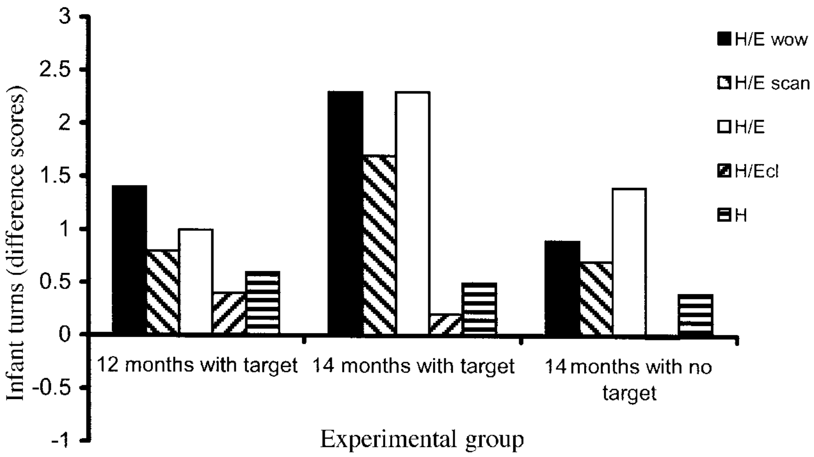


**Figure 2.** Mean difference scores of 12- and 14-month-olds with targets, and 14-month-olds without targets, to five adult head-turn cues (H/E wow, H/E scan, H/E, H and H/Ecl). H/E = standard head and eye turn, H/E wow = standard turn plus 'oh wow' exclamation, H/E scan = standard turn plus scan of target periphery, H = head turn with eyes remaining frontal, H/Ecl = head turn with closed eyes. Error bars represent the standard error.

two non-congruent cue groups ($p < .01$, by Tukey test). Examination of individual data reinforces the 12-vs. 14-month difference. Using a criteria score of +2 (probability level: 4.9%), only 4 of 16 12-month-olds scored +2 or higher on the H/E cue, whereas 12 of 16 14-month-olds did so ($\chi^2 = 6.12$, $p < .02$). The comparable proportion for 14-month-olds to the H cue was 2 of 16 and for 12-month-olds, 3 of 16. Responding to the H and H/Ecl cues did not exceed chance at 12 or 14 months. Thus, for 14-month-olds at least, the eyes played a co-equal role with the head in gaze following to presented targets.

### *Latency*

Comparable analyses of the latency scores (left-hand portion of Table 2) yielded no significant differences between cues, ages, or cue × age interactions for either the

**Table 2.** Mean (SD) latencies of response in seconds in the various cue × age subgroups

| | Targets | | | No targets |
|---|---|---|---|---|
| | 12 months | 14 months | All | 14 months |
| H/E wow | 2.85 (0.75) | 3.98 (1.05) | 3.41 (1.35) | 3.27 (0.92) |
| H/E scan | 2.95 (1.63) | 3.04 (0.98) | 3.00 (0.99) | 2.58 (0.58) |
| H/E | 2.82 (1.32) | 2.81 (1.07) | 2.82 (1.22) | 3.52 (1.32) |
| H | 2.30 (1.13) | 3.45 (1.07) | 2.88 (1.91) | 2.85 (1.48) |
| H/Ecl | 3.23 (1.91) | 3.03 (0.09) | 3.13 (1.78) | 3.42 (1.15) |

congruent or the unenhanced comparisons. Most important, the overall response latency to the H cue was not significantly longer than that to the H/E cue, nor was it longer to the 'eyes closed' cue than to the H/E cue.

## Discussion

The major purpose of Expt. 1 was to re-examine the gaze following of 12- and 14-month-olds to congruent head/eye cues vs. head-only cues, using Corkum and Moore's (1995) response criteria, but retaining visual targets on the cubicle walls and reducing response time. In contrast with Corkum and Moore's findings, gaze following at 14 months was significantly greater to the H/E cue than to the two non-congruent cues, suggesting that eye orientation is indeed a significant part of the stimulus pattern governing gaze following at this age. However, since the difference was not significant for 12-month-olds, the eyes would appear to play less of a role for them.

The second purpose of Expt. 1 was to provide a test of referential understanding, particularly for the age group (14 months) that proved sensitive to eye status. Since neither the wow nor the scan cues yielded more turning than the standard H/E cue, it is tempting to conclude that looking is not construed as referential behaviour at 14 months. This conclusion, however, must be tempered by a potential artifact that might have reduced responding to the two enhanced cues, namely, that these manipulations might have drawn attention to the experimenter, thus reducing tendencies to turn to the side targets. On the other hand, the response latencies to the wow and scan cues were not significantly longer than that to the H/E cue, suggesting that the former may not have attracted special attention. Reinforcing this conclusion is the fact that the wow cue produced significantly more gaze following than the standard H/E cue for 18-month-olds in the Butler *et al.* (2000) study. Nevertheless, since one is on precarious grounds trying to draw conclusiosn from negative findings, whether 14-month-olds regard looking as involving visual contact is still an open question.

It remains to consider what was responsible for the discrepancy between our 14-month results (particularly the strong differential between the H/E and H cues) and the lack of such a difference for Corkum and Moore's (1995) 15-month no-target group. Was it the presence of targets, the reduction in response time, or something else? The fact that the mean difference score to our H/E cue was considerably enhanced relative to C & M's identical cue (2.38 turns in four trials for our 14/15-month-olds versus 1.1 in four trials for C & M's 15-month group), whereas there was no difference in responding to the H cue (0.5 turns here versus 0.5 in their study), suggests that the critical factor was not the reduction in response time. Reduction in response time was expected to reduce responding to the H cue compared to C & M's data (though it clearly did not) but it certainly would not have enhanced responding to the H/E cue. Indeed, as previously noted, there were no latency differences between the H and H/E cues. We are left, then, with the presence of targets or some other unknown cause to account for our data.

Given the possible importance of targets, it was necessary to repeat Expt. 1 with a 14-month sample tested under no-target conditions. This would allow us to determine more definitively whether the presence of targets or some other feature of our experimental situation was responsible for the difference between our congruent – non-congruent comparison and that of Corkum and Moore. Experiment 2 provided this replication.

# EXPERIMENT 2 — Gaze following without targets

## Design and method

### *Participants*

Participants were 14 infants at 14 months of age ($M$ = 14–14; range = 14–0 to 15–4). The 9 females and 5 males were all full-term (> 37 weeks gestation), of normal birth weight (> 2.5 kg), with 5-min Apgars of at least 7, and had experienced no birth complications or major health problems. Two additional infants were excluded due to fussiness ($N$ = 1) and experimental error ($N$ = 1). All infants were recruited through birth records collected from the same suburban town halls and locally posted flyers as in Expt. 1, and were completely equivalent in social class and demographics to the original group.

### *Setting*

Experimental sessions were identical to Expt. 1, except that there were no pictorial targets. The experimenter made turns to the same location as in Expt. 1, and to ensure that this was the case, a small piece of sticky tape was placed on the curtains where the targets had previously been located.

### *Procedure*

The procedures were identical to Expt. 1, and the same five cues were tested (H/E, H/E wow, H/E scan, H, and H/Ecl).

### *Scoring*

Two naïve observers, blind to condition, cue, and age scored the videotapes of infant turns on each trial. As before, a turn consisted of the first head and/or eye turn, in the horizontal plane. Reliability of scoring for all turns was determined by calculating Cohen's kappa coefficient for 50% of the data ($N$ = 7). The kappa value was .94. As in Expt. 1, difference scores between matched and mismatched turns were calculated for each cue for each infant.

## Results

### *Gaze following*

A preliminary mixed-model ANOVA of the difference scores in Expt. 2 was conducted with sex and trial order as between-subjects variables and direction of head turn, type of cue, and trial block as within-subjects variables. The analysis yielded no main or interaction effects for trial order, block, or direction of turn. There was an unexplained significant interaction between cue and sex ($F(4,20) = 2.64, p < .05$) with boys turning more to the H/E cue than girls, whereas there was no sex difference for the other cues. Since there was no overall sex difference, and since the number of cases for each gender in each cue condition was small, it seems likely that this effect was a consequence of chance variation. Accordingly, on all subsequent analyses, the trial order, direction of turn, and sex data were collapsed.

The bottom three rows of Table 1 provide a summary of the mean number of matched turns, mismatched turns, and difference scores for the various cue subgroups in the present no-target condition. The overall proportion of mismatched turning here was 31.0% slightly, more than the 22.7% for the 14-month-old group in Expt. 1, but closer to Corkum and Moore's (1995) overall 33.3% for 15-month-olds. Examination of the no-target groups reveals that as in Expt. 1, the proportion of mismatched turning was much greater to the two non-congruent cues combined (46.2%) than to the three congruent cues combined (20.5%). Overall, there was no difference in the proportion of mismatched turns between the no-target and target groups across cues.

#### *Analysis of gaze following in the no-target condition*

The right-hand portion of Fig. 2 depicts the mean difference scores of the 14-month-olds in the no-target condition for each cue. Comparison of the three congruent cues in the no-target condition yielded, as before, no significant difference. All three produced above-chance responding. Analysis of the three unenhanced cues in this condition yielded a significant cue difference ($F(2,12) = 8.14$, $p < .002$), again favouring the congruent cue (means: H/E = 1.50, H = 0.38, H/Ecl = $-0.07$). The H/E mean significantly exceeded each of the two non-congruent means ($p < .05$ by Tukey test in each case), neither of which elicited above-chance responding. Thus, even without targets, the eyes appear to have played a significant role in 14-month gaze following.

#### *Comparison of the no-target and target conditions*

Comparison of responding to the three congruent cues for the 14-month-olds in the target and no-target condition yielded a significant target effect ($F(1,26) = 13.07$, $p < .002$), infants turning overall more in the target condition ($M = 2.15$ vs. 1.05, respectively). There were no other main or interaction effects. Analysis of the three unenhanced cues yielded a highly significant cue effect ($F(2,26) = 24.59$, $p < .0001$), the H/E cue overall producing significantly more turning than each of the two non-congruent cues (H/E = 1.79, H = .44, H/Ecl = .03)—$p < .01$, in each case. There was no Target effect here and no Target × Cue interaction. In summary, although responding was greater overall in the target condition, responding to the congruent H/E cue was stronger than to the two non-congruent cues, regardless of the presence of the targets.

## Latency

The right-hand portion of Table 2 presents the mean latencies of the 14-month-olds in the no-target condition. There were no cue differences in latency within this condition and no differences in comparison with the 14-month-olds in the target condition, indicating again that response latencies were not longer to the non-congruent cues.

## Discussion

The results of Expt. 2 indicate that the absence of targets clearly reduced responding to the congruent cues compared with the previous target group. However, even with no targets, and in direct contrast with Corkum and Moore's original finding, the H/E cue yielded significantly more turning than the H cue (as well as the 'eyes closed' cue). In considering what might have been responsible for this discrepancy, a reduction in response time seems again to be ruled out. As was the case in Expt. 1, the reduction could not have accounted for the enhancement in responding to the H/E cue relative to the same cue in Corkum and Moore's study (1.5 turns in 4 trials here versus 1.1 turns in 4 trials for their 15 month group), nor could it have accounted for the minuscule decrease in responding to the H cue (0.38 turns here versus 0.50 turns in their study). The only other possibility that comes to mind is that the relatively few cases in Corkum & Moore's study ($N = 12$ per age group) might have mitigated against attaining statistical significance for the H/E vs. H comparison.

One caveat that might be raised regarding the present results (as well as those of Corkum and Moore) is that the odd nature of the H and H/Ecl turns (mothers never turn their head and eyes independently) might have attracted attention at the expense of the side targets. Two pieces of evidence, however, argue against this explanation. First, in the aforementioned Butler *et al.* experiment, 14-month-olds were shown very odd stimuli (experimenter turning while surrounded by tall opaque barriers), and yet responding remained well above chance. Second, in an experiment from another laboratory (Brooks & Meltzoff, 2001), not only were 14-month-olds also found to gaze follow minimally to closed-eye turns, but by contrast, they responded robustly to turns with blindfolded eyes, thus again seeming to eliminate stimulus novelty as a source of response reduction.

## GENERAL DISCUSSION

Taken together, the results of Expts. 1 and 2 are consistent with the view that infants of 14 months recognize that adult looking involves a conjoint turn of the head and eyes. Whether this means that they realize that when people look, they see something is more problematic. There are actually a number of reasons to be cautious about a mentalist interpretation of the 14-month behaviour pattern. For one thing, it makes developmental sense that as eye turns become differentiated from head turns between 12 and 18 months, they might assume the same directional cueing role as the head prior to cognizance of their referential role. Second, as Butterworth and Jarrett (1991) have argued, beyond 12 months infants may simply become more adept at projecting imaginary trajectories from the head and eye orientation of others to distant targets, without necessarily attributing visual experience to them.

A third reason for caution relates to the broader findings of Butler *et al.* (2000), where gaze following was tested with solid partitions interposed between adult and target. It was expected that infants who comprehend that looking is object-directed would turn less when the adult's view of the peripheral targets was obstructed by opaque barriers than when there were no barriers or the barriers were made transparent by cutting out 'windows' within them. Infants who do not so comprehend and for whom the adult's head turn merely specifies the location of interesting targets were expected to respond equally in all three conditions, since the nature of the turn is identical no matter what the status of the barrier. While 18-month-olds yielded a distinct referential looking pattern (minimal responding in the barrier condition, maximal in the no barrier and window conditions), 14-month-olds responded in an unexpected manner (maximal responding in the no barrier condition, equivalently reduced responding in the barrier and window conditions). The failure to find strong responding in the window condition at 14 months or to observe peeking at the inside of the partition in the barrier condition (as did the 18-month-olds) would appear to rule out referential understanding. However, the failure to find equal responding in all three conditions would also appear to rule out a directional control hypothesis. Finally, the possibility that 14-month-olds are merely projecting vectors to specific targets is also questionable, given that they seemed to have difficulty projecting them through windows or to realize that they cannot pass through solid partitions (gaze following was reduced in the barrier condition but remained well above chance). In summary, a convincing case for a mentalist interpretation of gaze following by 14-month-olds is yet to be made, but at the same time, the particular non-mentalist mechanism that might govern their behaviour remains indeterminate.

A final question arises as to why gaze following studies have failed to yield evidence of referential understanding in infants younger than 18 months, whereas such understanding, as previously noted, is implicated in social referencing and verbal labelling studies (see Baldwin & Tomasello, 1998, for an overview of the latter.) While we have no ready answer to this question, two possible explanations may relate to methodological and conceptual differences between the two sets of research. On the methodological side, in the gaze following paradigm, target and adult are not typically located within the same visual field, whereas in the social referencing and verbal labelling studies, they usually occupy the same visual field from the infant's perspective. Thus, it may simply be harder for younger infants to construe a distant target as an object of the adult's attention than a proximal target. In addition, the attentional behaviour of the adult is much more prominent in the latter studies (including gestural and postural as well as visual components) whereas in the typical gaze following paradigm a head turn is the sole response. Young infants may require much more contextual support than is provided in the latter.

On the conceptual side, the two research areas pose distinctly different problems for the child. In gaze following, the infant is confronted with a location problem ('where is it?') for which a geometric or projection mechanism may suffice. By contrast, the problem for the child in verbal labelling and social referencing is a 'what' problem and is cast in a referential frame already familiar to the child ('what does this new word refer to?'; 'what is mom warning me about now?').

These observations suggest two possible ways that might be used to reveal referential comprehension in young infants in the gaze-following paradigm. First, a more distinctly referential quality could be imposed on gaze following by tapping into the infant's pre-existing referential stance for language and emotion. Thus, the adult might say while turning 'there's that "modi"' or 'oh oh! watch out for that!' Such verbalizations should be more effective than our presently employed 'oh wow', because they elicit an already acquired referential mind set. Second, our methodological speculation suggests that anything that could narrow the gap between adult and target as well as enhance ecological validity in the gaze following paradigm might yield evidence of referential understanding at younger ages. One obvious adjustment is to combine pointing with head turning. Indeed, in a recent study Deak, Flom, and Pick (2000) found that such a combination significantly enhanced gaze following at 12 and

18 months relative to head turning alone. While this result could be attributed to improved geometric projection (Deak *et al.* prefer this explanation) rather than referential understanding, if pointing were employed in a barrier paradigm, firmer evidence of referential comprehension might emerge prior to 18 months. We have just completed such a study with results indicating such comprehension (Caron, Kiel, Dayton, & Butler, in press).

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