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Newborns' preferential tracking of face-like stimuli and its subsequent decline*

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Abstract

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Goren, Sarty, and Wu (1975) claimed that newborn infants will follow a slowly moving schematic face stimulus with their head and eyes further than they will follow scrambled faces or blank stimuli. Despite the far-reaching theoretical importance of this finding, it has remained controversial and been largely ignored. In Experiment 1 we replicate the basic findings of the study. In Experiment 2 we attempt a second replication in a different maternity hospital, and extend the orig-

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inal findings with evidence suggesting that both the particular configuration of features, and some aspects of the features themselves, are important for preferential tracking in the first hour of life. In Experiment 3 we use a different technique to trace the preferential tracking of faces over the first five months of life. The preferential tracking of faces declines during the second month. The possible causes and consequences of this observation are discussed.

Introduction

More than a decade ago, Goren, Sarty, and Wu (1975) published the results of a study that examined the way newborn infants (median age 9 min) tracked a moving schematic face, scrambled "faces", or a blank head outline. Their results were quite unequivocal: head and eye movement measurements indicated that there was a strong "preference" for the face pattern over the other stimuli.

Despite the far-reaching theoretical implications of these findings, they have remained largely ignored by psychologists. First, the results imply that infants enter the world with a degree of innate perceptual "knowledge". Zuckerman and Rock (1957) had earlier argued that "perceptual organization must occur *before* experience ... can exert any influence" (p. 294). Furthermore, they reasoned that the need for some prior perceptual organization was both logical and a likely product of adaptive evolution. Fantz (1966) echoed these views but was only able to show that neonates reliably discriminate stripes from a blank field.

The second theoretical consequence of the findings of Goren et al. arises from their use of face-like patterns. There has been some debate in recent years as to the possible uniqueness of faces as visual objects (Ellis, 1975; Hay & Young, 1982; Teuber, 1978). Various lines of evidence have been examined which could support the view that a separate processing mechanism for the perceptual analysis of faces is required from that which analyses non face-like objects. These include evidence from localisation within the brain (prosopagnosia), modularity, and uniqueness of processing. In reviewing this evidence Ellis and Young (1989) and Morton and Johnson (1989) concluded that the only experiment which clearly demonstrates something unique about faces as visual stimuli is that reported by Goren and her colleagues with newborns.

The need for a replication of the Goren study is all the more pressing when considered within the context of the many other studies on infants' face preferences. Although there is some debate about the exact age at which a static schematic face is preferred over static scrambled faces, estimates varying from 2 to 4 months of age (see, for example, Haaf, Smith, & Smitty 1983; Maurer, 1985), there is general agreement about the lack of a preference in infants aged around 1 month. The lack of evidence for a preference at 1 month has led to the assumption that no such preference will be found in newborns either. For example, Maurer and Barrera (1981) examined the preferences of 1- and 2-month-old infants. In two experiments, using first a visual preference method and then a habituation technique, they found that the older babies reliably preferred and discriminated a schematic face from stimuli with scrambled facial features. The 1-month-old babies showed no such preferences. We have replicated this finding using similar testing methods (Johnson, Dziurawiec, Bartrip, & Morton, submitted). While Maurer and Barrera's experimental methods, as well as the ages of their samples, differed considerably from the experiment of Goren et al., the discrepancy in these results is nonetheless striking.

The first experiment presented here was designed to replicate the essential aspects of the study by Goren et al., but also included some refinements of data collection and analysis. In the Goren study, the experimenter both presented each stimulus and recorded head movements, while an assistant recorded eye movements, each being blind as to the actual stimulus being shown. We took this a stage further by video-recording the whole proceedings in which one experimenter presented each of the three stimuli in random order, and was blind to the particular stimulus shown to the baby on any trial. Ratings of head and eye movements, however, were later made from the videotape by two independent judges who were not only blind as to the stimuli but were not informed about the purpose of the experiment. In this way we are confident that no systematic influences by the experimenter can have biassed the data collection.

Experiment 1

Method

Subjects

The sample consisted of 24 newborns of mean gestational age 280 days (SD 8.39) who were tested within the first hour after birth. Subjects were delivered at the Aberdeen Maternity Hospital, Aberdeen, Scotland. Thirteen were male and 11 female. All infants met the screening criteria of normal delivery, a birthweight between 2500 and 4300 g and Apgars of at least 6 and 8 at 1 and 5 min, respectively. (In practice, Apgars were never lower than 7 and 9 respectively.) The mean age at the start of testing was 37 min (SD 12.5 min). The data from an additional group of 16 infants were rejected because of fussing (N = 4), insufficient attention/drowsiness (N = 10) and equipment failure (N = 2).

Obstetric medication for the sample was as follows: lumbar epidurals (N = 2), pethidine only (N = 5), pethidine/Entonox (N = 2), Entonox only (N = 10), no medication (N = 2). The inhalant anaesthetic (Entonox) was self-administered and used for analgesia rather than anaesthesia.

Three further infants were delivered via Caesarean section. Of this small group, one mother was administered a general anaesthetic and the other two lumbar epidurals. The choice of anaesthesia in these three cases was by maternal request. All other subjects were from spontaneous vaginal deliveries.

Stimuli

The stimuli were three head-shaped, head-sized, two-dimensional white forms with black features of a human face, as used by Goren et al. (1975). The stimuli, referred to as *face*, *scrambled* and *blank*, can be seen in Figure 1. A fourth stimulus used by Goren et al., a moderately scrambled face, to which their infants responded no differently than to *scrambled*, was not included in the present study in order to reduce the length of the testing session.

The experimenter shuffled the stimuli and presented them approximately 18–25 cm from the infant's face. The experimenter (S.Dz.) was entirely unaware of the order of presentation of stimuli during testing. Only the identical, unmarked reverse sides of the stimuli were visible to the experimenter. Illumination of the stimuli was provided primarily by natural light from a very large window situated above and behind the infant.

Apparatus

As in the Goren et al. study each infant was placed on its back on the experimenter's lap and surrounded by a large protractor over which the stimuli were to be presented against a light-coloured ceiling 7 feet away. The infant reclined on thick towelling, with its neck supported by the experimenter's palm beneath the towelling. A video camera was positioned above and slightly behind the seated experimenter. The arrangement can be seen in Figure 2.

Procedure

Testing was carried out on the labour ward in a centrally sited room to which the newborns were brought as soon after birth as possible. Informed consent was obtained from at least one parent of each subject in the study. If the father was present at the delivery he was invited to view the testing on a small television

Figure 1. *The three stimuli used in Experiment 1.*

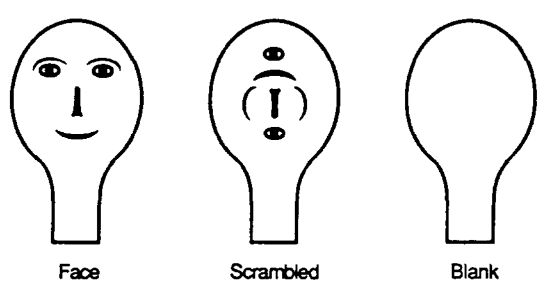
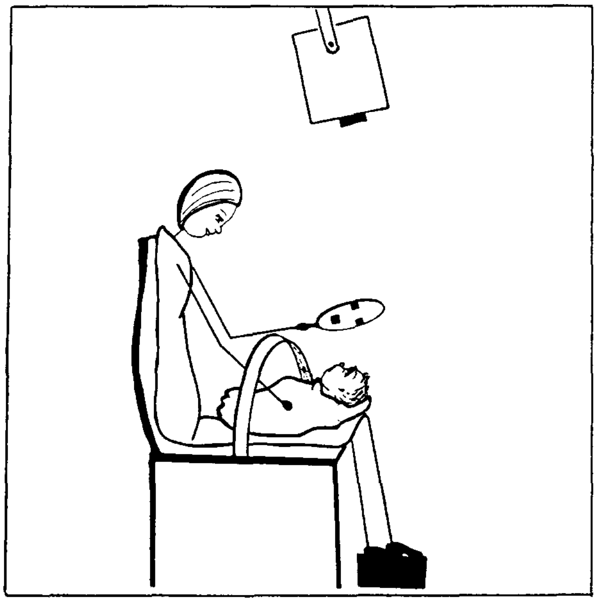


Figure 2. *The arrangement of experimenter, baby, stimulus, protractor and camera (drawing by Mani).*



monitor in the experimental room which displayed the newborn's behaviour.

When the baby had been placed in a supine position on the experimenter's lap, his or her head was aligned mid-line with the 0° mark on the protractor and the first stimulus was positioned centrally over that mark; that is, the stimulus was directly in front of the baby's face. As soon as the infant fixated the stimulus, it was moved by the experimenter slowly to one side along the arc of the protractor from 0° to 90° (at a rate of approximately 5° per second). If an infant responded to a stimulus with a large eye- and/or head-turn (>60°) he or she was tested to the other side. If the infant failed to turn or turned only minimally, up to seven attempts were made to elicit a reasonable turn to each side. The procedure was then repeated to the opposite side. Thus the first stimulus was randomly selected and the infant tested with it until turning had been elicited on the left and the right. The next stimulus, also randomly selected, was then used. This was followed by the third stimulus. Due to the lighting conditions the experimenter could not see the stimulus cards reflected in the pupils of the infant's eyes. The infant's eye- and head-turning in pursuit of the stimulus were recorded on videotape for subsequent analysis. As in the study by Goren et al., the extent of following, measured in terms of degrees of arc, was determined by comparing the final nose position and eye orientation on each trial with the protractor demarcations. For each stimulus, the infant's score for both head- and eye-turning was the average of the best score out of the trials to the right side and to the left side, with a theoretical maximum possible of 90° for each stimulus.

Judgement

The videotape records were analysed by two independent observers who were unaware of either the purpose of the study or the patterning on the stimuli. Their judgements formed the sole measures for subsequent statistical analysis. Pearson correlation coefficients comparing the interjudge reliability indicated an overall agreement of $r = 0.812$ for head-turning and $r = 0.806$ for eye-turning assessments. Major disagreements (>5° of arc) between the two judges were resolved by a third judge, also blind to the stimuli being presented, and these final corrected assessments comprised the data for the analyses reported below.

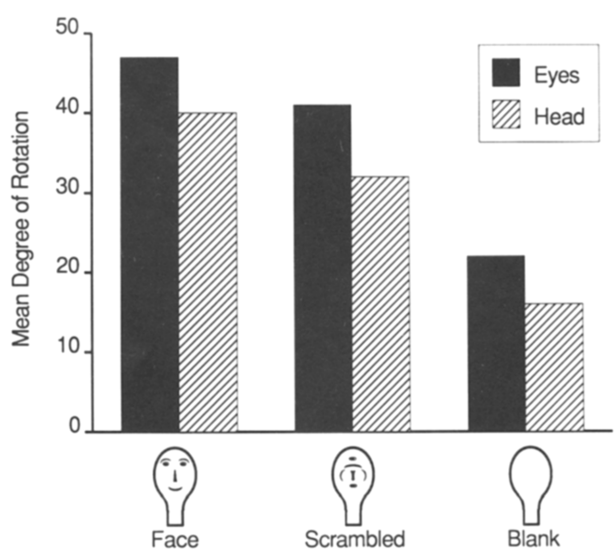
Results

The mean head- and eye-turning responses to the three stimuli are shown in Figure 3. Separate ANOVAs (Subjects × Treatments) were applied and revealed the following.

Head-turning

$F = 46.3$, $df = 2, 46$, $p < .0001$. A Tukey test (alpha = 0.05) was then used to determine the critical differences (in degrees) between responses to the three stimuli. With $q = 3.44$ the critical difference was found to be 6.2°. Thus responses

Figure 3. *Mean head and eye turning for the* face, scrambled *and* blank *stimuli.*



to the *face* (40.6°) are significantly greater than those to *scrambled* (30.9°), which, in turn, are greater than those to *blank* (16.4°).

Eye-turning

$F = 64.7$, $df = 2, 46$, $p < .0001$. A Tukey test (alpha $= 0.05$, $q = 3.44$) was also used here to determine whether differences between responses to the three stimuli were significant. As with the head-turning data, each of the three comparisons turned out to be significantly different (critical difference = 6.1°): *face* (48.4°) > *scrambled* (40.0°) > *blank* (20.7°).

Discussion

The present study clearly replicated the findings of Goren et al. (1975). Neonates do appear to track the moving face-like pattern further than the pattern with facial features disarranged, and both patterned stimuli elicit greater looking behaviour than does a head shape with no internal features. The mean extent of both head and eye movements recorded in this replication, however, are considerably less than those cited in the original study. Moreover, the greater eye- as compared to head-turning found in the present study is more likely than the reverse advantage reported by Goren et al. The difference found in the latter study may have resulted from different experimenters being employed to record eye and head movements. In the present study two independent judges examined video recordings to determine both head and eye movements and their ratings were averaged.

Maurer and Young (1983) attempted to replicate the results reported by Goren et al. and found preferential tracking of the face-like pattern when they used eye movements as the dependent measure. However, they failed to replicate the preferential head-turning observed in the original study. This may have been due to either (1) the infants were between 12 hours and 15 days old, thus being considerably older than both those used in the original study and those used in the present replication, and/or (2) the fact that they were tested in a sitting position, in contrast to the supine position adopted both in the Goren et al. and the present study. Indeed, the very low degree of head turning in the Maurer and Young study may have resulted in a "floor" effect.

It may be observed at this point that, by video-recording the babies' responses in the present study, it is possible for us to make some informal examination of the scanning movements made by the infants' eyes as they followed the stimulus. The impression given at times was that they were actively scanning the pattern components. However, in view of the psychophysical evidence supporting the view that the amount of information that can be obtained from faces in early infancy is limited (see Souther & Banks, 1979, for example), it is possible that the infants are simply responding to the configuration of high contrast areas that constitute a face, and not to the features per se. We investigated this possibility in Experiment 2.

Experiment 2

In Experiment 1 we replicated the result of the Goren et al. experiment using similar stimuli. In the next experiment we altered the stimuli to allow us to begin to investigate what aspect of the face pattern used in the earlier study was responsible for attracting the newborns' attention. There are a number of differences between the realistic face stimulus and the other stimuli in Experiment 1. Infant psychophysical studies referred to earlier suggest that infants may not be able to resolve the details that constitute a facial feature (e.g., Souther & Banks, 1979). Thus, it may be that the newborns are simply responding to the three high-contrast areas, "blobs", that constitute the configuration or arrangement of features which comprise a face. We used a stimulus composed of three dark squares (15 mm × 15 mm) in the appropriate locations for the eyes and mouth region in this experiment. If the newborns are using the configuration of high-contrast elements to track faces, then the realistic face should not preferred over this stimulus which we term *config*. As a control stimulus we used an identical but inverted pattern.

Method

Subjects

The sample consisted of 43 newborns from the delivery ward of the Obstetrics Department of University College Hospital, London. All infants met the screening criteria of normal delivery, a birth-weight between 2600 and 4400 g and Apgars of at least 6 and 8 at 1 and 5 min respectively. The mean age at start of testing was 43 min (SD 2.9 min). Data from a further 28 babies was discarded for fussing, sleeping or failure to respond to more than one stimulus.

Obstetric medication for the sample was as follows: lumbar epidurals (N = 9), pethidine only (N = 10), pethidine/Entonox (N = 3), Entonox only (N = 3), other or no medication (N = 18). All subjects were from spontaneous vaginal deliveries.

Stimuli, apparatus, procedure and judgement

The procedure employed was identical to that in Experiment 1, except in two respects. First, four rather than three stimuli were used. The four stimuli are shown in Figure 4. They comprise the *face*, the *config* stimulus, the inverted configuration (*inverse*) and a scrambled face pattern we call *linear*. The second difference in procedure was that rather than the infant's neck being supported by the experimenter's palm beneath towelling, the infant lay in a specially de-

Figure 4. *The four stimuli used in Experiment 2.*

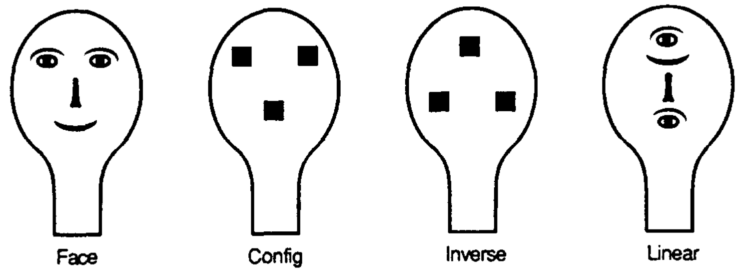
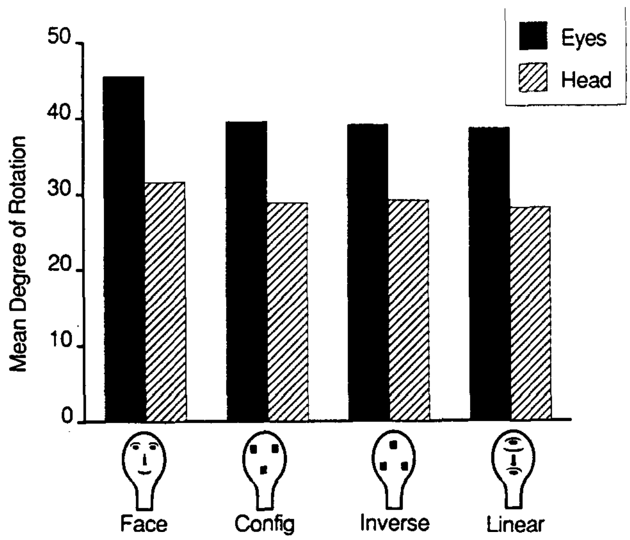


Figure 5. *The mean head- and eye-turning for the four stimuli in Experiment 2.*



signed holder with head rest which fitted on the experimenter's lap. As in Experiment 1, the videotape records were analysed by an observer unaware of the patterning on the stimuli.

Results

The mean head- and eye-turning responses to the four stimuli are shown in Figure 5. Since the data were not normally distributed we applied non-parametric statistics to the results of this experiment.

Head-turning

A Friedman two-way analysis of variance revealed no significant effect of stimulus on the degree of head-turning ($X^2 = 1.44$, $df = 3$, $p > .6$). No individual comparisons reached significance.

Eye movements

A Friedman two-way analysis of variance revealed a significant effect of stimulus on the degree of tracking as measured by eye movements ($X^2 = 9.36$, $df = 3$, $p < .025$). Individual comparisons (Wilcoxon) revealed that the schematic *face* was significantly different from *linear* and from *inverse* (both $p < .01$), and almost significantly different from *config* ($p = .07$).

Discussion

As the third replication of the eye movement data reported in the Goren et al. study, we conclude that infants in the first hour of life are sensitive to the structure of the human face to some degree of detail. Further, our results suggest that a face-like configuration of elements alone is insufficient; some characteristics of facial features may be important in addition to the arrangement. Of course, it still remains possible that other non-facial features arranged in the facial configuration will elicit the same amount of eye-tracking as the face-like pattern, and this is currently under investigation (see later discussion on the linear systems model).

Although the eye movement data have been replicated with three different populations of infants, whether newborns will track a moving face further by head-turning must still remain an open question. However, in Experiment 2 the mean amount of head-turning was lower than that in Experiment 1, and corresponded more closely with that in the study by Maurer and Young. Thus it is conceivable that a certain baseline of average head-turning is required before a differential response can be obtained. It should be noted that the measure of eye movement will include a portion attributable to head movement, since eye movement was measured relative to the 0° start position rather than to head position.

The data obtained from Experiments 1 and 2 support the result of Goren et al., and strengthen the argument for fairly complex perceptual organisation being present at birth. The proposal that face-like patterns have special significance to the newborn also gains some qualified support. However, since other meaningful objects (e.g., hands, breasts) have not yet been employed using this paradigm, we can say nothing unequivocal about the uniqueness of the response.

The finding that neonates are attracted by face-like patterns appears to correspond with ideas about early infant imitative processes that have been crystallised in recent years by the work of Meltzoff and Moore (1977) and Field, Woodson, Greenberg, and Cohen (1982), who have claimed that very young infants can imitate facial gestures and expressions (moving). These findings have not always proved replicable (e.g., Hayes & Watson, 1979; Jacobson, 1979; Kleiner &

Fagan, 1984) and we do not wish to become involved in the current debate over the validity of the data. Nevertheless, it can now be claimed with some degree of confidence that neonates do find slowly moving face-like patterns with high contrast definition particularly attractive stimuli. That is not to say that neonates process information about faces to the extent that adults do (see Bruce, 1988); obviously they do not. All that we can say is that the newborn brain is predisposed to track patterns that have certain face-like properties.

The finding of a preference for face-like patterns in newborns appears contradictory with two bodies of evidence. First, experiments exist which have purported to demonstrate that newborn preferences for face stimuli over lattices can be accounted for solely in terms of the amplitude spectra of the stimuli, and not in terms of the structural properties of the stimuli. For example, Kleiner (1987) decomposed two basic stimuli – a schematic face and a lattice pattern – into their component amplitude and phase spectra. These were then recombined to create two new stimuli – one composed of the amplitude spectrum of the face together with the phase spectrum of the lattice pattern, and the other with the phase spectrum of the face together with the amplitude spectrum of the lattice. In accordance with the linear systems model (LSM), Kleiner predicted that newborns' preference would depend entirely on the amplitude spectrum and not at all on the phase spectrum. Kleiner used a preference paradigm with 48 infants of an average age 1.7 days. The results broadly conformed with her predictions: for example, there was no preference for the crossed stimulus with the phase of the face over the lattice (phase and amplitude of lattice). The outcome of one crucial comparison, however, was not predicted by her account. As we have said, LSM explicitly claims that phase information is irrelevant to newborns' preferences. To the newborn, then, the crossed stimulus with the amplitude of the face should be equally as attractive as the schematic face (phase and amplitude of the face). This is not the case since newborns showed a very strong preference for the latter in her experiment. We conclude from this result that whatever is attractive about the schematic face cannot be decomposed to its amplitude spectra alone, and must therefore have to do with the relative spatial arrangement of elements of a face (see Morton, Johnson, & Maurer, 1990, and response by Kleiner, 1990).

The second, and more significant body of evidence which our data appears to contradict, is the failure by several experimenters to detect discriminatory responses between faces and scrambled face stimuli in infants under 2 months (see Maurer, 1985, for review). This apparent discrepancy may be accounted for by one of the following explanations: (1) although newborn infants show a preference for faces, this preference declines over the first few days of life, before emerging again at 2 months old; (2) the tracking technique is an especially sensitive measure of a propensity for the newborn to attend to faces. This propensity and its time course are largely independent of the mechanisms underlying the emergence of face preference in other types of preference tests at 2 months.

In Experiment 3, in an attempt to decide between these possibilities, we test the ability of infants to track face-like stimuli over the first 5 months of age.

Experiment 3

Experiments 1 and 2 confirmed that newborn infants will track a face-like pattern further than other patterns. In this next experiment we trace infants' tracking to face-like stimuli until 5 months. In particular, we were interested to see whether infants around 1 month old would preferentially track faces, this being an age where most investigators have failed to find a face preference using standard visual preference and habituation techniques (see Maurer, 1985, for review).

In pilot studies it became apparent that it is not easy to elicit differential responses in infants around 1 month old tested supine. Most stimuli are tracked through 90°; that is, there is a "ceiling" effect. Consequently, we decided that, rather than moving the stimuli round the infant, we would move the infant while keeping the stimuli in a fixed location. The latter is equivalent to the former in that in both cases infants had to turn their heads and eyes in order to keep the stimulus in view.

In this experiment we used four stimuli (Figure 6). Identical but static stimuli had been used in another study in which we examined 1-, 3- and 5-month-olds' preferences using an infant control procedure (Johnson et al., submitted). In common with previous workers who used the infant control procedure, we failed to find any preference for a face-like pattern in the 1-month-old group. The present experiment would determine whether that failure was influenced by the particular testing technique employed, indicating that different mechanisms might underlie the preferences for faces found in the newborn from those that begin to emerge around 2 months of age.

Method

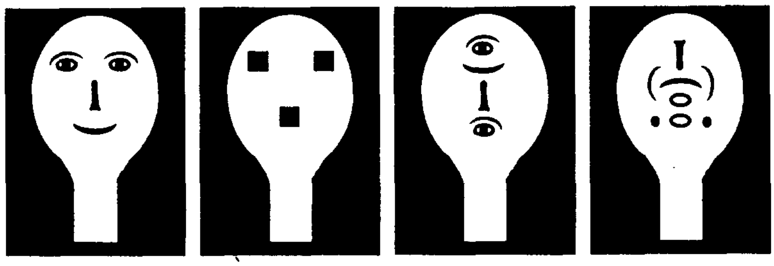
Subjects

The subjects were 38 1-month-olds (mean age 32.4 days, range 25–46 days), 16 3-month-olds (mean age 10.8 weeks, range 10–12 weeks), and 16 5-month-olds (mean age 18.8 weeks, range 18–20 weeks), all normal full-term births. There were approximately equal numbers of males and females in each group. A further 25 1-month-olds, 12 2-month-olds, and 12 5-month-olds did not complete the experiment satisfactorily due to fussing, drowsiness or technical failure.

Stimuli

All four stimuli were life-size white head outlines on a grey background. Two

Figure 6. *The four stimuli used in Experiment 3.*



of the stimuli contained the internal features of the human face, one in the correct configuration (*face*) and one symmetrically scrambled (*linear*). We also used the *config* stimulus used in the previous experiment. The final stimulus had the features of the face dismembered and scrambled symmetrically (*scrambled*). This object had neither whole features of a face nor its configuration. The stimuli were projected from slides which were matched for average luminance (6.15–6.60 lux). The four stimuli were presented twice, initially in random order and then in the reverse order.

Apparatus

The 3- and 5-month-old babies sat on their mothers' lap facing a rear projection screen. Due to the difficulty in supporting very young infants upright, an experienced baby holder held the 1-month-old infants. A video camera was mounted just above the projection screen and was masked from the infant. Behind the screen the experimenter could view the infant's face on a monitor. When viewing the monitor the experimenter could not see the slide being presented. The mother (or holder) sat on a chair which could rotate through 90° in either direction. This consisted of a commercial office revolving chair with an electric motor built into the base. The motor was geared so that it drove the chair round at a rate of 1 revolution per minute. This rotation was smooth and the motor virtually noise and vibration free. The movement of the chair and the monitoring of its angle in relation to the central screen was controlled by a BBC microcomputer.

Procedure

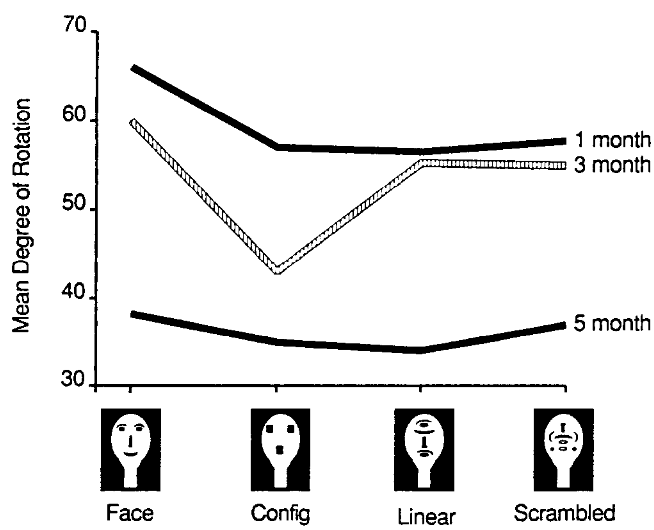
An experimenter brought the mother and infant (3- and 5-month-olds) into the room and ensured that the baby was sitting upright on the mother's lap with back supported. The baby's eyes were around 90 cm from the screen. The experimenter asked the mother to hold the baby securely and upright and requested that she not squeeze, chat to, or otherwise interact with the child. Finally, the room lights were dimmed and the mother was asked to keep her eyes closed for the duration of the experiment. Mothers who did not comply with the instructions were reminded of them, and the data from persistent offenders were not used. The same procedure was followed for the younger infants, except that an experienced holder replaced the mother.

The procedure which followed was similar in some respects to that used by Maurer and Barrera (1981). However, in contrast to previous preference procedures we used a moving chair which altered the angle between the infant and a stimulus projected on a screen. A small red flashing light just above the screen served to attract the infant's attention. The experimenter watched a monitor screen showing the infant's face and, once the infant was looking toward the slide screen, the experimenter pressed a button which advanced the projector to the next slide and started a timer. Five seconds later the motor controlling the chair was switched on. After rotating through 90° the chair returned to the starting position ready for the next trial. For each infant the chair rotated four times to the right and four times to the left (one rotation in each direction for each of the four slides). For the entire experiment the infant's face and the timer were recorded on video-tape, and the length of time that the infant looked at each slide was later assessed by a scorer blind as to the stimulus being shown.

Results

The mean angle of the chair at which infants stopped looking at the stimuli for the three age groups is shown in Figure 7. In neither the 3- nor the 5-month age

Figure 7. *Mean chair angle at disengagement from each of the four stimuli for the three age groups.*



groups was the overall ANOVA significant (3-month-olds, $F(3,60) = 1.37$; 5-month-olds, $F(3,60) = 0.23$). In contrast, there was a significant effect of stimulus on extent of tracking in infants around 1 month of age ($F(3,111) = 2.80$, $p < .05$). Individual comparisons revealed that the schematic *face* was tracked significantly further than all of the other stimuli (*config*, $p < .02$; *linear*, $p < 0.01$; *scrambled*, $p < 0.05$).

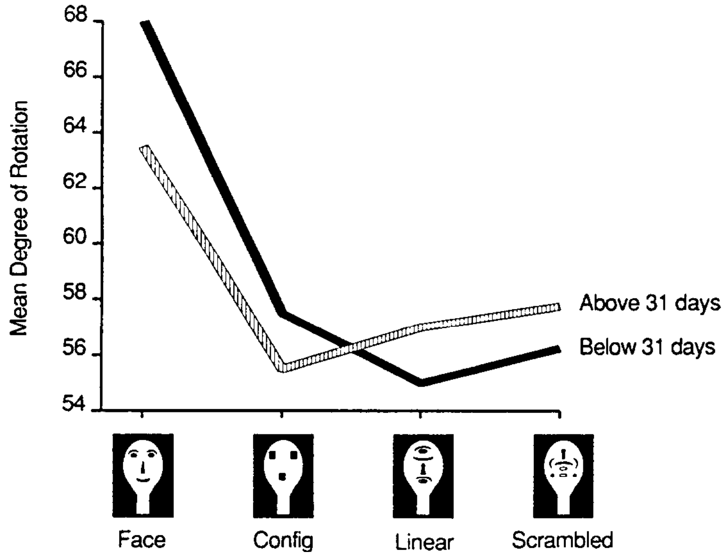
Discussion

It is apparent that infants around 1 month will track a schematic face further than they will track stimuli which possess facial features in the wrong arrangement (*linear*), or non-facial features in a facial arrangement (*config*). In contrast, the 3- and 5-month-old infants showed no evidence of discriminatory tracking of any of the stimuli studied.

The fact that the youngest age group showed a discriminatory response indicates that the procedure employed, although slightly different from that used with the newborns, is equally effective. The failure to find a discriminatory response in the older infants cannot be attributed to a ceiling effect since the mean angles of disengagement were significantly different from the maximum 90° for all stimuli at all ages. The results suggest, therefore, that there is a real decline in the preferential tracking of face-like stimuli sometime between 1 and 3 months after birth. In order to investigate the decline in preferential tracking in more detail we subdivided our 1-month-old group into an "older" and a "younger" group (see Figure 8). In the younger group (mean age 27.7 days, range 25–30 days, $n = 21$) the schematic face was tracked significantly further than the other stimuli (*config*, $p = .07$; *linear*, $p < .02$; *scrambled*, $p < .05$) whereas in the older group (mean age 38.3 days, range 32–46 days, $n = 17$) no individual comparisons were significant. This difference suggests that the preferential tracking of faces declines between 4 and 6 weeks after birth.

To our knowledge this is the first demonstration of such a preference in infants around 1 month. This may be either because of the novel technique we used to assess face preferences, or because of the exact age of the infants studied. For example, using a sensitive infant control procedure with static stimuli Maurer and Barrera (1981) and Johnson et al. (submitted) failed to find a preference for schematic faces over scrambled schematic ones. However, as well as the preference technique differing from that used in the present study, in both of these previous studies the 1-month-old sample only included infants of 30 days and over (as opposed to the 25- to 30-day-olds used in the present "younger" group of 1-month-olds). However, the fact that Fantz (1966) and Fantz and Nevis (1967) failed to find a preference for a facial configuration of facial features using both infant control and paired presentations of static stimuli in infants from 1 to 4 weeks old strongly suggests that it is the particular technique employed which accounts for the different results from the present study.

Figure 8. *Mean chair angle at disengagement from each of the four stimuli for the "older" and "younger" groups of infants around 1 month.*



General discussion

The results of Experiments 1 and 2 establish that newborn infants within an hour of birth possess some specific information about the arrangement of particular features that compose a face. The results of Experiment 3 suggest that the preferential tracking of face-like patterns declines sharply after about 30 days of age. These findings raise two further questions: first, why does this decline in preference take place; and second, what is the purpose of preferential tracking of faces over the first month of life?

With regard to the first question, it is interesting to note that several newborn sensory motor reflexes decline in the second or third month of life (Johnson, 1990a). For example, Muir and his collaborators (Muir, Abraham, Forbes, & Harris, 1979; Muir, Clifton, & Clarkson, 1989) and Field, Muir, Pilon, Sinclair, and Dodwell (1980) have studied the development of orienting to sound sources over the first 4 months of life. They found a decline of responsiveness after the first 2 months, with a subsequent re-emergence at the end of the fourth month. Dodwell (1983), after reviewing this and other evidence, suggests that the "built-in and biologically adaptive tendency to orient toward external sources of stimulation" may be controlled by subcortical mechanisms, and further that these responses may be inhibited around the second or third month of life by the emergence of cortical activity. Another example of the decline of a newborn sensory motor reflex may be early imitation. Vinter (1986) has proposed that early imitation in young infants is mediated by subcortical structures, and that it declines around 6–8 weeks (Field, Goldstein, Vega-Lahr, & Porter, 1986; Maratos, 1982).

The decline observed in the present study takes place earlier than those just mentioned, suggesting a degree of independence, not only between sensory modalities but also between different newborn visual responses. Johnson (1990b) has suggested a number of possible neural pathways which may underlie the face-specific tracking in newborns. One possibility is that circuits within the superior colliculus contain information about facial features and their appropriate arrangement. This would not be surprising in view of the other complex information-processing functions that this structure is known to be capable of (e.g., Stein & Gordon, 1981). An alternative proposal involves the deeper layers of the primary visual cortex. On the basis of evidence from the postnatal development of cortical cytoarchitectonics, Johnson (1990b) argues that the deeper layers (5 and 6) of the primary visual cortex in the newborn may be both receiving thalamic innervation and projecting to subcortical structures. Furthermore, by virtue of an unusual cortico-cortical projection from large pyramidal cells in layer 6, a cortical region which has been identified with face-processing in the macaque (the superior temporal sulcus) may also receive visual information before most other cortical areas. It is possible that this partial cortical functioning in the newborn also underlies the ability to discriminate between mother and stranger at 3 or 4 days old (Bushnell, Sai, & Mullin, 1989), although there is no reason to suppose that subcortical structures could not also support such a preference.

Turning to the second issue – that of the purpose of preferential tracking of faces over the first month – there are a number of possibilities. One class of explanations is in terms of the social or evolutionary survival value of such tracking. According to such an account the infant's prolonged tracking of faces increases its chances of survival in the hands of its care-givers. There is little evidence for or against such types of explanation at present.

Another class of accounts of the function of the system supporting the preferential tracking of faces concerns its role in constraining the input to later developing systems. A clear example of this type occurs in the acquisition of filial preferences by the domestic chick. Two separate systems are thought to be involved in this process: first, a predisposition for the young bird to attend toward the face region of adult conspecifics; and second, a system which learns about the characteristics of a range of objects merely by exposure to them. It has been proposed that the former system biasses the latter, ensuring that it learns about the characteristics of an individual adult bird, the mother hen (Horn, 1985; Johnson, 1991; Johnson, Bolhuis, & Horn, 1985).

By analogy with the explanatory model for chicks, Johnson and Morton (in press; Johnson, 1988; Morton & Johnson, 1989, in press) have suggested that two separate systems underlie the processing of faces in early infancy: first, a system present from very shortly after birth which ensures that the young infant orients toward face-like patterns: this is the system we suppose to be engaged by the tracking tasks discussed in this paper; second, a later-developing system dependent upon mature cortical functioning which is ultimately responsible for the sophisticated face-processing abilities of the adult. By this view, a primary purpose of the first system is to ensure that during the first month or so of life appropriate input (i.e., faces) is provided to the rapidly developing cortical circuitry that will subsequently underlie face-processing in the adult.

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