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Brief report

Facing still faces: What visual cues affect infants' observations of others?

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ABSTRACT

We used eye-tracking technique to examine gaze shifts of 9-, 16-, and 24-month-old infants who were presented with still images of a conversation between two individuals facing each other or turning away from each other. The results showed that body orientation, as measured by the face-to-face effect, is sufficient to provide infants with crucial information about others' social engagement.

Decades of research inform us about how infants follow the gaze of another person and engage in dyadic interactions. However, their perception and understanding of others' social interactions remains a largely unexplored territory. Although we know that young children pay attention to conversations (e.g. Barton & Tomasello, 1991) and listen in on them (Rogoff, Paradise, Meija Arauz, Correa-Chavez, & Angelillo, 2003), we lack insight on the concrete cognitive mechanisms that are crucial for detecting, following and understanding social interactions between other individuals.

Measuring infants' gaze with eye-tracking technique can provide important information that feed into a clearer understanding of these processes. Previous investigations inform us that children are able to and become better at predicting turn-taking events in a conversation between 1 and 3 years of age and show a preference for social in comparison to non-social turn-taking events (Bakker, Kochukhova, & von Hofsten, 2011; von Hofsten, Uhlig, Adell, & Kochukhova, 2009). Even before predictive gaze shifts emerge, 3-month-old infants shift their gaze back and forth between two social partners (Fivaz-Depeursinge, Favez, Lavanchy, de Noni, & Frascarolo, 2005; McHale, Fivaz-Depeursinge, Dickstein, Robertson, & Daley, 2008) and do so less when an adult interacts with an object than with another person (Tremblay & Rovira, 2007). Not only the kind of interaction seems important, but also how two social partners are oriented to each other. A recent eye tracking study by Augusti, Melinder, and Gredebäck (2010) explored how the body orientation of adults in a conversation affect infants' gaze shifts. Between 4 and 6 months, infants begin to shift their gaze more often between actors that stand face-to-face instead of back-to-back to each other. In this article, we refer to these results using the term 'face-to-face effect'. These findings suggest that body orientation has an impact on how infants observe a conversation. At the same time, they trigger further questions: can body information alone inform infants about an ongoing interaction, much like gaze direction informs infants about where others are directing their attention? In other words, when young children are watching two individuals talk, what do they require to interpret this as a conversation? Maybe it is sufficient to see that two people are facing each other. That would mean that body orientation alone facilitates the face-to-face effect. Or does it take the addition of dynamic cues

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(such as motion) for infants to derive information from what they observe? In this study, we would like to propose that body orientation (as static visual information) is sufficient to perceive a communicative situation. Taken together, our study aims to clarify whether the face-to-face effect can be seen in response to static information of body orientation. Additionally, we would like to look beyond body orientation and explore infants' usage of information from others' eyes. The gaze following literature informs us that infants use others' gaze to guide their own attention (D'Entremont, 2000; Hood, Willen, & Driver, 1998). Not only eye gaze direction, but also the eye status – whether someone's eyes are open or closed – are informative to infants. This is not surprising because the high contrast information of the eye has been thought of as particularly salient facial information (Kobayashi & Kohshima, 2001). Around one year of age, infants are sensitive to the eye status of another person (Tomasello, Hare, Lehmann, & Call, 2007) and do not follow her gaze when her eyes are closed (Brooks & Meltzoff, 2005). Thus, closed eyes change the communicative meaning of a dyadic/triadic social situation. In the current study we were interested if, in the context of others' social engagement, eye status would influence infants' gaze shifts. Given the previous findings on the role of eye status, we would like to propose that eye status as static visual has an effect on how infants perceive a social situation (i.e. resulting in a different amount of gaze shifts depending on eye status). Taken together, the current study aimed to explore the role of static visual information, namely body orientation and eye status, in infants' observation of social scenes.

The final sample consisted of 15 infants at 9 months of age ($M = 279$ days, $SD = 5$ days, 5 boys), 15 infants at 16 months of age ($M = 506$ days, $SD = 9$ days, 8 boys) and 16 infants at 24 months of age ($M = 736$ days, $SD = 10$ days, 5 boys). All infants were born within three weeks of the expected date. One additional 9-, one 16-and two 24-month-olds were excluded for lack of attention. Another eight 9-month-old infants were excluded due to an error in the stimulus presentation. The study was conducted at the Uppsala Child- and Babylab and approved by the Regional Ethic Committee according to the 1964 Declaration of Helsinki. Before the experimental session, participating families were informed about the purpose of the study and signed a consent form. Parents received a gift voucher (value: 10 €). The participants' gaze direction was measured by a Tobii T120 corneal-reflection near-infrared eye tracker (precision 1°, accuracy 0.5°, 50 Hz) using a standard 5 point calibration. All infants were seated in front of the eye tracker in a distance of 60 cm to the monitor, either in a safety car seat (9-month-olds), on their parent's lap (16-month-olds) or on a chair (24-month-olds). We presented the infants with colored images depicting two different adults in profile view before a white background. The adults were turned toward (face-to-face) or away (back-to-back) from each other and had open or closed eyes. The stimuli were created from individual photographs we took of three male and three female university students (profile view, one photo with open, one with closed eyes). We used GIMP to create the final images, each displaying a pair of individuals. Adults' face-to-face images with open eyes were taken as a template to create the other experimental conditions. We manipulated the body orientation of the adults by flipping their single images horizontally to create a back-to-back condition. To ensure a similar distance (18.0°) between the faces (length: 12.4°, width: 8.6°) in both conditions, we centered the flipping at the cheekbone. For the eyes closed conditions, we pasted the closed eye features onto the template picture with open eyes. Cloning and smoothing tools were used to obtain a natural result. Each face appeared once at the right and once at the left side of the screen, resulting in a total of 120 images. These were further divided into two sets of 60 images (15 images per condition). Each child saw one set, half of each age group saw the first, the other half the second set. The experiment lasted approximately 30 min and contained two blocks of stimuli presentation, which were divided by a break. Each block lasted for 3.5 min and contained 30 trials. Each trial consisted of an attention grabber (2 s), followed by an image (5 s). Trials were presented in randomized order. We analyzed gaze shifts the infants made between the two adults. More specifically, our dependent variable was the average number of gaze shifts per picture between two pre-defined Areas Of Interest (AOI) (Fig. 1, A).

The size and position of the AOIs was kept identical for all images. Gaze shifts require saccades following a fixation in one followed by a fixation in the other AOI. For the detection of fixations we used the Tobii fixation filter with a fixation radius of 35 pixels. Data were exported from Tobii Studio into AVI-format and were analyzed using a frame-by-frame resolution in VirtualDub (www.virtualdub.org). The gaze replay movies were time-locked at 50 Hz and included both gaze shifts and the stimuli. Data analysis was performed using a general linear model with mixed factorial design. This included the between-subject-factor AGE (9-, 16- and 24-month-olds) and the repeated within-subject-factors BODY (face-to-face and back-to-back) and EYES (open and closed). The results of the repeated-measures ANOVA showed a main effect of body orientation ($F(1,43) = 7.95$, $p = .007$, $\eta p^2 = .156$). The face-to-face condition resulted in more gaze shifts ($M = 1.799$, $SE = 0.105$) than the back-to-back condition ($M = 1.617$, $SE = 0.086$). There was no significant main effect for eye status ($F(1,43) = 1.09$, $p = .302$, $\eta p^2 = .025$). Furthermore, there was a main effect of age ($F(2,43) = 3.74$, $p = .032$, $\eta p^2 = .148$) with increasing gaze shifts over age and, as a Scheffé-test showed, a significant difference ($p = .004$) between the 9- ($M = 1.461$, $SE = 0.157$) and the 24-month-old infants ($M = 2.041$, $SE = 0.152$). The mean gaze shifts for each condition are presented in Table 1.

When taking a closer look at the main effect of body orientation in each age group, we found that 66.6% of 9-month-old participants had a face-to-face effect (more gaze shifts in the face-to-face than back-to-back condition) as well as 60% of the children in the group of 16-month-olds and 68.75% in the 24-month-olds (Fig. 1).

Our results support the hypothesis that body orientation is sufficient to affect infants' gaze shifts because our data show a similar pattern to the findings of Augusti et al. (2010). Therefore, we can conclude that from the age of 9 months onward, body orientation – as static visual information – functions as a cue for infants' observations and guides their attention, explaining the face-to-face effect. Apparently, infants do not need to rely on any other visual or auditory information – such as contingent motion cues or language – to make such a differentiation. Furthermore, the current data support the hypothesis that infants

Table 1
Mean number of gaze shifts and standard error values for each experimental condition and age group.

Age	Condition	Mean	Standard error
9-month-olds	Back-to-back	1.39	0.126
	Face-to-face	1.531	0.123
	Eyes closed	1.448	0.116
	Eyes open	1.495	0.117
16-month-olds	Back-to-back	1.496	0.126
	Face-to-face	1.749	0.161
	Eyes closed	1.551	0.136
	Eyes open	1.656	0.138
24-month-olds	Back-to-back	1.965	0.181
	Face-to-face	2.116	0.234
	Eyes closed	1.99	0.19
	Eyes open	2.073	0.218

do not use eye status as a cue when they only rely on static information. This is particularly interesting, given the earlier reports from gaze following studies, suggesting sensitivity to eye status from 10 or 11 months of age (Brooks & Meltzoff, 2005). Therefore, eye status per se is not important in the current context but most likely becomes relevant in combination with other cues (except body orientation) in a richer social context. The current study marks the first step of exploring the meaning of static visual information for infants' observation. Expanding our knowledge on how infants' observe others interaction is important for several reasons. First, knowing at what age infants can understand certain information from social interactions informs about how their language understanding develops when they listen in on others' conversations. Second, it can help to further define from what point infants are less dependant on scaffolding from dyadic cues and how they perform in monitoring others (Carpenter, Nagell, & Tomasello, 1998). These new insights can also inform the robotic community by helping to further develop models of the face-to-face effect in robots (Wilkinson, Metta, & Gredebäck, 2011). Future studies should continue to map out the importance of different cues of infants' observation of others' interactions. Possible next steps are to explore whether different factors of gaze, namely body orientation, head direction and eye gaze direction (Kobayashi & Kohshima, 2001), have an impact on the infants' observation. Furthermore, it needs to be investigated how contingent events and mutual gaze (between actors and the infant) influence infants' gaze shifts in the context of static as well as dynamic visual information.

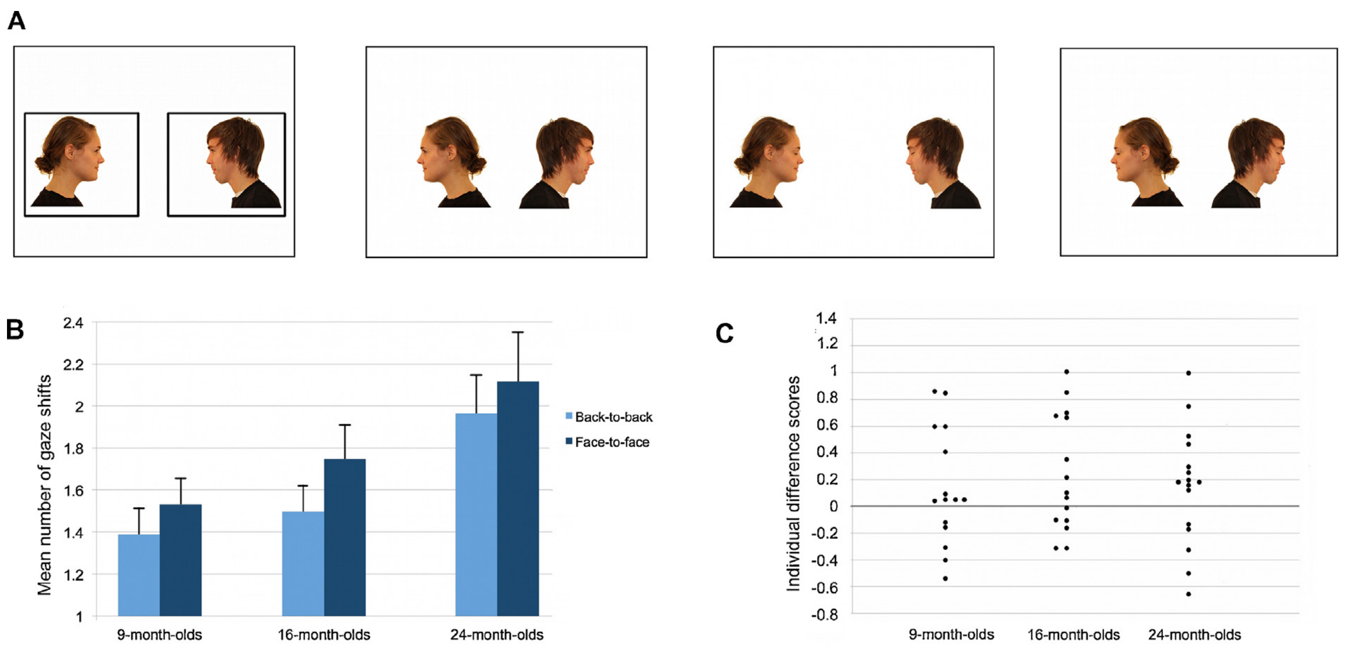

Fig. 1. (A) Experimental design with 4 conditions (from left to right): face-to-face, back-to-back, face-to-face eyes closed, back-to-back eyes closed. (B) Infants make more gaze shifts in the face-to-face than in the back-to-back condition. The *y*-axis displays the mean number of gaze shifts during the 5 s of stimulus presentation. Columns represent conditions, grouped by age (*x*-axis). Error bars indicate standard error values. (C) Individual (averaged) difference scores per age group for body orientation. Positive values indicate more gaze shifts to the face-to-face than the back-to-back conditions.

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