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Processing of faces and emotional expressions in infants at risk of social phobia

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Individuals with social phobia display social information processing biases yet their aetiological significance is unclear. Infants of mothers with social phobia and control infants’ responses were assessed at 10 days, 10 and 16 weeks, and 10 months to faces versus non-faces, variations in intensity of emotional expressions, and gaze direction. Infant temperament and maternal behaviours were also assessed. Both groups showed a preference for faces over non-faces at 10 days and 10 weeks, and full faces over profiles at 16 weeks; they also looked more to high vs. low intensity angry faces at 10 weeks, and fearful faces at 10 months; however, index infants’ initial orientation and overall looking to high-intensity fear faces was relatively less
INTRODUCTION

Social phobia is a chronic, debilitating disorder, affecting 7 to 13% of individuals, and is characterised by intense fear of scrutiny and negative evaluation by others (Yonkers, Dyck, & Keller, 2001). Little is known about its aetiology (e.g., Rapee & Spence, 2004). Disturbances in social information processing, particularly of faces and emotional expressions, have been implicated in the maintenance of social phobia in both adults (e.g., Bögels & Mansell, 2004) and children (e.g., Hadwin et al., 2003; Stirling, Eley, & Clark, 2006); yet, whether they are of aetiological significance is unknown. The purpose of this study was to investigate early characteristics of processing of face and emotional expression in infants at risk of social phobia.

Processing of faces and emotional expressions in social anxiety

Studies of processing of faces and emotional expressions among individuals with social phobia can be considered in three categories of response to: (i) face vs. non-face stimuli; (ii) direct vs. averted gaze; and (iii) emotional expressions. In adults, studies of responses to face vs. non-face stimuli have shown that, in conditions of threat, socially anxious individuals direct attention away from faces, including those with positive expressions (Garner, Mogg, & Bradley, 2006; Mansell, Clark, Ehlers, & Chen, 1999), and, in clinic populations, this generalises to non-threat conditions (Chen, Ehlers, Clark, & Mansell, 2002). The avoidance of eye contact has been a frequently noted characteristic of the clinical profile of social phobia (Trower & Gilbert, 1989), and information-processing studies have shown that adults with social phobia spend less time scanning prominent facial features, such as the eyes, than non-anxious people (Horley, Williams, Gonsalvez, & Gordon, 2003).

More evidence exists regarding socially anxious adults’ responses to emotional facial expressions. This suggests that affected individuals do not differ from non-socially anxious adults in their ability to correctly identify different types of emotion, whether in clinical (e.g., Merckelbach, Van Hout, Ven den Hout, & Mersch, 1989; Phillipot & Douillez, 2005) or non-clinical (Douillez & Phillipot, 2003) populations. However, studies show that socially anxious individuals exhibit distinctive attentional responses to emotional faces (e.g., Bögels & Mansell, 2004), identify angry faces at lower levels of
emotional intensity (Joorman & Gotlib, 2006), and interpret ambiguous facial expressions as threatening (Yoon & Zinbarg, 2007). These studies suggest that, while social anxiety is not associated with differences in ability to recognise emotional expressions, it is associated with a heightened sensitivity to potentially threatening facial expressions at early stages in processing. Furthermore, there is growing support for the vigilance–avoidance hypothesis (e.g., Mogg, Bradley, de Bono, & Painter, 1997), which suggests that while socially anxious individuals initially direct attention towards relevant threat cues (hypervigilance), they then avoid them. It is not clear whether this reflects a general emotionality bias (e.g., Mansell et al., 1999), or else a more specific negativity bias (e.g., Winton, Clark, & Edelman, 1995).

Fewer studies have examined responses to face stimuli in socially anxious children, and only tentative conclusions can be drawn. First, in contrast to studies with adults, deficits in emotion discrimination have been reported among younger populations, in both clinic (Simonian, Beidel, Turner, Berkes, & Long, 2001) and non-clinic samples (Battaglia et al., 2004; Melfsen & Florin, 2002). Overall, studies suggest that socially anxious children have general difficulties in emotion discrimination, rather than their simply interpreting faces in an overly negative way.

Second, an association between social anxiety and attentional processes has been identified among younger populations. Specifically, child social anxiety symptoms (but not general anxiety) have been found to be associated with avoidance of both fearful and angry faces (Stirling et al., 2006).

The place of social information processing in the aetiology of social phobia

The extent to which the characteristic information-processing biases evident in adults and children with social phobia are implicated in the development of the disorder, or are a consequence of social anxiety, is unclear. Social phobia is known to aggregate in families (e.g., Lieb et al., 2000; Mancini, van Ameringen, Szatmari, Fugere, & Boyle, 1996), with a genetic contribution accounting for about 10% of heritability (Nelson et al., 2000). Some investigators have proposed that genetically-based individual differences in social skills, including poor abilities to discriminate facial expressions of emotion, lead to repeated experiences of social failure, which in turn lead to social anxiety (Rapee & Spence, 2004). Similarly, the “integral bias hypothesis” proposes that individual cognitive biases, such as the propensity to avoid certain social stimuli, are an integral part of (or a risk factor for) social anxiety, and, as such, should be detectable among at-risk infants (Richards, French, Nash, Hadwin, & Donnelly, 2007). The “inferred-bias
hypothesis”, by contrast, proposes that social anxiety itself may interfere with social information processing (McClure & Nowicki, 2001; Richards et al., 2007). This suggests that social information processing and skills deficits should increase with age and are unlikely to be apparent in early infancy. Finally, the “inhibition hypothesis”, posits that a bias for threatening stimuli is normal in young children but, whereas non-anxious children learn to inhibit such responses, those with high anxiety are unable to do so (Kindt & van den Hout, 2001).

These hypotheses have been subjected to little investigation, and none in relation to the development of social anxiety. Nevertheless, infancy research has provided a wealth of data regarding the normative development of infants’ responses to faces that could elucidate the merits of the competing hypotheses.

**Face processing in infancy**

Even young infants have specialised responses to the face (see Slater, 1998). Studies of face processing among infants can be considered in the same three categories as for adults.

Despite their poor visual acuity, even young infants show social perceptual abilities (Muir & Nadel, 1998), and fairly consistent evidence has emerged indicating that new-born infants can discriminate, and prefer, simple face-like vs., non-face-like stimuli (Easterbrook, Kisilevsky, Muir & Laplante, 1999; Johnson & Morton, 1991); and, by two months, this is well established (e.g., Maurer & Barrera, 1981). By 5 months, infants are more discriminating, and will only show a face preference if the stimuli are complex (Morton & Johnson, 1991).

With regard to responses to gaze, infants show particular interest in people’s eyes from about 2 months (e.g., Maurer & Salapatek, 1976). Between 2 and 5 months, the ability to discriminate head and gaze direction shows rapid development (Caron, Caron, Roberts, & Brooks, 1997), including a growing preference for social partners who make eye contact (Hains & Muir, 1996).

Infants can discriminate between different types of facial expressions from an early age. Even newborns can detect changes in expression (e.g., Field, Woodson, Greenberg, & Cohen, 1982); and over the subsequent four months, infants become able to discriminate happy expressions from a range of negative ones (Nelson & Ludeman, 1986), with a preference shown for the former (Oster & Ewy, 1980). By 5 months, discrimination between different negative expressions is achieved (Schwartz, Izard, & Ansul, 1985). Notably, however, 7-month-olds look consistently more at fearful vs. happy faces (de Haan & Nelson, 1998; Kotsoni, de Haan, & Johnson, 2001).
Individual differences and psychopathology

Although individual differences in infant responses to face stimuli have been noted (e.g., Easterbrook, Kisilevsky, Hains, & Muir, 1999), few studies have addressed this issue systematically, and the extent to which they are a function of social experience, or more constitutional factors such as temperament, is unknown. Research with some clinical populations, including autism (Baron-Cohen, 1997) and Turner’s syndrome (Skuse et al., 1997), suggests that some aspects of recognition of emotional expressions may well have a genetic basis. Nevertheless, social experience may also be important. Thus, Kuchuk, Vibbert, and Bornstein (1986) found an association between mothers’ encouragement of attention to their face and 3-month-old infants’ responses to faces. The role of interaction experience is also suggested by studies showing that infants look more to faces showing expressions differing from those to which they have previously been exposed (de Haan, Belsky, Reid, Volein, & Johnson, 2004; Field, Pickens, Fox, Gonzalez, & Nawrocki, 1998; Striano, Brennan, & Vanman, 2002). Notably, mothers with social phobia have been found to show specific parenting difficulties with their infants in social contexts. Thus, in the presence of a stranger, affected mothers encourage their infants’ interaction with the stranger less, and display more anxious behaviour (Murray, Cooper, Creswell, Schofield, & Sack, 2007). Whether such parental responses influence infants’ processing of social stimuli has not been established.

The current study aimed to elucidate the development of social information processing in infants of mothers with social phobia, compared to infants of unaffected, control, mothers, in order to determine whether, and at what point in development, equivalent responses to social stimuli that are characteristic of older children and adults with social phobia emerge. Specifically, we focused on infants’ responses to (i) faces versus non-faces; (ii) forward-facing versus averted gaze; and (iii) emotional expressions of varying kinds and intensity. With regard to the latter, given that social anxiety is associated with an avoidance of extreme expressions, even when positive (Mansell et al., 1999), we examined infant responses to extreme emotional expressions in comparison to moderate expressions. In addition, based on the suggestion that early face processing differences may be a result of experiences with caregivers, we aimed to assess whether responses to faces develop as a function of (i) endogenous infant characteristics, i.e., temperament, and/or (ii) characteristics of mother–infant interactions. We assessed infant face processing at four time points. As we were interested in the extent to which face-processing characteristics represent endogenous characteristics, the first assessment was conducted when the infants were 10 days old. Numerous studies have established that neonates are able to discriminate between face-like and non-face-like images, yet at this age infants will have
had little exposure to maternal expressions of social anxiety. The next assessment was conducted at 10 weeks of age. At this age face-to-face interactions are a primary source of infant social interactions. While social phobia does not seem to impair maternal social responsiveness to her child in this context, early signs of reduced social responsiveness begin to emerge at around this age in infants of socially phobic mothers that are predicted by concurrent maternal regulation of infant behaviour (Murray et al., 2007). We were therefore interested to assess the infants independently of maternal active involvement, within an experimental paradigm. The next assessment was conducted at 16 weeks, when infant visual abilities have developed rapidly and numerous processes relevant to the processing of faces (e.g., discrimination of gaze direction and emotional expressions) are established (e.g., Caron et al., 1997; Nelson & Ludeman, 1986). Finally, the infants were assessed at 10 months. This was of particular interest since, at this age, social-referencing abilities emerge, and children have the ability to identify their mother’s responses to other people (e.g., Baldwin & Moses, 1996), and maternal social behaviours may therefore be particularly influential.

METHOD

Sample

Mothers attending antenatal clinics were screened with an 8-item version of the Social Interaction and Anxiety Scale and the Social Phobia Scale (SIAS and SPS; Mattick & Clarke, 1998) to detect social phobia. Items were included on the basis of their high factor loadings on these measures. A pilot of each screen identified cut-off scores for the top 10% of respondents. High scoring women were interviewed to confirm diagnosis using the Structured Clinical Interview for DSM-IV Axis I disorders (SCID-1; First, Spitzer, Gibbon, & Williams, 1995), administered by trained psychologists and mental-health clinicians. Those meeting criteria for a DSM-IV diagnosis of social phobia were recruited. Controls were selected randomly from the low-scoring women, who were also interviewed to confirm the absence of psychiatric disorder. A total of 96 women were recruited into the index group, and 94 as controls (see Murray et al., 2007, for full recruitment details). Numbers of infants with complete data at the different ages are given in Tables 1–3.

Procedure

Infants were assessed when aged 10 days in the home, in quiet conditions, and in university research rooms at 10 weeks, 16 weeks and 10 months of age. Response to faces vs. non-faces was assessed at the first three time points. Response to emotional expressions of varying intensity was assessed
at all but the 10-day assessment; and response to gaze direction was assessed at 16 weeks and 10 months. Assessments of maternal behaviours and infant temperament (behavioural inhibition) were made at 10 and 16 weeks, respectively. For all infant looking procedures in the laboratory, infants sat facing a screen within a booth with low-lighting, on the experimenter’s lap at 16 weeks and on their mother’s lap at 10 months (to avoid effects of infant stranger fear at later visits). Stimuli were displayed on a projection screen at 90 cm distance from the infant. The infants’ attention was first attracted to the screen by an image of a mobile doll. Infants were videotaped throughout, and their behaviour scored by two researchers who were blind to maternal diagnosis and stimulus condition.

### Infant looking times to faces and non-faces; Means (SDs)

<table>
<thead>
<tr>
<th></th>
<th>10 days</th>
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<td></td>
<td>(n = 45)</td>
<td>(n = 53)</td>
<td></td>
<td>(n = 74)</td>
<td>(n = 81)</td>
<td></td>
<td>(n = 82)</td>
<td>(n = 71)</td>
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<tr>
<td>Faces</td>
<td>30.79</td>
<td>37.14</td>
<td>54.29</td>
<td>45.85</td>
<td>15.99</td>
<td>17.18</td>
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<tr>
<td></td>
<td>(39.20)</td>
<td>(44.79)</td>
<td>(51.24)</td>
<td>(38.43)</td>
<td>(14.34)</td>
<td>(14.08)</td>
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<tr>
<td>Non-faces</td>
<td>24.57</td>
<td>23.20</td>
<td>43.97</td>
<td>37.87</td>
<td>18.45</td>
<td>17.53</td>
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<td></td>
<td>(31.49)</td>
<td>(29.64)</td>
<td>(38.22)</td>
<td>(40.35)</td>
<td>(12.64)</td>
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Infant face-processing assessments

**10-day assessment**

*Face vs. non-face.* At 10 days, infants completed a preferential looking task using the procedure for assessments of neonates of Turati, Simion, Milani, and Umilta (2002) and others. Infants were simultaneously presented with two head-shaped, head-sized, boards with black on white features, shown either as a face or else inverted—retaining symmetry (following Morton & Johnson, 1991; Johnson, Dziurawiec, Ellis, & Morton, 1991; see Figure 1). The head boards were mounted against a black background at an angle of 70° from the infant’s viewing position. The infant was positioned on an experimenter’s lap 50 cm from the board. A second experimenter, who was blind to stimulus position, viewed the infant through a spy-hole in the board and recorded infant gaze direction onto a DAT audio tape, using a button-box. Once the infant had looked away from both stimuli for a total of four seconds, the trial ended. There were two trials, with each stimulus being displayed to each side, and the order of presentation being counterbalanced across subjects.
| TargetSide | 10 weeks |       |       |       |       | 16 weeks |       |       |       | 10 months |       |       |       |      |       |       |      |       |       |      |       |       |      |       |       |      |       |       |      |
|------------|----------|--------|--------|--------|--------|----------|--------|--------|--------|-----------|--------|--------|--------|------|--------|--------|------|--------|--------|------|--------|--------|------|--------|--------|------|--------|--------|------|--------|--------|------|--------|--------|------|
|            | SP (n = 53) | Control (n = 56) |       | SP (n = 39) | Control (n = 35) |       | SP (n = 40) | Control (n = 45) |       |
|            | Right     | Left    |        | Right     | Left    | Right     | Left    | Right     | Left    | Right     | Left    | Right     | Left    | Right     | Left    | Right     | Left    | Right     | Left    |
| Angry      | Low (0 & 25%) |          |        | High (75 & 100%) |          |        |        |        |        |        |        |        |        |        |        |        |        |        |
| Right      | 0.73 (0.56) | 1.13 (0.59) |        | 0.88 (0.60) | 1.21 (0.62) |        | 0.86 (0.69) | 1.14 (0.68) |        | 1.06 (0.72) | 1.12 (0.72) |        | 0.92 (0.62) | 1.05 (0.64) |        | 1.06 (0.72) | 1.05 (0.64) |        |
| Left       | 0.84 (0.59) | 1.15 (0.60) |        | 0.73 (0.51) | 1.30 (0.61) |        | 0.94 (0.64) | 1.17 (0.67) |        | 0.97 (0.67) | 1.02 (0.61) |        | 1.01 (0.63) | 1.05 (0.60) |        | 1.01 (0.67) | 1.05 (0.60) |        |
| Happy      | Low (0 & 25%) |          |        | High (75 & 100%) |          |        |        |        |        |        |        |        |        |        |        |        |        |        |
| Right      | 0.95 (0.65) | 1.08 (0.66) |        | 0.87 (0.43) | 1.11 (0.50) |        | 0.98 (0.52) | 1.11 (0.48) |        | 1.06 (0.47) | 1.04 (0.47) |        | 1.01 (0.41) | 1.04 (0.42) |        | 1.01 (0.47) | 1.04 (0.42) |        |
| Left       | 0.89 (0.67) | 1.15 (0.69) |        | 0.87 (0.43) | 1.11 (0.50) |        | 0.98 (0.52) | 1.11 (0.48) |        | 1.06 (0.47) | 1.04 (0.47) |        | 1.01 (0.41) | 1.04 (0.42) |        | 1.01 (0.47) | 1.04 (0.42) |        |
| Fearful    | Low (0 & 25%) |          |        | High (75 & 100%) |          |        |        |        |        |        |        |        |        |        |        |        |        |        |
| Right      | 1.06 (0.72) | 1.12 (0.72) |        | 0.97 (0.47) | 1.01 (0.47) |        | 1.00 (0.41) | 1.00 (0.41) |        | 1.06 (0.53) | 1.06 (0.53) |        | 1.10 (0.41) | 1.10 (0.41) |        | 1.10 (0.41) | 1.10 (0.41) |        |
| Left       | 0.97 (0.67) | 1.02 (0.61) |        | 0.97 (0.47) | 1.01 (0.47) |        | 1.00 (0.41) | 1.00 (0.41) |        | 1.06 (0.53) | 1.06 (0.53) |        | 1.10 (0.41) | 1.10 (0.41) |        | 1.10 (0.41) | 1.10 (0.41) |        |

Note: Variability in n across trials due to infant fatigue or irritability (max n given).
10-week assessment

Face vs. non-face. At this assessment the face and inverted array (equivalent to stimuli shown at 10 days) were presented alternately, each being shown twice, with order of presentation across subjects counterbalanced (1: face/inversion/inversion/face; 2: inversion/face/face/inversion), following the procedure of Morton and Johnson (1991). The experimenter, who was blind to condition, recorded infant fixations on the stimuli using a button-box. When the infant had looked away from the stimulus for 5 seconds, the attractor was shown again, before displaying the next trial. Infant responses were video recorded and duration of infant gaze was scored from the video using a button-box.

Emotional expression. To assess infants’ responses to varying intensities of emotional expression, continua depicting different intensities of anger, happiness, and fear were taken from the FEEST (Young, Perrett, Calder, Sprengelmeyer, & Ekman, 2002). Each continuum consisted of a prototype expression face (considered to be 100% intensity for that expression) from the Ekman and Friesen (1976) series, and morphed images interpolated between the prototype expression and its corresponding neutral. So, for example, the neutral face of model MF in the Ekman and Friesen series was taken to represent 0% happiness, and then 25%, 50%, and 75% happy morphs were created by interpolating between MF’s neutral (0% happy) and her prototype happy (100%) expressions. A different model was used for each continuum, and the stimuli are shown in Figure 2. The faces from the
Figure 1. Face–non-face stimuli (10 weeks).

Figure 2. Emotional faces of varying intensity.
Ekman and Friesen (1976) series used to create these continua were as follows: anger (neutral NR-1-03, anger NR-2-07), happiness (neutral MF-1-02, happy MF-1-06), fear (neutral MO-1-05, fear MO-1-23). Hairstyles and picture backgrounds were masked, so that all differences between stimuli were emotion-relevant.

Twenty-four face pairs were shown. Within each, one face was shown at 50% intensity and the other showed varying intensities of the same emotion, either happiness, anger or fear (8 pairs including each emotion type). In this way, the standard (50%) face could be of higher or lower emotional intensity than the comparison face. The order of emotion type was counterbalanced across participants and visits. Each face pair was presented for 10 seconds, and the same attractor was shown at the start of each trial.

16-week assessment

Face vs. non-face. At 16 weeks, looking to faces vs. non-faces was assessed using more complex, moving stimuli (see Morton & Johnson, 1991). Stimuli were either a head-sized, black on white moving schematic face or a moving scrambled array (with symmetrical elements; see Figure 3). In each case, the appearance of movement was achieved by the display of internal features being alternated each second from one static presentation to another. The procedure for the assessment of infant responses to faces vs. non-faces and to emotional faces was the same as at the 10-week visit. The order of presentation was counterbalanced with the order of presentation from the previous visit.

Gaze direction. Infants were shown video clips of two female models, smiling and addressing the infant for 50 seconds, and either facing the infant

![Figure 3. Face-non-face stimuli (16 weeks).](image)
or with head and eyes averted (i.e., in profile). The full-face vs. profile clips were recorded simultaneously, using different camera angles. There were four trials, counterbalanced for each of the two models, and across gaze direction conditions and assessments.

10 months

Responses to emotional expressions and varying gaze direction were assessed following the same procedures used at the 16-week assessment.

Maternal behaviour

Maternal behaviour was assessed at 10 weeks. This was video recorded during a two-minute period when a female stranger entered the room where mother and infant were settled, approached, and attempted to engage the infant in play (see Murray et al., 2007, for full details). The mother’s behaviour was scored by two researchers who were unaware of maternal diagnosis.

Infant behavioural inhibition

Behavioural inhibition was assessed at 16 weeks using the procedure devised by Kagan and colleagues (1994). Infants were exposed to a series of unfamiliar visual, auditory, and olfactory stimuli. Their behaviour was video recorded throughout. The assessment was administered and scored by two trained researchers who were blind to maternal group (see Cooper, Murray, Schofield, Sadiqui, & Wehl, 2008).

Measures

Infant responses to face vs. non-face stimuli, emotional expressions and gaze direction

Looking times. The duration of infant looking to each stimulus type within each trial was recorded using a button box by scorers trained to a high level of reliability on a sample of 36 videotapes (ICC = .97).

Infant behaviours. The extent to which infants displayed a range of positive and negative behaviours was coded for the gaze-direction procedure (unlike the other, static face, stimuli, presentations for this assessment afforded more active social participation). Positive behaviours were: leaning/reaching towards the screen, positive shaping of the mouth, tonguing, smiling and mother-referencing in a positive way. Negative behaviours were: back arching/squirming, pouting, crying, yawning, frowning, touching of face/clothes/hand-wringing, grimacing, clenching
fists and sucking fists/thumb. Intra-class correlations, based on ratings of 40 infants were .74 for positive behaviours and .83 for negative behaviours.

**Infant behavioural inhibition**

On the basis of the degree of movement and distress shown in response to each stimulus, infants were classified as being either behaviourally inhibited or not, following the criteria established by Kagan and colleagues. Intra-class correlations for the two scales, based on ratings for 20 infants were each .99. For the classification of infants as inhibited or non-inhibited kappa was 1.00.

**Maternal behaviour**

This was scored on the following 5-point scales: (i) engagement with the stranger (greeting, eye-contact, smiling, conversing); (ii) encouragement to the infant to interact with the stranger (e.g., making positive comments, encouraging facial expressions and gestures); and (iii) expressed anxiety (e.g., biting lip, tense posture, worried expression). A random sample of 20 videotapes were scored by two researchers and confirmed a high level of reliability (mean ICC = .86, range .78–.94).

**Data analysis**

In procedures in which two faces were presented simultaneously (face vs. non-face at 10 days; emotional faces at all visits) cases were excluded from analyses if the infant looked to one side (left/right) only throughout all trials. Associations between infant responses and gender were first explored; none were significant, so gender was not considered further. Comparisons between responses to face stimuli by infants of mothers in the social phobia and control groups were made using paired samples \( t \)-tests or repeated measures analysis of variance where variables were normally distributed. Otherwise, transformed data were used where this improved the distribution, or non-parametric tests were used. Where significant differences were found between groups we (i) assessed the pattern of looking responses in more detail to explore whether differential looking to high intensity faces were consistent with differences in initial (hypervigilance) and subsequent (avoidance) responses; and (ii) examined associations with infant temperament and maternal behaviour. For dichotomous data (BI classification), this was based on repeated measures analysis of variance; for continuous data, repeated measures analyses were used with maternal behaviours entered as covariates.
RESULTS

Throughout the results effect sizes are reported as $r$. Demographic characteristics of the sample have been described elsewhere (e.g., Murray et al., 2007); the two study groups were similar in terms of maternal age, ethnicity, socioeconomic status and marital status, and the distribution of infant gender. Means and $SD$s for infant behaviours in response to the face vs. non face, intensity of emotional expression, and full-face vs. profile stimuli are shown in Tables 1–3, respectively.

Face vs. non-face

A main effect for stimulus type (face/non-face) was found at the first two assessments, 10 days: $F(1, 96) = 3.95, p = .05, r = .20$; 10 weeks: $F(1, 153) = 5.47, p = .02, r = .19$, representing a general preference for faces over non-faces, but was this not significant at 16 weeks, $F(1, 151) = 1.82, p = .18$. The interaction between stimulus type and infant group was not significant at any assessment, 10 days: $F(1, 96) = 1.29, p = .26$; 10 weeks: $F(1, 153) = 0.28, p = .60$; 16 weeks: $F(1, 151) = 1.17, p = .28$.

Emotional expression

Due to the infants’ young age, participant numbers across trials varied due to fatigue/distress or side bias, and therefore separate analyses were conducted to avoid significant data loss. Responses to emotional expressions were first assessed based on the proportion of time spent looking at the target versus the 50% expression. For this procedure, responses to the left and right side typically did not correlate sufficiently highly to combine them ($r = .06$ to $.73$), so these were analysed separately. No group differences were found in the proportion of time spent looking at the target expression for all emotion types, presented to either side, at all assessments (see Table 2). As we were particularly interested in infants’ differential responses to varying intensity emotions, repeated measures analyses were conducted to compare responses to the 50% morphed expressions to high intensity (75 and 100%) versus low intensity (0 and 25%) expressions. At the 10-week assessment, a main effect of intensity of angry expressions was found when the target stimulus was presented on the left side, $F(1, 91) = 3.86, p = .05, r = .20$, reflecting a general tendency to look more to high-intensity faces. The effect was not significant when the target was presented on the right side, $F(1, 90) = 0.90, p = .35$, although the data followed the same pattern (see Table 2). The interaction with group was not significant for either side, Left: $F(1, 91) = 1.70, p = .20$; Right: $F(1, 90) = 2.66, p = .11$. For happy faces, there was no effect of emotional intensity, Left: $F(1, 102) = 0.02, p = .88$; Right: $F(1, 97) = 0.19, p = .66$, or interaction between intensity and group, Left:
For fearful faces, no main effect of intensity was identified, Left: $F(1, 69) = 0.04, p = .85$; Right: $F(1, 74) = 1.73, p = .19$, however the Group $\times$ Intensity interaction was significant when the target stimulus was presented on the right, $F(1, 74) = 3.95, p = .05, r = .22$, reflecting a pattern of increased looking to high-intensity faces by controls, and reduced looking to high-intensity faces by index group infants (see Figure 4). The interaction was not significant when the target was presented on the left, $F(1, 69) = 0.28, p = .60$, although the pattern of results was the same. In order to explore whether differential looking to high-intensity faces represented differences in initial (hypervigilance) and subsequent (avoidance) responses, we compared groups on the following variables (i) which stimulus the infant looked to first (target/neutral); (ii) the length of the first look to target/control stimuli; and (iii) the total number of looks to target/control stimuli. Infants of non-anxious mothers’ first looks were more frequently to the target stimulus (presented on the right) than infants of socially phobic mothers, $\chi^2(1) = 4.02, p = .04$, Odds Ratio = 2.59. There were not significant interactions, however, between maternal group and either the length of the first look to the target versus control stimuli, $F(1, 66) = 0.10, p = .76$, or the number of looks to target vs. control stimuli, $F(1, 66) = 1.36, p = .25$.

**Figure 4.** Interaction between participant group and level of emotional intensity of fearful expressions (presented on the right side).
At 16 weeks and 10 months, neither main effects nor interaction effects were significant for any emotion type (see Table 3), with the exception of a main effect for intensity of fearful faces at 10 months, when presented on the right, $F(1, 85) = 8.63, p = .004; r = .30$. Notably, the pattern of results for high- versus low-intensity fearful faces for the social phobia and control groups at this assessment was consistent with that at 10 weeks, with controls showing a heightened preference for high-intensity faces, which was absent among the social phobia group; specifically there was a significant effect of intensity for controls, who looked more at high-intensity fearful faces presented on the right, $t(47) = 2.99, p = .004; r = .24$, but not for the index group, $t(38) = 1.42, p = .16$.

Gaze direction

At 16 weeks, an overall preference for full faces compared to profile was not found based on infant looking time (Wilcoxon $Z = 0.06, p = .95$); however, infants did look longer at full faces compared to profiles at the 10-month assessment ($Z = 2.86, p = .004, r = .33$). The same pattern was found for the infants of socially phobic mothers (16 weeks: $Z = 0.26, p = .79$; 10 months: $Z = 2.45, p = .01, r = .40$) and infants of control mothers (16 weeks: $Z = 0.53, p = .60$; 10 months: $Z = 1.76, p = .08, r = .26$). There were no significant group differences (Social phobia vs. Control) at either time point on total looking times to full face (16 weeks: Mann–Whitney $U = 523.00, p = .95$; 10 months: $U = 623.00, p = .40$) or profile (16 weeks: $U = 495.00, p = .67$; 10 months: $U = 577.00, p = .18$).

When infant emotional responses were considered, at 16 weeks, infants were significantly more positive towards full vs. profile faces ($Z = 3.15, p = .002, r = .36$), although there was no difference in the frequency of negative behaviours ($Z = 0.33, p = .74$). The same pattern was found for infants of socially phobic mothers (positive behaviours: $Z = 2.62, p = .009, r = .45$; negative behaviours: $Z = 0.23, p = .82$) and control mothers (positive behaviours: $Z = 1.95, p = .05, r = .30$; negative behaviours: $Z = 0.64, p = .52$). The groups did not differ in the frequency of positive behaviours to full faces ($U = 692.00, p = .69$), profiles ($U = 730.50, p = .65$) or negative behaviours to full ($U = 579.00, p = .12$) or profile faces ($U = 668.50, p = .30$).

At 10 months, infants did not differ in either positive or negative behaviours to full faces compared to profile faces (positive: $Z = 0.91, p = .36$; negative: $Z = 0.56, p = .58$), and this was also the case for each group when considered separately (Social Phobia: positive behaviours, $Z = 0.16, p = .87$; negative behaviours, $Z = 0.40, p = .69$; Control: positive behaviours, $Z = 1.10, p = .27$; negative behaviours $Z = 0.40, p = .69$). The groups did not differ in the frequency of positive behaviours to full faces (Mann–Whitney
Associations with infant temperament and maternal behaviours

Infants’ responses to high- or low-intensity fearful faces, presented on the right side, at the 10-week assessment were not significantly associated with the infants’ behavioural inhibition classification, $F(1, 100) = 0.19, p = .67$, or maternal behaviours, engagement with the stranger: $F(1, 104) = 0.43, p = .51$; encouragement: $F(1, 103) = 0.01, p = .91$; expressed anxiety: $F(1, 103) = 0.13, p = .72$.

DISCUSSION

Distinctive responses to faces and emotional expressions among individuals with social phobia have been frequently reported (e.g., Bögels & Mansell, 2004); however, their aetiological significance is unclear. We addressed this issue by assessing face processing among infants at risk of developing social phobia (i.e., offspring of socially phobic mothers) and a comparison group (i.e., offspring of mothers with no history of anxiety disorder). Specifically, we focused on infant responses to faces versus non-faces, emotional expressions of varying type and intensity, and variations in gaze direction. We also aimed to assess the contribution of infant temperament and maternal behaviours to infant face-processing differences.

The results were consistent with findings from normative infancy research (e.g., Hains & Muir, 1996; Morton & Johnson, 1991); thus, overall, infants showed a preference in terms of looking times for (i) faces over non-faces at 10 days and 10 weeks; and in terms of behavioural response for (ii) full faces over profile faces at 16 weeks. Furthermore, at 10 weeks, infants looked more to high- than low-intensity angry faces, and fearful faces at 10 months. The latter finding extends previous research, which has not been able to determine whether differential responses occur specifically to emotional expressions, or whether they relate to differences in stimulus complexity. In the current study, our methodology allowed investigation of the effect of intensity within emotion types (i.e., angry, happy, fearful), with faces being morphed so that only the extent of emotional expression changed. This provides more direct evidence that infants respond specifically to emotional characteristics of faces.

We found no effects of maternal social phobia assessments of faces versus non-faces or of gaze direction, at any age; however, differences between infants of socially phobic and control mothers were apparent in responses to intensity of emotional expression. Specifically, at 10 weeks, control infants
initially oriented to and spent more time looking to high- than low-intensity fearful faces whereas infants of socially phobic mothers did the reverse. These results do not provide evidence for initial hypervigilance to potentially threat-related faces, but rather suggest relative avoidance in infants at risk of developing social phobia. While caution is required when considering these results, they do suggest that infants of mothers with social phobia may show characteristic processing biases to emotional expressions at an early age.

This pattern of results is consistent with findings with adults (e.g., Bögels & Mansell, 2004) and children (Stirling et al., 2006) in that social anxiety is associated with avoidance of fearful expressions. Unlike these studies, however, the current findings favour a specific response to fearful expressions, rather than a negativity (e.g., Winton et al., 1995) or general emotionality bias (e.g., Mansell et al., 1999).

While we found a similar pattern of results at 10 weeks and 10 months, it was not found at the 16-week assessment. The reasons for this are unclear; however, Morton and Johnson (1991) have suggested that, as children’s representation of faces develops, increasingly complex stimuli are required; for example, by 5 months, a still, black and white representation of a face is uninteresting. Consistent with this suggestion, there was less variability in response to emotional faces generally at this age in our study; however we also failed to find the anticipated main effects of looking times to both faces versus non-faces (using moving stimuli) and gaze direction (full-face vs. profile) at 16 weeks. The fact that infants in our study altered their looking behaviour less at this age on the basis of a range of social information may reflect the general reduction in interest seen between 12 weeks (Sylveste-Bradley & Trevarthen, 1972) and the onset of social referencing skills from about 9–10 months (Baldwin & Moses, 1996).

We were interested to assess whether infants’ responses were linked to endogenous infant characteristics, or early experiences with caregivers, and we chose infant behavioural inhibition and maternal behaviours with a stranger as markers of these constructs. Infant responses to high- versus low-intensity fearful faces were not accounted for by either measure, leaving open the possibility of more specific genetic bases for intergenerational transmission of social responses. It is important to note, of course, that the maternal behaviours assessed within a laboratory setting represent a small fraction of infant social experience, so this null finding does not necessarily rule out early environmental influences. Further, it will be interesting to continue to track responses to emotional expressions as these infants develop, as it is likely that the influence of social experience may become particularly salient after 10 months of age.

There are a number of reasons to remain cautious when considering our results. In particular, significant findings represented small-medium effect sizes, showing that maternal group appears to explain a relatively small
proportion of the variance in children’s social emotion processing. A large number of tests were required to evaluate the emotional expression data, due to significant numbers of young infants having incomplete trials because of fatigue, etc. Nevertheless, due to the novel line of investigation, we did not want to be overly conservative in an attempt to reduce Type 1 error, and our findings’ general consistency with both infancy research and findings from children and adults with social phobia is encouraging. Second, for infant responses to emotional expressions, the side of presentation of the index face was important: responses to angry faces were pronounced for left-side presentations, while the interaction effects of group and intensity of fearful expressions were most pronounced for presentations on the right. Our results for angry faces are consistent with those of other studies with adults (Mogg & Bradley, 1999, 2002), suggesting that lateralised brain mechanisms may play a critical role in the processing of these face stimuli (Morris, Öhman, & Dolan, 1998); lateralisation results for fear faces, are not, however, so clear-cut, and further research on this issue is warranted.

With these limitations in mind, the current study provides tentative support for the integral bias hypothesis, which suggests that individual cognitive biases are an integral part of social anxiety and as such are detectable among at-risk infants (e.g., Richards et al., 2007). Specifically, infants of mothers with social phobia appear to show avoidance of high-intensity fearful faces. The longer term consequences of these early social information-processing characteristics are unclear, and whether this behaviour is a precursor of the development of later socially anxious behaviour remains to be investigated.

REFERENCES


