

Direct Gaze May Modulate Face Recognition in Newborns

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Faces are important for non-verbal communication in daily life, and eye gaze direction provides important information for adult–infant interaction. Four-month-old infants and adults better recognize faces when accompanied with direct gaze, suggesting a special status of ‘eye contact’. Whether mutual gaze plays a role in face recognition from birth, or whether it requires expertise, is investigated in this paper. We conducted a between subjects design, for a total of four experiments, two involving habituation (1a, 1b) and two involving preference tests (2a, 2b), to investigate newborns’ ability to recognize faces when gaze direction is manipulated. We predicted that a face accompanied with direct gaze would be better recognized by newborns. In contrast, we expected no evidence of identity recognition when newborns were familiarized with a face with averted gaze. According with our expectations, newborns were able to recognize a face identity when previously familiarized with direct gaze, but not with averted gaze. However, this effect was face identity-specific. Overall, our results suggest that direct gaze can modulate face processing and affects preferences and face identity learning in newborns. Copyright © 2010 John Wiley & Sons, Ltd.

Key words: newborns; face recognition; gaze direction

Given their communicative importance, eyes are a central characteristic of faces. Information from the eye region is important for different functions in social interaction, such as the automatic shifting of attention (Driver *et al.*, 1999; Friesen & Kingstone, 1998), regulating turn taking in conversation (Argyle & Cook, 1976), and inferring mental states (Baron-Cohen, 1995). In this study, we aim to investigate the

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role of direct and averted gaze in identity recognition at birth. Newborns are attracted by open eyes (Bakti, Baron-Cohen, Wheelwright, Connellan, & Ahluwalia, 2000) and prefer to look at faces with direct gaze rather than averted gaze (Farroni, Csibra, Simion, & Johnson, 2002). Further, neonates' preference for eye contact is sensitive to the contrast polarity of the inner elements (pupil and sclera), as they are not attracted either by a face-like configuration or real faces with typical face phase contrast reversed (Farroni *et al.*, 2005). In fact, it is demonstrated by the Bogart illusion in adults that perceived gaze is defined on the basis of a darker spot (iris/pupil) within a lighter background (sclera) (Sinha, 2000). Even newborns have been shown to be sensitive to this contrast, as they do not prefer upright to inverted face-like configurations when presented with white elements on a dark background (negative polarity) (Farroni *et al.*, 2005). In contrast, the preference for upright faces was established with configuration of black elements on a white background (positive polarity), and by placing dark irises within the white elements in the negative polarity face configurations. Given these early and well-established predispositions to discriminate fine details of faces, we can address the question how eye gaze affects face recognition very early in development.

Adults and infants electrophysiological studies have provided evidence supporting the importance of the eye region within a face. Face-sensitive neural responses occurring 170 ms after stimulus onset have been measured in humans using scalp electrodes (Bentin, Allison, Puce, Perez, & McCarthy, 1996). This early component, named the N170, is thought to reflect basic structural encoding of faces, and it has also been observed in infants ('infant N170', de Haan, Pascalis, & Johnson, 2002). In addition, Farroni *et al.* (Farroni *et al.*, 2002) tested 4-month-old infants with faces displaying direct and averted gaze, and showed that direct gaze processing modulates the 'infant N170' by enhancing its amplitude.

Eye gaze direction is also an important indicator of another individual's focus of attention (Kleinke, 1986). Several studies have demonstrated that eye gaze and head position induce the observer to shift attention automatically in the direction indicated by these cues (Friesen & Kingstone, 1998; Langton & Bruce, 1999). It has been shown that seeing such social cues may trigger a reflexive visual orienting in the cued direction. Studies based on Posner's (1980) classic spatial cuing paradigm found that unilateral targets are detected faster when a central face is gazing in the direction of the target location (valid condition) than to the opposite site (invalid condition). Gaze cuing effects have also been demonstrated in young infants by measuring saccadic reaction times to target stimuli after gaze cues (Farroni, Johnson, Brockbank, & Simion, 2000; Hood, Willen, & Driver, 1998). Farroni *et al.* (2000) provided evidence that the direction of perceived motion of stimulus elements is the most important factor in subsequently directing infants' attention to peripheral targets. In addition, Farroni, Mansfield, Lai, and Johnson (2003) showed that 4-month-old infants could follow adults' eye movements if they have previously been engaged in a period of mutual gaze.

Data from these behavioral studies converge well with neuroimaging data from studies with adults, suggesting that there are specialized brain mechanisms that are sensitive to eyes, eye movement, and gaze direction (Allison, Puce, & McCarthy, 2000; Calder *et al.*, 2002; George, Driver, & Dolan, 2001; Hoffman & Haxby, 2000). Gaze direction analysis and spatial attention orienting may constitute one part of the distributed neural system involved in face processing (Haxby, Hoffman, & Gobbini, 2000). Haxby *et al.* (2000) have proposed a model of the neural human system that mediates face perception. They suggested a distinction between the representation of invariant aspects of faces that underlie recognition of individuals, and the representation of changeable aspects of faces,

such as facial expression and eye gaze, which play a more central role in social communication. Recently, Engell and Haxby (2007) investigated facial expression and gaze direction in human superior temporal sulcus. They found that within the right superior temporal sulcus distinct, though overlapping, regions support expression and gaze direction perception.

While neuroimaging data are in support of dissociable systems involved in face perception, findings from behavioral studies suggest that identity recognition and facial expression, and facial expression and eye gaze processing are interconnected, and not completely independent (Ganel, Goshen-Gottstein, & Ganel, 2004; Ganel, Goshen-Gottstein, & Goodale, 2005; Winston, Henson, Fine-Goulden, & Dolan, 2004). Using Garner's paradigm, the observation that a change in one dimension impairs the ability to detect changes in the other dimension, yields evidence that, although identity and emotion may be processed by partially dissociable neural systems, the two pathways are likely to interact in the production of behavioral responses (Winston *et al.*, 2004) and that computing gaze direction is an essential component of expression processing (Ganel *et al.*, 2004).

Fewer studies have investigated the interaction between these three dimensions in infants. Recently, Farroni, Massaccesi, Menon, and Johnson (2007) investigated whether gaze direction has any effect on face identity recognition in 4-month-old infants. Infants were tested with a visual habituation procedure with faces presenting both direct and averted gaze. Following exposure to a face with direct gaze, infants subsequently showed evidence of having recognized the face. In contrast, no such preference has been observed in infants habituated to a face with averted gaze. As a result, eye contact seems to elicit deeper processing of a face by infants.

The issue addressed in the current work is to investigate whether the findings found with infants (Farroni *et al.*, 2007) can be extended to newborns, and therefore whether eye contact may elicit deeper face processing from birth without the need of experience. A definitive answer to this last question is anyway difficult to ascertain as newborns at the time of testing will have at least few hours of experience with conspecifics. However, the attempt is to identify visual responses to gaze direction as early as possible, in order to be able to hypothesize the presence, or the absence, of pre-determined mechanisms that guide and engage newborns' responses in presence of direct gaze. Therefore, in the present study we investigated the role of gaze direction in face recognition at birth, carrying out visual habituation and preference tests and presenting newborns with the same stimuli used by Farroni *et al.* (2007). Because of newborns' short span of attention, a total of four experiments were run, each with a different group of babies. Since newborns prefer to look at faces with direct gaze (Farroni *et al.*, 2002), and infants as young as 4-month-old recognize faces displaying direct gaze (Farroni *et al.*, 2007), we predicted that babies habituated with a face accompanied with direct gaze will demonstrate recognition of that face by displaying a novelty preference for an unfamiliar stimulus. In contrast, we expected no preference when newborns were familiarized with a face presenting averted gaze. In each experiment, total looking times and frequency of orienting were calculated. Difference in total looking times has been recognized as evidence of discrimination among the stimuli, whereas orienting measures are likely to better reflect activity in subcortical pathways (Johnson, 2005).

EXPERIMENT 1

In the first two experiments (1a and 1b), we used a visual habituation procedure to investigate whether gaze direction modulates identity recognition from birth.

In Experiment 1a, newborns were shown a face with direct gaze, and subsequently given a preference test involving the same face and a novel one, both of them with direct gaze. The aim was testing whether eye contact attracts newborns' attention and induces identity recognition from birth. Since newborns prefer faces that look at them directly than faces with averted gaze (Farroni *et al.*, 2002), it is possible that, as with adults and 4-month-old infants, eye contact may modulate identity recognition at birth. In fact, if direct gaze evokes a deeper analysis of other aspects of the person's face such as identity, we predicted that newborns that had previously seen a face accompanied with direct gaze would subsequently demonstrate recognition of that face by displaying a novelty preference for an unfamiliar face.

In Experiment 1b, the same procedure and face stimuli were used, in order to test identity recognition when faces displayed an averted gaze. Therefore, newborns were presented with a face accompanied with averted gaze, and subsequently given a preference test involving the same face and a novel one, both of them with averted gaze. Farroni *et al.* (2007) found no recognition of individual faces in 4-month-old infants after familiarization with faces displaying averted gaze; therefore, we hypothesized that we would not find recognition of the habituated face in newborns.

Method

Participants

Full-term newborns were selected to participate in the study from the Pediatric Unit of the Hospital of Monfalcone. All newborns met the criteria of normal delivery, and an Apgar score of at least 8 at 5 min old.

A total of 16 newborns participated in Experiment 1a. A further 3 newborns were excluded from the analysis because of fussiness during the experiment, and 3 more due to a strong side bias. Their postnatal age was between 24 and 120 h (mean 56 h), and they had a birth weight between 2550 and 4370 g.

In Experiment 1b, 26 newborns were tested. Eight of them were not included in the final sample, 2 for strong side bias, 2 for technical errors and 4 for fussiness during the experiment. Thus, the final sample consisted of 18 babies. Their postnatal age was between 24 and 72 h (mean 45 h), and they had a birth weight between 2690 and 3880 g.

Parents were informed about the procedure and gave their consent to their child's participation.

Apparatus and stimuli

Newborns sat on the experimenter's lap in front of the monitor. The experimenter holding the newborn was not aware of the hypotheses under test. The newborn's eye level was aligned to the center of the screen at the same height as the eyes of the stimulus face. Each trial began with the flickering LED in the center. As soon as the newborn fixated on the light, another experimenter, who monitored the infant's eyes through a video camera, started the sequence of the trial by pressing a key on the computer keyboard. This action automatically turned off the LED, and the two stimuli appeared simultaneously on the monitor.

The stimuli were grey scale photographs of two real female faces. Two different face identities were used, face A and face B (Figure 1), presented on a 26-inch computer monitor at 35 cm distance from newborns. Faces subtended a visual angle of $33.4^\circ \times 22.6^\circ$ and the external contour of the eye was about $4.1^\circ \times 1.6^\circ$. The distance between the two stimuli was 7 cm.

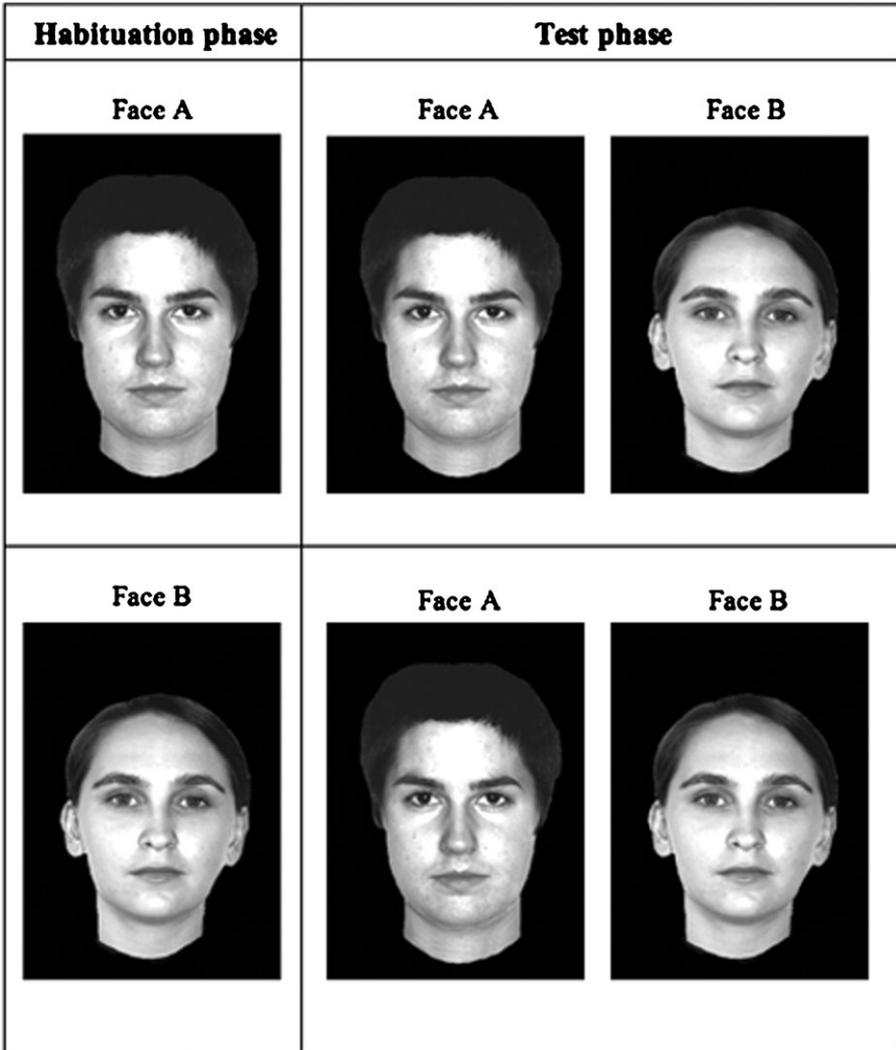


Figure 1. Stimuli used in Experiment 1a (habituation procedure with faces displaying a direct gaze).

Procedure

The experiments were carried out using a visual habituation technique with infant control procedure (Slater, Earle, Morison, & Rose, 1985). The infant was judged to have habituated when, from the fourth fixation on, the sum of any three consecutive fixations was 50% or less than the total of the first three fixations. When the habituation criterion was reached, the stimulus was automatically turned off and a preference test phase started. The initial side of the two stimuli, left or right, was counterbalanced across subjects.

During habituation two identical face images were presented (either face A or face B). The habituation was followed by a preference test in which a preference could be expressed between the familiar face and a novel one. The two test stimuli were shown in both left and right positions, the positions being

reversed from the first to the second presentation. Each presentation lasted at least 20 s.

The stimulus presented during the habituation was a face with direct gaze in Experiment 1a and a face with averted gaze in Experiment 1b. Habituation phase was followed by a preference test with the familiar face and a novel one, both of them with direct gaze (Figure 1) or averted gaze (Figure 2) in Experiment 1a and 1b, respectively. A video camera recorded the newborns' eye movement to monitor their looking behavior and to allow off-line coding of their fixations. Subsequently, two coders, who were unaware of the stimuli presented, analyzed videotapes of the baby's eye movements throughout the trial. The coders recorded, separately for each stimulus and each trial, the frequency of orienting

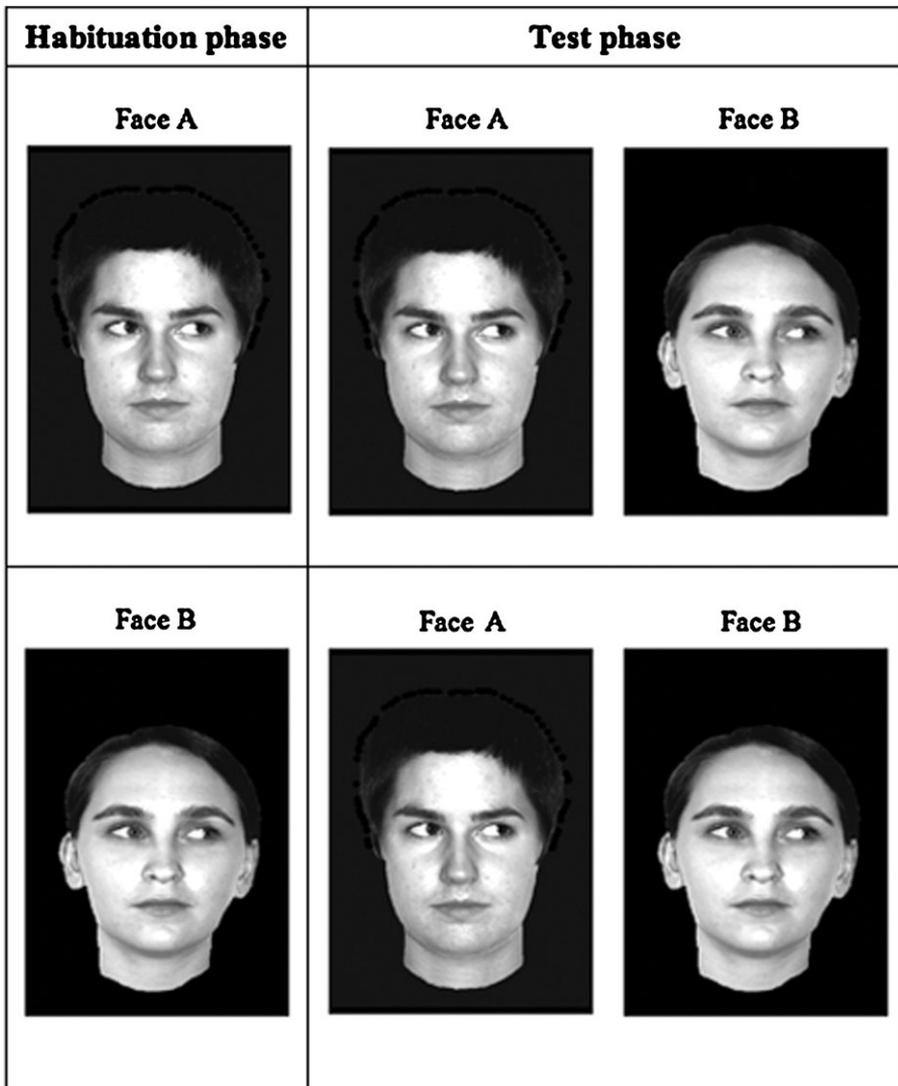


Figure 2. Stimuli used in Experiment 1b (habituation procedure with faces displaying an averted gaze).

response and the total fixation time. Interrater reliability was calculated for 10% of the participants in each experiment. High intercoder reliability was achieved (Cohen's kappa = 0.85 for the duration of fixation and 0.98 for the number of orientations).

Results and Discussion

A paired samples *t*-test was performed to compare the average total fixation time to reach the habituation criterion for the two faces in Experiment 1a. This comparison revealed no significant effect. During the test phase, data were analyzed performing a 2×2 analysis of variance (ANOVA), novelty (novel versus familiar) \times identity condition (face A or face B), to test whether infants were able to recognize the face seen in habituation phase. With regard to the total looking time, a main effect of identity was found ($F(1, 14) = 23.88, p < 0.001$) and the analyses revealed a significant interaction between novelty and identity ($F(1, 14) = 12.97, p = 0.003$). The novelty factor and the interaction with identity were significant for the frequency of orienting (novelty: $F(1, 14) = 8.67, p = 0.011$; interaction: $F(1, 14) = 14.11, p = 0.002$). As shown in Tables 1 and 2, newborns habituated with face A, tended to look towards the novel stimulus (face B) in the preference test (total looking time ($t(14) = 2.002, p = 0.065$); frequency of orienting ($t(14) = 2.081, p = 0.056$)), while newborns who saw face B, preferred looking at familiar stimulus (face B) in the preference phase (total looking time ($t(14) = -4.336, p = 0.001$); frequency of orienting ($t(14) = -2.420, p = 0.03$)).

A paired samples *t*-test was performed to compare the average total fixation time to reach the habituation criterion for the two faces in Experiment 1b. This comparison revealed no significant effect. As predicted, and shown in Tables 3 and 4, no significant effects came out for both the total looking time

Table 1. Mean total looking times (s) at the novel and familiar faces in Experiment 1a

| | N | Mean | S.D. | S.E. |
|--------------------------------|---|------|------|------|
| <i>Total looking times</i> | | | | |
| <i>Habituation with Face A</i> | | | | |
| Novel | 8 | 24.9 | 5.6 | 2.0 |
| Familiar | 8 | 17.9 | 6.7 | 2.4 |
| <i>Habituation with Face B</i> | | | | |
| Novel | 8 | 18.9 | 6.4 | 2.3 |
| Familiar | 8 | 38.2 | 11.4 | 4.0 |

Table 2. Frequency of orienting at the novel and familiar faces in Experiment 1a

| | N | Mean | S.D. | S.E. |
|--------------------------------|---|------|------|------|
| <i>Frequency of orienting</i> | | | | |
| <i>Habituation with Face A</i> | | | | |
| Novel | 8 | 5.9 | 1.8 | 0.64 |
| Familiar | 8 | 5.4 | 2.1 | 0.73 |
| <i>Habituation with Face B</i> | | | | |
| Novel | 8 | 3.4 | 2.0 | 0.72 |
| Familiar | 8 | 8.0 | 2.27 | 0.8 |

Table 3. Mean total looking times (s) at the novel and familiar faces in Experiment 1b

| | N | Mean | S.D. | S.E. |
|--------------------------------|---|------|------|------|
| <i>Total looking times</i> | | | | |
| <i>Habituation with Face A</i> | | | | |
| Novel | 8 | 20.8 | 7.4 | 2.5 |
| Familiar | 8 | 21.3 | 6.0 | 2.0 |
| <i>Habituation with Face B</i> | | | | |
| Novel | 8 | 19.0 | 10.0 | 3.3 |
| Familiar | 8 | 23.5 | 13.5 | 4.5 |

Table 4. Frequency of orienting at the novel and familiar faces in Experiment 1b

| | N | Mean | S.D. | S.E. |
|--------------------------------|---|------|------|------|
| <i>Frequency of orienting</i> | | | | |
| <i>Habituation with Face A</i> | | | | |
| Novel | 8 | 10.7 | 4.9 | 1.6 |
| Familiar | 8 | 9.8 | 3.2 | 1.1 |
| <i>Habituation with Face B</i> | | | | |
| Novel | 8 | 9.2 | 4.2 | 1.4 |
| Familiar | 8 | 10.0 | 3.8 | 1.3 |

(novelty: $F(1, 16) = 0.354$, $p = 0.560$; identity: $F(1, 16) = 0.020$, $p = 0.889$; novelty \times identity: $F(1, 16) = 0.228$, $p = 0.639$) and the frequency of orienting (novelty: $F(1, 16) = 0.005$, $p = 0.944$; identity: $F(1, 16) = 0.121$, $p = 0.733$; novelty \times identity: $F(1, 16) = 1.134$, $p = 0.303$).

An ANOVA between Experiment 1a and 1b, with novelty (novel or familiar) as factor within subjects and gaze (direct-Experiment 1a or averted-Experiment 1b) and identity (face A or face B) as factors between subjects, revealed a significant effect of the gaze, for both the total looking times ($F(1, 30) = 8.95$, $p = 0.006$) and the frequency of orienting ($F(1, 30) = 16.71$, $p < 0.001$). Newborns spent more time looking at faces with direct gaze ($m = 24.97$ s) than at faces with averted gaze ($m = 21.19$ s), but they oriented more frequently to faces with averted gaze ($m = 9.9$) than with direct gaze ($m = 5.8$). The apparent incongruence among the observed results may be explained by the meaning of the two measures. While orienting measures may better reflect the biases within a subcortical route (Johnson, 2005) since peripheral stimuli impinge on the temporal visual field, the longer duration spent looking at the direct gaze reflects experience acquired over the first few days. The ANOVA also revealed a main effect of identity ($F(1, 30) = 8.632$, $p = 0.006$), with longer looking times to face B ($m = 24.94$ s) than to face A ($m = 21.23$ s), and a main effect of novelty ($F(1, 30) = 7.45$, $p = 0.011$), with overall longer looking times to familiar faces ($m = 25.22$ s) than to novel faces ($m = 20.94$ s). These effects were modulated by a two-way interaction between gaze and identity ($F(1, 30) = 7.37$, $p = 0.011$) and a three-way interaction between

novelty, gaze and identity ($F(1, 30) = 4.10, p = 0.05$), which confirmed that newborns in Experiment 1a (direct gaze) preferred to look at face B than at face A after being habituated with face B ($t(14) = -4.336, p = 0.001$). A One-way ANOVA was also performed to compare the average total fixation time to reach the habituation criterion for the two faces in both Experiments 1a and 1b, and non-significant effects were yielded ($F(1, 31) = 0.311, p = 0.581$).

Findings from Experiment 1a, suggest that eye contact may induce identity recognition, but that this is not true for all the face identities. In fact, we found that newborns showed evidence of identity recognition, looking at the novel face (face B), following exposure to only one of the two face stimuli used (face A). As predicted, and in accord with a previous study involving 4-month-old infants (Farroni *et al.*, 2007) results from Experiment 1b show that faces with averted eye gaze do not facilitate subsequent recognition in newborns. Cross analyses between the two experiments revealed differential responses to the faces used: overall, newborns looked longer at faces with direct gaze, at previously seen faces, and they preferred face B. The interactions confirmed that newborns oriented to face B accompanied with direct gaze after being familiarized with it.

We conclude that newborns may show face recognition ability after exposure to faces with direct gaze, suggesting that eye direction is important for face recognition. As this ability was shown only for a specific face identity, it may also be that babies spontaneously prefer face B to face A. In order to test this latter hypothesis, in the next experiments two visual preference tests comparing faces A and B, first with direct gaze (Experiment 2a) and then with averted gaze (Experiment 2b), were carried out.

EXPERIMENT 2

The results obtained in Experiment 1 caused us to run two more experiments to explore further whether gaze direction is critical for face recognition at birth. In particular, as results from Experiment 1a indicated a possible spontaneous preference for one face over the other, we decided to conduct a visual preference test between the two faces used. Also, since the non-significant results from Experiment 1b led us to hypothesize that gaze direction plays a relevant role for identity recognition from birth, we ran a preference test between the faces with averted gaze.

In Experiment 2a and 2b, we ran a visual preference between the same stimuli previously used, accompanied with direct and averted gaze, respectively. Our aim was to test whether newborns show a visual preference for one of the two faces, since results from Experiment 1a suggested a visual preference for face B. Our hypothesis was that if babies show a face preference, regardless of gaze direction, it would mean that they process face identity independently from direct gaze. Alternatively, if neonates show a face preference for a face only when accompanied with a direct gaze, and not when accompanied with an averted gaze, it would mean that eye gaze direction affects face identity processing at birth.

Method

Participants

Full-term newborns were selected to participate in the study from the Pediatric Unit of the Hospital of Monfalcone. All newborns met the criteria of normal delivery, and an Apgar score of at least 8 at 5 min old.

In Experiment 2a, a total of nine newborns participated. One further newborn was not included in the final sample due to a strong side bias. Their postnatal age was between 24 and 120 h (mean 45 h), and they had a birth weight between 2780 g and 4120 g.

Nine newborns were tested in Experiment 2b. A further three newborns were excluded, one for a strong side bias, and two more for fussiness during the experiment. Their postnatal age was between 26 and 86 h (mean 52 h), and they had a birth weight between 3210 and 3810 g.

Parents were informed about the procedure and gave their consent to their child's participation.

Apparatus and stimuli

The apparatus was the same used in Experiment 1. The stimuli were the same face identities used in the previous experiments, and faces displayed direct gaze in Experiment 2a (Figure 3), and averted gaze in Experiment 2b (Figure 4).

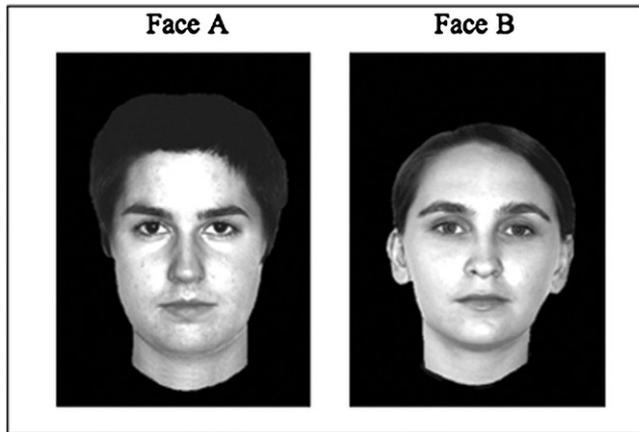


Figure 3. Stimuli used in Experiment 2a (visual preference test with faces displaying a direct gaze).

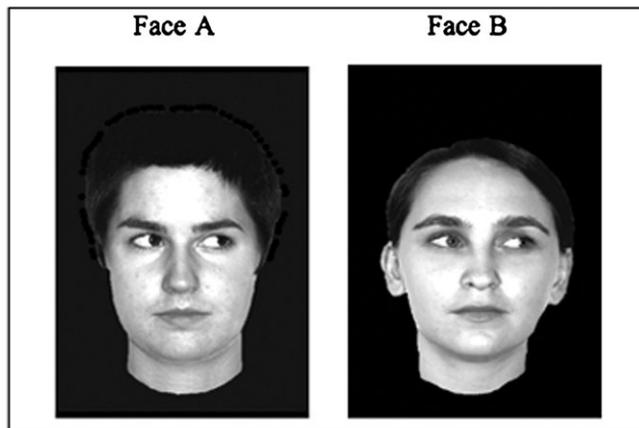


Figure 4. Stimuli used in Experiment 2b (visual preference test with faces displaying an averted gaze).

Procedure

The experiments were carried out using an 'infant control preferential looking technique' (Valenza, Simion, Macchi Cassia, & Umiltà, 1996). Infants were shown two different faces (face A and face B), one on the right and one on the left of the center of the screen, either with direct gaze or averted gaze. Newborns were presented with two trials in which the position of the stimuli was reversed. The initial side of the two stimuli, left or right, was counterbalanced across the subjects. The stimuli remained on the screen as long as the infants fixated one of them. When they shifted their gaze from the display for more than 10 s, the experimenter turned off the stimuli.

Results and Discussion

We analyzed newborns' looking behavior (frequency of orienting and total looking time) as a function of identity (face A or face B).

In Experiment 2a, newborns showed significantly greater total looking time at face A ($t(8) = 3.402$, $p = 0.009$) than at face B. These results show that, contrary to expectation, babies spontaneously prefer face A ($m = 47.57$ s), and not face B ($m = 31.36$ s). Thus, this spontaneous preference cannot explain the identity-specific results observed in Experiment 1a. The frequency of orienting towards the two faces was not significant ($t(8) = 0.654$, $p = 0.531$) (Table 5).

In Experiment 2b, no significant effects were observed for the total looking time ($t(8) = 0.424$, $p = 0.683$) or the frequency of orienting ($t(8) = -0.398$, $p = 0.701$) (Table 6). The preference that newborns showed for face A accompanied with direct gaze (Experiment 2a) was not evident when the same face was presented with averted gaze. As a consequence, this suggests that identity

Table 5. Mean total looking times (s) and frequency of orienting at faces A and B in Experiment 2a

| | N | Mean | S.D. | S.E. |
|-------------------------------|---|------|------|------|
| <i>Total looking times</i> | | | | |
| Face A | 9 | 47.6 | 13.3 | 4.5 |
| Face B | 9 | 31.4 | 14.4 | 4.8 |
| <i>Frequency of orienting</i> | | | | |
| Face A | 9 | 13.0 | 3.8 | 1.3 |
| Face B | 9 | 12.0 | 6.0 | 2.0 |

Table 6. Mean total looking times (s) and frequency of orienting at faces A and B in Experiment 2b

| | N | Mean | S.D. | S.E. |
|-------------------------------|---|------|------|------|
| <i>Total looking times</i> | | | | |
| Face A | 9 | 64.0 | 32.6 | 10.8 |
| Face B | 9 | 57.0 | 22.6 | 7.5 |
| <i>Frequency of orienting</i> | | | | |
| Face A | 9 | 11.0 | 3.9 | 1.3 |
| Face B | 9 | 12.0 | 3.0 | 1.0 |

and gaze processing are not independent at birth, but that they interact at some level.

To test this latter hypothesis, a 2×2 ANOVA between Experiment 2a and 2b, with identity (face A or face B) as a within-subject factor and gaze direction (direct-Experiment 2a or averted-Experiment 2b) as a between-subject factor, was performed. The analyses showed a significant effect of gaze ($F(1,16) = 12.09$, $p = 0.003$), with longer looking times for averted gaze ($m = 60.6$ s) than direct gaze ($m = 39.5$ s). This evidence suggests a novelty effect for the averted gaze, and it could be interpreted as a facilitation of direct gaze, supporting the importance of the eye contact. According to neuroimaging studies, gaze direction modulates responses also in adults. George *et al.* (2001) found that the fusiform gyrus shows a stronger activation to direct gaze than averted gaze, suggesting that 'gaze-contact indicates the likelihood of imminent social interaction' (George *et al.*, 2001; p.1110). In the present study, the interaction between gaze and identity was not significant ($F(1, 16) = 0.301$, $p = 0.591$); however, newborns spent longer fixation time to face B with averted gaze ($m = 57.12$ s) than with direct gaze ($m = 31.36$ s). These findings suggest that non-preferred faces, especially when accompanied with an averted gaze, require a greater allocation of attention.

GENERAL DISCUSSION AND CONCLUSION

In the current study, newborn ability to recognize a face identity was investigated by using the same design employed by Farroni *et al.* (2007). The aim was to test whether the same abilities found in 4-month-old infants may be observed also at birth, and therefore if they do not require prolonged experience. Specifically, newborns were habituated with a face displaying either a direct gaze (Experiment 1a) or averted gaze (Experiment 1b). The neonates were then presented with a preference test with the familiar face previously seen in a habituation phase and a novel one, displaying the same gaze direction. We predicted that babies habituated with a face accompanied with direct gaze, but not with averted gaze, would show a novelty preference for the unfamiliar stimulus, demonstrating that face identity recognition depends on direct gaze, as observed in older infants (Farroni *et al.*, 2007).

The current findings provide evidence that gaze direction is an important factor in face recognition from birth, and they partially confirm the hypothesis that direct gaze modulates face processing. In fact, while at least one face accompanied with direct gaze was subsequently recognized by newborns, different face identities with averted gaze were not preferred or recognized. We found that for newborns, in contrast to older infants and adults (Farroni *et al.*, 2007; George *et al.*, 2001) the specific face identity involved is important. More specifically, in Experiment 1a, we found different looking behaviour with the two face stimuli used. Newborns habituated with face A, oriented towards the novel stimulus (face B) in the preference test, while newborns habituated with face B, oriented towards the familiar stimulus (face B). This result led us to hypothesize a basic spontaneous preference for face B. We tested this hypothesis in Experiment 2a, running a visual preference test between the two face stimuli used. Contrary to this hypothesis, we observed a spontaneous preference for face A. Thus, this spontaneous preference cannot account for the main effect found in Experiment 1a. One possible explanation is that familiarity with a specific face (habituation phase) reverses the spontaneous preference for a stimulus. But it is

also possible that the spontaneous preference for a face facilitates its processing resulting in a better recognition, at least in newborns. In fact, babies who were habituated with the preferred face (A), oriented to the novel stimulus (B) perhaps because they had enough time to process the familiar face, allowing them to orient towards the new stimulus. In contrast, babies habituated with the non-preferred face (B), continued to look at the same stimulus in the preference test, perhaps because they need more time to process it. An alternative explanation might be that newborns have perceived face A as more threatening than face B. Therefore, they might have given face A processing priority in the preference task, and processed it more quickly in the habituation phase, being able to move on to the other stimulus at the test phase. Whether face A was perceived as more threatening is hard to determine, but it may be that its perceptual characteristics attracted and increased newborns' attention, which in turn might have allowed a facilitated processing of the stimulus itself.

With regard to Experiments 1b, we found that averted gaze does not allow later discrimination between faces. From this evidence and the results from Experiment 1a we conclude that identity and eye gaze processing are interconnected to some degree shortly after birth.

In Experiment 2b, averted gaze removed the spontaneous preference shown by newborns for a specific face identity. Similarly, a recent study found that newborns prefer faces displaying a happy expression, but this preference is removed when the same happy face is accompanied with averted gaze (Rigato, Menon, Farroni, & Johnson, 2008). This evidence and the results of the present study support the view that direct gaze is a fundamental feature in a face to be preferred by neonates. Direct gaze is one of the most important signals to engage communicative partners, and to maintain social interactions, even in absence of language. In previous studies, neonates showed preferences for socially relevant face stimuli. Specifically, they prefer looking at upright than inverted face configuration (Johnson, Dziurawiec, Ellis, & Morton, 1991; Valenza *et al.*, 1996), and at direct gaze than averted gaze (Farroni *et al.*, 2002). Further, for face-like stimuli to be preferred, they need to be presented in the contrast polarity characteristic of faces under natural lighting conditions, with the natural inner contrast of the eyes, such as dark pupil and white sclera (Farroni *et al.*, 2005). The analyses run between the two preference studies (Experiments 2a and 2b) suggested a facilitation of processing of direct gaze than averted gaze, pointing out the informative role of mutual gaze in social interaction. In fact, the comparison between the two experiments revealed that newborns spent an overall longer time looking at faces with averted gaze than with direct gaze.

Additional studies are needed to explore these findings further. Particularly recommended would be replicating these experiments using a different and larger set of faces so that even if newborns spontaneously prefer one face over the others, this effect would not affect the overall results. Asking adults to rate the attractiveness of the faces would also be helpful in order to use faces that are judged as being equivalent. Another possibility would be slightly modifying the habituation phase of the procedure used, adding more time for stimulus presentation after the newborn has reached the habituation criterion. In fact, it may be that the visual habituation technique with infant control procedure does not always reflect the habituation criterion in newborns. However, from the present study we conclude that while direct gaze influences preferences and identity learning in newborns, these effects are face identity-specific.

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