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Gaze following as a function of affective expression in 3-, 6- and 9-month-old infants

Isabel De Groote [a,*], Herbert Roeyers [a], Tricia Striano [b,c]

[a] *Research Group Developmental Disorders, Ghent University, Ghent, Belgium*
[b] *Neurocognition & Development Group, Center for Advanced studies, University Leipzig, Leipzig, Germany*
[c] *Kennedy Center for Human Development and Department of Pediatrics, Vanderbilt University, Nashville, United States*

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Abstract

The influence of affective expression on gaze following was investigated in 3-, 6- and 9-month-old infants. Gaze following became more robust at the older ages. There was no strong evidence that infants' gaze following activity was differentially influenced by the adult's affective expression, but rather for a developmental difference in emotion processing.

Keywords: Infants; Gaze following; Emotion processing; Joint attention; Affect

The ability to follow another person's gaze to the object of their attention is considered as an early manifestation of joint attention (e.g., Butterworth & Cochran, 1980). Since the original work of Scaife and Bruner (1975), researchers have probed the ability of young infants to follow others' gaze. Many studies placed the onset of gaze following from about 9 months of age or later (for a review, see Butterworth, 2004). However, when using less stringent criteria, gaze following can be observed at least as early as 3 months (D'Entremont, 2000; Hood, Willen, & Driver, 1998). From about this age, infants are also able to process information about these objects (Reid & Striano, 2005; Reid, Striano, Kaufman, & Johnson, 2004). As infants are increasingly involved with objects at 5 to 6 months of age, gaze following becomes more flexible. However, these are still fragile forms of gaze following and are highly dependent on context. For instance, position (within or beyond the visual field) and motion (stationary versus moving) of the target object influence the gaze following of young infants (D'Entremont, 2000). Also, salience and redundancy affect gaze following of 9-month-old infants (Flom, Deák, Phill, & Pick, 2004). In addition, 12- and 18-month-old infants are more likely to follow gaze when the objects are distinctive and complex, e.g., multicolored and uniquely shaped (Deák, Flom, & Pick, 2000). The ability to integrate information across spatiotemporal gaps is considered one of the underlying processes that allow the transition to more robust forms of gaze following after 9 months of age (Butterworth, 2004).

An adults' affective expression might also influence infant gaze following. This may be especially true for preverbal infants, given that affective expressions are important for social signaling (Papoušek & Papoušek, 2002). The influence of affective expression on infants' exploratory behavior is clear in social referencing from about 12 months of age

* Corresponding author at: Ghent University, Research Group Developmental Disorders, H. Dunantlaan 2, B – 9000 Gent, Belgium. Tel.: +32 9 264 91 06; fax: +32 9 264 64 89.
E-mail address: Degrooteisabel@yahoo.com (I. De Groote).

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(e.g., Repacholi, 1998). There is evidence for discrimination among different facial expressions after 2 months of age, as infants increasingly scan internal features of the face (for a review, see Witherington, Campos, & Hertenstein, 2004). For example, 10-week-old infants looked away from their mother significantly more when she directed an angry expression towards them, compared to directing a happy expression (Haviland & Lelwica, 1987). Infants not only react to facial expressions, but also to paralinguistic aspects of affective expressions, such as pitch or tone of voice (Reissland & Shepherd, 2002). Additionally, infants integrate affect from the face and voice. For example, tone of voice and facial expression of a strange adult that were emotionally congruent elicited a larger positive component in 7-month-old infants' ERP than did emotionally incongruent information (Grossman, Striano, & Frederici, 2006; Walker, 1982). Accordingly, Flom and Pick (2005) investigated to what extent adults' affective – facial – expression influenced 7-month-old infants' gaze following. Infants were assigned to one of three affective expressions (sad, happy, neutral) displayed by the experimenter. The results showed that when the experimenter displayed a neutral affective expression towards the object, infants followed the gaze more than when the experimenter displayed a happy or sad expression. Only when the experimenter displayed a neutral expression was the difference between looks to the correct and incorrect objects significantly different from chance (i.e. zero). The authors argued that the infants focused their visual attention on the adults' affective display rather than its referential nature.

In the current study, we extended the question originally posed by Flom and Pick. In particular, we were interested in the development of the capacity to follow another's gaze as a function of affective expression. We tested 3-, 6-, and 9-month-old infants. In addition, we manipulated the adult's facial and vocal expression – unlike face only as in Flom and Picks' original study. Baldwin and Moses (1994) suggested that infants are less confused about the topic of affective communication if referential cues are clear and strong (i.e. multiple cues). We examined the influence of affective expression on 3-, 6- and 9-month-olds' gaze following. A happy and disgusted expression was displayed by congruent facial and vocal expressions. These two expressions were used in previous research on the relation between affective expression and social referencing, as a form of joint attention (e.g. Baldwin & Moses, 1994; Hornik, Risenhoover, & Gunnar, 1987; Repacholi, 1998). As a working hypothesis, we expected that the infants, independent of age, would follow the gaze of the partner more when she expressed happiness compared to when she expressed disgust.

1. Method

Forty-five healthy infants participated. There where 3 age groups: 3-month-olds ($n = 16$, $M = 3$ months 7 days, 9 males and 7 females), 6-month-olds ($n = 16$, $M = 6$ months 18 days, 7 males and 9 females) and 9-month-olds ($n = 12$, $M = 9$ months 29 days, 6 males and 6 females). Infants where recruited from a database of infants from families who had expressed interest to participate in child development research. Infants were from White, primarily middle-class families living in the east of Germany. Data from 13 additional infants were excluded due to preterm birth ($n = 1$), or for failing to complete all phases of the study due to fussiness (6 months, $n = 2$; 9 months, $n = 9$), or technical failure (6 months, $n = 1$). Fussiness was defined as crying for more than 20 s. The parents gave their consent for participation. The children received a small gift after completion of the session.

The experiment took place in a small laboratory room (approximately 2 m × 2 m). The infants sat in a commercial infant seat, placed on a table. The experimenter sat on a chair facing the infant. The infant and the experimenter were sitting at eye-level, about 60 cm apart from each other. Two multicolored balls of about 10 cm were mounted on posts, at the eye-level of the infant. The posts were positioned about 60 cm away, one to the right and one to the left at about 45° from the infant's midline. Two digital video cameras at a distance of about 1.5 m from the infant, took a close-up of the infant's behavior. A third video camera recorded the behavior of the experimenter. The output of the three cameras was fed into a digital quad. The wall, table, posts and camera tripod where covered with black curtains to minimize visual distraction.

The experiment started with a dyadic interaction. When the experimenter judged that the infant was alert and looking to her, she started the first trial. Each infant received 10 trials: 5 trials with happy affect in block and 5 with disgusted affect in block. Side and order were counterbalanced across infants. Each trial took about 16 s and consisted of a short normal, playful 'dyadic' interaction for about 8 s, followed by the experimenter turning her head and eyes towards the target object for about 8 s and expressing the emotion. When the experimenter judged that the infant was distracted or not engaged in the dyadic interaction, the experimenter continued the dyadic interaction until the child was engaged. The facial expressions were based upon the descriptions by Ekman and Friesen (1975). Affect was displayed by congruent facial and vocal expressions. Happy affect consisted of a very happy, smiling face and a very happy tone of

voice. Disgusted affect meant expressing disgust by face (by lifting the upper lip which creates wrinkles on the nose and lowering the inner corner of the brow) and voice. In both conditions the experimenter was describing the object, through which the content of the talk was neutral. All the infants were tested by the same female experimenter.

One observer blind to the hypothesis and conditions coded all tapes. The observer first coded the behavior of the experimenter and thereafter the behaviors of the infant. The experimenter's behaviors were categorised as: (a) looking to the right side, and expressing happiness, (b) looking to the right side, and expressing disgust, (c) looking to the left side, and expressing disgust, (d) looking to the left side, and expressing happiness. For the infant, only the first head or eye turn after an adult head turn was coded: (a) looking to left object (b) looking to right object, (c) no change: looking to the experimenter's face (d) looking away: infant looks somewhere else than at the experimenter or in the horizontal plane (e.g., looking at the correct side but not exactly to the target object, looking towards the ceiling, seat or his or her feet).

After coding the behaviors, each infant look was categorised as a correct look if the infant matched the target of the experimenter's turn, or 'incorrect look' if it was to the opposite target. Following the standard gaze following literature (e.g., Brooks & Meltzoff, 2005; Corkum & Moore, 1998; Flom et al., 2004), we calculated a difference score, by subtracting the number of correct incorrect looks from the number of the correct looks. Infant looks categorised as no change or looking away were not included in the calculation of the difference score. As we had five trials in each affect condition, the possible range for the looking score could vary form −5 to +5.

The latency of the gaze following was also analysed, defined as the time lag from the start of the head turn period (i.e. start of head turn of the experimenter) to the occurrence of the first head turn of the infant that matched the adult head turn. Following Brooks and Meltzoff (2005), we also created a dichotomous score (yes or no) for whether or not the infants looked at the correct target on any trial. A second observer independently coded 25% randomly selected infants. The mean Cohen's Kappa for all variables was at least .91.

2. Results

As measured by an independent *t*-test, there was no significant effect of the lateral position of the target object (right versus left) on the frequency of gaze following in the happy condition and disgust condition, and no significant presentation-order effect for frequency of gaze following in the happy condition and in the disgust condition (all $ps > .10$). All subsequent analyses were collapsed across these variables.

To test if infants were reliably demonstrating the capacity to follow gaze across both affect conditions, the mean difference score was compared to chance (i.e. zero) using a single sample *t*-test. There was a trend that 3-month-olds followed the gaze more than chance in the disgust condition $t(15) = 1.96$, $p = .07$, but not in the happy condition. However, only a minority of the 3-month-old children had looking scores that were higher than zero, indicating that the results for the disgust condition were carried by only a few infants with large positive looking scores (see Fig. 1).

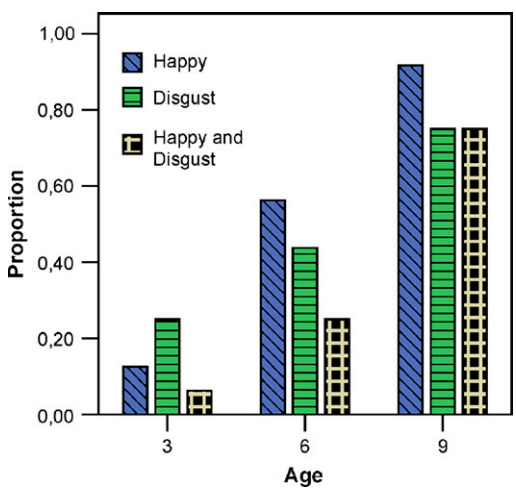

Fig. 1. Proportion of infants in each age group and condition who had a looking score greater than zero in happy versus disgust versus both conditions.

Table 1
Mean and standard deviation for gaze following in each age group and condition

Variables	Age group		
	3 months	6 months *M* (S.D.)	9 months
Happy condition			
Difference score	−.12 (1.09)	1.44 (2.31)	2.25 (1.48)
Correct looks	.16 (0.34)	2.00 (1.90)	2.50 (1.44)
Incorrect looks	.25 (1.00)	.56 (0.89)	.25 (0.62)
Disgust condition			
Difference score	.69 (1.40)	1.00 (1.83)	2.42 (2.07)
Correct looks	.69 (1.40)	1.31 (1.74)	2.75 (1.86)
Incorrect looks	.00 (0)	.31 (0.60)	.33 (0.49)

Six-month ($t(15) = 2.49$, $p < .05$, $t(15) = 2.19$, $p < .05$) as well as 9-month-olds ($t(11) = 5.25$, $p < .00$ and $t(11) = 4.05$, $p < .00$) followed the gaze significantly more than chance in the happy, as well as in the disgust condition (see Table 1). As measured by a chi-square analysis, the number of infants who looked reliably in the happy condition, as well as in the disgust condition, differed significantly accordingly to age, χ^2 $(2, N = 44) = 17.58$, $p < .00$ and χ^2 $(2, N = 44) = 6.94$, $p < .05$ (see Fig. 1).

As only a minority of the 3-month-old children had a positive looking score we did not include this age group in the next analyses on the possible differential effect of affect.

First, we performed a 2 (age: 6 versus 9) × 2 (condition: happy versus disgust) analysis of variance (ANOVA) on the frequency of gaze following. There was no significant main effect of affect, $F < 1$ or interaction effect of affect and age, $F(1, 26) = .30$, N.S. However, the between-subject age reached significance, $F(1, 26) = 4.75$, $p = .04$. Six-month-olds followed gaze significantly less than 9-month-olds. Doing the same analysis, when including only the 6 and 9-month-olds who reliably followed gaze (difference score >0) in minimum one condition, revealed similar results. There was no significant main effect of affect and no affect x age interaction. Results were similar when using age as covariate.

Additionally, in examining how quickly the infants looked (latency) to the target object in both affect conditions, we only included infants who had a first head turn that matched the direction of the adult head turn in both conditions. Three (19%) 3-month-old infants, 7 (44%) 6-month-old infants and 11 (92%) 9-month-old infants met this criterion. Therefore, 3-month-olds were not entered into this analysis. We performed a 2 (age: 6 versus 9) × 2 (condition: happy versus disgust) ANOVA. There was no main effect of affect (i.e. condition), $F(1, 16) = 2.03$, $p = .17$, and age, $F < 1$. However, there was a significant interaction effect of affect and age on the latency of the first look to the target object, $F(1, 16) = 5.76$, $p = .03$. Six-month-olds looked more quickly to the target object when the experimenter expressed happy affect, while 9-month-olds looked more quickly when the experimenter expressed disgusted affect (See Fig. 2). The same age × affect interaction effect was found when only taking into account the 6- and 9-month-old infants who reliably followed gaze in both conditions, $F(1, 11) = 8.12$, $p < .05$. When using age as covariate, there was a main effect of affect, $F(1,16) = 7.47$, $p < .05$, and an age × affect effect, $F(1,16) = 6.71$, $p < .05$, but no main effect of age. However, when restricting the analysis to each age group (6 and 9 months), there was only a main effect of affect in the 6-monh-old age group, but not in the 9-month-old age group. Six-month-old infants looked more quickly in the happy affect condition, while 9-month-old infants were equally fast in both conditions.

One possibility for why there was a trend for 3-month-olds to follow the gaze of the experimenter only in the disgust condition at a level greater than chance might be that the infants looked longer away from the face of the experimenter due to an induced disgusted affect. By looking away, it could be that they had more chance to detect the object. We therefore examined whether the duration of looking to the face of the examiner differed across conditions. Only the 8 s following the head turn of the experimenter were coded. This hypothesis was not confirmed by a 2 (age: 3 versus 6 versus 9) × 2 (condition: happy versus disgust) ANOVA. There was no main effect of condition, $F(1, 41) = 2.72$, N.S. or interaction effect of condition and age, $F(2, 41) = 95.76$, N.S. However, there was a trend for a main effect of age, $F(2, 41) = 2.63$, $p = .08$. Three-month-olds tended to look more to the face of the examiner than 9-month-olds (Post hoc Test, Tukey, $p = .07$).

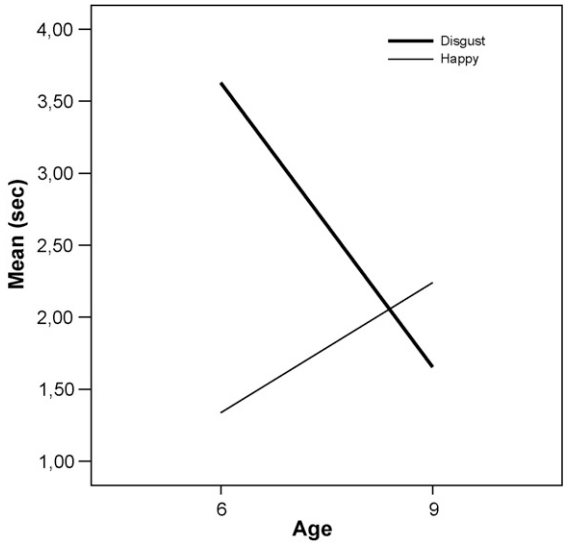

Fig. 2. Latency of gaze following in disgust and happy condition.

3. Discussion

The preliminary aim of this study was to determine if the affective expression of the interacting partner has an influence on infants' gaze following. As both emotion recognition and gaze following are gradually developing skills, 3-, 6-, and 9-month-old infants were tested. We used a modified joint visual attention task, in which the emotions of the interacting adult were varied and displayed in a congruent, multimodal way.

This study supports the existing literature that gaze following is a gradually developing skill that can already be observed in some 3-month-old infants. D'Entremont (2000) found that 3- and 6-month-olds followed the adults' gaze when the target object was placed at 40° from the infant's midline. These results support the view of Butterworth (2004), who suggests that 3-month-olds exhibit a 'fragile' form of gaze following compared to the more 'robust' gaze following of 9-month-olds. In our study, there was a tendency for 3-month-olds to follow gaze more reliably when the experimenter expressed disgust. However, as only a minority of the 3-month-olds followed gaze reliably, the results were carried by only a few infants with large positive looking score. About half of the 6-month-olds and the majority of the 9-month-olds followed gaze reliably. As we found that 3-month-olds tended to look more than chance when the experimenter expressed disgust, the question could be whether the 3-month-old infants did look to the side as a consequence of the negative expression of the experimenter. Overall, it is clear that infants preferentially look at happy poses over sad, neutral or angry poses from early in development (Haviland & Lelwica, 1987). It may be that the more negative affective expression, thus a less pleasant interaction, led to more gazing away from the face of the experimenter. It could therefore be that the infants in our study noticed the object by coincidence when looking away. However, the infants did not avert their gaze from the experimenter more when she displayed disgust compared to when she displayed happiness. Additionally, only looking at the target object was taken into account. Looking to the correct side, without fixating the object was not counted as a correct look. The finding that the 6-month-old infants of all ages looked more than chance in one or both conditions is to some extent in contrast with the results of Flom and Pick (2005), who found that 7-month-olds' frequency of gaze following did not reach significance when the interacting partner showed a happy or sad expression, but only when a neutral expression was displayed. One of their hypotheses was that the infants were attending to the information that was 'most interesting' or 'easiest to detect'. One possible explanation for the inconsistency with their finding is that the facial expressions were combined with a corresponding vocal expression in our study. However, approximately the same number of infants in both studies followed gaze, suggesting that the children in our study would follow gaze more when a neutral expression was displayed. It should be noted, however, that this skill may be rather "head following" than gaze following. Nine-month-olds follow an adults' head movement even when the eyes of the interacting person are closed, whereas 10-11-month-olds significantly followed adult turns more often when the eyes were opened (Brooks & Meltzoff, 2005).

Regarding the main question on the relation between the affective expression and gaze following, we explored the effect of disgust and a happy expression. Contrary to our hypothesis, we did not find a clear evidence for a differential effect, when taking into account the frequency of gaze following and latency of gaze following. We expected that infants would differentiate when the affect would be presented in a multimodal way. When taking into account how quickly the infants looked to the target object, there was only a clear differential effect in the 6-month-old infants. As only a minority of the 3-month-olds followed gaze reliable, we did not take into account this age group. Six-month-olds looked more quickly to the target object when the experimenter displayed a happy expression towards the object. In contrast with this, 9-month-olds looked equally fast when the experimenter expressed disgust versus happiness towards the object. The same result was found when only the infants who reliable followed gaze were included in the analysis.

Our results suggest that infants are motivated to look where the other person is looking, no matter which emotion the other person is displaying. However, our hypothesis that affect has a differential effect on very young infants' gaze following rate and speed was not supported. In this sense, our results are in line with Flom and Pick (2005), reporting that young infants do not understand the referential nature of emotions. Our results rather provide evidence for age differences in emotion processing. Disgusted emotion seems more difficult to process, as there were longer latencies in the young age group. There is some evidence for this result in literature. Seven-month-old infants not only discriminated between emotional congruence and incongruence in facial and vocal expression, but also between two incongruent conditions. Namely, when a happy face was presented with an angry voice, a larger negative component in infants' ERPs was elicited than when an angry face was presented with a happy voice. The authors stated that happy emotional expressions are ubiquitous in infants' everyday social interactions, while expressions of anger are generally less common early in development (Grossman et al., 2006). The same argument may be applicable for happy versus disgust emotions.

Given the limited sample, the results should be interpreted with care. In future studies it will be useful to test more infants and across a wider range of emotions. The inclusion of a neutral condition was not included in our study, given the possibility of carryover effect and losing children because of fatigue. Including a neutral condition would be useful in further studies.

In sum, gaze following is a gradual developmental skill. There seems no evidence that infants understand the referential meaning of emotions at 9 months of age or earlier. The results rather provide evidence for differences in emotion processing as a function of age, with disgusted emotion being more difficult to process before 9 months of age. Future research will be needed to determine possible age differences in emotion processing in general as well age differences in understanding emotions in a referential context.

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