Preliminary communication

Maternal anxiety and neural responses to infant faces

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ABSTRACT

Background: Women may be especially vulnerable to anxiety during the postpartum period and early infancy. However, little is known regarding the potential impact of maternal anxiety on the neural processing of infant-relevant information.

Methods: In this ERP study, 47 recent mothers viewed neutral and distressed infant faces, concurrent with EEG collection. We examined the N170 as a perceptual marker of face processing and the late positive potential (LPP) as an index of engagement with stimulus processing. Mothers also completed the Spielberger State–Trait Anxiety Inventory.

Results: While the N170 was unaffected by infant affect and anxiety levels, the LPP was greater in amplitude for distressed vs. neutral faces. Moreover, the degree of LPP amplitude elicited by neutral infant faces was positively correlated with state anxiety. There were no associations between anxiety and the LPP elicited by distressed infant faces.

Limitations: We employed self-report measures of state and trait anxiety symptomatology and including diagnostic classification of anxiety disorders will be important in future research.

Conclusions: These results indicate that recent mothers with higher levels of state anxiety may be more engaged with processing neutral infant cues.

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1. Maternal anxiety and neural responses to infant faces

As caretakers, mothers play a vital role in the physical and psychological development of the child. Parental psychopathology can impede this critical dynamic, impacting the parent–child relationship and the child's overall health and well-being (Pechtel et al., 2013; Swain et al., 2007). A number of studies suggest that prevalence rates of anxiety symptoms and anxiety disorders are increasingly common during the postpartum period, with rates of anxiety (30%) reported to be higher than for depression (12%) at 8 weeks postpartum (Wenzel et al., 2003, 2005). Despite these prevalence rates, we know relatively little about how a mother's anxiety relates to her sensitivity to infant signals of emotion, particularly at a neurophysiological level. Given this, rapid processing of infant cues may impact downstream parenting behavior (Rutherford and Mayes, 2011), understanding whether or not a mother's anxiety impacts her perception of infant cues is warranted. In the present study, we employed event-related potentials (ERPs) to examine whether anxiety symptomatology in mothers was associated with the neural response to infant affective pictures.

1.1. Maternal anxiety

The assessment of antenatal and postnatal anxiety is beneficial in identifying women potentially vulnerable to anxiety disorders. Maternal anxiety may have adverse outcomes for the developing child in terms of preterm delivery, lower birth weight and later cognitive, affective and behavioral disturbances (Annivererno et al., 2013). Furthermore, mothers with postpartum anxiety disorders may also have greater difficulty bonding with their child (Tietz et al., 2014). Given the comorbidity between depression and anxiety, maternal anxiety is typically assessed only in studies of postpartum depression. However, concerns have been raised as to the high rates of anxiety symptoms that seem to exceed depression symptomatology during the postpartum period, warranting postpartum anxiety to be studied in its own right (Wenzel et al., 2003, 2005). Notably, maternal anxiety may remain fairly stable during the initial months postpartum: state anxiety at one week postpartum predicted maternal anxiety symptoms 4 and 8 weeks later (Dennis et al., 2013). Consistent with this, anxiety during pregnancy has been found to predict both anxiety as well as depression symptomatology relatively late into the postnatal period (Heron et al., 2004).
While a number of studies have examined the impact of maternal anxiety on child outcome measures, few have investigated how maternal anxiety affects the perception of infant faces. A recent behavioral report found that relative to healthy controls, mothers with generalized anxiety disorder (GAD) evidenced heightened sensitivity to the detection of happy infant emotional expressions in a perceptual morphing task, with comparable detection performance to controls in respect of sad infant faces (Arteche et al., 2011). In contrast, lower levels of trait anxiety were found to be associated with greater amygdala activity when mothers viewed photographs of their own infant smiling compared to an unfamiliar infant smiling (Barrett et al., 2011). With respect to infant and adult emotional face perception, one study of maternal depressed mood in the postpartum period reported that across the sample, state anxiety was most commonly associated with the evaluation of these facial stimuli; specifically, there were positive correlations between state anxiety and evaluations of disgust and sad infant faces expressing negative emotions, and an inverse correlation between state anxiety and evaluations of neutral infant expressions (Gil et al., 2011). However, null findings for anxiety and maternal perception of infant faces have also been reported (Stein et al., 2010). Therefore the extent to which anxiety modulates infant face perception is still not well understood, with mixed findings across multiple paradigms.

1.2. ERP investigations of infant face perception: N170

Here we employed ERPs to probe the time course of the neural correlates of infant face processing and how these processes may be modulated by maternal anxiety during the postpartum period and early infancy. Only a handful of studies have employed ERPs to probe neural responses to infant faces in mothers. One widely studied face processing ERP, the N170, is a negative deflection typically peaking approximately 170 ms post-stimulus presentation (Bentin et al., 1996). The N170 is believed to reflect the initial categorization of stimuli as faces (Rossion and Jacques, 2011).

Consistent with its presumed role indexing the perception of a visual stimulus as a face, the N170 is not modulated by infant familiarity (Bornstein et al., 2013; Grasso et al., 2009). However, some studies report that infant expression modulates maternal N170 responses, with infant distress provoking the largest N170 amplitude (Proverbio et al., 2006; Rodrigo et al., 2011). These latter studies required categorization of infant affect following stimulus presentation. However, when mothers passively view infant faces, no N170 modulation by emotional expression has been found (Noll et al., 2012). Notably, Noll et al. (2012) also observed an association between N170 amplitudes to infant faces and depression symptomatology in mothers and non-mothers, suggesting the N170 may have utility as a neural marker of maternal sensitivity to infant cues in some aspects of clinical symptomatology. Consistent with this finding, another report found that among mothers with a history of substantiated neglect toward their children (as compared to non-neglectful mothers), the N170 was not modulated by infant affect during an emotional face categorization task (Rodrigo et al., 2011). Thus the N170 may be valuable in the pursuit of understanding individual variability in early markers of infant face perception.

Findings regarding variability in the N170 as a function of anxiety have been mixed. In one study that presented fearful faces for just 16 ms, N170 amplitudes were significantly attenuated in high trait anxious participants relative to their low trait anxious counterparts (Walentowska and Wronka, 2010). However, other studies find that the N170 is unaffected by anxiety in participants completing a visual oddball task with fearful and happy faces (Rossignol et al., 2005). Similarly, anxiety does not differentiate the N170 measured during a facial categorization task presenting fearful, happy and neutral faces (Morel et al., 2014). Finally, the N170 elicited by multiple facial emotions was also unrelated to social anxiety (Rossignol et al., 2012). While the majority of the studies reviewed suggest null emotion and anxiety effects on N170, few if any reports have examined the association between the N170 elicited by infant emotional faces and anxiety among mothers, a group who may have a heightened sensitivity to this class of stimuli.

1.3. ERP investigations of infant face perception: LPP

The LPP is a late slow wave of the ERP waveform measured over central–parietal and occipital regions. The LPP is greater when elicited by emotional as compared to neutral images (Cuthbert et al., 2000). Modulation of the LPP by emotion has been found for threatening faces as compared to neutral faces (Schupp et al., 2004) and for high arousing images as compared to low arousing images (Schupp et al., 2000). The LPP is thought to represent the sustained allocation of attention to processing motivationally relevant visual stimuli (Schupp et al., 2000, 2004).

Fewer studies have examined the LPP elicited by infant faces although later components including the P300 and N/P600 have yielded modulations by infant affect and familiarity (Bornstein et al., 2013; Grasso et al., 2009). Notably, Rodrigo et al. (2011) reported the LPP was greater in amplitude following distressed infant faces as compared to neutral infant faces. No study to date has examined the relationship between maternal anxiety and LPP amplitudes elicited by infant faces. However in non-parents, higher levels of trait anxiety were associated with greater LPP amplitudes to fearful and happy adult faces (Holmes et al., 2009). An increased LPP response to threat has also been reported in young adults high in social anxiety (Moser et al., 2008).

1.4. Maternal anxiety, ERPs and the present study

One recent study has examined whether anxiety was associated with ERPs elicited by mothers (N = 16) viewing photographs of their own and unfamiliar children (aged 5–6 years) in an oddball task (Doi and Shinhara, 2012). In this study, the children’s eye-gaze was manipulated such that photographs showed eye-gaze as either being oriented straight ahead or else gaze was averted. While there was no association between state anxiety and N170 amplitude elicited by any of the stimulus conditions (familiar/unfamiliar, straight gaze/averted gaze), state anxiety did predict the amplitude of the P3. Specifically, higher state anxiety scores were associated with a larger P3 response when mother’s viewed photographs of their own children averting their gaze and unfamiliar children gazing straight ahead. Doi and Shinhara (2012) interpreted this finding as perhaps suggesting these familiarity-gaze direction categories may be more negatively valenced in increasingly anxious mothers.

In building on this prior work and existing research in parents and non-parents, we asked recent mothers to passively view photographs of unfamiliar infant faces while simultaneously recording EEG. Given existing ERP data documenting the sensitivity to infant emotional expressions in maternal samples and the wealth of data employing negatively valenced stimuli more generally in anxiety research, we chose to compare distress to neutral infant facial expressions. We measured both state and trait levels of anxiety and examined these as a function of N170 and LPP responses to infant faces. We hypothesized that (1) given this is a passive viewing task, the N170 would not be modulated by infant emotional expression but the LPP would be greater to distress as compared to neutral infant faces; (2) mothers reporting higher levels of anxiety (state and trait) would have a greater neural response to infant cues as indexed by the N170 and LPP – reflecting increased sensitivity as well as sustained processing of infant cues using a task that has already shown N170 associations with clinical symptomatology (Noll...
et al., 2012, c.f., Doi and Shinohara, 2012); and (3) the relationship between anxiety (state and trait), and our neural markers of infant face processing would be most notable when mothers viewed distressed infant faces.

2. Methods

2.1. Participants

The Human Investigations Committee at Yale School of Medicine approved all procedures prior to recruitment and all women provided informed consent. Forty-seven mothers (M=28 years, SD=5.7) were recruited through flyers posted in the community. Mothers were recruited and completed the laboratory visit during the postpartum and infancy period following delivery (M=8 months; SD=5 months; range 1–23 months). Self-reported ethnicity was African American (n=21), Caucasian (n=14), Hispanic (n=3), Hispanic/Latino (n=5), Asian (n=2), Caucasian and African American (n=1), and 1 mother did not report.

2.2. Apparatus and stimuli

Continuous EEG was recorded using Net Station 4.2.1 with a sampling rate of 250 Hz and high impedance amplifiers (Net Amps 200, 1 Hz high pass, 100 Hz low pass). A 128 Hydrocel Ag/AgCl electrode sensor net (Electrical Geodesics, Inc; Tucker, 1993) was placed on the participant’s head and fitted according to manufacturer specifications. All electrodes were spaced evenly and symmetrically to cover the scalp from nasion to inion and from left to right ear. Prior to application, the net had been soaking in a warm potassium chloride solution to serve as the electrolyte. Electrodes were referenced to Cz during EEG recording and impedances were kept below 40 kΩ.

Infant face stimuli, sized 18.3 cm (2.16") by 11.5 cm (1.81"), drawn from Proverbio et al. (2006) were presented to participants using E-Prime 1.2 software. The stimuli set contained 25 neutral infant faces and 25 distressed infant faces; all infants were unfamiliar to the mothers. All images had been rated previously and were all grayscale pictures of Caucasian infants, aged approximately 15 months (Proverbio et al., 2006). We additionally asked 10 nulliparous women to re-rate these stimuli according to the Self-Assessment Manikin that is employed to assess arousal and pleasure ratings of other affective stimuli (Lang et al., 2008). Distressed infant faces (M=6.42; SD=1.06) were rated as more arousing than neutral infant faces (M=4.66; SD=.99), p <.05. Moreover, distressed infant faces (M=2.40; SD=.99) were rated as less pleasurable than neutral infant faces (M=5.62; SD=1.05), p <.001. Each face was clearly in the foreground of its image, rotated no more than 45° from a frontal or inclined position. Images were viewed at a distance of 91.4 cm in a sound-attenuated room, with low ambient illumination. Visual offset of the stimuli was 19 ms.

2.3. Measures

To assess anxiety we employed the State–Trait Anxiety Inventory (STAI; Spielberger et al., 1983). Both State and Trait measures consist of 20 items that participants respond to by using a 4-point Likert scale, where “1” represents “almost never” and “4” represents “almost always”. Example items from the State measure would include “I am worried” or “I feel calm” and participants are asked to complete the items as to how they currently feel. Example items from the Trait measure would include “I worry too much over something that really doesn’t matter” or “I am content”, and participants report how these items apply to them more generally. A higher score on these measures indicates a higher level of anxiety. Although there are no clinical cut-offs for the STAI, past studies report scores ranging from 39–45 as being clinically significant (Kvaal et al., 2005). Both the State (.92) and Trait (.90) scales have good median alpha reliability coefficients (Spielberger et al., 1983).

2.4. Procedure

Participants completed the state and trait anxiety measures prior to the EEG portion of the visit. EEG data was recorded throughout all trials. A trial sequence consisted of a central fixation cross (2000 ms) that was followed by a blank screen that varied in presentation time (500–700 ms). An infant face was then centrally presented for 1500 ms followed by another blank screen. Each face was only presented once during the EEG recording and therefore there were 50 trials in total. Participants were asked to attend to each image as it was presented on the screen and sit as still as possible. The image set was presented one time through and was randomized for facial expression.

2.5. Data analysis

Using Net Station 4.2.1, the raw EEG data was pre-processed and prepared for statistical analysis. Prior to segmentation, each file was digitally filtered with a 30 Hz low-pass filter to reduce environmental noise artifacts. EEG signal was segmented into epochs of 1 s, beginning 100 ms before and ending 900 ms after stimulus onset. Electrode channels that had artifacts remaining in more than 50% of the trials were excluded and replaced through spline interpolation. Ocular Artifact Removal (OAR; Gratton et al., 1983), using a blink slope threshold=14 μV/ms, was applied where there were fewer than 14 blink and other artifact free trials per condition in the averaged file without using OAR. OAR was applied to data from 16 participants. At completion of pre-processing, there were on average 21 trials per condition across all participants.

Electrode clusters are presented in Fig. 1. For the N170, electrodes of interest were selected based on scalp regions characteristically eliciting the N170 (Bentin et al., 1996), also conforming to electrode sites previously assessed in dense-array EEG face perception studies (Cheung et al., 2010; McPartland et al., 2004; Noll et al., 2012). These electrode sites consisted of six neighboring electrodes over the left lateral posterior scalp (58, 59, 64, 65, 68, and 69) and six neighboring electrodes over the right lateral posterior scalp (89, 90, 91, 94, 95, and 96). ERP data were averaged across the six electrode sites in each hemisphere. The time window for the N170 was derived and customized for each individual participant using the Net Station user defined event function that enables statistical extraction of each component to be representative of the variability in waveforms. Specifically, the N170 is identified at each electrode site for each participant and marked as an event that is then extracted for statistical analysis. The N170 time window ranged across participants from 130 ms to 200 ms and the peak was defined as the minimum amplitude falling in that range.

For the LPP mean amplitudes, ERP data were averaged across 15 electrode sites over central scalp regions (80, 87, 93, 79, 86, 78, 31, 54, 37, 42, 53, 61, 55, 62, Cz; overlapping with past dense-array LPP research). The time window of the LPP was chosen by visual inspection of the grand averaged data. The resultant time windows for the LPP was the mean amplitude observed between 500 and 800 ms after stimulus onset. The LPP was examined in each participant’s averaged data to confirm that the component of interest was captured at each electrode site. Mean amplitude of the LPP was averaged across each electrode group within the specified time window and was statistically extracted for each participant. One participant was excluded from the LPP analysis.
given that their mean LPP elicited by neutral infant faces was > 3 SD from the LPP mean for this condition. This participant was not an outlier in the N170 amplitude scores and was included in that analysis.

3. Results

3.1. N170

Mean N170 amplitude as a function of emotional expression is shown in Fig. 1. A 2 × 2 repeated measures ANOVA was performed to investigate emotional expression (negative, neutral) and hemisphere (left, right) on N170 amplitude. There was no main effect of emotional expression ($F < 1$), hemisphere ($F < 1$), or their interaction ($F < 1$). Taken together, these results suggest that the N170 was unaffected by hemisphere and the emotional expression of the infant faces. Thus, N170 amplitudes were averaged together to yield a single N170 amplitude for analysis with anxiety data.

3.2. LPP

A paired samples t-test comparing mean LPP amplitude elicited by neutral and distressed infant faces evidenced a statistically significant difference between the two conditions, $t(45)=2.11$, $p=.04$. As depicted in Fig. 1, the LPP was larger in amplitude when elicited by distressed infant faces compared to neutral infant faces.

3.3. Anxiety and ERP data

Pearson’s correlations were conducted to examine the relationship between N170 and LPP amplitudes and measures of anxiety. The mean State anxiety score in this sample was 29 ($SD=8$, range: 12–50) and the mean Trait anxiety score was 33 ($SD=10$, range: 16–59). These measures were also highly correlated, $r(47)=.70$, $p<.001$. We found no association between N170 amplitudes and State, $r(47)=.12$, $p=.44$, or Trait, $r(47)=.17$, $p=.24$, anxiety scores. Examination of LPP amplitudes yielded a different pattern of results. While mean LPP amplitudes elicited by distressed infant faces were not associated with State, $r(46)=.25$, $p=.10$, or Trait, $r(46)=.18$, $p=.23$, anxiety scores, there were statistically significant associations between mean LPP amplitudes elicited by neutral infant faces and our anxiety measures (Fig. 2). Specifically, higher levels of State anxiety were associated with a greater LPP amplitude to neutral infant faces, $r(46)=.40$, $p=.006$. A similar pattern emerged between the LPP amplitudes elicited by neutral infant faces and Trait anxiety, which did not reach statistical significance, $r(46)=.28$, $p=.063$.

Fig. 1. Electrode array (Panel A), exemplar infant face stimuli (Panel B) and ERP waveforms for the maternal group illustrating the N170 (Panel C) and LPP (Panel D) as a function of infant emotional expression.
4. Discussion

Given the increasing prevalence rates of anxiety disorders in early motherhood, an emerging body of work examines how anxiety may impact processing of infant cues. Here we extend this research examining the relationship between maternal anxiety and ERP neural correlates of infant cue perception during early infancy. Specifically, recent mothers viewed photographs of infant faces that were either neutral in expression or were clearly distressed. Our analysis focused on two well-established ERP components, the N170 and the LPP, as an early and late marker, respectively, of face perception. Our findings and their implications are discussed below.

4.1. Infant faces: N170

Consistent with one prior study (Noll et al., 2012), we found that infant emotional expression did not modulate N170 amplitude in this maternal sample. However, this finding contradicts prior research finding an enhanced N170 elicited by infant faces showing distress (Proverbio et al., 2006; Rodrigo et al., 2011). This outcome mirrors the broader body of adult work on affective face modulation of the N170 which has yielded conflicting results (Blau et al., 2007; Eimer and Holmes, 2002). Possibly, the emotion modulation effects previously reported for infant stimuli are due to the categorization tasks that were employed (i.e., participants were asked to identify the emotional expression of the infant face on each trial), rather than the more common passive viewing task used here and in other work (Noll et al., 2012). Thus the nature of the task employed may prove valuable for understanding the extent to which the N170 is affected by emotional expression in maternal samples viewing infant faces.

Consistent with Doi and Shinohara (2012), we also found that the amplitude of the N170 elicited by infant faces was not associated with levels of state, as well as trait, anxiety. This finding resonates with weak anxiety-ERP associations reported in previous work employing oddball (Rossignol et al., 2005) and categorization (Morel et al., 2014) tasks in adult face perception studies. Given that the N170 reflects the initial categorization of visual stimuli as faces, it may not be surprising that such an early and low-level stage of visual processing is unassociated with anxiety. Furthermore, only one prior study reported N170 and anxiety associations when employing subliminally presented fearful faces (Walentowska and Wróńska, 2010). Therefore understanding variability in tasks that may promote N170 sensitivity to anxiety levels will be important in future experiments employing infant, as well as adult, facial stimuli.

4.2. Infant faces: LPP

Replicating prior research employing infant faces (Rodrigo et al., 2011) and adult faces (Schupp et al., 2004), the LPP was modulated by infant emotional expression. Specifically, the mean amplitude of the LPP was greater when elicited by distressed infant faces compared to neutral infant faces. These findings converge with the broader theoretical interpretation that the LPP indexes sustained processing of motivationally relevant information (Schupp et al., 2000, 2004). We observed that higher levels of state anxiety were associated with greater LPP mean amplitudes specifically when viewing neutral infant faces. There was a similar trend between trait anxiety and the neutral infant LPP, though this did not reach statistical significance. In contrast, the LPP to infant distressed faces was not associated with either state or trait anxiety.

One interpretation of our finding a positive correlation between anxiety and the LPP to neutral faces may relate to the ambiguity of these infant facial expressions, which are neither extremely positive nor extremely negative in their communicative content. Possibly increasing levels of anxiety may increase the interpretation of an ambiguous stimulus as negative or threatening (Mathews and MacLeod, 1994). Past behavioral studies have also suggested that ambiguous information may be interpreted in a threatening way in patients with generalized anxiety disorder (GAD; Mathews and MacLeod, 1994; Mathews et al., 1989). Furthermore, individuals high in social anxiety report ambiguous social vignettes (Constans et al., 1999) and neutral faces (Yoon and Zinbarg, 2007) as more negative and threatening than low socially anxious participants. A related literature has also documented intolerance of uncertainty as differentiating participants with GAD from non-anxious control participants – and this has been central in conceptual models of GAD (Dugas et al., 1998). Therefore, the positive association between anxiety and the neutral infant face LPP reported here may also relate to maternal uncertainty of the infant’s affective states.

A second interpretation of these data may reflect that while these infant faces were not expressing positive emotions (e.g., smiles or laughter), they may be considered as mildly positive given that infant faces are associated with a number of core features (e.g., round face, large eyes) that may make them more appealing (Glocker et al., 2009; Lorenz, 1943). Indeed, enhancing these features increases “cuteness” ratings of these stimuli in non-parents (Glocker et al., 2009). Thus the neutral face LPP–anxiety association we observed may also reflect the relationship between anxiety and the neutral response to more positive affective stimuli. This interpretation would be consistent with other behavioral work suggesting there may be a positivity bias towards infant face cues in anxiety (Arteche et al., 2011). In understanding the functional significance of such a positivity bias in maternal anxiety, it has been hypothesized that this relationship may reflect the need for reassurance seeking as a component of anxiety disorders – a smiling infant may be reassuring to anxious mothers that their caregiving is appropriate (Arteche et al., 2011). Thus positively valenced infant faces may be more salient in maternal anxiety than distressed infant faces. Our ongoing work is beginning to tease apart potential positivity vs. ambiguity relationships in maternal anxiety to further inform our understanding of the findings reported here.

4.3. Limitations and future directions

The present study should be considered in light of its limitations and directions for future research. We have shown that mothers with greater levels of anxiety are more engaged by neutral infant faces. In the literature on anxiety and parenting, it has been shown that
mothers of anxious children tend to be more intrusive and exert more control over their children (McLeod et al., 2007; Rapee, 1997). However, it may be that the attentional antecedents of these behaviors begin much earlier in the child’s life. Thus in our next set of studies, we will examine whether or not heightened attentional engagement has downstream effects on behavior.

This was a community sample of women presenting typically with sub-clinical levels of anxiety based on a self-report measure. In future studies, it would be valuable to include a diagnostic classification of anxiety disorders in order to examine discrete categorization of the presence and absence of anxiety disorders in addition to more continuous measures. Nevertheless, even these moderate levels of anxiety were sufficient to be associated with the LPP elicited by neutral infant faces, and emerging evidence supports the strength and predictive power of the STAI in motherhood (Dennis et al., 2013), indicating its value in parenting research.

Here we examined the neural response to unfamiliar infant faces in mothers. Our maternal sample varied in the time since delivery when they participated (M = 8 months), capturing the postpartum period and early infancy. Future work should more tightly control the time period since delivery, and examine the potential for change in the relationship between neural markers of infant cue perception and anxiety over time. This work could also be expanded to use mother’s own infant face stimuli as well as examining other measures of parenting, including parity, to further understand the role of experience in the findings reported here. For instance, past studies examining familiar and unfamiliar infant face processing have evidenced an enhanced neural response when mothers viewed photographs of their own child (Grasso et al., 2009). Thus, familiarity may augment the association between the LPP and anxiety levels irrespective of whether this association is related to ambiguity or reassurance seeking. We did not ask mothers to rate the infant faces in this study, which may have provided more insight into the valence of the stimuli to these women and be valuable in beginning to tease apart the ambiguity vs. positivity bias interpretations described here.

An extension of this work would be to examine the neural response to adult emotional expressions to examine whether the relationship between anxiety and neutral infant faces reported here represent an infant-specific effect or a more general face perception finding. Finally, we designed our task such that infant faces were randomly presented as static photographs. This approach may not properly capture the more dynamic nature of changes in infant affect mothers experience on a day to day basis, which may be gleaned from actual interactions, video stimuli and eye-tracking methodologies.

4.4. Conclusion

This study investigated the relationship between maternal state and trait anxiety and the N170 and LPP as neural markers of infant face perception. We document that anxiety in mothers, particularly maternal state anxiety, is associated with the sustained processing of neutral infant faces as indexed by the LPP. The process driving these findings may reflect the ambiguity in the expression of the neutral infant stimuli employed here, or possibly the generally positive valence of these infant faces. Nonetheless our findings highlight the relevance of maternal neural responses to infant emotional cues in the context of anxiety.

Conflict of interest
None.

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