The perception of facial expressions in newborns

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The ability of newborns to discriminate and respond to different emotional facial expressions remains controversial. We conducted three experiments in which we tested newborns' preferences, and their ability to discriminate between neutral, fearful, and happy facial expressions, using visual preference and habituation procedures. In the first two experiments, no evidence was found that newborns discriminate, or show a preference between, a fearful and a neutral face. In the third experiment, newborns looked significantly longer at a happy facial expression than a fearful one. We raise the possibility that this preference reflects experience acquired over the first few days of life. These results show that at least some expressions are discriminated and preferred in newborns only a few days old.

INTRODUCTION

The ability of infants to detect, discriminate, and process facial expressions has been debated for some time (Darwin, 1872; Ekman, Friesen, & Ellworth,

1972). In recent years this debate has been enhanced by evidence from adult cognitive neuroscience studies supporting the idea of a "quick and dirty" brain route for detecting some facial expressions that modulates the slower and more detailed cortical analysis of facial information (Adolphs & Tranel, 2003; Adolphs et al., 2005; de Gelder, 2006; Johnson, 2005). Specifically, this rapid route may depend on low spatial frequency information and be mediated by subcortical structures such as the superior colliculus, pulvinar, and amygdala (see Johnson, 2005). Given the lack of maturity in the cerebral cortex of the newborn human infant, one possibility is that this putative "quick and dirty" route guides the responses of newborns to some facial expressions, as well as orienting them to neutral faces in their visual environment (Johnson, 2005).

Many studies have been conducted on the development of the recognition of facial expressions during infancy (see De Haan & Nelson, 1998, for a review). Nevertheless, no clear conclusions can be drawn, and many questions remain. The first question concerns which expressions can be discriminated in the first few days after birth, and whether there is a particular expression that is preferred over others. A second question concerns what information is used by the infants to guide their preference. A third question that remains is at which age infants start to discriminate between different facial expressions.

While studies have mapped the development of the recognition of facial expressions during infancy and childhood (e.g., Kotsoni, De Haan, & Johnson, 2001), the issue of whether newborns can detect facial expressions has remained controversial. For example, Field, Woodson, Greenberg, and Cohen (1982, 1983) presented evidence that newborns can match their own facial expressions to a model face showing happiness, surprise, or sadness. However, an attempt to replicate these results with an improved procedure designed to eliminate experimenter error or unintentional bias failed to confirm the earlier report (Kaitz, Meschulach-Sarfaty, Auerbach, & Eidelman, 1988). Kaitz and colleagues showed newborns live faces that displayed different facial expressions or tongue protrusion. Two coders, blind as to the facial gesture being displayed, observed the newborn and coded their mouth and eye movements. These authors did not find evidence for selective imitation of emotional facial expressions since the newborns' facial movements did not vary with the different modelled expressions, and the observers were unable to guess the modelled expression by viewing the infants' faces. Importantly, this was not due to the sensitivity of the technique since significant evidence of matching to modelled tongue protrusion was found.

Given that newborns' ability to discriminate facial expressions remains controversial, we conducted three experiments in which we ascertained newborns' preferences, and ability to discriminate between, neutral, fearful, and happy facial expressions.

EXPERIMENT 1

Evidence from adult cognitive neuroscience indicates that fearful faces may maximally engage rapid and subcortical processing (Adolphs & Tranel, 2003; Adolphs et al., 2005). Given the possibility of unique processing of this facial expression, it is possible that newborns would be maximally sensitive to faces that display fear. In addition, the fearful expression contains wide eyes and an open mouth, and may therefore represent an enhancement of the features that orient newborns toward faces in general (Johnson, 2005). Thus, it is possible that the mechanisms that ensure that newborns orient toward faces (Johnson, Dziurawiec, Ellis, & Morton, 1991) and faces with direct gaze (Farroni, Csibra, Simion, & Johnson, 2002), may also cause them to preferentially orient to faces displaying fear. Such a preference has previously been observed in older infants (Nelson & Dolgin, 1985). An alternative possibility is that newborns, like older infants, find fearful faces aversive, and will thus display a preference for a neutral expression. Thus, in Experiment 1, we tested newborn infants to establish if they have a spontaneous preference for fearful versus neutral facial expressions.

Participants

Twenty-five normal, healthy, full-term newborns were selected from the maternity ward of the Pediatric Unit of the Hospital of Monfalcone. Eight babies were excluded from the final sample for various reasons. Four changed state during the experiment, one baby showed a strong side bias (they turned more than 85% of the time in one direction), and three others were excluded due to technical errors.

The 17 babies that completed the study met the screening criteria of normal delivery, a birth-weight between 2700 and 4270 g, and an Apgar score of at least 8 at 5 minutes. All were healthy and free of any known neurological or ocular abnormality. They were tested after the first 24 hours of life, the range of ages at time of test being from 24–96 hours postnatal (mean age of 46 hours). The testing took place during the hour proceeding the scheduled feeding time, if the baby was awake and in an alert state. Informed consent was obtained from the parents.

Apparatus and stimuli

The infants sat on the adult's lap 35 cm distant from a translucent screen. The baby holder was not actively involved in the experiment, was unaware of the hypothesis being tested in the experiment, and was not one of the authors. The newborn's eye level was aligned to the centre of the screen at

the same level as the eyes of the faces. A video camera focused on the infant's face allowing the experimenter to monitor their eye movements. Infants were shown two pictures of the same person's face, one on the right and one on the left of the centre of the screen. One of the faces had a neutral face (no emotion) and the other had a fearful expression; both faces had a straight head and direct gaze (see Figure 1). Two different identity faces were used, but each newborn saw only one of them (randomly assigned, face (a) or face (b)). The faces were of different ethnic origin in order to allow us to generalize the results obtained. Face (a) subtended a visual angle of 20.2×31.1 degrees, and the external contour of the eyes 4.1×1.6 degrees in the case of neutral face and 4.1×2.8 degrees in the case of the fearful face (e.g., life-size as viewed from 35 cm distance). Face (b) subtended a visual angle of 19.5×32.7 degrees, and the external contour of the eyes 4.9×1.6 degrees in the case of neutral face and 4.5×2.6 degrees in the case of the
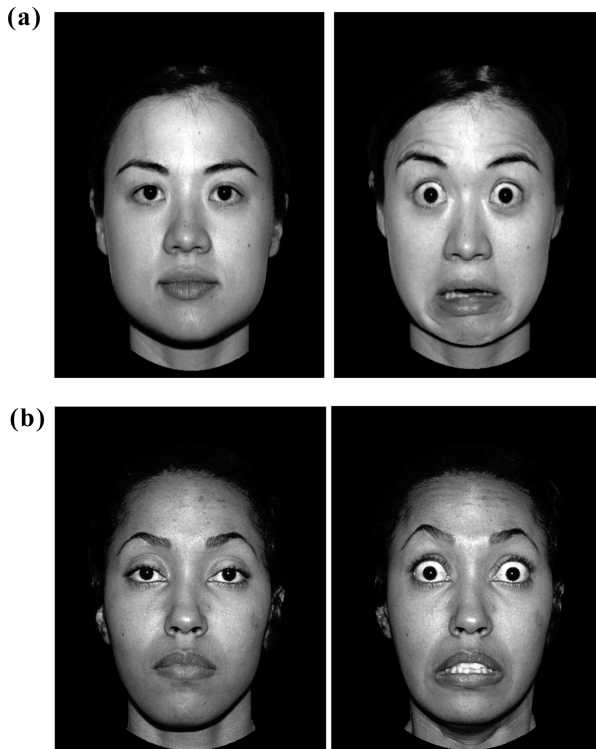
(a)

(b)

Figure 1. Stimuli used in Experiment 1. Half of the newborns saw photographic images of one face identity (a) and the other half saw the other face (b).

fearful face. In both stimuli the pupil was 1 cm in diameter. The two faces were 15.5 cm apart.

Procedure

Once the newborn was seated in front of the screen, as soon as she/he fixated the centre of the screen, the experimenter (who watched the newborn's eyes via a video monitor system) initiated a trial and presented the faces on the screen. The faces remained on for as long as the infant fixated on one of them (infant-control procedure). When the infants shifted their gaze away from the display for more than 10 s, the experimenter removed the faces and presented the next trial. In the second trial the location of the neutral and fear faces was reversed. Two trials were presented to the newborn with one left-to-right-reversal. This procedure has previously been used with newborns (e.g., Valenza, Simion, Macchi Cassia, & Umiltà, 1996). Two pseudo-random presentation sequences were used in which half of the infants saw a neutral face to the right and half to the left. Videotapes of the baby's eye movements throughout the trial were subsequently analysed by two coders blind as to the location of direct and averted gaze faces. The coders recorded, separately for each stimulus and each trial, the number of orienting responses and the total fixation time (interrater reliability for 10% of the total participants, Cohen's kappa = .88 for the duration of fixation and .90 for the number of orientations). While the coders could see the corneal reflection of the stimulus face (to help establish fixation), they could not see the details of the face, and they were blind as to expression being displayed.

Results and discussion

Preliminary statistical analyses showed no effects of order of presentation. As a consequence, data for each condition (neutral vs fearful face) were collapsed across this factor.

Two separate parametric tests were performed to compare the average total fixation time for each stimulus (neutral face vs fearful face) and the number of orientations in direction of each stimulus. Newborns did not show a significant difference in the total looking time at the neutral face ($M = 51.7$ s, $SD = 27.9$) or at the fearful face ($M = 43.4$ s, $SD = 16.9$), and they did not orient more frequently to either of the two facial expressions ($M = 20.35$, $SD = 7.2$ for the neutral face, and $M = 17.41$, $SD = 7.5$ for the fearful face).

Thus, in Experiment 1, newborns did not show any preference for one facial expression over the other. The next question that we investigated is whether newborns are able to discriminate between a face with a fearful expression and a neutral face.

EXPERIMENT 2

One obvious reason why newborns show no preference between fearful and neutral facial expressions is that they may not be able to discriminate between these stimuli. Alternatively, they may be able to discriminate between them, but they categorize and process them in the same way. Further, visual habituation may sometimes be a more sensitive technique for revealing newborn perceptual processing than preference measures. Therefore, in Experiment 2, we sought to determine whether newborns could discriminate between the two stimuli presented in Experiment 1 using a visual habituation and discrimination method.

Participants

Seventeen normal, healthy, full-term newborns were selected from the maternity ward of the Pediatric Unit of the Hospital of Monfalcone. Three babies were excluded from the final sample for various reasons. Two changed state during the experiment, one baby showed a strong side bias (they turned more than 85% of the time in one direction). The final sample consisted of 14 newborns. All of them met the screening criteria of normal delivery, a birth weight between 2610 and 3920 g, and a 5 minute Apgar score above 8. Infants were tested after the first 24 hours of life. Their ages at the time of testing ranged from approximately 24 to 120 hours ($M = 56$ h). Informed consent was obtained from the parents.

Apparatus and stimuli

The apparatus and the stimuli were the same as these used in Experiment 1. During the habituation phase the newborns viewed pairs of identical face stimuli (same identity, same expression, one on the right and one on the left of the screen) with either a neutral expression or a fearful expression. During the test phase the two different expressions of the same identity face were presented bilaterally.

Procedure

The experiment was carried out using a visual habituation technique with the infant-control procedure (Slater, Morison, Town, & Rose, 1985). The newborn 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 habituation with one of the two expressions was followed by a preference test in which a preference could be expressed between the familiar face expression (either neutral or fearful face) and the 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.

Results and discussion

During the habituation phase, the average total fixation time was 70.2 s ($SD = 21.6$) for the neutral expression and 72.0 s ($SD = 27.4$) for the fearful expression.

During the test phase, to test whether the infants were able to recognize the face seen previously, a 2×2 ANOVA was performed with the Stimulus Condition (familiar vs novel) and the Order Presentation (first vs second presentation) as within-subject factors. Only the order of presentation was significant, showing that the newborns looked more during the first presentation than the second one, independently of the stimulus condition, $F(1, 13) = 9.413$, $p = .009$. Most importantly, no significant effect of stimulus condition or interaction was found, showing that the newborns were unable to discriminate between the neutral and fearful faces.

Experiments 1 and 2 revealed no evidence that newborns prefer or discriminate fearful from neutral facial expressions. One possibility is that these stimuli are simply not discriminable to newborns. However, given their sensitivity to direction of eye gaze (Farroni et al., 2002) and individual identity (Pascalis & de Schonen, 1994; Pascalis, de Schonen, Morton, Deruelle, & Fabre-Grenet, 1995), this seems unlikely. A more intriguing possibility is that fearful and neutral expressions are discriminable, but are processed or categorized in the same way by newborns. This could be consistent with a perceptual learning view pointing to their lack of experience with fearful expressions, or with the view that fearful and neutral expressions both equally engage the primitive face detection mechanisms underlying their behaviour (Johnson, 2005).

EXPERIMENT 3

Since the first experiments failed to provide evidence for discrimination or preference between different facial expressions in newborns, in the next experiment we decided to compare the fearful expression to a happy facial expression. This comparison was selected for two reasons. First, contrasting fearful with happy may increase the perceptual distance between the stimuli as compared to the earlier pair. Second, although our healthy newborns had very limited experience of faces, this experience was likely to include happy and smiling faces.

Participants

Twenty-one normal, healthy, full-term newborns were selected from the maternity ward of the Pediatric Unit of the Hospital of Monfalcone. Nine babies were excluded from the final sample for various reasons. Five changed state during the experiment, three were excluded due to technical errors, and one for being more than two standard deviations beyond the mean average fixation time. The final sample consisted of 12 newborns. All of them met the screening criteria of normal delivery, a birth weight between 2300 and 4480 g, and a 5 minute Apgar score above 8. Infants were tested after the first 24 hours of life. Their ages at the time of testing ranged from approximately 31 to 87 hours ($M = 54$ h). Informed consent was obtained from the parents.

Apparatus and stimuli

The apparatus was the same as that used in Experiment 1. Infants were shown two pictures of the same person's face, one on the right and one on the left of the centre of the screen. One of the faces had a happy expression and the other had a fearful expression, both with a straight head and direct gaze (see Figure 2). The face subtended a visual angle of 19.5×32.7 degrees, and the external contour of the eyes 4.5×2.3 degrees in the case of the happy face and 4.5×2.6 degrees in the case of the fearful face (e.g., life-size as viewed from $30-35$ cm distance). In both stimuli the pupil was 0.7 cm in diameter. The two stimuli were 15.5 cm apart.

Procedure

The procedure was the same as that used in Experiment 1. The coders recorded, separately for each stimulus and each trial, the number of

Figure 2. Stimuli used in Experiment 3.

orienting responses and the total fixation time (interrater reliability for 10% of the total participants, Cohen's kappa = .87 for the duration of fixation and .89 for the number of orientations).

Results and discussion

Preliminary statistical analyses showed no effects of order of presentation. As a consequence, data for each condition (happy vs fearful face) were collapsed across this factor. Two separate parametric tests were performed to compare the average total fixation time for each stimulus (fearful vs happy face) and the number of orientations in direction of each stimulus. Newborns showed significantly greater total looking time at the happy face ($M = 57$ s, $SD = 18.5$) than at the fearful face ($M = 46$ s, $SD = 8.8$), $t(11) = -2.8$, $p = .017$, but they did not orient more frequently to the happy face ($M = 21.5$, $SD = 8.7$) than to the fearful one ($M = 19.7$, $SD = 7.6$).

In contrast to the negative results found in the previous experiments, in Experiment 3 we obtained evidence for a significant preference to look for longer at a happy face than a fearful one.

GENERAL DISCUSSION

In Experiments 1 and 2 we found no evidence that newborns can discriminate, or prefer, a fearful expression as compared to a neutral expression. This is despite the fact that the fearful expression contains wide eyes and a semi-open mouth, features that may have enhanced the salience of a face. However, when we compared a fearful expression to a happy one, newborns looked significantly longer at the latter. This preference for a happy face also demonstrates that newborns are able to discriminate happy from fearful expressions. These results go beyond the previously contradictory evidence on newborns perception of facial expressions to show that at least some facial expressions are discriminated and preferred over others.

These results potentially inform two strands of theory about the early development of facial expression perception. One idea is that perception of facial expressions is acquired through experience, and the perceptual dimensions relevant to different expressions are gradually discovered and used to differentiate perceptual inputs and associate them with different responses and consequences (Quinn & Johnson, 1997). According to this general view it is not surprising that happy is preferred, even from the first few days, since this facial expression is likely to have been present for most of the time that face-related stimuli were present in the newborn's visual world. Early perceptual learning is therefore likely to acquire this expression first, and even possibly before a neutral expression. Effects of early

experience on vocal expressions of emotion have already been described in newborns (Mastropieri & Turkewitz, 1999).

Another theoretical direction discussed earlier concerns cognitive neuroscience evidence for a rapid subcortical route sensitive to faces. In adults, this route is most sensitive to fearful expressions, possibly because of the wide eyes displayed in this expression (Whalen et al., 2004). One specific hypothesis is that this pathway may lead to aversion of fearful faces even in newborns. This prediction was not confirmed. Another hypothesis is that the subcortical route has a more general face detection role in infants and children (Johnson, 2005). This hypothesis is supported by functional MRI evidence that the amygdala is equally activated by neutral and fearful faces in children (Thomas et al., 2001). According to this hypothesis, fearful and neutral expressions both equally activate the subcortical route that may influence newborns face-related preferences (Johnson, 2005). Since these stimuli both activate the subcortical route they are both categorized as being the same kind of thing in the external world, and are therefore treated equivalently by the newborn. But, how are we to reconcile this view with the preference for a happy expression found in Experiment 3? It is important to note that while infants looked for significantly longer at the happy face as compared to the fearful one, they did not orient more frequently to this stimulus. Since orienting measures may better reflect the biases within a subcortical route (Johnson, 2005), a possibility is that the longer duration spent looking at the happy expression reflects experience acquired over the first few days. Orienting measures are likely to better reflect activity in subcortical pathways than fixation time since stimuli in the periphery impinge on the temporal visual field that is known to feed differentially into the subcortical visuo-motor route (de Gelder & Stekelenburg, 2005; Rafal, Henik, & Smith, 1992; Simion, Valenza, Umiltà, & Dalla Barba, 1995, 1998).

A further interpretation of our results relates to a recent study on the influence of the direction of the gaze on the perception of facial emotion in adults (Adams & Kleck, 2005). In this study it was demonstrated that when gaze direction matches the underlying behavioural intent (approach–avoidance) communicated by an emotional expression, the perception of that emotion would be enhanced. The authors demonstrated that direct gaze enhances the perception of approach-oriented emotions (anger and joy), while averted eye gaze enhances the perception of avoidance-oriented emotions (fear and sadness). According to this account, one possible interpretation of our results is that fearful faces are not preferred or discriminated by the newborns when associated with neutral faces because the direction of the gaze (i.e., direct gaze) is incongruent with the emotional expression communicated (i.e., fear). This hypothesis can be investigated in future work.

Whatever the mechanisms underlying the preference for happy expressions that we have observed, our results contribute to the growing body of evidence that, within the first few days after birth, newborns are sensitive to the characteristics of faces that are likely to maximize their chances of interacting with other conspecifics (Farroni et al., 2005).

REFERENCES

Adams, R. B., Jr., & Kleck, R. E. (2005). Effects of direct and averted gaze on the perception of facially communicated emotion. *Emotion*, *5*, 3–11.

Adolphs, R., & Tranel, D. (2003). Amygdala damage impairs emotion recognition from scenes only when they contain facial expressions. *Neuropsychologia*, *41*, 1281–1289.

Adolphs, R., Gosselin, F., Buchanan, T. W., Tranel, D., Schyns, P., & Damasio, A. R. (2005). A mechanism for impaired fear recognition after amygdala damage. *Nature*, *433*, 22–23.

Darwin, C. (1872). *The expression of emotion in man and animals*. London: John Murray.

de Gelder, B. (2006). Towards the neurobiology of emotional body language. *Nature Reviews Neuroscience*, *7*(3), 242–249.

de Gelder, B., & Stekelenburg, J. J. (2005). Nasal-temporal asymmetry of the N170 for processing faces in normal viewers but not in developmental prosopagnosia. *Neuroscience Letters*, *376*, 40–45.

De Haan, M., & Nelson, C. A. (1998). Discrimination and categorization of facial expressions of emotion during infancy. In A. Slater (Ed.), *Perceptual development* (pp. 287–309). Hove, UK: Psychology Press.

Ekman, P., Friesen, W. V., & Ellworth, P. (1972). *Emotion in the human face*. New York: Pergamon Press.

Farroni, T., Csibra, G., Simion, F., & Johnson, M. H. (2002). Eye contact detection in humans from birth. *Proceedings of the National Academy of Sciences (PNAS)*, *99*, 9602–9605.

Farroni, T., Johnson, M. H., Menon, E., Zulian, L., Faraguna, D., & Csibra, G. (2005). Newborns' preference for face-relevant stimuli: Effect of contrast polarity. *Proceeding of the National Academy of Sciences (PNAS)*, *102*, 17245–17250.

Field, T., Woodson, R., Greenberg, R., & Cohen, D. (1982). Discrimination and imitation of facial expression by neonates. *Science*, *218*, 179–181.

Field, T. M., Woodson, R., Greenberg, R., & Cohen, D. (1983). Discrimination and imitation of facial expressions by neonates. *Annual Progress in Child Psychiatry & Child Development*, *16*, 119–125.

Johnson, M. H. (2005). Subcortical face processing. *Nature Reviews Neuroscience*, *6*, 766–774.

Johnson, M. H., Dziurawiec, S., Ellis, H., & Morton, J. (1991). Newborns' preferential tracking of face-like stimuli and its subsequent decline. *Cognition*, *40*, 1–19.

Kaitz, M., Meschulach-Sarfaty, O., Auerbach, J., & Eidelman, A. (1988). A re-examination of newborns' ability to imitate facial expressions. *Developmental Psychology*, *24*, 3–7.

Kotsoni, E., De Haan, M., & Johnson, M. H. (2001). Categorical perception of facial expressions by 7-month-old infants. *Perception*, *30*, 1115–1125.

Mastropieri, D., & Turkewitz, G. (1999). Prenatal experience and neonatal responsiveness to vocal expressions of emotion. *Developmental Psychobiology*, *35*, 204–214.

Nelson, C. A., & Dolgin, K. (1985). The generalized discrimination of facial expressions by 7-month-old infants. *Child Development*, *56*, 58–61.

Pascalis, O., & de Schonen, S. (1994). Recognition memory in 3- to 4-day-old human neonates. *Neuroreport*, *5*, 1721–1724.

Pascalis, O., de Schonen, S., Morton, J., Deruelle, C., & Fabre-Grenet, M. (1995). Mother's face recognition by neonates: A replication and an extension. *Infant Behavior and Development*, *18*, 79–85.

Quinn, P. C., & Johnson, M. H. (1997). The emergence of category representations in infants: A connectionist analysis. *Journal of Experimental Child Psychology*, *66*, 236–263.

Rafal, R., Henik, A., & Smith, J. (1992). Extrageniculate contributions to reflex visual orienting in normal humans a temporal hemifield advantage. *Journal of Cognitive Neuroscience*, *3*, 323–329.

Simion, F., Valenza, E., Umiltà, C., & Dalla Barba, B. (1995). Inhibition of return in newborns is temporo-nasal asymmetrical. *Infant Behavior and Development*, *18*, 189–194.

Simion, F., Valenza, E., Umiltà, C., & Dalla Barba, B. (1998). Preferential orienting to faces in newborns: A temporal-nasal asymmetry. *Journal of Experimental Psychology: Human Perception and Performance*, *24*, 1399–1405.

Slater, A., Morison, V., Town, C., & Rose, D. (1985). Movement perception and identity constancy in the new-born infant. *British Journal of Developmental Psychology*, *3*, 211–220.

Thomas, K. M., Drevets, W. C., Whalen, P. J., Eccard, C. H., Dahl, R. E., Ryan, N. D., et al. (2001). Amygdala responses to facial expressions in children and adults. *Biological Psychiatry*, *49*, 309–316.

Valenza, E., Simion, F., Macchi Cassia, V., & Umiltà, C. (1996). Face preference at birth. *Journal of experimental psychology: Human Perception and Performance*, *22*, 892–903.

Whalen, P. J., Kagan, J., Cook, R. G., Davis, F. C., Kim, H., Polis, S. et al. (2004). Human amygdala responsivity to masked fearful eye whites. *Science*, *306*, 2061.