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BRIEF REPORT

A Demonstration of Gaze Following in 3- to 6-Month-Olds

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An adult, with a puppet held at shoulder height on either side (within the infant's visual field), interacted with 3- to-6-month-olds, turning her head intermittently to talk to a puppet. Seventy-three percent of infants' first eye-turns were in the direction of the adult head-turn.

3- to 6-month-olds joint attention adult-infant interactions infant eye gaze

Butterworth and co-workers (e.g., Butterworth & Cochran, 1980) operationally defined joint visual attention as the ability to follow another person's gaze. The ability to engage in joint visual attention is thought to be a major advance in the infant's communicative abilities, governing both social interaction and referential communication between infant and caregiver (e.g., Adamson, 1995). Butterworth and Grover (1990) suggested that joint visual attention allows for the development of gestures such as manual pointing, and Bruner (1983) identified it as a precursor to language acquisition. Joint visual attention also has been related to the infant's understanding of intentionality, which leads to the child's theory of mind—the understanding that others have mental states (e.g., Baron-Cohen, 1994).

The development of joint visual attention is thought to be a gradual process that has been demonstrated at 6 months of age. Butterworth and co-workers (Butterworth & Cochran, 1980; Butterworth & Grover, 1990; Butterworth & Jarrett, 1991) provided evidence by testing 6- to 18-month-olds in face-to-face interactions with their mothers. Periodically, their mothers turned to look at one of a series of targets positioned from 30 to 150 degrees on either side of the infant's midline. The 6-month-olds turned to look in the same direction as their mothers, but only reliably localized the targets closest to midline. When the mother looked at a more peripheral target, performance was at chance. The 12-month-olds localized any target in front of the infant, but still did not localize objects behind them. Finally, between 12 and 18 months of age, infants started localizing objects behind them. Corkum and Moore (1994) reported that infants could not even be conditioned to turn their heads towards lateral targets before 8-9 months and that infants younger than 10-12 months of age would not spontaneously follow adult gaze when targets were not visible.

This relatively late onset of joint visual attention contrasts with Scaife and Bruner's (1975) report that infants as young as 2 months of age will turn their heads to follow an adult's line of visual regard. They had an adult sit in front of the infant, interact, and establish eye contact. Once eye contact was established, the adult turned his head 90 degrees to fixate a target which was not visible to the infant. After re-establishing eye contact, the procedure was repeated once. Using a criterion of at least one head turn in the correct direction, 30% of their 2- to 4-month-olds followed the adult's gaze; this number increased with age so that by 11-14 months, all of their infants followed the adult's gaze. However, this performance criterion was probably too lenient.

The present study was designed in an attempt to optimize conditions for eliciting joint atten-

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tion responses in very young infants. In previous studies, adults stopped talking whenever they turned away from the infant to look at the target. However, young infants are sensitive to subtle perturbations in an adult's behavior during face-to-face interactions (Hains & Muir, 1996a; Muir & Hains, 1993), hence, we had our adult continue interacting with the target when they looked at it. Also, in previous studies the targets were either absent or positioned outside the infant's central visual field. Because the young infant's effective binocular visual field is relatively narrow during the first 6 months of life (Lewis & Maurer, 1992) we presented the targets close to the adult.

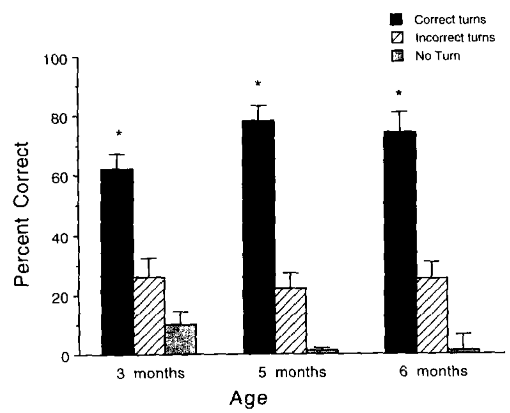
Names of mothers of infants were obtained from the birth announcements in a local newspaper, participants were recruited by phone, and informed consent obtained. Data from 24 infants were analysed; data for 2 infants were unusable because their eyes were not clearly visible and 1 infant cried. There were 8 infants in each of three groups: 3-month-olds (range 11-14 weeks), 4- to 5-month-olds (15 to 21 weeks), and 6-month-olds (range 22-26 weeks). The infants were from predominantly white, middle-class families.

Each infant was secured in an infant seat approximately 40 cm from a puppet theater consisting of a 60-cm by 60-cm wooden frame located at the infant's eye level. The female experimenter sat behind the frame between two hand puppets held within the frame on either side. The puppets were lions' heads, with large eyes directed forward, which were held by an adult so that the puppets' eyes were always directed towards the infant and the adult's arms were not visible. A camera placed to one side of the wooden frame recorded the infant while a second camera, behind and to the right of the infant, recorded the adult and puppets. The two signals were combined by a Sony special effects generator to produce a simultaneous recording of both adult and infant. A time-line was superimposed on this record for later analysis. The mothers could view the procedure on a monitor in another room.

During the procedure, the puppets swayed slowly from side to side in unison (about 1 cycle per 2 s); their movement was unrelated to either infant or adult behavior. The adult interacted with the infant, smiling and talking in infant-directed speech until she judged the infant to be fully engaged in the interaction. Then she turned her head 90 deg towards one of the puppets, while continuing to talk in infant-directed speech. After talking to the puppet for about 10 s, she turned back and re-engaged the infant in interaction. This object-referencing was repeated in random order at least 4 times (range 2 to 4 per side) during the 4-min procedure (it should be noted that the experimenter was not blind to the study's hypothesis).

The direction and time (in 100th s) of each eye turn for the infant and each head turn for the adult were recorded independently. During scoring, either the adult's or infant's image on the screen was covered, and the sound was turned off to eliminate observer bias. The two records were then compared to determine the direction and latency of the first infant eye-turn occurring after an adult head-turn was initiated. The direction was coded as correct only when the infant looked at the appropriate puppet. Otherwise the gaze was coded as no change when the infant continued to look at the adult or incorrect when gaze was directed either towards the other puppet or some other location. The occurrence of smiling by the infant was also recorded. Records from 25% of the infants were scored by a naive coder, in the manner described above. Only one eye-turn (of 40) was scored differently, and the mean difference in latency to any turn was 0.09 s.

Visual attention to the adult was not sustained. The infants looked between the puppets (gaze left, $M = 4.9$ per min; gaze right, $M = 4.4$ per min) and the adult's face but looked elsewhere infrequently ($M = 1.6$ per min). The total number of changes in infant eye direction ranged from 23 to 180 ($M = 79$, $SD = 39$), but did not differ across age groups. The direction of the first change in infant eye direction following an adult head-turn was recorded and coded as no change (N = 16), correct (N = 116), or incorrect (N = 43), resulting in 73% of the first eye-turns being in the correct direction (66% of all trials). Only one 3-month-old turned more often in the wrong direction, and 4 infants (1 at months, 1 at 5 months, 2 at 6 months of age) looked equally in both directions. The proportion of eye-turns in each category for each age group are shown in Figure 1. These data were analysed using a 1-between (age) × 1-within (correct vs. incorrect



Note. * represents a significant difference between the proportion of correct and incorrect responses to adult head-turns.

Figure 1. The mean proportion of no turns, turns toward, and turns away as a function of infant age.

turns) ANOVA. There were significantly more turns in the correct direction than no turns and incorrect turns combined, $F(2, 21) = 22.23$, $p < .01$, but no main effect of age or interaction.

The duration of the first eye-turn ranged from 0.14 s to 8.9 s ($M = 2.54$ s, $SD = 2.40$ s), with no age differences. The latency to an eye turn following the adult's head-turn was also examined. The t tests showed no significant difference either in latency for correct ($M = 2.12$ s, $SD = 2.20$ s) and incorrect turns ($M = 2.88$ s, $SD = 3.30$ s), or in latency for eye turns to the left ($M = 2.24$ s, $SD = 2.50$ s) and right ($M = 2.02$ s, $SD = 2.00$ s).

Almost all of the episodes of smiling began while infants were looking at the adult and usually disappeared when the infant looked at the puppet (two infants showed distress each time the adult broke eye contact). The duration ranged from 0 to a maximum of 103 s ($M = 28.00$ s, $SD = 29.10$ s). Analyses showed no age differences in amount of smiling.

It should be noted that we used first eye-turn rather than the traditional head-turn measure because we believed that the youngest age group may not have sufficient control of the neck muscles to turn their heads readily while seated. The eye-turn measure revealed that infants as young as 3 months of age will follow adult head-turns when the object of the adult's attention is within the infant's visual field, and the adult head-turning is part of an ongoing social interaction. The infants' behavior can be characterized as follows: They became engaged with the adult in a dyadic interaction, looking and smiling at her. They also showed their awareness of the two noninteracting puppets by visually scanning between them, without smiling. When the adult looked at a puppet, in most cases, infants looked at the same puppet, only occasionally looking at the other puppet or continuing to gaze at the adult while her head was turned. Once the infants looked at the target puppet, they looked back at the adult without prompting, and when the adult reinstated eye contact, infants re-engaged in an active interaction by looking and smiling at her.

There are several possible explanations for the infants' behavior, other than the operation of some joint visual attention mechanism. Our infants may have given the appearance of gaze following but actually may have been tracking the adult's nose or attempting to maintain eye contact as she turned her head. This seems unlikely given the relatively long latencies for an eye-turn—over 2 s (compared with latency for a head-turn to off-centered sound of about 1 s; Muir, Humphrey, & Humphrey, 1994). Furthermore, when Hains and Muir (1996b) had adults avert their gaze without a visible target while interacting with infants of this age, they found no evidence of infant gaze following. Possibly our infants were imitating the adult's behavior; but, the adult turned her head, while the infants' responses consisted primarily of brief eye-turns, often without accompanying head-turns. Finally, infants may have learned that turning their eyes, cued by the adult's head-turn, produced a visually interesting result (the puppet), which could be considered a conditioned response (Gewirtz & Pelaez-Nogueras, 1992). However, the puppets were identical, so turning in the same direction as the adult was not differentially reinforced.

Hains and Muir (1996b) showed that infants are less responsive when adults do not make eye contact during face-to-face interactions. In the present study, we show that when the adult turns to interact with a near-by object, infants as young as 3 months of age will glance at that object. Thus, they have the ability to follow another person's gaze—the minimal requirement for joint attention. However, given the brevity of the young infant's puppet-directed shift in gaze, it should only be considered a precursor of a joint attention mechanism. This response may not match the complex joint attention responses of older infants described by Butterworth (1991) and others.

AUTHORS' NOTE

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