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Mother's Face Recognition by Neonates: A Replication and an Extension

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Previous experimenters have found that 4-day-old neonates look longer at their mother's face than at a stranger's face. We have replicated this finding under conditions where the infants are only provided with visual information on identity, with all the usual stimuli associated with the presence of the mother's face absent. The structure responsible for this cannot be equated with *Conspec*, the innate structure underlying face preference in neonates (Johnson & Morton, 1991). In a second experiment, we show that infants do not discriminate mother from stranger when both women are wearing head scarves. This indicates that, unlike older infants (de Schonen, Gil de Diaz, & Mathivet, 1986; de Schonen & Mathivet, 1990), neonates acquire a representation of their mother's face in which the hair line and outer contour have an integral part. This suggests that the system responsible for the neonates' performance is not the same as the one at work in older infants.

neonates faces physiognomic processing

Field, Cohen, Garcia, and Greenberg (1984) and Bushnell, Sai, and Mullin (1989) have established that 4-day-old neonates look longer at their mother's face than at a stranger's face despite the fact that they are only provided with visual information on identity. In Bushnell et al.'s study, the mother was instructed not to talk, and the olfactory information was controlled by spraying a strong air-freshener between the mother and her infant before each trial. More recently, using a High Amplitude Sucking (HAS) technique, Walton, Bower, and Bower (1992) observed that this preference for the mother's face also held when the mother's and the stranger's faces were video recorded. In neither of these studies was the contextual information completely changed, however. In Bushnell et al.'s study, the infant was held by an experimenter, providing tactile stimulation and warmth that might be part of the context in which the mother's face most often becomes available to the infant. In Walton et al.'s (1992) study, on the other hand, the infant was not held by an experimenter, but the situation used by the authors included a sucking response, which is a behavior and a source of stimulation associated with the presence of the mother's face during neonates' early learning experience. Two questions then arise. The first is whether or not the mother preference is to be attributed to a face-specific recognition mechanism or to some more general learning mechanism. The second, linked question concerns which parts of the mother's face are essential for the preference to be found.

If there exists at birth a specific mechanism for learning individual faces, then recognition should be possible even when the face is encountered in a completely different context (de Schonen & Mathivet, 1989). The infant will have learned the mother's face in a multimodal context. If we want to be certain that no information from this context is present during the recognition test, we must use a visual

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attention task, and the neonate must not be held in the arms. This is why we first replicated the study by Bushnell et al. (1989) on neonates, using a preferential fixation technique but with the neonate placed in a special chair (Experiment 1). There is, of course, also the possibility that a preference for mother's face could be found even though the mechanism responsible for learning is not specific for faces. If neonates have a specific mechanism for processing individual faces at 4 days, then they should be able to recognize their mother's face on the basis of its internal structure alone, that is, when the outer contour of her head and the hair/face separation line are masked. It would make no biological sense to have a special mechanism that relied on variable factors such as hair outline.

The second aim of this study, then, was to test whether the infants used the external characteristics of the face or whether the internal structure of the face was encoded. Clearly, as they become familiar with a particular face, adults mainly use the internal structure in recognition, though the shape of the head may also be used with unfamiliar faces (Ellis, Sheperd, & Davies, 1979; Endo, Takahashi, & Maruyama, 1984; Young, Hay, McWeeny, Flude, & Ellis, 1985). Davidoff, Matthews, and Newcombe (1986) reported the case of a prosopagnosic patient who used the hairline of faces in order to recognize people. In addition, the color and contour of the hair could form a cue. Despite the fact that the visual acuity and sensitivity to contrast are very poor at 4 days old, information about the internal structure of the face is nevertheless found in the low spatial frequency spectrum and might be sufficient for discriminating between two individual faces and recognizing a particular one. The elongation and orientation of the long axis of the eyes and mouth relative one to the other and the distance between these features are all specific to a particular face (or to a small class of faces), and they might be picked up by the neonate despite his/her visual limitations. From the age of 4 months, infants are able to process the internal facial features or configuration in order to differentiate between and recognize faces (Bushnell, 1982; de Schonen & Mathivet, 1990). They also recognize their mother's face even when the hair/face separation line and the outer head contour are covered with a scarf (de Schonen et al., 1986). The question is how early can we find such abilities.

The only indication that a neonate is able to attend to the immobile inner parts of a face is given by the data demonstrating that they show more interest in schematic faces than in scrambled control stimuli (Goren, Sarty, & Wu, 1975; Johnson, Dziurawiec, Ellis, & Morton, 1991). Because this ability is present from birth, it must either be due to the operation of general perceptual mechanisms or to an innate, face-specific system. Johnson and Morton (1991; Morton & Johnson, 1991) opted for the latter and attributed the inborn face preference to a mechanism they called CONSPEC. CONSPEC must process the internal facial configuration inasmuch as it needs to match a general pattern, perhaps comprising just three dark patches in a triangle, corresponding to eyes and mouth. However, it is not supposed that CONSPEC processes the individual features that characterize the internal configuration of a particular face.

In spite of these qualifications, it is possible that the neonate effectively processes information about individual faces and, in particular, the information that characterizes mother. If this were the case, we should find that neonates still look longer to their mother's face than to a stranger's face, when both women wear a scarf around their head, leaving visible only the internal structure (Experiment 2). On the other hand, the visual preference for the mother's face over a stranger's face might vanish when the hair/face separation line and the outer contour of the hair are masked. In this case, we will be able to conclude that the mechanism responsible for the preference of mother's face to the stranger's is not specifically tuned to face processing. Instead, we would assume that the preference for mother's face is produced by a general pattern-processing system. The role of CONSPEC would remain solely that of attracting attention towards the face.

EXPERIMENT 1

Method

Subjects

Subjects were 34 neonates, 19 males and 15 females (M age = 78 hours, range = 72–120, SD = 17; M birth weight = 3.30 Kg, range = 2.90–4.40, SD = 0.37), with normal Apgar

scores after 5 min (M = 9, range = 7–10), born at the Sainte Monique's maternity ward at Saint-Joseph's Hospital, Marseilles. The data of 39 additional infants (19 males, 20 females) were discarded from the final sample because (a) the infants exhibited a lateral bias in their looking behavior (the data on 5 infants looking for less than 4 s towards one side—left or right—over the two trials were discarded because of the lateral bias), or (b) the infants fussed or fell asleep before the end of the experiment (21 infants), or (c) there were technical failures of various kinds (5 infants), or (d) mothers talked or smiled during the experiment (8 infants).

Apparatus and stimuli

The infant sat in a foam armchair specially designed to support a neonate. The head was supported on each side but was free to rotate from side to side. The foam armchair was attached to a high chair. The infant faced the midline of a large grey screen (100 cm in width and 80 cm in height) 25 cm (±5 cm) away from his/her eyes. On each side of the midline of the screen, two apertures were cut (24 cm × 30 cm) at the infant's head level. The two apertures were 14 cm apart. Through a hole in the middle of this panel, between the two apertures, a video camera recorded the infant's face during the whole experiment. Another camera situated behind the infant recorded the mother's face and the stranger's face. With each child, the stranger was either another mother from the same maternity ward or, in some cases, another young woman. The stranger's face and head were chosen so as to be broadly similar in terms of complexion, hair color, and general hair style. During the study, the mother and the stranger had a white towel draped around their necks in order to mask their clothing. They were told to look at the infant's eyes keeping a neutral expression and not to move, talk, or smile. Mothers who always wore glasses or earrings during the day were excluded from the sample. Before each trial, a strong apple-perfumed air-freshener was sprayed onto the screen. This was to ensure that mother's smell could play no role in the experiment.

Procedure

Once the infant had been fastened to the chair, the cardboard mask hiding the two apertures in the screen was removed and the two women appeared at the windows, slightly above the infant's face, leaning over it, so that the infant was in the best possible position for viewing the faces. A white-coated observer stood centrally behind the two faces, viewing the infant through the same aperture as the video camera, noting the infants' fixations and calculating their total duration by pressing a button connected to a microcomputer. An interval which never lasted for less than 3 min and more than 4 min elapsed between the time when the mother gave her infant to the experimenter when entering the room and the time when she appeared at the window. A trial began when the infant looked at either face and ended after a total of 16 s of fixation towards either or both faces had occurred. After the first trial, a cardboard mask was used to mask the apertures while the mother and the stranger changed places. The procedure used in the second trial was identical to that in the first trial. Half of the male and half of the female infants had their mother on the right side in the first trial and on the left side in the second trial, and vice-versa with the other infants. The fixation time towards either face was based on the video-recording analysis performed by two observers independently. The judges did not know on which side the mother was. The two judges never disagreed about the direction of the fixation (on the mother's face or the stranger's face) but only about the precise moment where a fixation on the mother's or on the stranger's face started or ended. The greatest disagreement did not amount to more than a total of 2 s in a trial, however. These disagreements involved five infants and did not concern the start more than the end of fixations towards either the mother or the stranger. The judges eventually reached a common agreement. The video recordings of the 34 pairs of mother's and stranger's faces were analyzed by another judge in order to check that the women strictly followed the instructions to stay motionless keeping a neutral expression. No known additional cues can have helped to discriminate between the two women because the judge could not guess better than chance level which woman was the mother.

RESULTS

The amount of time spent by each infant looking to the mother in each trial was analyzed by an ANOVA (2 sex × 2 side × 2 trial) with trials as the repeated measure. No single factor and no interactions were significant. The sex factor approached significance, $F(1, 30) = 3.07$, $.05 < p < .10$, with females looking longer to the mother than males (mean fixation time in the first trial, mother on the right side, females: M = 12.90 s, SD = 1.90; males: M = 9.27 s, SD = 4.26; mother on the left side, females: M = 9.85 s, SD = 2.96; males: M = 9.16 s, SD = 4.49; second trial, mother on the right side, females: M = 12.74 s, SD = 3.03; males: M = 10.18 s, SD = 3.11; mother on the left side, females: M = 11.07 s, SD = 2.06; males: M = 10.90 s, SD = 5.66). No significant difference was found to exist either between the sides of presentation, $F(1, 30) = 0.11$, $p > .10$, or between the trials, $F(1, 30) = 1.76$, $p > .10$. The looking times towards the mother were compared with those towards the stranger. In the two trials combined, the mean fixation time was longer towards the mother (M = 21.26 s, SD = 5.60) than towards the stranger (M = 10.70 s, SD = 5.60), $t(33) = 5.5$, $p < .0001$, two-tailed. In the female group, the mean fixation on the mother was 23.14 s (SD = 3.27), $t(14) = 8.4$, $p < .0001$, and in the male group, it was 19.76 s (SD = 6.60), $t(18) = 8.4$, $p < .025$. The preferential fixation on the mother's face occurred in both trials (first trial, mean fixation time on the mother: 10.03 s, SD = 3.80, $t(33) = 3.1$, $p < .005$, two-tailed; second trial, mean fixation time on the mother: 11.22 s,

SD = 3.86, $t(33)$ = 4.9, $p < .0001$, two-tailed). The fixation on the mother's face was longer than on the stranger's, whether the mother's face was on the right side or on the left side (mean fixation time on the mother when presented on the right side: 11.07 s, SD = 3.55, $t(33)$ = 5.0; $p < .0001$; when presented on the left side: 10.19 s, SD = 4.12, $t(33)$ = 3.1, $p < .005$).

DISCUSSION

The first aim of this study was to replicate Bushnell et al.'s (1989) study showing the existence of a visual preference for the mother's face and to test whether this effect holds even when all the usual stimuli that are associated with the presence of the mother's face are absent. Our results show that even when the recognition test included none of the stimuli other than the mother's face and head, neonates recognized their mother. It can be concluded that at this age the access to the representation of the mother's face is independent of the context of stimulation and circumstances in which the information has been originally acquired. This argues in favor of the assumption that this learning competence specifically concerns visual events or objects if not faces alone.

The recognition performance of neonates can be differentiated from that of amnesic patients. McKee and Squire (1993) have shown that adult amnesic patients do not show any visual preference for photographs of either faces or objects after habituation with one of the photographs when the time elapsing between the habituation and the test is 2 min or more, whereas normal adults show a preference for the new stimulus after a much longer interval. Our participants exhibited a systematic preference for the familiar face after an interval of 3 min. The preference must, then, be based on something other than a transitory memory store.

EXPERIMENT 2

The second aim of this study was to find out on what visual cues the neonate's preference for the mother's face is based. As mentioned in the introduction, the neonate's visual limitations do not preclude the processing of differences between individual facial configurations or between salient features. If neonates processed their mother's face with the same CONSPEC mechanism that allows them to attend longer to a schematic facelike pattern than to a scrambled face, they could base a preference on the internal configuration of the features of their mother's face or on the basis of the shape and size of these features. In this case, the infant would still be more familiar with her/his mother's face than with a stranger's face even when both women wore scarves around their heads. If, on the contrary, as proposed by Johnson and Morton (1991), the visual cues that are processed by the infant are drawn from the outer contour of the head and hair outline, the scarf will remove all possibility of visual preference. In a study by de Schonen et al. (1986), it was shown that 4- to 9-month-old infants recognized their mother's face on color slides, at least with their right hemisphere, despite the fact that she was wearing a scarf around her head. Are the systems involved in individual face processing at the age of 4 months already at work during the first few days of life? Experiment 2 was designed to test whether neonates maintain their visual preference for their mother's face when the mother and the stranger both wear scarves around their heads.

Method

Subjects

The subjects were recruited at the same maternity ward as in Experiment 1. Twenty neonates (10 females, 10 males), with a mean age of 96 hours (range = 72–168, SD = 26.4, M birth weight: 3.2 kg, range = 2.9–3.9, SD = 0.3) and normal Apgar scores at 5 min (range = 7–10, M = 9), constituted the final sample. The data on 46 additional infants were discarded: 18 for technical reasons (with the electrical system of the video recorder), 15 because they either fell asleep or fussed before completing the two trials, and 13 because they exhibited a lateral bias (over the two trials, they looked to one side for less than a total of 4 s: 6 infants had a right bias, and 7 had a left bias). The apparatus and procedure were exactly the same as in Experiment 1, except for two changes in the stimuli and in the duration of presentation.

Stimuli

The mother and the stranger each wore a pale pink scarf attached under the chin. The color of the scarf was chosen to reduce as much as possible the line of contrast between scarf and face, in order to avoid attracting the infant's visual attention to nonrelevant cues while nevertheless changing the hair/face line and the head outer contour.

Procedure

The procedure was similar to that in Experiment 1 except for the duration of presentation, which was set, for each trial, at 20 s of total fixation towards either or both faces (as in Bushnell et al.'s (1989) study, instead of 16 s as in Experiment 1). We thought that infants might have learned the hair outline as well as the inner configuration of their

mother's face. Because a scarf transforms the outer contour of the head in such a way that the infant cannot detect it any longer, it might therefore take longer to recognize a face than when the face is accompanied by the usual outline. The rest of the procedure was identical to that in Experiment 1. As in Experiment 1, an interval which never lasted for less than 3 min or more than 4 min elapsed between the time when the mother gave her infant to the experimenter when entering the room and the time when she appeared at the window.

RESULTS

The amount of time spent looking at the mother was analyzed in an ANOVA (2 sex × 2 side × 2 trial), with trials as repeated measures. No simple factor was significant (sex: $F(1, 16) = 0.02$, $p > .10$; side: $F(1, 16) = 1.17$, $p > .10$; trial: $F(1, 16) = 0.00$). No interaction was found to be significant. The amount of time spent looking at the mother was compared with the amount spent looking at the stranger. During the two presentations combined, the mean looking time towards the mother was 20.57 s (SD = 8.98). This did not differ significantly from the looking time towards the stranger (19.43 s, SD = 8.98), $t(19) = 0.3$, $p > .10$. During the first trial, the mean looking time towards the mother was 10.32 s (SD = 6.21), which was not significantly different from the mean looking time towards the stranger (9.68 s, SD = 6.15), $t(19) = 0.2$, $p > .10$. During the second trial, the mean looking time towards the mother was 10.26 s (SD = 6.56), which again did not differ significantly from the mean looking time towards the stranger (9.74 s, SD = 6.96), $t(19) = 0.2$, $p > .10$. The mean looking time towards the mother during the two trials was 21.62 s (SD = 8.84) in the female group and 19.53 s (SD = 9.47) in the male group. These values did not differ significantly from the mean looking time towards the stranger, $t(9) = 0.6$, $p > .10$, and $t(9) = 0.2$, $p > .10$, respectively. The mean looking time towards the mother did not differ significantly from that towards the stranger whether the mother was on the infant's right or left (right: $t(19) = 1.1$, $p > .10$; left: $t(19) = 0.9$, $p > .10$). In order to compare the data from Experiment 2 with that from Experiment 1, only the first 16 s of looking time in each trial in Experiment 1 were taken into consideration. Comparisons between the amount of looking time towards the mother versus the stranger during the two trials in Experiment 2 yielded the same results as when the whole 20-s period per trial was taken into consideration. The mean amount of time spent looking at the mother was 16.10 s (SD = 8.23), which did not differ from the amount of time spent looking at the stranger (M = 15.98, SD = 8.24), $t(19) = 0.0$, $p > .10$. An ANOVA was performed on the amount of time spent looking at the mother in Experiments 1 and 2 (2 experiment × 2 sex × 2 side × 2 trial). Only the experiment factor was found to be significant: The amount of time spent looking at the mother was longer in Experiment 1 than in Experiment 2, $F(1, 46) = 7.35$, $p < .01$. No other simple factor and no interaction were significant.

DISCUSSION

When the hair/face separation line and the outer contour of the mother's head were masked, the infant's visual preference for this face disappeared. Because in this situation, as in Experiment 1, the infants' gaze shifted from one face to the other several times per trial, it cannot be claimed that the pink scarf hiding the hair inhibited the infants from looking at the two faces. Our results strongly suggest that the hair/face separation line and the outer contour of the head constitute crucial information which is included by neonates in their representation of their mother's face.

GENERAL DISCUSSION

Neonates seem to learn something about their mother's head or head and face during the first few days of life. Unlike older infants (Bushnell, 1982; de Schonen et al., 1986; de Schonen & Mathivet, 1990), neonates do not acquire a representation of their mother's face in which the inner configuration of the features is independent from the hair line and outer contour. This suggests that the system responsible for the neonates' performance is not the same as the one at work in older infants. Although the CONSPEC mechanism hypothesized by Johnson and Morton (1991) is triggered by general aspects of internal facial features, our results show that preference for mother's face does not depend on such information alone. Johnson and Morton contrasted CONSPEC with the second mechanism, CONLERN, which is responsible for maintaining foveal fixation on faces and learning the characteristics of human faces in general (as opposed to those of other species). The data indicate that this is not capable of controlling attention until the

infant is about 2 months of age, because it is not till that age that there is an advantage for schematic faces using the infant control paradigm (Morton & Johnson, 1991). It, too, cannot be responsible for the data we have presented here on the selective response to mother at 3 days of age, though we do imagine that it would be responsible for mother preference in older infants. Does that mean that we have to assume the existence of a third mechanism dedicated to learning about individual faces and difference between faces in neonates? It seems unlikely that the performance observed in this study needs to be explained by a very specific mechanism. A simpler account is that Conspec attracts the infants' attention towards faces and another general pattern-learning mechanism, then acquires information about the mother's face.

We have argued in the discussion of Experiment 1 that the mechanism that acquires information about the mother's face is specifically visual in the sense that the visual information can be processed independently of the associated information provided by other modalities. This does not imply that this mechanism is face specific. It is only later on, after the 2nd month, that it is demonstrated that infants process the internal features and configuration of a face. This implicates a system separate from that operating at birth. However this second system need not be restricted to face processing either (de Schonen, 1989; de Schonen & Mathivet, 1989; Johnson & Morton, 1991; Morton & Johnson, 1989, 1991). As mentioned previously, from the age of 4 months onwards, infants recognize their mother's face (in a frontal full view) with their right hemisphere (but not with the left), even when the mother's hairline and outer contour of the head is masked by a scarf (de Schonen et al., 1986; de Schonen & Mathivet, 1990). Morton (1993) has reported that as early as the 40th day of life, an infant looks longer at the mother's face, even when she is wearing a scarf. These data suggest that between the age of 2 and 4 months, the infant face-processing competence changes.

Why does an infant look at the mother's face for longer than at an unfamiliar face? In studies where visual habituation was followed by a visual preference test, neonates have been found to look at the unfamiliar stimulus longer than at the familiar (habituated) one (see, for instance, Slater, 1993). The neonate's preference for mother, in spite of her familiarity, might be because the mother's face or head is a visual cue to which is associated an operant response (looking at the mother's face) and a rewarding outcome. Stimuli involved in contingent learning paradigms often show a familiarity effect (see, for instance, data by Rovee-Collier, 1990). Recognition of the mother's head would then be an instance of procedural memory (habit memory). On the other hand, habit memory seems to be sensitive in many cases to the presence of habitual contextual cues (Rovee-Collier & Dufault, 1991). The independence of the recognition performance to the habitual contextual cues here argue against the idea that mother's face recognition in neonates is an instance of a habit memory. We are left with the conclusion that learning aspects of mother's face is special in at least this manner.

We have replicated Bushnell et al.'s (1989) rather surprising result. Newborns have learned something about the way their mothers look by the time they are 4 days old. Still more surprising is the fact that what they have learned is somehow coded, or at least accessible, independently from information of other kinds associated with the occurrence of mother's face. However, it seems that what they have learned has to do with the outer features of the face rather than the inner features. This conclusion leads to the prediction that newborn infants will be equally interested in another woman with the same face shape, hairstyle, and color and would lose interest in mother if she changed the color and style of her hair, at least if only visual information were available.

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