



PAPER

Here's looking at you, kid: attention to infant emotional faces in mothers and non-mothers

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Abstract

Infant facial cues play a critical role in eliciting care and nurturance from an adult caregiver. Using an attentional capture paradigm we investigated attentional processing of adult and infant emotional facial expressions in a sample of mothers (n = 29) and non-mothers (n = 37) to determine whether infant faces were associated with greater task interference. Responses to infant target stimuli were slower than adult target stimuli in both groups. This effect was modulated by parental status, such that mothers compared to non-mothers showed longer response times to infant compared to adult faces. Both groups also responded more slowly to emotional faces, an effect that was more marked for infant emotional faces. Finally, it was found that greater levels of mothers' self-reported parental distress was associated with less task interference when processing infant faces. These findings indicate that for adult women, infant faces in general and emotional infant faces in particular, preferentially engage attention compared to adult faces. However, for mothers, infant faces appear to be more salient in general. Therefore, infant faces may constitute a special class of social stimuli. We suggest that alterations in attentional processing in motherhood may constitute an adaptive behavioural change associated with becoming a parent.

Introduction

Facial cues play a critical role in an infant's efforts to engage and elicit nurturance from their caregiver. Allocating sufficient attention to infant faces is of clear adaptive value as it increases the likelihood that the basic needs of a highly dependent infant will be met (Bard, 1994). Human faces in general have been shown to elicit preferential allocation of attention, in part due to the social information they provide (e.g. Ro, Russell & Lavie, 2001; Öhman, Lunqvist & Esteves, 2001; Vuilleumier, 2000). The question arises whether infant faces are a special case. Lorenz (1943, 1971) was the first to propose the concept of Kindchenschema or 'baby schema', a configuration of perceptual features found in newborns across species, including a high, slightly bulging forehead, large eyes, and rounded cheeks. He suggested that these newborn cues elicited a set of affective and behavioural responses that formed the foundation of

caretaking behaviour. Developmental studies using behavioural and observational measures have demonstrated that individual differences in recognizing and responding to infant cues contribute to maternal sensitivity, which can profoundly influence later child development (e.g. Ainsworth, Blehar, Waters & Wall, 1978; McElwain & Booth-LaForce, 2006; Swain, Lorberbaum, Kose & Strathearn, 2007; Mills-Koonce, Gariépy, Proper, Sutton, Calkins, Moore & Cox, 2007).

Researchers have investigated the effect of face age on attentional processing of faces, with own-age faces found to be more distracting than other-age faces (e.g. Ebner & Johnson, 2010). However, there is a lack of experimental studies investigating whether adults in general, and parents in particular, differentially process infant facial cues as compared to adult faces. In one study, Brosch and colleagues used a dot-probe task with a group of college students to investigate the relative degree of attentional capture to infant as compared to adult faces

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(Brosch, Sander & Scherer, 2007). On trials where an adult and infant neutral face were simultaneously presented, participants were found to respond significantly faster to a target that followed the infant compared to the adult face. Furthermore, the magnitude of the attentional modulation was positively correlated with subjective arousal ratings of the infant faces. While these findings provide evidence that infant faces are prioritized by the attention system in adults, they do not address whether attentional processing is influenced by the presence of infant affect or parental status. In another study, Pearson and colleagues (2010) investigated the ability of pregnant women to disengage attention from infant and adult faces displaying negative, positive and neutral emotional superimposed over a go/no-go signal (Pearson, Cooper, Penton-Voak, Lightman & Evans, 2010). As predicted, reaction times (RTs) to a peripheral target were found to be slower when infant compared to adult faces appeared on the central go/no-go signal. In their follow-up study, Pearson and colleagues found that the women who showed greater attentional bias towards infant distress during late pregnancy reported more successful mother–infant relationships at 3–6 months postpartum (Pearson, Lightman & Evans, 2011). This study provides evidence for an association between basic attentional processes and maternal relationship quality.

While these preliminary experimental findings suggest that infant compared to adult faces preferentially engage the attentional system, the influence of parental status has not been directly investigated. An enhanced pattern of attentional allocation to infant faces in parents compared to non-parents would make evolutionary sense, and may help promote the adult's caregiving responses. Parent-specific effects may follow from the direct experience of caregiving or from the biological demands of becoming a parent. For example, we know that pregnancy and childbirth is associated with a cascade of changes in neuroendocrine systems (e.g. dopamine-reward and oxytocinergic systems), which are thought to help regulate maternal behaviour (Brunton & Russell, 2008; Strathearn, Fonagy, Amico & Montague, 2009).

An emerging neuroimaging literature suggests that parents do indeed process infant cues differently. Images of one's own child have been shown to activate a neural network comprising emotion and reward processing regions, which may underpin maternal attachment and caregiving behaviours, setting the maternal relationship apart from other social attachments (Strathearn *et al.*, 2009; Bartels & Zeki, 2004). The extant evidence further suggests that differences in neural activation are evident even when mothers view an unfamiliar infant. In a near-

infrared spectroscopy (NIRS) study Nishitani and colleagues compared activity in the prefrontal cortex (PFC) while mothers and non-mothers discriminated emotional facial expressions of unfamiliar adults and children. Mothers were found to show increased right PFC activation when discriminating infant facial expressions compared to non-mothers. However, there was no difference in PFC activation between mothers and non-mothers when discriminating adult faces, suggesting that the right PFC may be involved in maternal-specific behaviours (Nishitani, Doi, Koyama & Shinohara, 2011).

These neuroimaging studies are broadly consistent with a small number of electrophysiological studies that have begun to delineate the early time course of attentional allocation to infant facial stimuli. It has been reported that mothers demonstrate event-related potential (ERP) patterns indicative of increased attentional allocation to their own child's face compared to the faces of other children or adults (Grasso, Moser, Dozier & Simons, 2009). In line with the fMRI findings, ERP studies have also reported differential processing of unfamiliar infant faces in parents compared to non-parents (although see Noll, Mayes & Rutherford, 2012). Proverbio and colleagues reported greater neural response in mothers compared to non-mothers to infant facial expression; it is suggested that this may reflect a greater empathic response or increased arousal to infant faces in parents (Proverbio, Brignone, Matarazzo, Del Zotto & Zani, 2006). Interestingly, the neural response in the parents was influenced by the degree of infant distress, an effect not seen in the non-parent group.

These neurobiological findings suggest that attentional allocation to infant faces should differ at the behavioural level in parents compared to non-parents. However, even among parents individual differences in attentional processing of infant facial cues are likely. Symptoms of depression or stress, as well as the nature of the maternal–infant relationship, are thought to partly account for these differences. For example, Pearson and colleagues, in their go/no-go study of pregnant women, also investigated the influence of depression symptoms on processing infant affect. They found that non-depressed pregnant women took longer to disengage attention from distressed compared with non-distressed infant faces, but no such effect was observed in women experiencing depressive symptoms (Pearson *et al.*, 2010). Thus, the presence of depressive symptoms may moderate attentional processing of infant cues. This would be consistent with a broader literature of behavioural and observational studies that have suggested that symptoms of depression correlate with maternal insensitivity to infant cues and to poor quality caregiving (e.g.

Brockington, Aucamp & Fraser, 2006; Laurent & Ablow, 2012; Murray, Fiori-Cowley, Hooper & Cooper, 1996; Murray & Cooper, 2003).

Similarly, parental stress (that is, stress associated with the parenting role or the parent–child relationship) is associated with reduced parental sensitivity and poorer parent–child interaction (Belsky, 1984; Deater-Deckard, 1998; Huth-Bocks & Hughes, 2008; Taylor, Guterman, Lee & Rathouz, 2009). For example, studies have shown that parents experiencing higher levels of parenting stress show less sensitive interactive behaviours when playing with their children during observed play sequences (e.g. Pelchat, Bisson, Bois & Saucier, 2003). It has also been shown that parenting stress mediates the relationship between maltreatment history and maternal insensitivity in a community sample of mothers (Pereira, Vickers, Atkinson, Gonzalez, Wekerle & Levitan, 2012). However, research into parenting stress tends to recruit high-risk samples and rely on self-report and observations; previous studies have not investigated the impact of parenting stress on processing of infant faces.

The current study sought to extend our understanding of processing of infant faces and specifically the impact of parental status. In addition we sought to explore the impact (if any) of infant affect, levels of maternal depressive symptoms and levels of parenting stress. To achieve this we employed an irrelevant feature visual search paradigm, modified from Theeuwes (1991, 1992, 1994) and from Hodsoll, Viding and Lavie (2011). This type of paradigm permits the investigation of whether a unique feature of a scene, unrelated to the primary search task, can capture or engage attention. Here we asked participants to search for blue-eyed target faces (the ‘odd-one out’) among two brown-eyed non-target (distractor) faces, and then indicate if the blue-eyed target was tilted to the left or right. The type of face was varied such that response times to adult versus infant faces were measured. In addition, we varied the affect of the target and non-target faces. Slower responses to an emotional target face as compared to neutral conditions would be consistent with greater attentional interference. Slower responses in the presence of emotional non-target faces as compared to neutral conditions would suggest greater attentional capture. Advantages of this type of paradigm include the fact that face age and affect are completely independent of the eye-colour-based search task and that the face stimuli do not appear at fixation (Hodsoll *et al.*, 2011).

Using this paradigm we addressed four main questions in a group of parents (first-time mothers) and a group of non-parents (women without children). *Firstly, do infant compared to adult faces engage greater attention?* On the basis of previous studies, we predicted slower RTs in

search arrays containing infant faces across both parents and non-parents. *Secondly, does being a parent enhance the degree to which attention is engaged by infant faces?* While previous studies investigating parents and non-parents separately have reported preferential attentional allocation to infant faces, these groups have not previously been compared directly. The neuroimaging evidence indicating that parental status is associated with altered neural processing of infant facial affect provided a tentative basis to predict greater attentional allocation for infant faces at the behavioural level, in the parent compared to the non-parent group. *Thirdly, does affect alter attentional processing of infant facial cues?* On the basis of previous neuroimaging and neurophysiological studies, we predicted that the presence of affect would heighten the degree of attentional processing for infant faces and that this would be more pronounced for infant compared to adult faces (e.g. Noriuchi, Kikuchi & Senoo, 2008; Proverbio *et al.*, 2006). *Finally, are concurrent levels of depression and parental stress associated with individual differences during attentional processing of infant facial affect?*

Methods

Participants

Sixty-nine women, 31 first-time mothers and 38 non-mothers, were recruited for the study. Three participants (two mothers and one non-mother) were subsequently excluded due to pregnancy during the course of the study. This left a final sample of 29 mothers and 37 non-mothers. The women were aged between 23 and 43 years old (mothers: $M = 28.68$ years, $SD = 4.7$; non-mothers: $M = 30.59$ years, $SD = 5.03$; $t(64) = -1.59$; $p = .12$). All participants classified their ethnicity as Caucasian. Participants had Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) IQ scores ranging from 108 to 129 ($M = 117.35$, $SD = 5.18$). The WASI scores were comparable between mothers and non-mothers ($t(64) = -1.22$, $p = .114$). There were also no differences between the mothers and non-mothers in total household income ($\chi^2(7, N = 66) = 6.7$, $p = .46$), educational level ($\chi^2(2, N = 66) = 2.14$, $p = .34$), or number of years in education ($t(64) = .84$, $p = .41$; see Supplementary Materials (Table S1)). All participants reported normal or corrected-to-normal vision and were right handed. All of the mothers had a singleton pregnancy, reported that they had at some point breast-fed their child but that they were no longer breast-feeding, and their children were aged between 6 and 21 months ($M = 11.92$ months, $SD = 4.06$). All of the

non-parents reported some experience of caring for young children (answering yes to either of the questions 'I have cared for friends' children' or 'I have cared for younger family members'), but none reported working with children on a daily basis or having any non-biological step-children.

Questionnaire measures

Beck Depression Inventory (BDI-II; Beck, Steer & Brown, 1996)

The BDI, administered to both mothers and non-mothers, is a 21-item self-report questionnaire designed to assess the intensity of symptoms of depression. This inventory includes items covering the major components of depression, including sadness, pessimism, a feeling of failure, feelings of guilt and punishment, self-dislike, and lack of energy. For each item, participants are required to indicate which statement best describes how they felt during the past two weeks, including the current day. Each item is assessed on a 4-point scale from 0 to 3, with higher scores indicating more severe depressive symptoms. The total BDI score is calculated by summing the scores from all 21 items. The BDI has been shown to have high internal consistency, excellent internal reliability, good test-retest reliability, and correlates with other measures of depression (Beck *et al.*, 1996; Beck, Steer & Garbin, 1988; Dozois, Dobson & Ahnberg, 1998).

Parenting Stress Index – Short form (PSI-SF; Abidin, 1995)

The PSI-SF was administered to mothers only. It is a measure that screens for stress in the parent-child relationship, identifies dysfunctional parenting and predicts the potential for parental behaviour problems and difficulties within the family. The short form is derived from the full-scale PSI and consists of 36 items regarding the parent's relationship with their child, which they rate on a 5-point Likert scale from 'strongly agree' to 'strongly disagree'. These items comprise three subscales: parental distress, difficult child characteristics, and dysfunctional parent-child interaction. The parental distress scale assesses feelings of parental incompetence, stresses associated with restrictions on lifestyle, conflicts with the child's other parent, lack of social support, and depression (e.g. 'Since having this child, I have been unable to do new and different things'). The parent-child dysfunctional interaction scale assesses the parent's perception that the child does not measure up to expectations ('My child doesn't seem to learn as quickly as most children'). Finally, the difficult child scale

assesses the temperament and manageability of the child ('My child easily gets upset over the smallest things'). Correlation between total scores on the long and short form of the PSI is high (.87; Abidin, 1995). The scales of the PSI and PSI-SF have been shown to have adequate internal consistency and 6-month test-retest reliability, and are correlated with observed parent-child behaviour (Abidin, 1995; Haskett, Ahern, Ward & Allaire, 2006; Reitman, Currier & Stickle, 2002).

Stimuli

Participants completed two attentional capture tasks that were adapted from Hodsoll *et al.* (2011). One task contained 24 colour images of the faces of four different Caucasian infants: two female and two male infants, aged 6–12 months. These images were provided by Baylor College of Medicine courtesy of L. Strathearn (see Strathearn *et al.*, 2009). The other task contained 24 colour images of four different Caucasian adult faces; two females and two males, taken from the NimStim battery of emotional faces (Tottenham *et al.*, 2009). For both adult and infant stimuli, each identity had an image showing a neutral expression, a distressed/sad expression, and a content/happy expression. In a preliminary study, 10 individuals (four mothers and six non-mothers) who did not take part in the main study rated all images for valence and arousal on a scale of 1–5. Analysis of the valence and arousal ratings indicated that happy adult and infant stimuli were rated as more positive than both neutral ($M = 4.7$, $SE = .09$ vs. $M = 3.0$, $SE = .05$, $p < .001$) and distressed adult and infant stimuli ($M = 1.2$, $SE = .09$, $p < .001$). Distressed adult and infant stimuli were rated as more negative than neutral adult and infant stimuli ($M = 1.2$, $SE = .09$ vs. $M = 3.0$, $SE = .05$, $p < .001$). Baby stimuli were rated as more arousing than adult stimuli [$M = 3.9$, $SE = .06$ vs. $M = 3.6$, $SE = .07$; $F(1, 9) = 19.31$, $p < .01$]. Distressed infant and adult images were rated as more arousing than both happy ($M = 4.7$, $SE = .08$ vs. $M = 4.3$, $SE = .07$, $p < .05$) and neutral infant and adult images ($M = 2.3$, $SE = .11$, $p < .001$), while happy infant and adult images were rated as more arousing than neutral infant and adult images ($M = 4.3$, $SE = .07$ vs. $M = 2.3$, $SE = .11$, $p < .01$).

All of the images were edited using Paint.net¹ software so that each identity displayed blue eyes on some trials (when target) and brown eyes on other trials (when non-target/distractor). Images were also edited so that the same iris colours were used across infant and adult faces

¹ Free software available from <http://www.getpaint.net>

and iris and sclera size were matched across infant and adult stimuli. To confirm iris and sclera sizes across face ages, mixed model ANOVAs were conducted on the size of each (in pixels) for the adult and infant stimuli, with emotion entered as a within-subjects variable and face age as a between-subjects variable. This analysis indicated a main effect of emotion for sclera size ($F(2, 12) = 6.83, p < .01$), with happy faces ($M = 8.75, SE = .38$) and sad faces ($M = 8.88, SE = .35$) having smaller sclera than neutral faces ($M = 10.38, SE = .24$). There was also a main effect for iris size ($F(2, 12) = 47.62, p < .001$), with happy faces ($M = 44.25, SE = .25$) and sad faces ($M = 45.38, SE = .32$) having smaller irises than neutral faces ($M = 48.36, SE = .52$). No effect was found of face age for either sclera size ($F(1, 6) = 1.0, p = .36$) or iris size ($F(1, 6) = 2.18, p = .13$), and no interactions between emotion type and face age were found. Thus, while eye size varied by emotion, there were no differences in iris and sclera size across infant and adult stimuli.

The dimensions of the stimuli were 2.1 cm (vertically) by 1.7 cm (horizontally). The faces were presented on a black background in a virtual triangle with the centre of each image placed at 1.3 cm from a central fixation cross (see Figure 1). There was a 0.5 cm gap between images. Stimuli were viewed at a distance of 60 cm meaning that they were subtended at a visual angle of 4.5° vertically and 3.6° horizontally. The mean diameter of the iris was 2.60 mm for infant faces and 2.79 mm for adult faces, and 2.54 mm for happy faces, 2.29 mm for sad faces and 3.05 mm for neutral faces (with 1 pixel = 0.44 mm).

Procedure

The participants visited the testing laboratory for approximately 1.5 hours, completing the questionnaire measures first followed by the computer tasks. Participants were tested individually in a dedicated room with low lighting and were given instructions at the beginning of each task. The computer tasks were conducted using a Hewlett Packard Compaq Windows PC laptop with a 2.8-GHz Pentium Four Processor and a 15" monitor with a resolution of 1024×768 and a screen refresh rate of 60 Hz. Stimuli were presented and RTs recorded using E-Prime V.1.2 (Schneider, Eschman & Zuccolotto, 2002).

Participants completed the adult and infant attentional capture tasks in the same session, with the order counterbalanced across participants. These tasks were identical with the exception of the stimuli presented. Each task consisted of two blocks of 96 trials that were preceded by a short practice block of 12 trials. Within each block, one-quarter of the trials (24 trials) were neutral conditions in which no emotional faces were present. On one-half (48 trials) of the total trials within each block, the non-target face had an emotional expression (emotional non-target condition). On the other quarter (24 trials) of the trials the target face had an emotional expression (emotional target condition). Taking the adult and infant tasks together, a 2 (Face Age: Adult or infant) $\times 2$ (Emotion: Happy or sad) $\times 3$ (Search condition: Emotional target, emotional non-target, and all neutral) repeated-measures design was employed, resulting in 12 experimental conditions.

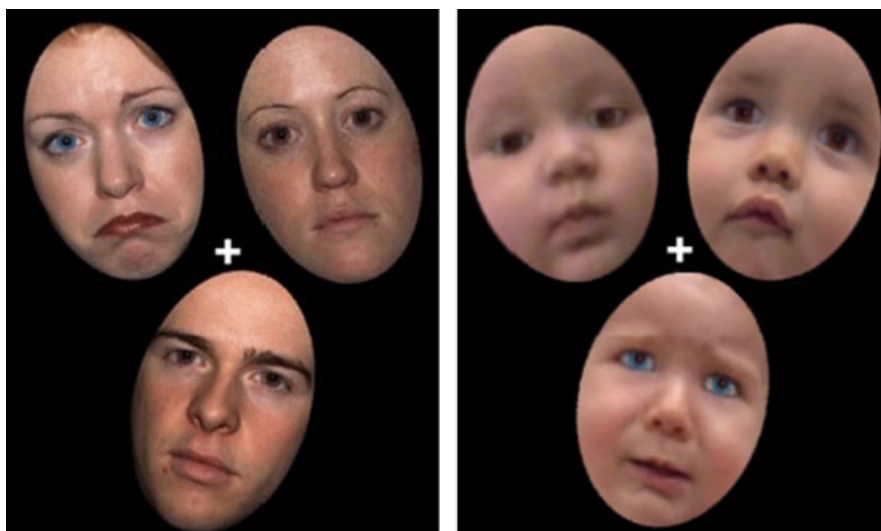


Figure 1 Example displays from the visual search task (not to scale) illustrating adult and infant arrays, with an emotional blue-eyed target among neutral brown-eyed targets in both cases.

Within each block, the trial type (i.e. whether emotional faces were absent, or whether the emotional face was the target face or a non-target face) was randomized across trials. The location of the identities and the orientation of each stimulus were also randomized across trials. The identities of the faces were randomized across trials, but the presentation was constrained to ensure that the identity of the target was not the same in trial *N* as it was in trial *N*–1 and no same identity was shown on the same display (e.g. blue-eyed Baby A would not appear in the same display as brown-eyed Baby A) and the identity of the emotional face was never the same on consecutive trials. Participants were instructed to search for a blue-eyed baby or adult target singleton in a display with two brown-eyed baby or adult non-target faces. Each of the three faces in the display was tilted either 15° to the left or 15° to the right (orientation was randomized). Once the target was located, participants were required to indicate whether it was tilted to the left (by pressing the ‘m’ key – marked with an ‘L’ sticker for left) or right (by pressing the ‘k’ key – marked with an ‘R’ sticker for right). Participants were instructed to focus on a central white fixation cross throughout each trial and to be as fast and accurate in their responses as possible. There were 500 ms between the onset of the fixation cross and the onset of the stimuli. Stimuli remained on screen until a response was made, but a trial was aborted if no response was registered within 3000 ms. Auditory feedback (100 ms tone) was given if an incorrect response was made. In total, the tasks took approximately 30 minutes to complete.

Results

Reaction times

The effect of the presence of task-irrelevant emotion (as an emotional singleton on either the target or non-

target) on time taken to locate and respond to the target was assessed. Anticipatory (< 150 ms) responses were excluded from the RT analysis (0.42% of total trials), as were incorrect responses (4.27% of total trials). For the remaining data, outliers (2.5 *SDs* from mean) were calculated for each participant’s range of RTs and removed from analysis (7.59% of total trials), and mean correct RTs for each experimental condition were then calculated. One participant (a mother) was removed from all analyses due to having a high error rate across all trials (> 40%). Means and standard deviations of reaction times can be seen in Table 1.

A 2 (Face age: Adult or infant) × 2 (Emotion category: Happy or sad) × 3 (Search condition: Emotional target, emotional non-target, and all neutral) repeated-measures ANOVA was conducted on the RT data, with Group (mother or non-mother) entered as a between-subjects variable. Effect sizes are reported as partial eta squared (η_p^2).

A main effect of Face Age was observed ($F(1, 63) = 60.19, p < .001, \eta_p^2 = .49$), such that RTs to correct responses were significantly slower in infant face conditions ($M = 1029.81, SE = 24.85$) than adult face conditions ($M = 876.8, SE = 17.88$). This was qualified by an interaction between Face Age and Group ($F(1, 63) = 5.26, p < .05, \eta_p^2 = .08$), indicating that the RTs to infant and adult face targets differed for parents and non-parents. Inspection of the data (see Table 1 and Figure 2) indicates that although RTs to correct responses were slower for infant face conditions than adult face conditions in both mothers (mean difference = 198.26, $p < .001$) and non-mothers (mean difference = 107.77, $p < .001$), the effect was more pronounced for mothers, suggesting that mothers’ RTs were particularly affected by infant stimuli. There was also a main effect of Group ($F(1, 63) = 12.30, p < .005, \eta_p^2 = .16$), such that mothers had longer RTs to correct responses overall ($M = 1020.90, SE = 29.08$) compared

Table 1 Descriptive statistics for reaction time (ms) for all trial conditions for both mothers and non-mothers

	Parent status							
	Non-Mother (<i>N</i> = 37)				Mother (<i>N</i> = 28)			
	Infant stimuli		Adult stimuli		Infant stimuli		Adult stimuli	
	Mean	<i>SD</i>	Mean	<i>SD</i>	Mean	<i>SD</i>	Mean	<i>SD</i>
Happy Target RT	1037.42	184.11	878.19	162.48	1254.12	278.85	966.49	149.43
Happy Non-Target RT	896.66	152.74	805.15	152.02	1052.97	223.32	914.58	142.38
Neutral trials within Happy Blocks RT	889.57	150.43	809.96	151.38	1039.41	211.35	898.22	151.98
Sad Target RT	1039.21	202.4	853.81	151.72	1230.34	314.95	942.94	153.58
Sad Non-Target RT	883.77	162.72	830.72	148.02	1082.81	251.49	913.83	156.36
Neutral trials within Sad Blocks RT	890.94	156.79	813.13	140.13	1060.52	264.54	984.55	149.06

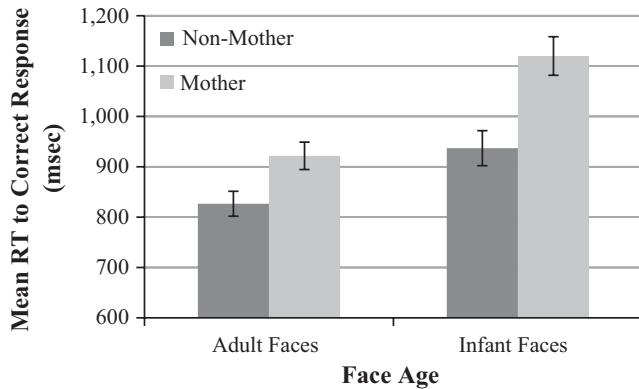


Figure 2 Mean RT to correct response for non-mothers and mothers as a function of stimulus type.

to non-mothers ($M = 885.71$, $SE = 25.3$). There was no main effect of Emotion category ($F(1, 63) = .01$, $p = .94$), and no Face Age \times Emotion interaction ($F(1, 63) = .24$, $p = .63$). There was a main effect of Search condition ($F(2, 126) = 225.43$, $p < .001$, $\eta_p^2 = .78$). Post-hoc pairwise comparisons (Bonferroni corrected) indicated that participants' RTs to correct responses were slower in emotional target conditions than emotional non-target conditions (mean difference = 102.75, $p < .001$), and slower in emotional target conditions than in neutral conditions (mean difference = 113.28, $p < .001$). There was also a significant difference between emotional non-target and neutral conditions (mean difference = 10.52, $p < .05$). These findings suggest that facial emotion was associated with longer RTs, especially when emotion appeared on a target face. There was also an Emotion \times Search condition interaction ($F(2, 126) = 4.98$, $p < .05$, $\eta_p^2 = .07$). Further investigation of this interaction using post-hoc comparisons, with Bonferroni correction applied, revealed that RTs to correct response were significantly longer for both happy and sad target conditions as compared to neutral conditions. However, while there was a trend for RTs to be longer in sad non-target conditions as compared to neutral conditions (mean difference = 13.0, $p = .08$), the difference in RTs between happy non-target conditions as compared to neutral conditions did not approach significance (mean difference = 8.05, $p = .56$).

Finally, there was also a Face Age by Search condition interaction ($F(2, 126) = 74.27$, $p < .001$, $\eta_p^2 = .54$). This indicates that the Search condition (i.e. whether a task-irrelevant emotion was present or not) affected RTs to correct responses differently for adult and infant facial stimuli. To further investigate this interaction, contrasts were performed comparing RTs to correct responses in emotional singleton conditions to RTs in neutral conditions across adult and infant stimuli. These revealed that

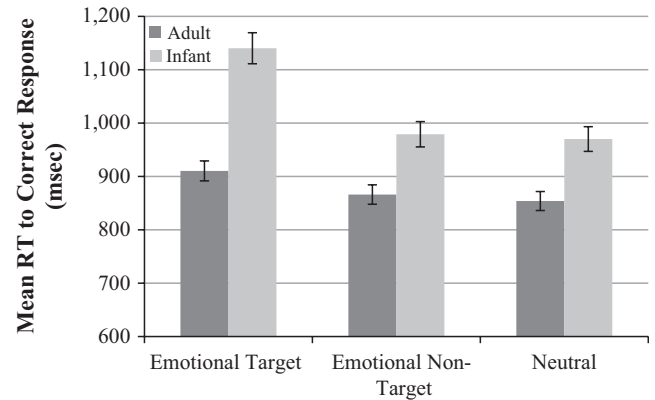


Figure 3 Mean RT to correct response for each experimental condition as a function of stimulus type.

the effect of longer RTs for emotional target conditions as compared to neutral conditions was particularly pronounced for infant stimuli as compared to adult stimuli ($F(1, 63) = 97.35$, $p < .001$, $\eta_p^2 = .61$, see Figure 3). There were no other group interactions or other interactions.

In summary, for both groups RTs to correct responses were significantly slower to infant stimuli than to adult stimuli; this effect was more pronounced for mothers as compared to non-mothers. For both infant and adult stimuli, RTs were slower when an emotional face was present than when all faces were neutral. The effect of slowed RTs for emotional non-targets as compared to neutral conditions appeared to be driven by sad faces, whereas both happy and sad target faces slowed RTs as compared to neutral conditions. RTs were slowest when the target face displayed an emotion as compared to neutral conditions and this effect was particularly pronounced for infant stimuli.

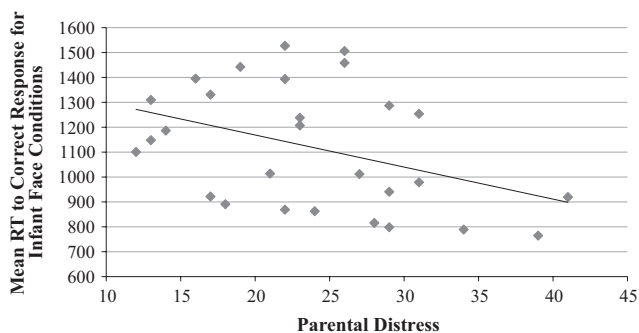
Correlations

We then assessed whether RTs to correct responses for adult and infant stimuli were associated with measures of depression and parental stress using exploratory two-tailed Pearson correlations. Mean, standard deviation and range of scores on the measures of stress and depression are reported in Table 2. Given the group differences in chronological age, the association between age and RT was also explored.

Age did not significantly correlate with RT to infant ($r(64) = .12$, $p = .37$) or adult faces ($r(64) = .08$, $p = .52$). There were also no significant correlations between BDI scores and RT to infant ($r(64) = -.12$, $p = .33$) or adult faces ($r(64) = -.03$, $p = .83$). As PSI was only measured in mothers, correlations between PSI

Table 2 Descriptive statistics for measures of depression and parenting stress

	Parent status			
	Non-Mother (<i>N</i> = 37)		Mother (<i>N</i> = 29)	
	Mean (<i>SD</i>)	Range	Mean (<i>SD</i>)	Range
BDI	7.64 (7.12)	0–30	8.04 (4.86)	1–19
PSI Total	–	–	61.82 (17.76)	42–107
PSI Distress	–	–	23.79 (7.58)	12–41
PSI Dysfunctional Interaction	–	–	16.57 (5.66)	12–36
PSI Difficult Child	–	–	21.68 (7.22)	14–43

**Figure 4** Correlation between PSI Distress Subscale and RT to infant faces (mothers only).

scores and RTs to correct responses were investigated for mothers only. There were no significant correlations between RTs to correct responses for adult faces and the difficult child subscale ($r(28) = .181, p = .36$) or the dysfunctional interaction subscale ($r(28) = .149, p = .45$), nor between RTs to correct responses for infant faces and the difficult child subscale ($r(28) = -.161, p = .41$) or the dysfunctional interaction subscale ($r(28) = -.064, p = .75$). As shown in Figure 4, there was a significant negative correlation between the distress subscale of the PSI and RTs for infant faces ($r(28) = -.40; p < .05$) but not for adult faces ($r(28) = -.017; p = .93$). These exploratory correlational analyses suggest that in mothers RTs to infant images are associated with level of parental distress; higher levels of parental distress appear to be associated with less attentional capture by emotional infant faces.

Discussion

This study is the first to investigate attentional processing of adult and infant emotional facial expressions in a sample of parents and non-parents. We found that responses to infant face targets were slower

than adult face targets. This effect was modulated by parental status, such that parents showed longer response times to infant compared to adult faces than non-parents. Responses were slower when a task-irrelevant emotion was present on the target face; however, this was moderated by stimulus type, such that responses were particularly slow to infant emotional target faces. A correlation analysis also revealed that mothers' self-reported parental distress was negatively correlated with responses to infant faces, but not to adult faces. We will first discuss the observed differential responses to infant versus adult faces and how this was influenced by parental status, and then consider the influence of facial affect on task performance.

Consistent with previous research in pregnant women (Pearson *et al.*, 2010), we found that RTs were significantly slower when participants searched for target stimuli in the presence of infant faces than in the presence of adult faces. This suggests that, across conditions, infant stimuli interfered with task performance more than adult faces, slowing response decision times. There may be a quality intrinsic to infant faces which facilitates increased allocation of attention. This is in line with appraisal theories of emotion, which predict that stimuli that are evaluated as important or significant demand increased allocation of attention and processing (Sander, Grandjean & Scherer, 2005). Infant faces may have engaged more attention, interfering with task performance, because they were more arousing (Brosch *et al.*, 2007; Lorenz, 1943). Indeed, the infant stimuli used in this study were rated as more emotionally arousing than the adult stimuli, even when showing neutral facial expressions. Similarly, Brosch and colleagues (2007) observed increased attentional bias towards neutral infant faces as compared to neutral adult faces, and found that this attentional bias was modulated by the arousal potential of the stimuli. However, if greater arousal ratings were driving greater attentional interference then we would have expected to observe slower reaction times for distressed versus happy emotions. In fact, no difference was found between these conditions. This suggests that a simple conceptualization of arousal would not be sufficient on its own to account for the observed pattern of slower responses to infant faces. Nonetheless, these findings indicate that infant faces are processed in a manner that differs in important ways from the manner in which adult faces are processed. Such a bias in how infant faces are processed has possible evolutionary value as it primes adults to pay attention to, recognize and process child cues which may be important for their care and well-being (Lorenz, 1943).

We were also interested in whether processing of infant and adult faces would be modulated by parental status. The difference in RTs between infant and adult stimuli conditions was found to be larger for mothers than for non-mothers, suggesting that parental status affects responsiveness to infant faces as compared to adult faces. This finding is consistent with neuroimaging evidence that has demonstrated differential neural processing of infant and adult faces for mothers as compared with non-mothers (e.g. Nishitani *et al.*, 2011; Proverbio *et al.*, 2006) and provides important evidence that parenting is associated with a behavioural change in processing infant cues. The neural and hormonal changes associated with pregnancy and parenting may underlie the development of parenting behaviours, such as sensitivity to infant visual cues (Brunton & Russell, 2008; Strathearn *et al.*, 2009). Mothers may give infant faces attentional priority over other features in a scene because they find them more salient than non-parents. Mothers may also experience increased arousal to infant faces or an increased empathic response (Strathearn *et al.*, 2009; Nishitani *et al.*, 2011). The difference in responding between parents and non-parents may also reflect familiarity or 'expertise' with infant faces. Furthermore, it is necessary for mothers to prioritize and maintain attention to infant signals as this enables them to engage with and sensitively respond to infant cues, which is necessary for adapting to the specific demands of infant care, whereas non-parents are not yet required to fulfil a caregiving role on a day-to-day basis.

We also found that mothers had slower responses overall than non-mothers, including to adult faces. One possibility is that the slower RTs seen in mothers reflects an increase in attention to social stimuli in general for parents as compared to non-parents. The transition to parenthood may involve a more general shift in processing of social and emotional stimuli rather than just infant-focused attentional changes. This hypothesis requires further investigation.

We also investigated the impact of affect on attentional bias to infant and adult facial stimuli. Our paradigm allowed us to investigate how participants responded in the presence of emotional expressions (happiness and sadness) both on target faces and on non-target faces. We did not find any main effects of emotion type, consistent with a previous study using the same paradigm (Hodsoll *et al.*, 2011), although we did find an emotion by condition interaction. Specifically, across both adult and infant stimuli, responses to the primary search task were slower when an emotional facial expression (either happy or sad) appeared on the target face compared to when all faces in the scene were neutral and compared to when emotion appeared on a

non-target face. Slow RTs in emotional target conditions compared to other search conditions suggests that an emotional target face distracts attention away from the primary search task. This effect may occur because once the target face has been located on the basis of eye colour and participants scan the whole face in order to report the direction of the tilt (rather than one specific feature), the emotional expression then captures attention and delays execution of the search task. This emotional interference effect for emotional target faces was found to be larger for infant stimuli than for adult stimuli, suggesting that not only do adults respond differentially to infant and adult stimuli, but also that they appear to be attuned to emotionally salient infant faces. Again, increased attention towards emotional infant signals may be an important adaptation to facilitate sensitivity to infant needs and promote caregiving behaviour (Ainsworth *et al.*, 1978; Slade, 2005).

We also found that responses were slower when an emotion appeared on non-target faces as compared to when all faces were neutral, although the emotion by condition interaction appeared to suggest that this effect was driven by sad non-target faces. This attentional capture effect for emotional non-target faces was not as strong as the effect seen for emotional target faces. It is possible that the specific demands of the current task may have attenuated the influence of non-target 'distractors' on attention. For example, a previous study required participants to search for target faces based on the gender discrimination ('search for the male face'), which is not practical with infant stimuli (e.g. Hodsoll *et al.*, 2011). In the current study, participants were requested to search for the infant or adult face with a pre-specified eye colour, which focuses attention to the eye area of non-target images, whereas gender discrimination requires holistic processing of the whole face. One consequence of this directed attention would be to reduce holistic face processing and therefore potentially minimize processing of the facial affect in non-target distractors (Horstmann & Becker, 2008).

Finally, a correlation analysis explored the association between responses to infant and adult faces and measures of depression and parental stress. RTs to adult faces and infant faces were not found to correlate with symptoms of depression for either parents or non-parents. By contrast, previous research has shown that depressed women process emotional infant faces somewhat differently from non-depressed women (Pearson *et al.*, 2010). One possibility is that such effects are evident only in clinically depressed samples and more normative symptom levels do not account for individual differences in attentional processing. However, we did observe a negative correlation between RTs to infant

images and levels of parental distress in the mothers, as measured by the distress subscale of the PSI. Parental distress appears to influence the mothers' attentional bias, with infant faces engaging attention less in mothers with higher levels of parental distress. Although only a modest effect, this preliminary finding suggests that mothers experiencing higher levels of parental distress are less sensitive to infant stimuli than parents who experience lower levels of parental distress. This may be interpreted in two ways. Mothers who allocate fewer attentional resources to infant stimuli may consequently experience higher levels of parental distress, as they may feel that infant signals are more ambiguous (cognition to parental distress effect). Alternatively, higher levels of parental distress may cause difficulties in processing infant cues, perhaps due to problems in emotion regulation (parental distress to cognition effect).

We note some potential limitations in the present study. While our non-parents all reported at least some experience of caring for young infants, it will be important in future to investigate whether there are differences in infant face processing between groups of non-mothers with different levels of exposure to the daily care of young infants (e.g. nursery workers or teachers as compared to those with no experience of childcare). This would help tease out whether the parent-specific effects observed here are due to the experience of parenting *per se*, or simply due to differences in childcare experience. Another important follow-up study will be to compare responses of fathers and non-fathers. Such studies may help us to further delineate whether differences in infant face processing between those with and without children is specific to motherhood or relates to the experience of parenting more generally. It should also be noted that the data presented in this study were cross-sectional and the mothers had children aged from 6 to 19 months. Future studies may wish to restrict the age range of children to very young infants, or investigate whether the attentional bias towards infant faces changes from non-parent, through pregnancy, to becoming a first-time parent. A further limitation is that the current design used pictures of unfamiliar infants. It will be important for future studies to explore how attentional processes may vary in relation to a mother's own child.

In conclusion, this study extends existing research on visual processing of infant and adult emotional cues by demonstrating that infant faces in general and emotional infant faces in particular preferentially engage attention compared to adult faces. We demonstrate for the first time, at the behavioural level, that this attentional bias for infant faces is more pronounced in mothers than in non-mothers. Infant social and emotional cues are necessary to elicit appropriate caregiving responses; it

is therefore important that individuals are able to rapidly attend to and respond to infant cues in an environment where there is other information competing for attention. Our findings suggest that motherhood is associated with increased attention to infant faces, perhaps reflecting part of a wider set of adaptive behavioural changes associated with parenthood. Further understanding the attentional processing of infant facial cues will help delineate the basic cognitive mechanisms that contribute to maternal sensitivity and may help inform clinical interventions for parents at risk.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Participant Demographics.