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Investigating the Effects of Perinatal Status and Gender on Adults' Responses to Infant and Adult Facial Emotion

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The perception of emotion in infant faces is a key parental skill, thought to be impacted by caregiving experience. It is widely assumed that women, and in particular mothers in the postnatal period, are more attuned to infant facial expressions than men. However, empirical evidence for this is lacking, and it is not yet clear whether potential differences in emotion processing between adults during pregnancy and postnatally are specific to infant expressions or extend to faces of all ages. In this cross-sectional study using a subsample from a Finnish birth cohort ($N = 610$), we examine adult and infant facial expression perception in pre- and postnatal men and women. Women rated the happy infant faces more positively on the valence (pleasure) dimension than men, but men rated the faces higher on the arousal (excited) dimension measure. There were no significant differences between adults responding during pregnancy or postnatally, but first-time mothers rated the faces as higher in arousal overall than multiparous mothers. The ability to identify specific emotions (e.g., sadness) in adult faces correlated with judgments of emotion in similarly valenced infant faces. We conclude that adults differ in their sensitivity to positive or negative emotions, independent of whether they are expressed in infant or adult faces. We did not find that perinatal status (pre- and postnatal) was associated with differences in sensitivity to emotion in infant or adult faces. Men and women were differentially sensitive to the valence and arousal in infant faces, independent of the timing of their responses.

Keywords: face processing, parenting, infant faces, gender differences, parental status

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Parenthood often brings about dramatic changes in emotional and behavioral functioning. For mothers, these changes are driven by a combination of neuroendocrinal and experiential factors (Leuner, Glasper, & Gould, 2010), which may support sensitive, responsive caregiving. Much of our understanding of how pregnancy and parenthood take their effects is derived from nonhuman animal models. In other species, parenthood clearly alters how adults perceive and react to infants and their signals. For example, in rodents the transition to parenthood is characterized by a suppression in infant-directed aggression and an increased motivation to attend to infants and provide care (for review, see Feldman, 2015). However, this two-stage process of reduced aversion to infants, and then heightened motivation to respond, differs from that seen in humans.

Human adults respond positively to infants and infant cues (as demonstrated using implicit measures, Senese et al., 2013) and are

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motivated toward caretaking, independent of parental status (Feldman, 2015). In comparison with other species therefore, parenthood may have more nuanced (or more difficult to measure) effects on human adults' perception of infant signals. For instance, one study found no difference in parents' and nonparents' ratings of distress in infant faces, as presented in video clips (with other visual and audio information removed; Irwin, 2003). Another study reported that parents and nonparents differed only in their interpretation of low emotion intensity infant faces (Parsons, Young, Jegindoe Elmholdt, & Kringelbach, 2017).

Parenthood: Broad Effects on Cognitive and Emotional Processing

Animal models highlight that parenthood can impact brain and emotional functioning, beyond enhanced responses to infant-specific cues. In nonhuman rodent mothers at least (mice, rats, voles), the early postnatal period involves a shift where animals become less reactive to a range of negative or aversive environmental events (Agrati & Lonstein, 2016). Early postpartum nonhuman females show reduced fear and anxious behaviors compared with nulliparous females, greater resilience to stress, and better memory (D. Agrati, Zuluaga, Fernández-Guasti, Meikle, & Ferreira, 2008; Fleming & Luebke, 1981; Lonstein, 2005; Miller, Piasecki, & Lonstein, 2011). While these changes do not directly impact caregiving, they may indirectly benefit the animal and their offspring by supporting conditions in which the animal is more motivated to explore the environment and better able to forage for food.

Studies on human parents are less conclusive. Studies on cognitive changes have also reported mixed results, and are not entirely consistent with the positive effects reported in animal studies (Anderson & Rutherford, 2012; Macbeth & Luine, 2010). These discrepancies between nonhuman and human studies highlight the need to investigate the impact of parenthood on cognitive and emotional processes. Furthermore, the majority of studies on human parenthood have focused on mothers, and there is a new emphasis on understanding the mechanisms and effects of fatherhood (for review, see Feldman, Braun, & Champagne, 2019).

Emotion Processing in Pregnancy and the Postpartum Period

In women, the large shifts in sex hormones from early to late pregnancy and postpartum impact emotion processing systems (for review, see Osório, de Paula Cassis, Machado de Sousa, Poli-Neto, & Martín-Santos, 2018). For example, rises in estrogen have been shown to correlate with increases in selective attention toward fearful faces during pregnancy (Roos et al., 2012). Raised levels of progesterone, also characteristic of pregnancy, have also been associated with changes in the perception of disgust and fear expressions (Conway et al., 2007). Such changes in women may be adaptive in that they support sensitivity to emotional stimuli and hypervigilance toward emotional signals of threat by late pregnancy (Pearson, Lightman, & Evans, 2009). These findings are of interest, given the nonhuman animal studies demonstrating anxiolytic effects of the postpartum period. For instance, Pearson, Lightman, and Evans (2009) demonstrated higher accuracy scores in recognizing emotional expressions signaling threat or harm (fearful, angry, and disgusted faces) during late, compared with early, pregnancy (recognition accuracy of happy and surprise faces at ceiling, and therefore not analyzed). However, we know little about whether emotion processing differs in women during pregnancy compared with the postpartum period and beyond.

There is also a question as to how emotion processing in the postpartum period, compared with during a partner's pregnancy, might be different in men. While men do not go through the same dramatic biological and hormonal changes as women, the pregnancy of a partner does seem to have a measurable impact on men's physiology. In expectant fathers, both testosterone (Edelstein et al., 2015; Saxbe et al., 2017) and estradiol (Edelstein et al., 2015) have been shown to decline, when measured longitudinally during pregnancy. Lower basal testosterone has been correlated with more responsiveness to infant cues (Storey, Walsh, Quinton, & Wynne-Edwards, 2000) and stronger self-reported sympathy to infant crying (Fleming, Corter, Stallings, & Steiner, 2002). Declines in testosterone could therefore signal an adaptive change in expectant fathers, but there has been remarkably little work on whether there are differences in men's processing of infant signals before and after childbirth. One study, which included 11 first-time expectant fathers found no difference in their appraisal of infant facial emotion compared with men who were not fathers, or fathers with young infants (Maack et al., 2017). There is also intriguing evidence that caregiving experience in men can result in altered processing in brain sociocognitive circuits (Abraham et al., 2014). Investigating whether there are differences in emotion processing during pregnancy and after, and how these processes might differ in men and women is therefore of interest.

In general, women are reported to have better emotion recognition capacities across all emotions compared with men (meta analyses; J. A. Hall, 1978; Thompson & Voyer, 2014). This female advantage is often framed as an adaptation, which evolved from females' comparatively greater responsibility for infant caregiving (Babchuk, Hames, & Thompson, 1985). Caregiving requires rapid and accurate recognition of nonverbal emotion, of which facial expressions are a primary mode of communication. A related prediction is that negative facial expressions, which might signal a threat to infant survival, may be especially salient to caregivers, the "fitness threat hypothesis" (Hampson, van Anders, & Mullin, 2006). However, studies directly examining gender differences have rarely considered potential differential effects of parental status. Might becoming a parent confer an advantage on emotion recognition for both men and women?

While it is well-established that there are individual differences in how well adults recognize emotion in adult faces, and that parental experience might impact the recognition of infant emotion, the relationship between how we respond to emotion in infant and adult faces is unclear. Infant faces have distinct morphological configurations, including large and low-lying eyes, a rounded face and bulging cheeks. These features are referred to as "kinderschema," an innate mechanism for eliciting caregiving responses that are necessary for infant survival (Lorenz, 1971) and maternal tendencies have been associated with motivational responses to these features (Hahn, DeBruine, & Jones, 2015). There is also converging evidence that infant faces have a privileged status: they elicit specialized processing in the adult brain, they are prioritized above adult faces in some attentional tasks, and receive more

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positive affective responses (Hahn & Perrett, 2014; Luo et al., 2015; Parsons, Stark, Young, Stein, & Kringelbach, 2013).

Infant facial expressions are often described as more fleeting, subtle, and even less well-organized than older children (Sullivan & Lewis, 2003) and indeed adults. Infant facial expressions may be less differentiated than adults (e.g., fear and anger expressions have been shown to overlap; Oster, Hegley, & Nagel, 1992), but it is plausible that recognition and responses to facial expressions may share a common mechanism, independent of the age of the individual expressing the emotion.

Disrupted Processing of Facial Emotion

Understanding how caregiving behavior can be adversely impacted by psychiatric conditions, such as depression and anxiety, is important because of long-term implications for child development AQ: 5 (Bakermans-Kranenburg, Van Ijzendoorn, & Juffer, 2003; Murray, AQ: 6 Hipwell, Hooper, Stein, & Cooper, 1996). Mothers with postnatal depression can have difficulties interpreting negative infant facial expressions (Stein et al., 2010), and even subclinical depressive symptoms can be associated with more negative ratings of negative infant facial expressions (Parsons et al., 2017). Such findings are consistent with studies on processing of adult facial expressions, which have reported a bias in interpreting faces with negative, or ambiguous valence in depression (Bouhuys, Bloem, & AQ:7-8 Groothuis, 1995; George et al., 1998).

Whether anxiety or alexithymia can disrupt processing of infant facial emotion has not been examined. Alexithymia is a personality construct comprising difficulties identifying and verbalizing feelings, and an externally oriented thinking style (Kajanoja, Scheinin, Karlsson, Karlsson, & Karukivi, 2017; Sifneos, 1973). Both anxiety and alexithymia have been empirically linked to disrupted recognition of adult facial emotion (Starita, Borhani, Bertini, & Scarpazza, 2018), and anxiety has been shown to impair identification of happy faces (Arteche et al., 2011). As for depression, subclinical symptoms of anxiety or alexithymia, may also have an impact on face processing, but this remains to be tested.

Current Study

Emotion perception can be conceptualized either from a dimensional viewpoint where intensities of lower-order dimensions (typically valence and arousal) are evaluated (from low to high, e.g., Posner, Russell, & Peterson, 2005), or from a categorical viewpoint, where emotion signals are assigned discrete category labels (typically basic emotions such as anger and fear, e.g., Ekman, 1992). Because infant faces do not yet display all basic emotions in categorical fashion, we decided to use a hybrid approach in the present study. Participants were asked to rate the valence and arousal dimensions from the infant faces, yielding indices of sensitivity to infant emotional signals. To obtain comparable sensitivity data with categorical perception accuracy for the adult faces, the subjects performed a six alternate forced choice Task 6AFC for three different morphed intensities of the adult faces.

We investigated the perception of emotion in adult and infant faces in men and women during pregnancy and postpartum. The aims of this work were twofold. First, we aimed to examine whether perinatal status impacts perception of emotion in infant faces. Previous work has compared adults with and without young infants (e.g., Parsons et al., 2017) or at different stages of pregnancy (Pearson et al., 2009). Here, we compare adults during pregnancy or postpartum, which allows us to examine the impact of caregiving experience on emotion processing, while controlling for the expectation of having a child. Second, we aimed to investigate whether effects of perinatal status were specific to infant faces, or altered sensitivity to facial cues of emotion more generally. Animal studies have suggested that becoming a parent alters more general emotion processing, beyond infant cues (Feldman, 2015, 2016; Swain et al., 2014). Here, we tested the specificity of effects of perinatal status by examining how adults respond to emotions expressed by infants and adults. We used the opportunity to examine men and women taking part in a population-based birth cohort in Finland ("FinnBrain"). This allowed us to test a large, well-characterized sample of adults (including measures of depression, anxiety, and alexithymia) comparing emotion recognition accuracy during pregnancy and at different stages postpartum.

Method

Participants

Participants comprised a subsample of Finnish families participating in the FinnBrain Birth Cohort Study (Karlsson et al., 2018). Recruitment to the study took place at the maternal welfare clinics serving an area within Southwest Finland and the Åland Islands. Pregnant women were recruited on a rolling basis between December 2011 and April 2015. The total sample consisted of 175 males and 435 females (mean age 32 years, $SD = 4.6$). This total sample size provided more then 95% power to detect a small effect size (f = 0.2, with 4 groups). Most of the sample (74.4%) responded during the postnatal period (women: $n = 330$, mean days postpartum = 381, $SD = 254$; men: $n = 124$, mean days postpartum = 343, $SD = 259$). Those responding during pregnancy (51 males, 105 females) typically did so during the third trimester (women: mean days before birth = 60, $SD = 43$, men: mean days before birth = 64, $SD = 46$). Two-hundred and 41 women reported being first-time mothers, 171 were already mothers and 198 (primarily men, no data available on previous fatherhood) did not report on this. Of the total sample, 57.3% of the FinnBrain index children were male. Male participants were older on average than female participants by around a year (male: M = 32.96, $SD = 5.48$; female: $M = 31.64$, $SD = 4.15$, $F(1, 609) = 10.35$, $p = .001$). Data on education level was available from 584 participants. Of these, 41.6% had university-level degrees, 31% reported either vocational or academic training (e.g., nursing) and the remainder reported 9–12 years of total education.

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This study was conducted online, by sending participants a link to the two emotion face perception tasks (adult faces, infant faces), and asked to complete the task on a computer. Participants were invited to complete the task within a fixed time window, which meant that there was considerable variability in their gestational stage. Most participants were invited during the postpartum period because they had already been recruited into the birth cohort sample at the time of the current study. The order of these two tasks was varied across participants and in total took between 20 and 30 min to complete. The Joint Ethics Committee of the University of Turku and South-Western Hospital District approved the study protocol.

Participants completed postal and electronic questionnaires separate to the current task at four timepoints (first, second, and third trimester and 6 months postpartum). At the end of the first trimester (gestational weeks 14–16) participants completed the Edinburgh Postnatal Depression Scale (EPDS) and the Symptom Checklist −90 (SCL) anxiety subscale. During the next two trimesters (gestational weeks 24 and 34), mothers completed the EPDS, SCL-90. The Toronto Alexithymia Scale (TAS-20) was completed 6 months postnatally.

Infant Facial Emotion Perception Task

Participants were presented with 50 infant facial expressions, 10 different infant faces presenting an expression for each of five target emotions (positive, muted positive, neutral, muted negative, negative; see Parsons et al., 2017; Stein et al., 2010) in a random order. All infant faces were forward facing, with eye gaze toward the camera. The infants were aged between 3 and 14 months. Images were in color, matched for luminance in Adobe Photoshop, sized to 760 × 827 pixels, with a resolution of 72 pixels/inch. Participants used Likert scales (0–9) to rate the infant faces individually on two dimensions, calm-excited (arousal) and positive-negative (valence). The task was adapted from previous studies using these five face categories (Arteche et al., 2011; Parsons et al., 2016; Stein et al., 2010), but asking participants to rate arousal in addition to valence. The instructions emphasized that participants rate the valence and arousal of the infant faces, rather than their own valence or arousal.

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Adult Face Emotion Recognition Task

Participants' emotion recognition accuracy was tested using a set of 108 adult faces. Faces consisted of six basic emotions (anger, happy, sad, fear, happiness, disgust), using both male and female models (with three examples of each) at three morphed emotion intensities (low: 30%, medium: 60%, high: 100%). Faces were taken from the KDEF-dyn Database (Calvo, Fernández-Martín, Recio, & Lundqvist, 2018) based on Karolinska Directed Emotional Faces (Lundqvist, Flykt, & Öhman, 1998). Participants were instructed to select one of seven words (neutral/joy/sad/anger/disgust/fear/surprise) that best described the emotion expressed in the face of the person on screen.

Questionnaire Measures

Three questionnaire measures were used: the EPDS, the TAS-20, and the anxiety subscale of the SCL-90. The EPDS is a widely used measure of both postnatal and prenatal depression (Cox, Holden, & Sagovsky, 1987) and consists of 10 items rated from 0 to 3 (higher scores indicate more depressive symptoms). The anxiety subscale of Symptom Checklist 90 (SCL-90) is a reliable and valid measure of anxiety symptoms in both clinical and research settings (Derogatis, Lipman, & Covi, 1973; Derogatis et al., 1983; Holi, Sammallahti, & Aalberg, 1998) and consists of 10 items rated from 0 to 5. Alexithymia was measured using the 20-item Toronto Alexithymia Scale (Parker, Taylor, & Bagby, 2003). It consists of the following three subscales: difficulty identifying feelings (DIF), difficulty describing feelings (DDF), and externally oriented thinking (EOT). It has satisfactory psychometric properties, as demonstrated in several populations (Joukamaa et al., 2001; Taylor, Bagby, & Parker, 2003).

Analysis Strategy

For the infant face task, a repeated measures general linear model (GLM) was used with five emotion categories (most positive, muted positive, neutral, muted negative, most negative). Gender and current perinatal status (pregnant, postnatal) were between-participants factors. We also compared the performance of first-time mothers and mothers who already had children. Post hoc tests of the main effects were conducted using Bonferroni-adjusted alpha levels of .005 per test (.05/10).

For the adult face task, accuracy scores were analyzed using a repeated measures GLM, with six emotion categories (sad, disgust, anger, fear, surprise, happy) and gender and perinatal status (pregnant, postnatal) as between-participants factors. We also analyzed the effects of first-time motherhood, examining data from women only, separate from men. All other analyses use the full sample of participants.

Taking the average SCL-90 anxiety subscale scores and the average EPDS scores from the three timepoints (gestational weeks 14, 24, 34), females reported higher scores than males (mean difference 1-point, SCL, $F(1, 550) = 9.3$, $p = .002$; mean difference 1.5-points, EPDS, $F(1, 532) = 22$, $p < .001$). Males also scored significantly higher on the TAS-20 compared with women (mean difference 2 points, $F(1, 520) = 6.5$, $p = .01$). We repeated our main analyses with average EPDS, average SCL and TAS-20 scores as covariates (see online supplementary materials). These covariates did not alter the pattern or significance of the results. There were also no significant differences between first-time mothers and mothers who already had children on mean EPDS ($p = .54$), TAS ($p = .74$), or SCL scores ($p = .05$; Bonferroni adjusted alpha level of .02).

Results

Valence and Arousal Ratings for Infant Faces

Figure 1 presents a scatterplot of the valence and arousal ratings for the five infant face emotion categories ($N = 610$). The most "negative faces" were rated as high in arousal (toward excited) and low in valence (toward sad), whereas the "most positive" faces were rated as high on valence (toward happy) and had a wider distribution of arousal ratings. F1

Gender and Perinatal Status

For the valence ratings, there was a significant Emotion Category × Gender Effect (see Table 1). Women's ratings of the valence of the infant faces were overall more positive for the "happy" faces than men's (most positive: $t(608) = 5.79$, $p = .0001$, Hedge's g = 0.51, 95% CI [0.24, 0.48]; muted positive: $t(608) = 5.02$, $p = .0001$, Hedge's g = 0.45, 95% CI [0.21, 0.49]; see Figure 2). For the "sad" faces (most negative, muted negative) T1, AQ:11 F2

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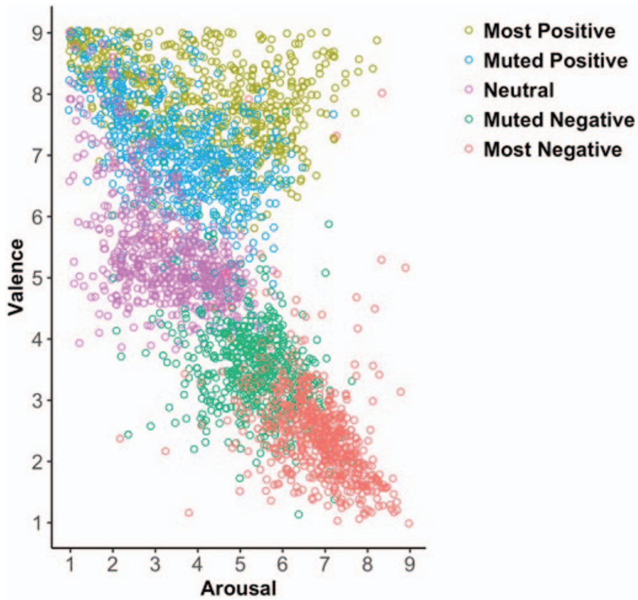

Figure 1. Overlay scatterplot, displaying the full sample of participants' valence and arousal ratings ($N = 610$) for the five infant face categories. See the online article for the color version of this figure.

and the neutral faces, there was no significant difference between women's and men's ratings (all p values > 0.03).

For the arousal ratings, there was a significant main effect of gender, and a significant interaction between gender and emotion category (see Table 2). For the happy faces, the opposite pattern of effects was evident compared with that seen for the valence ratings. Men rated the "happy" infant faces as higher in arousal (toward more "excited"), compared with women (most positive: $t(608) = -4.2$, $p = .0001$, Hedge's g = 0.37, 95% CI [−0.93, −0.34]; muted positive: $t(608) = -4.01$, $p = .0001$, Hedge's g = 0.36, 95% CI [−.65, −.22]). For the muted negative and neutral faces, there were no significant differences in men and women's ratings (all p values >0.05). For the most negative faces, men rated these as lower in arousal than women, $t(608) = 3$, $p = .0003$, Hedge's g = 0.27, 95% CI [.09, .41]. There was no main

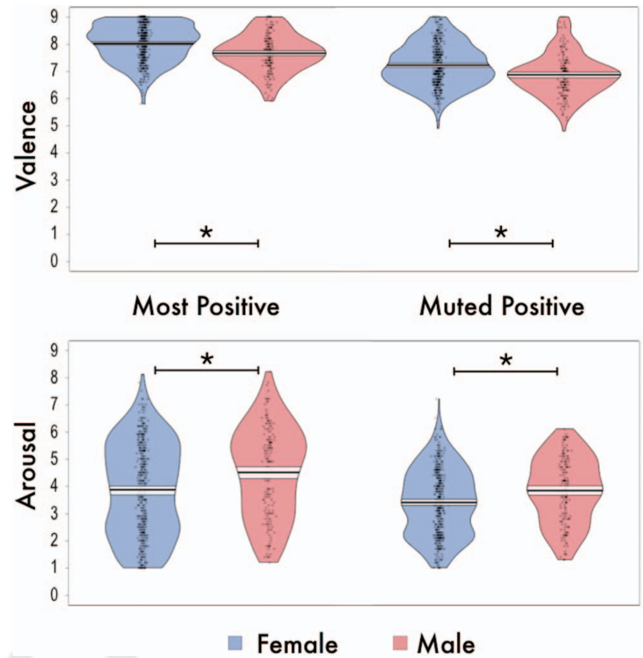

Figure 2. Pirate plot illustrating the differences between men and women for the happy infant faces across (a) valence ratings and (b) arousal ratings. For the valence ratings, women provided more positive ratings than men, but for the arousal ratings, men rated the faces as more intense than women. Raw data are represented by the black dots, the horizontal bar represents the mean, the colored regions show smoothed densities and the white rectangle shows the confidence intervals. See the online article for the color version of this figure.

effect of perinatal status, and no other significant interaction effects.

There was a wide variation in the perinatal timing of participants' responses, so we conducted exploratory analyses assessing the correlation between number of days before birth or postpartum and ratings of infant valence and arousal (see Table 4). For participants responding during pregnancy, there were no significant associations between the number of days before birth and any of the valence or arousal ratings. In women, there were no significant associations between number of days postpartum and valence and arousal ratings. However, for men responding during the postnatal period, there were significant correlations between timing of responses and valence ratings for the happy infant faces (most positive, $r = -0.23$, $p = .01$, muted positive, $r = -0.27$, $p = .01$), with less positive ratings as the number of days postpartum increased. Relationships with neutral or negative faces were not significant.

Primiparity in Mothers

To investigate the effect of first-time motherhood on perception of infant emotion, we compared first time mothers ($n = 241$) and mothers with other children ($n = 171$; data on primiparity was not available from fathers). For the valence ratings, there were no main effects of primiparity, or interaction effects between primiparity and infant face category (p values > .09). For the arousal ratings, there was a significant main effect of primiparity, $F(1, 410) =$

Table 1
Demographic Information and Participants' Scores on the SCL and EPDS Across Three Timepoints (Gestation Weeks 14, 24, 36)

	Female				Male			
	Preg		Postnatal		Preg		Postnatal	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age	31.97	4.0	31.5	4.2	32.8	4.85	33	5.74
SCL (gw 14)	2.96	3.6	3.1	4.1	1.26	1.7	2.7	3.4
EPDS (gw 14)	4.6	3.86	5.0	4.1	2.49	2.14	3.54	3.2
SCL (gw 24)	3.9	5.15	3.4	3.9	2.2	3.9	2.67	3.6
EPDs (gw 24)	4.86	4.1	4.6	3.96	2.56	2.1	3.6	3.45
SCL (gw 36)	3.45	5.1	2.7	3.26	1.9	2.86	2.1	3.15
EPDS (gw 36)	4.62	4.01	4.6	3.98	3.1	2.92	3.3	3.5
TAS-20	39.74	8.9	39.84	10	40.3	7.9	42.96	10.15

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Table 2
GLM for (a) Valence Ratings and (b) Arousal Ratings With Infant Emotion Category as the Repeated Measures Variable, and Gender and Perinatal Status as the Between-Subjects' Factors

Effect	Mean square	F	Sig.	η^2
(a) Valence ratings				
Gender	5.5	3.18	.07	0
Perinatal status	0	0	.99	0
Gender × Perinatal status	0	0	.98	0
Emotion category × Gender	12.43	15.54#	.00*	.02
Emotion category × Perinatal status	.32	.4#	.66	.001
Emotion category × Gender × Perinatal status	.11	.13#	.87	0
(b) Arousal ratings				
Gender	13.51	4.33	.04*	.01
Perinatal status	.41	.13	.72	.0
Gender × Perinatal status	.54	.17	.68	0
Emotion category × Gender	26.42	12.09#	.00*	.02
Emotion category × Perinatal status	2.93	1.34#	.26	.002
Emotion category × Gender × Perinatal status	3.9	1.78#	.17	.003

Greenhouse-Geisser correction. * Statistically significant at $p < .05$.

4.55, $p = .03$, $\eta^2 = .01$, with first time mothers rating the infant faces as higher in arousal overall compared with mothers who already had children. The interaction between infant face category and primiparity was not significant ($p = .46$).

Overall, there were subtle differences in the perception of emotion in infant faces across the participant groups. Comparing men and women's responses, there were opposite patterns evident for the arousal and valence ratings for the happy faces. Comparing adults responding during pregnancy or postnatally, there were no significant differences on either the valence or arousal measures.

Depression, Anxiety, and Alexithymia Scores

There was no significant correlation between EPDS or SCL scores (at any of the three timepoints) and ratings of valence or arousal. There were no significant associations between TAS-20 scores and ratings of arousal or valence across the five infant emotion categories ($N = 522$, all $rs < 0.08$). Examining the TAS-20 subscales (difficulty describing feelings, difficulty identifying feeling, EOT), there was small, negative correlation between arousal ratings for the muted negative faces ($r = -0.11$, $p = .009$) with participants' EOT scores. Examining men and women separately, this correlation only held for men (men: $n = 139$, muted negative, $r = -0.22$, $p = .008$; most negative, $r = -0.17$, $p = .04$, women: $n = 387$, muted negative, $r = -.06$, $p = -26$; most negative, $r = -0.004$, $p = .94$). There were no correlations with any TAS-20 subscales and ratings of infant valence.

Adult Emotion Recognition Task

Accuracy scores were >70% across five of the six face emotion categories, and were highest overall for the "sad" and "surprise" faces ($M = 78.49\%$, $SD = 12\%$; $M = 78.98$, $SD = 12.23\%$) and lowest for the "fear" faces ($M = 46.46\%$, $SD = 17\%$).

Gender and Perinatal Status

There was a significant main effect of gender on emotion recognition accuracy (see Table 3). Women showed a recognition accuracy advantage for all emotions except the "happy" and "surprise" faces (see Figure 3). There was no difference between the accuracy scores of those responding during pregnancy or postnatally and No Gender × Perinatal Status interaction for any of the emotion categories. T3 F3

Intensity of Emotional Expressions

We also explored the effects of emotion intensity on recognition accuracy (see Figure 4). Low intensity emotions had the lowest accuracy scores (42%), whereas medium and high intensity emotions had accuracy scores greater than 80%. Again, there was a female recognition advantage across all three emotion intensities (see Table 3). Women showed a recognition accuracy advantage for all emotions except the happy and surprised faces. There was no difference between the accuracy scores of those responding during pregnancy or postnatally and No Gender × Perinatal Status interaction for any of the emotion intensity categories. F4

Depression and Anxiety Symptoms and Alexithymia Scores

There was also no significant correlation between EPDS or SCL scores averaged across the three timepoints and accuracy scores for any of six emotions or overall accuracy (accuracy score across all six emotions).

Examining each of the six emotion categories, the correlation between TAS total scores and accuracy was significant for the sad ($r = -.10$, $p = .02$) and angry faces ($r = -.14$, $p = .001$), and the overall accuracy scores ($r = -.09$, $p = .02$). For the TAS subscales, EOT scores correlated with accuracy for the sad ($r = -.19$, $p < .0001$), and angry faces ($r = -.16$, $p < .0001$), and overall accuracy ($r = -.15$, $p = .001$); although these effects were all small in magnitude.

Looking at the adult faces divided by intensity of expression (low, medium, high), there was a small, negative correlation between TAS total scores and accuracy on the high intensity faces

Table 3
Adult Face Task, With Emotion Category as the Repeated Measures Variable, and Gender and Perinatal Status as the Between-Subjects' Factors

Effect	Mean square	F	Sig.	η^2
Gender	405.9	47.49	.000*	.07
Perinatal status	.36	.06	.84	0
Gender × Perinatal status	.62	.07	.79	0
Emotion category × Gender	36.73#	5.79	.000*	.01
Emotion category × Perinatal status	1.86#	.29	.91	0
Emotion category × Gender × Perinatal status	3.5#	.55	.72	0

Greenhouse-Geisser correction. * Statistically Significant at $p < .05$.

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Table 4
GLM for Participants' Recognition Accuracy Scores on the Adult Face Task, With Divided by Emotion Intensity (High, Medium, Low) as the Repeated Measures Variable, and Gender and Perinatal Status as the Between-Subjects' Factors

Effect	Mean square	F	Sig.	η^2
Gender	22.56	47.49	.00*	.073
Perinatal status	.02	.04	.84	0
Gender × Perinatal status	.03	.07	.79	0
Emotion category × Gender	1.42#	5.86	.006	.01
Emotion category × Parent	.38#	1.59	.21	.003
Emotion category × Gender × Parent	.25#	1.04	.34	.002

Greenhouse-Geisser correction. * Statistically significant at $p < .05$.

AQ: 12 (Pearson's $r = -0.12$, $p = -0.006$), but not for the low or medium intensity faces (rs < 0.06).

The TAS subscale, EOT, was significantly correlated with accuracy scores for the low ($r = -.10$, $p = .03$), medium ($r = -.12$, $p = .008$), and high intensity faces ($r = -.13$, $p = .003$). The other subscales yielded nonsignificant correlations, except for the DDF scale, which was correlated with recognition accuracy for the high intensity faces ($r = -.13$, $p = .003$).

Given the gender differences in TAS scores, we explored whether these correlations were significant for both men and women. The TAS accuracy correlations, and the EOT accuracy correlations held only women ($n = 383$), who made up the majority of the sample.

The Relationship Between Accuracy of Adult Emotion Recognition and Ratings of Infant Emotion

Overall recognition accuracy (all adult face emotions) was significantly correlated with ratings of the infant positive faces (muted $r = .1$, $p = .01$; most positive; $r = .13$, $p = .002$, see Figure 5, there was a smaller negative correlation with most negative infant faces also, $r = -0.08$, $p = .04$). F5

There was a significant correlation between recognition accuracy of adult sad faces and ratings of emotion for the "muted negative" ($r = -.12$, $p = .004$) and "most negative" infant faces ($r = -0.11$, $p = .007$). Adults who were more accurate at recognizing adult sad faces rated infant negative faces more negatively. Accuracy of sad adult face recognition did not significantly correlate with ratings of emotion for either category of infant happy face (muted positive, $r = .06$, $p = .1$; most positive, $r = .07$, $p = .08$).

There was a significant correlation between recognition accuracy of adult happy faces and ratings of emotion in the "muted positive," $r = .15$, $p = .0001$ and "most positive" infant faces, $r = .11$, $p = .005$. Accuracy of happy adult face recognition did not significantly correlate with ratings of emotion for either category of infant sad face (muted negative; $r = .06$, $p = .15$ most negative, $r = -0.06$, $p = .18$; see Figure 6). F6

Discussion

In this study, we examined the perception of emotion in adult and infant faces, in a large cross-sectional sample of adults responding either during pregnancy or after the birth of their infants. For the infant faces, adults provided ratings of both valence and arousal, for the adult faces, adults identified the face's emotion. Our primary analysis focused on differences by perinatal status and gender on emotion perception. We also explored the interrelationship between responding on the infant and adult tasks.

Our main finding was that for the happy infant faces, women provided more positive valence ratings (most positive, muted positive), while men provided higher arousal ratings. We did not find effects of perinatal status (responding during pregnancy or postnatally).

Comparing responses on the adult and infant tasks, we found that the ability to identify specific emotions (happiness, sadness) in adult faces was associated with perception of the same emotion in infant faces. That is, adults who were more accurate at recognizing sadness in adult faces rated infant negative faces more negatively, and adults who were more accurate at recognizing happiness in adult faces rated infant positive faces more positively. This suggests that there may be an expression-specific emotion recognition mechanism across infant and adults faces.

Previous studies generally report on adults' perception of infant cues, and factors that impact on such perception, but not on broader emotion recognition capacities. Here we demonstrate that the recognition of distinct emotions in adult faces correlates with perception of comparable emotions in infant faces. Our results suggest that it is not simply that some adults are more accurate at recognition across all emotion categories across infant and adult faces. We observed that greater accuracy in detecting happiness in

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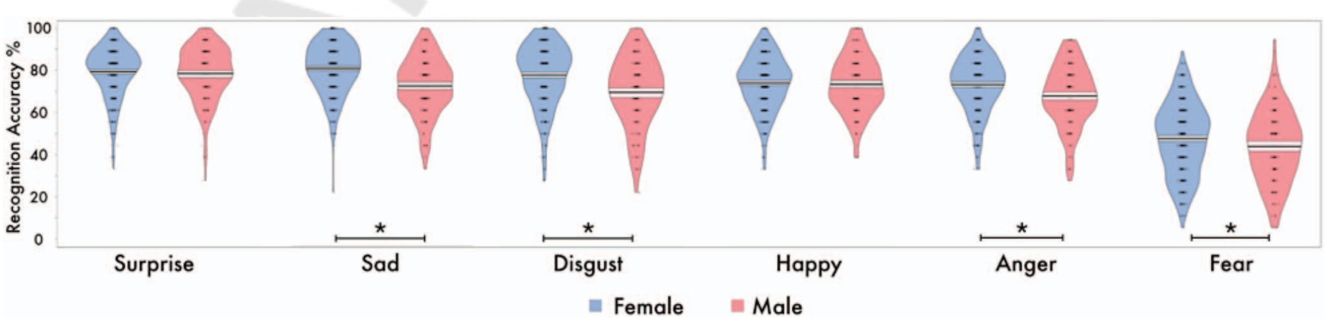

Figure 3. Percentage correct for each of the six emotion categories for men and women (with 95% HDI). Women were significantly more accurate than men in recognizing the negative emotional faces (sad, fear, anger, disgust; * $p < .05$). See the online article for the color version of this figure.

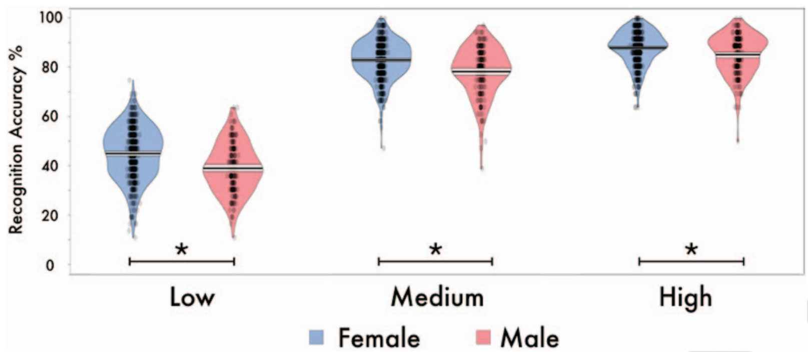

Figure 4. Percentage correct for each of the three emotion intensities (low, medium, and high, with 95% HDI) for men and women. Women had significantly higher scores at all three intensities (* $p < .05$). See the online article for the color version of this figure.

adult faces was correlated with more positive ratings of infant happy facial expression, but not more negative ratings of infant sad expressions. Rather, it may be that individuals become attuned to specific emotions expressed in faces, whereby some adults are more attuned to sadness in adult and infant faces, and others are more attuned to happiness.

The postpartum period for women is characterized by rapid changes in estradiol and progesterone levels before and immediately after delivery (Hendrick, Altshuler, & Suri, 1998). These hormones have a major role in basic emotion processing at this, and other times (Schiller, Meltzer-Brody, & Rubinow, 2015) and such changes are suggested to bring about differences in affective processing from birth to postpartum. For men, there are considerable changes also, depending to an extent on caregiving role and time spent with their infant (e.g., Abraham et al., 2014). In our cross-sectional study however, we did not find differences between adults responding during the prenatal and postnatal period on the infant task. Given our sample size, it is unlikely that there are moderate to large differences' in adults perception of infant valence during pregnancy and postnatally.

The majority of studies examining the effects of pregnancy, caregiving and changes in perinatal status have focused on adults' responses to infant faces specifically for reviews see (Piallini, De Palo, & Simonelli, 2015; Webb & Ayers, 2015) and most have focused on valence alone (Arteche et al., 2011; Parsons et al., 2017; Stein et al., 2010). The addition of the arousal measure is important because current models hold that emotional stimuli can be understood as a linear combination of their arousal and valence

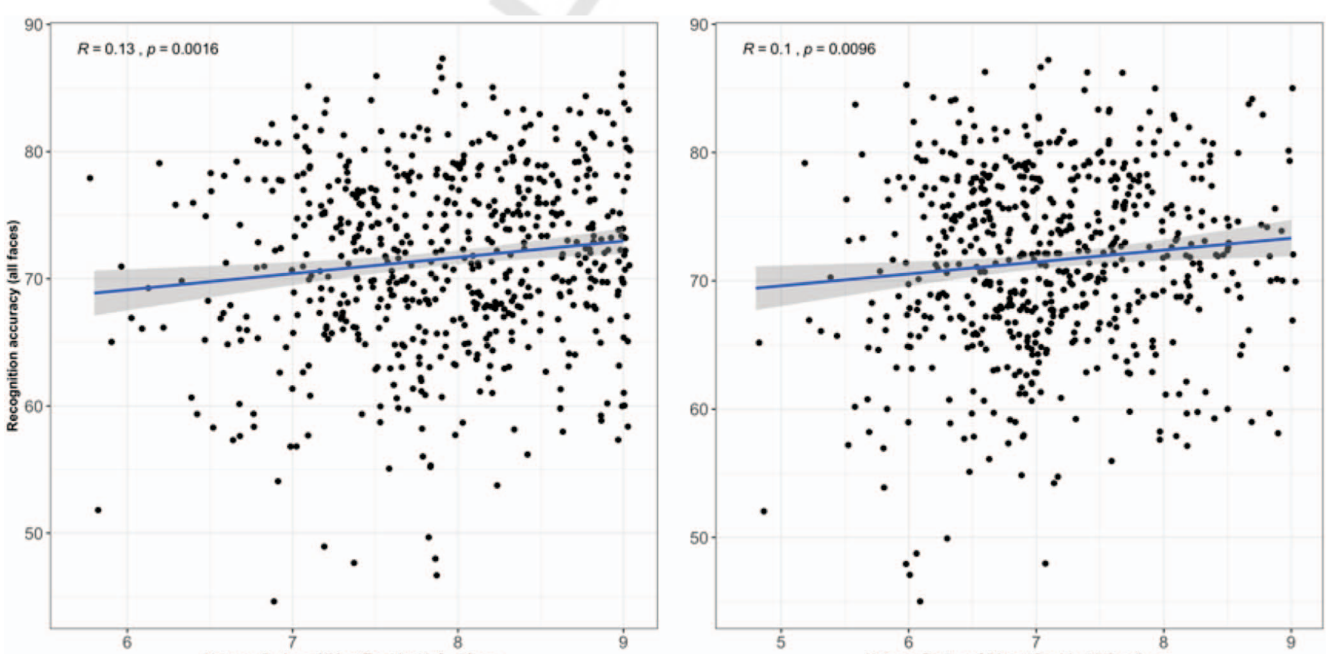

Figure 5. Scatterplots with a regression line, presenting the relationship between recognition accuracy (percentage) for all adult faces and valence ratings for the (left) most positive infant faces, and (right) the muted positive infant faces. See the online article for the color version of this figure.

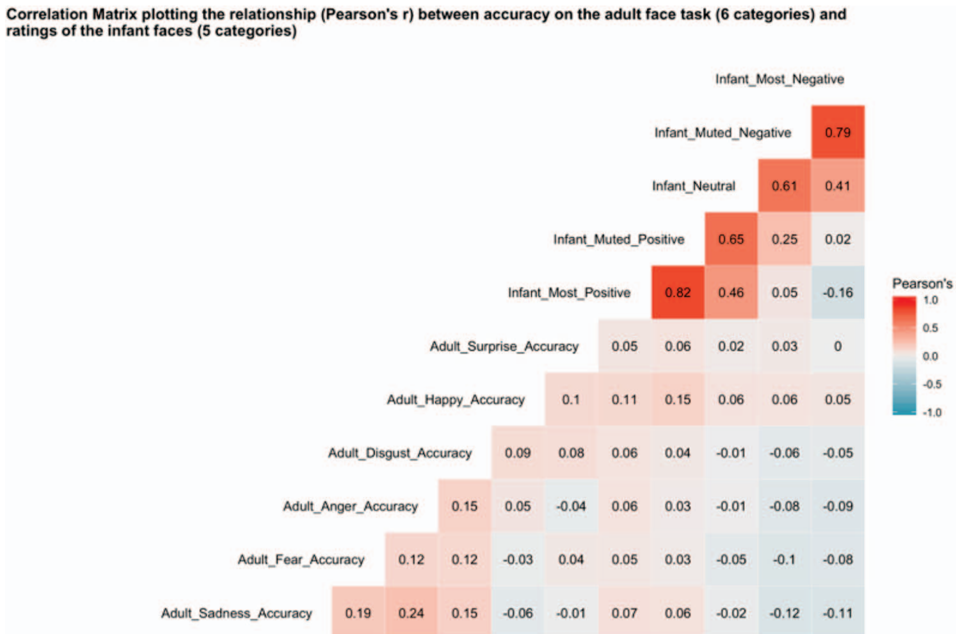

Figure 6. Correlation matrix plotting the relationship between valence ratings of the infant faces (five categories) and accuracy scores on the adult face task (six emotion categories). See the online article for the color version of this figure.

dimensions (Posner et al., 2005). Numerous studies have shown that women are more sensitive to features of infant cues than men (e.g., infant cuteness; Sprengelmeyer et al., 2009) and that mothers give more positive ratings of happy faces compared with fathers (Parsons et al., 2017), but here we show that men provided higher arousal ratings of infant faces than women.

Our inclusion of arousal dimension, where effects were opposite to that seen on the valence dimension, provides a more nuanced understanding of how adults process infant emotion. Women may be more sensitive to the valence of infant faces, but men may be more sensitive to their arousal. This is consistent with work showing that men provide higher arousal ratings to pleasant, high-arousal stimuli than women (Ferrari, Bruno, Chattat, & Codispoti, 2017); our happy infant faces may be considered as pleasant, arousing stimuli. We speculate that these findings may also be linked to differences in the type of caregiving interaction behavior fathers and mothers tend to engage in. For instance, fathers spend a higher proportion of their interaction time with infants in play than mothers (Yarrow et al., 1984). Their style of interaction tends to be more physically stimulating and unpredictable than mothers' (Lewis & Lamb, 2003) possibly eliciting greater arousal in their infant's facial expressions. Furthermore, there is evidence that infants display more peaks in (rater-coded) high positive arousal during father infant interactions, compared with mother–infant interactions (Feldman, 2003).

We did note a difference between women's perception of infant facial expressions, dependent on primiparity. First-time mothers provided higher arousal ratings of the infant faces overall when compared with women with other children. Another study found that infant faces elicit greater neural activity (P300) in first-time mothers compared with multiparous women (Maupin, Rutherford, Landi, Potenza, & Mayes, 2018) argued to indicate greater allocation of attention.

We interpret our results with this finding in mind: First-time mothers show heightened sensitivity to the intensity of infant facial expressions. Another possibility is that mothers with more children were experiencing greater stress (Östberg & Hagekull, 2000), which might impact infant emotion perception, although we did not obtain a measure of mothers' current stress level.

Women overall were significantly more accurate than men in recognizing the negative adult emotion expressions (sad, fear, anger, disgust). We found no difference in accuracy scores for the happy and surprise faces. Looking across the three levels of intensity (low, moderate, high), women showed a recognition advantage over all three emotion intensities. These findings are consistent with previous studies demonstrating a female advantage in recognizing emotional faces (Hall & Matsumoto, 2004; Kret & De Gelder, 2012; Lambrecht, Kreifelts, & Wildgruber, 2014; Nowicki & Hartigan, 1988). There is also evidence suggesting heightened physiological arousal, as well as increased attentional capture, in females compared with males in response to emotional facial expressions (Bradley, Codispoti, Sabatinelli, & Lang, 2001; Grossman & Wood, 1993), although not all studies show these effects (Whittle, Yücel, Yap, & Allen, 2011). Our findings add further to the general evidence for a female emotion recognition advantage for adult faces. While the female recognition accuracy advantage was clear for the adult faces, men showed more attunement to arousal in happy infant faces than women.

We did not find any effects of depressive or anxiety symptoms, as measured by the EPDS and the SCL, on either the adult emotion recognition accuracy scores or the infant emotion ratings. We note, however, that the sample who completed these online tasks re-

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ported low levels of symptoms in general. In an exploratory analysis, we did find correlations between self-reported alexithymia symptoms (TAS-20) and recognition of the high intensity adult face emotions (particularly in women). There were also associations between alexithymia symptom levels and recognition of two negative face categories (sad, angry), but not for the four remaining categories. Analyzing the TAS-20 subscales, the EOT style scores correlated with accuracy scores, when considering the low, medium, and high intensity faces. EOT scores also correlated with ratings of arousal for the negative infant faces, but not for the other emotion categories, or for the valence ratings. Our findings are broadly in line with previous work demonstrating that alexithymia is associated with impaired emotion recognition (Grynberg et al., 2012), especially in adults meeting TAS-20 criteria for alexithymia (Lane et al., 2000; Parker et al., 1993).

AQ: 13 AQ:14, 15

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Limitations

We do not know whether the male participants had a previous child beyond that recorded with their current partner. We therefore cannot make any conclusions about differences between first-time or experienced fathers. We also did not collect data on participants' caregiving roles or involvement in caregiving experience. Most participants were female and completed the task in the postpartum period. We therefore do not have sufficient data about emotion perception or recognition at different stages of pregnancy. Finally, the paradigms for examining the perception of emotion in adult and infant and faces were not identical. For the adult faces, we asked participants to categorize each emotion, which allowed us to compute an accuracy score. For the infant faces, we asked participants to rate each facial expression on a scale, providing a dimensional measure of emotion perception, not an accuracy score. It is not possible to establish a true criterion for the emotion displayed in each infant face (i.e., for adult faces, actors generate a specific expression). An accuracy score is therefore of questionable validity. Furthermore, differentiated expressions for basic emotions like anger and fear are not always seen (Camras et al., 2007), which meant that we could not construct an infant task analogous to the adult one. Nevertheless, we identified correlations between how adults respond to specific emotions in infant and adult faces.

The majority of women participated at around the third trimester and far fewer responded in the days and weeks immediately postpartum. It may be that to measure pregnancy and postpartum differences, we need to target specific time windows. Nonetheless, we suggest that there are unlikely to be large, general effects on adult face emotion recognition accuracy between pregnancy and postpartum, given the large sample size recruited here. Furthermore, most effect sizes reported here were small. Finally, future work might examine whether differences between men and women's infant face emotion perception (arousal and valence) translate into differences in actual parent–infant interaction.

Conclusions

We report on findings from a large sample of adults participating in a population birth cohort study. We used a novel online data collection method, taking advantage of the natural variations in participants' perinatal status, which occurred as participants were enrolled on a rolling basis. Our results suggested interaction effects between gender, and the facial expression rated, for emotion ratings of infant faces. For the happy faces, women provided more positive valence ratings than men, but men provided higher arousal ratings than women. Examining the relationship between perception of emotion in infant and adult faces, we found that the ability to identify specific emotions in adult faces correlated with the rating of similar emotions in infant faces (e.g., recognition of adult sadness correlated with ratings of infant negative faces). We suggest that adults may differ in their attunement to specific emotions expressed in faces, be they adult or infant faces.

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