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# Anxiety and neural responses to infant and adult faces during pregnancy

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ABSTRACT

Women are vulnerable to anxiety during pregnancy and postpartum. However, little is known about antenatal anxiety and neural processing of infant-relevant information. In this experiment, the N170, P300, and LPP (late positive potential) event-related potentials were measured from 43 pregnant women as they viewed infant and adult faces, which were either neutral or distressed in expression. Mother's self-reported anxiety levels were also assessed. The N170 was comparable across face conditions and was not associated with anxiety. However, our central finding was that greater levels of antenatal anxiety were associated with a larger LPP, but only for neutral infant faces. Results suggest that antenatal anxiety may result in deeper processing of neutral, emotionally ambiguous, infant faces during pregnancy. These findings are discussed in light of other work indicating an interpretive bias toward threat in response to neutral stimuli in anxiety.

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## 1. Introduction

Pregnancy is a positive period of transition for many women—yet evidence also suggests that the pregnancy and postpartum period brings with it an increased prevalence of anxiety symptoms (Goodman, Chenausky, & Freeman, 2014; Wenzel, Haugen, Jackson, & Brendle, 2005; Wenzel, Haugen, Jackson, & Robinson, 2003)—perhaps even more so than depression (Lee et al., 2007). More than just a transitional emotional state of parturition, maternal prenatal anxiety is linked to a range of health relevant outcomes, including postpartum anxiety and depression symptoms (Heron, O'Connor, Evans, Golding, & Glover, 2004), preterm birth, and decreased infant birth weight (Anniverno, Bramante, Mencacci, & Durbano, 2013), disruptions to the child's cognition, affect, and behavior postpartum (Anniverno et al., 2013), and difficulty in mother–child bonding (Tietz, Zietlow, & Reck, 2014). To move beyond a symptom level understanding of emotional difficulties during pregnancy, research is needed to unpack brain-based neural correlates of prenatal anxiety in women.

Among available brain measures, event-related potentials (ERPs) are neural markers of perception, attention, and cognition that can be used to study women in the pregnancy period and their processing of motherhood-relevant cues (baby faces, baby sounds, and baby-relevant stimuli). A number of studies have examined rapid neural responses to infant emotional signals, such as infant cries or changes in facial affect, in maternal samples. Infant familiarity and emotional expression enhance ERPs implicated in attentional (P300) and sustained (LPP) processing of salient visual information (Maupin, Hayes, Mayes, & Rutherford, 2015). However, the extent to which infant facial expressions effect early ERPs associated with the structural encoding and perception of infant faces (N170) are mixed (Noll, Mayes, & Rutherford, 2012; Proverbio, Brignone, Matarazzo, Del Zotto, & Zani, 2006; Rodrigo et al., 2011). Importantly, emerging findings suggest that maternal characteristics, including emotional characteristics, may be associated with variation in ERP responses to infant cues (Noll et al., 2012; Rodrigo et al., 2011). In the current study, we examine how individual differences in anxiety relate to neural responses to infant faces in a sample of pregnant women.

There are few ERP studies of maternal mood during pregnancy and postpartum. Higher levels of prenatal depression symptoms were associated with a decreased P300 response elicited by distressed infant faces, when compared with happy and neutral infant faces (Rutherford, Graber, & Mayes, 2016). Depression symptoms in a sample of non-mothers and mothers were also correlated with N170 amplitudes elicited by infant faces irrespective of their emotional expression (Noll et al., 2012). With respect to anxiety, an initial study of mothers ($N = 16$) suggested that anxiety may impact

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the P300 elicited by children's faces – dependent on child familiarity and child eye-gaze direction (Doi & Shinohara, 2012). A second ERP study examined the extent to which state and trait anxiety was associated with N170 and LPP components elicited by unfamiliar infant neutral and distressed faces among 47 mothers of young infants (Malak, Crowley, Mayes, & Rutherford, 2015). While the N170 was not associated with anxiety levels, greater levels of anxiety were associated with larger LPP amplitudes elicited by neutral, but not distressed, infant faces. Malak et al. interpreted these findings as suggesting the ambiguity of neutral infant faces may be more anxiety-provoking for mothers given the absence of any clear communicative bids of the infant's internal state. Indeed, there is a rich literature indicating that greater anxiety is associated with a tendency to more readily perceive threat in ambiguity (e.g., Constans, Penn, Ihen, & Hope, 1999; Mathews & MacLeod, 1994; Mathews, Richards, & Eysenck, 1989), including with respect to adult neutral faces (Yoon & Zinbarg, 2007; Yoon & Zinbarg, 2008). However, the study by Malak et al. (2015) was restricted to the presentation of infant faces, thus leaving unexamined the question of whether maternal anxiety is related to adult face perception and whether such associations appear prenatally.

In this study, we were interested in whether antenatal anxiety was associated with N170, P300, and LPP ERP components elicited by infant and adult faces, which were expressing neutrality or distress. Given that depression may play an important role in the influence of maternal anxiety on caregiving (Tietz et al., 2014), we also controlled for depression in our analysis. We hypothesized that anxiety levels would be associated with LPP, but not with N170, amplitudes elicited by neutral infant faces, consistent with an interpretive bias to perceive threat in ambiguity (Malak et al., 2015). Given that similar infant socio-emotional characteristics affect the P300 and LPP (Maupin et al., 2015), we also hypothesized that the P300 elicited by neutral infant faces would be associated with anxiety levels. If this association reflects a neutral expression effect, we also anticipated similar associations between anxiety and the P300 and LPP elicited by neutral adult faces.

## 2. Methods

### 2.1. Participants

Forty-three pregnant women in their third trimester (mean age = 28 years, SD = 5 years; mean weeks gestation = 34 weeks; SD = 6 weeks; 24 primiparous, 18 multiparous, 1 woman did not report) were recruited through flyers posted in the community. Self-reported races were Caucasian ($n = 21$), African American ($n = 14$), Hispanic/Latino ($n = 3$), Asian ($n = 2$), and Other ($n = 3$). The Human Investigations Committee at Yale School of Medicine approved all procedures prior to recruitment, and all women provided informed consent.

### 2.2. Apparatus and stimuli

Net Station 4.2.1 with a sampling rate of 250 Hz and high impedance amplifiers (Net Amps 200, 0.1 Hz high pass, 100 Hz low pass) were employed to record continuous EEG. 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's 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 was soaked 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.

All experimental stimuli were grayscale photographs of 12 infant faces (Strathearn & McClure, 2002), 12 adult faces (Tottenham et al., 2009), and 24 houses. Each individual stimulus was repeated eight times in the paradigm. Infant and adult face sets consisted of six different infants and adults, respectively, each expressing neutral and distress. Infant and adult faces were also balanced for race (50% Caucasian and 50% African American; reflecting the predominant community demographic). Stimuli were sized on average 8.68 cm by 7.84 cm. Although stimuli had previously been rated within their respective databases, we asked 20 nulliparous women to re-rate these face stimuli according to the Self-Assessment Manikin that is employed to assess affective stimuli, focusing on the pleasure dimension to confirm the valence of these stimuli (Lang, Bradley, & Cuthbert, 2008). The pleasure dimension employed a Likert scale, ranging from "1" – "very happy, pleased, good" to "9" – "very unhappy, scared, sad". Adult distress faces (M = 6.77, SD = 1.08) were rated higher than adult neutral faces (M = 5.11, SD = 0.41), $t(19) = 6.50$, $p < 0.001$. Similarly, distressed infant faces (M = 7.39, SD = 0.80) were rated as higher than neutral infant faces (M = 3.84, SD = 0.94), $t(19) = 12.50$, $p < 0.001$. Images were viewed at a distance of 74 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 Beck Anxiety Inventory (Beck & Steer, 1990; Fydrich, Dowdall, & Chambless, 1992), which consists of 21 items describing symptoms of anxiety that participants respond to by using a 4-point Likert scale, where "0" represents "not at all" and "3" represents "severely – I could barely stand it" in responding to how much they have been bothered by the different symptoms during the past week, including the day of the laboratory visit. A higher score indicates a higher level of anxiety. Mean anxiety score was 11 (SD = 8, range 1–36). Sixteen mothers scored over the cutoff (score >11), indicating subthreshold anxiety levels (Karsten, Nolen, Penninx, & Hartman, 2011). The BAI has high internal consistency, reliability, and validity (Fydrich et al., 1992).

Anxiety levels were weakly correlated with parity, $r(42) = .02$, $p = .91$. In a subset of mothers, anxiety was weakly correlated with the timing of the pregnancy, $r(31) = 0.07$, $p = 0.71$ (assessed by responses to the item "Do you think that this is a good time for you to be pregnant?" with answers being either yes, not sure, or no) as well as the intentionality regarding the pregnancy, $r(31) = 0.20$, $p = 0.29$ (assessed by responses to the item "Before I became pregnant: I intended to get pregnant, my intentions kept changing, or I did not intend to get pregnant"). No correlations reached statistical significance.

The Beck Depression Inventory-II (Beck, Steer, & Brown, 1996) was also included ($M = 10$; SD = 7) and was strongly positively correlated with anxiety, $r(43) = 0.61$, $p < 0.001$. Thirty-eight mothers reported depression symptoms in the minimal to mild range, and five participants reported depression symptoms in the moderate to severe range. Depression was included as a covariate in any analyses where anxiety effects were reported.

### 2.4. Procedure

Participants first completed the questionnaire measures and then the ERP paradigm. A trial sequence consisted of a central fixation cross (jittered between 400 and 600 ms), stimulus presentation (1000 ms), and a blank screen (1000 ms). All stimuli were randomly selected and presented on a uniform black background. There were four blocks of 108 experimental trials. Within each block, 48 face (50% infant; 50% distress) and 48 house stimuli were presented.

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