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Impact of Parity and Salivary Hormonal Levels on Motivation Toward Infant Emotions

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Infant faces have been shown to be particularly motivating stimuli for women. No studies, however, have compared mothers and nonmothers in whether parity modulates approach motivation toward emotional infant faces. We studied 54 Finnish first-time mothers and 42 nonmothers in a pay-per-view key-press task where the participants were shown 20 infant faces with smiling and crying expressions. Participants were able to adjust the time each face was visible. In addition, salivary testosterone, estradiol, and cortisol levels were measured and their impact on motivation toward infants analyzed. When controlling for the hormonal levels, happy infant faces were viewed longer than crying faces and there was no difference in mean viewing times between mothers and nonmothers. An interaction between parity and emotion emerged: Mothers were more motivated to view happy faces and less motivated to view crying infant faces than nonmothers. Testosterone had a significant effect on viewing times: The higher the testosterone levels were, the shorter amount of time infant faces were viewed. This indicates that testosterone is inversely associated with approach motivation to emotional infant stimuli. This study is the first to compare mothers and nonmothers in a task measuring motivational responses to infant stimuli and indicates that the difference between the approach motivation caused by happy and distressed infant emotions might be more heightened in new mothers.

Keywords: parenting, approach motivation, avoidance, infant emotions, hormones

Infant emotions and needs are expressed through facial expressions and vocalizations, which function to capture the caregiver's attention, and motivate them to attend to the infant's needs (Bornstein et al., 2017; Piallini et al., 2015). For the parent to be able to respond to the infant's cues in the most efficient way, their attention needs to be attuned to the child signals (Ainsworth et al., 1974; Dudek & Haley, 2020). Parental attention might, however, be affected by their motivation and attitudes toward babies and parental approach motivation toward the infant might be an important prerequisite for sensitive parenting (Rilling, 2013). By comparing parents and nonparents, it is possible to investigate whether parity has an effect on approach motivation toward infants and whether such approach motivation might be stronger in parents. In addition, during the transition to parenthood several key parenting related

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hormones undergo major changes and these changes have been associated with sensitive caregiving behavior (Edelstein et al., 2017; Sinisalo et al., 2022). In this light, hormonal factors are a potential mechanism underlying the presumable differences between parents and nonparents in their approach motivation toward infants. In this study, we investigated whether mothers and nonmothers differ in their effort to view emotional infant faces (i.e., approach motivation) and whether the motivation toward infant emotions shows associations with salivary estradiol, testosterone, or cortisol levels.

Infant faces motivate people in a distinctive way. For example, women are more eager to exert effort to view infant faces compared to similar nonhuman face stimuli such as dolls or kittens (Charles et al., 2013). The motivation to view infant faces might also be dependent on the features of the infant. One such example is the cuteness of the infant or the alignment with the so called "baby schema" which refers to infantile features (i.e., big round head, high forehead, small nose and mouth, and big eyes; Lorenz, 1943). Infant faces morphed to appear higher in cuteness (i.e., by exaggerating their infantile features) have been noticed to elicit stronger self-reported caretaking motivation compared to infants morphed to appear lower in cuteness, independent of parental status (Glocker et al., 2009; Hahn, DeBruine, & Jones, 2015). In addition, self-reported maternal tendencies in nulliparous women have been related to greater approach responses toward infant faces that were morphed to be cuter (Hahn, DeBruine, & Jones, 2015). Parsons et al. (2014) further found that perceived infant temperament affects motivation toward infant faces: laughing infants were rated as cuter and their faces were viewed longer (i.e., more effort was exerted to lengthen their visibility) than sad infants. Together these results suggest that infant emotion might affect the perception of infant cuteness which, in turn, might affect the degree to which infant faces trigger the motivational systems of the viewer.

As noted above, positive infant emotions also trigger approach–avoidance related behavior in people, but the evidence is somewhat mixed regarding other emotions. A few studies have used a joystick to explore approach–avoidance responses to emotional infant faces. Using an instructed approach–avoidance task, Mizokawa et al. (2013) found that in Japanese university students (N = 40, all nonparents) both happy and sad adult and infant faces inflicted quicker approach than avoidance responses in general, and only in response to sad infant faces the participants' self-rated motivation to help was associated with slower avoidant behavior when instructed to do so. De Carli et al. (2017) used similar methods in a sample of 63 Italian university students and found that nulliparous women tended to avoid sad, neutral, or sleepy infant expressions, and that this effect was enhanced after a sad mood induction. No tendency for approach or avoidance was found for happy expressions. Hiraoka et al. (2019) used a balancing board to study approach–avoidance related postural movements and found that infant crying vocalizations triggered approach-related postural movements in a small sample of 20 primiparous and multiparous mothers of infants under 24 months, and these movements were also related to the perceived urgency of the infant cry. Overall, positive facial expressions generally motivate approach responses, and in women, infant faces motivate approach more than adult faces.

To date, however, it is unclear whether these phenomena are stronger in parents than in nonparents, and no studies have compared mothers and nonmothers with tasks sensitive to motivational tendencies, which would give important insights on how the motivation toward infant stimuli might develop during the transition to parenthood. Research has shown that parents and nonparents evaluate the intensity of infant distress similarly (Irwin, 2003) and overall show more positive implicit associations toward infant faces than adult faces, although there is individual variation: Senese et al. (2013) observed that human infants evoked a range of implicit associations from largely positive to medium negative implicit reactions in a sample of parents and nonparents. New mothers have been found to show changes in their explicit but not implicit evaluations of infants from pregnancy to postpartum as their explicit responses (i.e., locating the target object, such as the word "*baby*," between two opposite adjectives using a 7-point scale) in the postpartum period were more positive than the prenatal responses (Senese et al., 2018). Furthermore, when finding a target face among three options, both first-time mothers and nonmothers (total $N = 150$) had slower reaction times in the presence of infant faces compared to adult faces, but this effect was stronger in mothers, indicating a stronger attention bias to infant faces in mothers (Thompson-Booth et al., 2014a, 2014b). These findings indicate that becoming a parent might have an impact on attention and approach motivation toward infants. Brain research also suggests parity-related differences in perceiving infant cues. For example, a recent meta-analysis showed that in electroencephalography (EEG) studies the face-sensitive N170 component to infant faces is larger in parents than in nonparents ($N = 223$, Vuoriainen et al., 2022). In addition, compared to nulliparous women, Chinese first-time mothers showed greater activity in brain regions implicated in empathic processing and mentalization when viewing infant facial expressions (N = 42, Zhang et al., 2020). Finally, Strathearn et al. (2008) found that in a community sample of first-time mothers (N = 28), their brain regions related to reward-processing were more activated when they viewed pictures of their own infant's emotional face compared to unknown infants' faces.

Both neural and hormonal systems go through adaptive changes during pregnancy and the postpartum period (Edelstein et al., 2015; Hoekzema et al., 2017; Kim et al., 2010; Oatridge et al., 2002), which may have consequences for parenting related behaviors. Animal studies (e.g., in rodents and sheep) have shown dramatic changes in maternal behavior toward the offspring after parturition, with a shift from total aversion to pronounced interest and care toward the offspring (Numan, 2007). This shift has been related to elevated estradiol and prolactin levels during pregnancy, followed by sudden drop of progesterone near parturition that together have an effect on the oxytocin receptors in the medial preoptic area of the hypothalamus, thus onsetting maternal behavior (Numan et al., 1977; Pfaff et al., 2011). In humans, a similar shift in motivation toward infants is not as evident, as humans are an alloparental species. However, similar changes in hormonal levels during the transition to parenthood and associations between hormones and parental behavior have been observed in humans (Rilling, 2013; Rilling & Young, 2014). For example, the levels of gonadal hormones testosterone and estradiol as well as the stress-related hormone cortisol all increase during pregnancy (Edelstein et al., 2015; Fleming, Ruble, et al., 1997). After pregnancy, parents have lower testosterone levels than nonparents (Barrett et al., 2013; Grebe et al., 2019), and higher levels of testosterone have been associated with lower parenting quality (Bakermans-Kranenburg et al., 2022; Edelstein et al., 2017; Meijer et al., 2019; Weisman et al., 2014) although much of the research is done with male-only samples.

Similar findings between parental sensitivity and cortisol have been published (Finegood et al., 2016; Sinisalo et al., 2022), although cortisol levels have also been positively associated with heightened responsiveness to infant odors (Fleming, Steiner, & Corter, 1997) and sympathy triggered by crying infant stimuli (Stallings et al., 2001). Estradiol levels, on the other hand, have been positively associated with higher parental sensitivity (Glynn et al., 2016), although not in fathers with high testosterone levels (Bakermans-Kranenburg et al., 2022).

In this light, approach motivation to infant stimuli may also be affected by these key parenting related hormones. For example, when presented with two different alternatives of the same face and asked to choose the one higher in cuteness, premenopausal women have been shown to be more often correct in cuteness discrimination of infant faces than postmenopausal women and, in addition, women using oral contraceptives were shown to be more often correct than women not using oral contraceptives (Sprengelmeyer et al., 2009). Sprengelmeyer et al. (2009) suggest that this could be due to the heightened estrogen and progesterone levels in premenopausal (compared to postmenopausal) women and in women taking oral contraceptives. Hahn, DeBruine, Fisher, and Jones (2015) found that when nulliparous female university students (N = 60) were presented with infants varying in cuteness and instructed to adjust the viewing time by key presses, high infant cuteness was more rewarding (i.e., viewing times were longer) when participants' salivary testosterone levels were high. Cortisol has been inversely linked to approach behavior in some studies (Roelofs et al., 2005; Van Peer et al., 2007), but these results are from mixed or male-only samples and did not compare parents and nonparents. There are no studies comparing mothers and nonmothers in their motivation toward infants, or examining whether motivational responses are associated with hormonal levels within these groups. However, our previous findings indicated a negative association between testosterone levels and fertility motivation (i.e., "baby fever") in nonmothers (Sinisalo et al., 2022). This suggests that motivation toward infants might be inversely related to testosterone levels.

In this study, we examined nulliparous and primiparous women (i.e., women without children and first-time mothers, respectively) viewing emotional (happy and crying) infant faces and adjusting the viewing time with a simple key-press paradigm. In addition, salivary hormonal levels were analyzed. According to our preregistration, our first hypothesis was that mothers exert more effort to view emotional infant faces compared to nonmothers. Second, we hypothesized that infants' positive emotions elicit more efforts to view them than negative emotions in both mothers and nonmothers. Third, we expected nonmothers to be less motivated to view negative infant emotions than mothers, but we expected the two groups to not differ in their motivation to view positive infant emotions. Fourth, we explored whether the viewing times in the two groups are associated with hormonal factors (estradiol, testosterone, and cortisol). This was an explorative research question, and we did not set a priori hypotheses regarding the hormonal data.

Method

Participants

In total, 96 women (54 mothers, 42 nonmothers) participated in the study. We recruited 22–37-year-old female participants from the Pirkanmaa region in Finland. Mothers (M_{age} = 29.91, SD = 2.96) were recruited by invitation letters based on their contact information obtained from the Finnish Digital and Population Data Services Agency, and nonmothers (M_{age} = 26.35, SD = 2.95) were recruited via university email lists. All participants were required to be in a couple relationship with a duration longer than 6 months, to live together with their partner, and to have adequate skills in Finnish. Mothers were required to have one child around 6 months of age (M_{age} = 7.19 months, SD = 1.48) and nonmothers were required to not have children of their own or their partner's. Half of the mothers were married (50%) whereas in the nonmother group a subset was married (17%). At the time of the participation 81% of the mothers were breastfeeding their infant. For more detailed sample description, see Sinisalo et al. (2022).

Procedure

This study is part of the TransParent project investigating changes in processing infant cues during the transition to parenthood (for sample size determination and power calculations, see Sinisalo et al., 2022). The data were collected during 2018–2019. The study protocol was reviewed by the Ethics Committee of the Tampere Region.

The participants were called before the laboratory visit to give instructions. The participants were asked not to eat or drink for a full hour before the visit. To control for the hormonal effects of menstrual cycle (Gandara et al., 2007; Liening et al., 2010; van Anders et al., 2014) and hormonal contraceptives (Montoya & Bos, 2017; van Anders et al., 2014), the laboratory visit was scheduled in the luteal phase of the cycle whenever possible. In addition, due to the effect of breastfeeding on hormonal levels, the breastfeeding mothers were asked to breastfeed their baby 1 hr before visiting the laboratory (White-Traut et al., 2009). Finally, to control for the diurnal variation of hormone levels, the laboratory visits took place between 12 p.m. and 6 p.m. (Endendijk et al., 2016; van Anders et al., 2014).

When participants arrived at the laboratory, they first received information about the study, signed informed consent, and completed a short questionnaire. Next, they gave a saliva sample with a Salivette polypropylene swab (Sarstedt, Nümbrecht, Germany). Participants were instructed to chew the swab for 1 full minute and then set the swab into a polyethylene container without touching the swab with their hands. Later during the visit, another saliva sample was collected to examine hormonal reactivity, which is reported elsewhere (Sinisalo et al., 2022). The swabs were initially stored in −20 °C– −30 °C for a maximum of 1 week and then transported in dry ice to a liquid nitrogen freezer (−80 °C). The samples were analyzed in the Finnish Institute of Occupational Health (Helsinki, Finland). The whole laboratory visit included six different tasks and lasted approximately 75–90 min. The motivation task reported here was the last task the participants carried out during the laboratory visit.

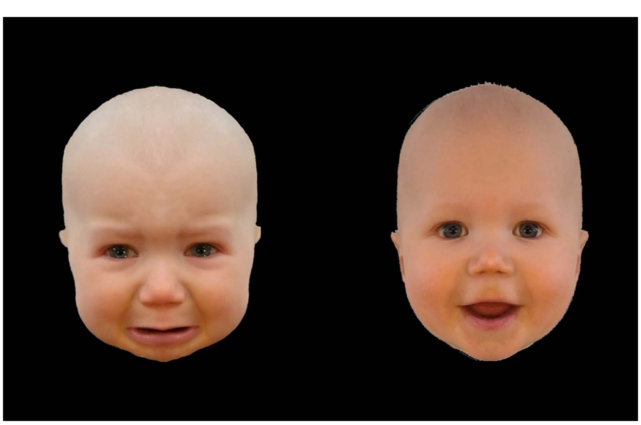
A few days after the laboratory visit the participants received a link to an online questionnaire via email. The questionnaire consisted of background information (education, income, and relationship status and length) and items assessing depressive symptoms (Radloff, 1977), anxiety (Bieling et al., 1998), relationship satisfaction (Funk & Rogge, 2007), and reflective functioning (Fonagy et al., 2016). Pregnancy complications, the infant's health, and maternal postnatal attachment representations (Condon, 2015) were reported by the mothers. Nonmothers were asked about their wishes of having children in the future, experience of taking care of children, and their fertility motivation (i.e., "baby fever," using the Attitudes Toward Babies Scale; Brase & Brase, 2012). The online questionnaire was filled in by all nonmothers and 94% of the mothers.

Measures

Viewing Time

The key-press task for measuring viewing time of emotional infant faces was performed in an internet browser (Firefox) on a desktop computer. The participants were shown pictures of infant faces and asked to either press keys 7 and 8 repeatedly to prolong the viewing time or alternatively shorten the viewing time by pressing keys 1 and 2 repeatedly. The faces of 10 infants with happy expressions and the same 10 infants with crying expressions (obtained from Strathearn et al., 2008, see example stimuli in Figure 1.) were shown in a random order for a total of 20 trials. The face stimuli were edited in WebMorph (https://debruine.github.io/project/webmorph/) by first applying a black background mask surrounding the face contour. Next, to reduce the influence of idiosyncratic features of the individual stimuli (e.g., strong expressive differences between each side of the face), the *mirror* function was applied in WebMorph to increase the symmetry of each face. The faces were then matched for brightness. On the screen, they measured approximately 7.5° and 6.5° of visual angle vertically and horizontally, respectively, when viewed from a 60-cm distance. The viewing time was adjusted by 100-ms intervals for each paired key-press. When no keys were pressed, each face appeared for 4 s on the screen. Before the actual task, the participants practiced pressing the keys for four trials without infant stimuli. During the task, participants were alone in the lab space. Participants were told that the time would pass even if no keys were pressed. The passing of time was illustrated with a bar next to the infant face on the left side of the screen. The total time of the task was approximately 2 min depending on the key presses.

Figure 1
Example of the Emotional Infant Face Stimuli



Note. These images have been created for illustrative purposes and were not used in the actual task. For more reference images, see Strathearn et al. (2008). See the online article for the color version of this figure.

The adjustment of viewing time for each face was measured by the number of key presses during the task. Decreasing the viewing time resulted in a negative value whereas increasing the viewing time received a positive value. If the participant did not press any keys, the viewing time score was 0.

Cortisol

Salivary cortisol was analyzed with chemiluminescence immunoassay (LIA, IBL International, RE62011). Measuring range of the method is 0.43–88 nmol/L. The coefficients of variation percent of intraassay and interassay of the method were 5% and 7%, respectively. The analysis was successful for 98% of the cortisol samples.

Testosterone

Salivary testosterone was analyzed with enzyme immunoassay for the quantitative determination of free testosterone in saliva (EIA, IBL International, RE52631). Measuring range of the method is 10–900 pg/ml. The coefficients of variation percent for intraassay and interassay of the method were 6% and 9%, respectively. The analysis was successful for 99% of the testosterone samples.

Estradiol

Salivary estradiol was analyzed with luminescence immunoassay (IBL International, RE62141). Measuring range is 0.3–64 pg/ml. The coefficient of variation percent was 7.2%–13.3% for intraassay and 7.2%–14.8% for interassay. Analysis was successful for 78% of the saliva samples. Estradiol was the last hormone to be analyzed from the saliva samples and unfortunately, in some cases, (6%) there was not enough saliva for the analysis. The rest of the nonsuccessful estradiol samples were too low in measuring range.

Covariates

Age of the participant, educational years, time of day of the lab visit, relationship duration, menstrual cycle phase, and the use of hormonal birth control were investigated as covariates. The covariates that differed between the two groups were included in the main analysis.

Statistical Analyses

Statistical analyses were performed with R (Version 4.2.2; R Core Team, 2022). Extreme values in both hormonal and viewing time data were winsorized to $M \pm 3$ *SD* so that the original rank order of the values remained the same. In total, 34 individual viewing times (i.e., 1.77% of the trials) were winsorized (16 in the crying face condition and 18 in the happy face condition). Considering the hormonal values, in total six values were winsorized. The hormonal values were square root (estradiol and testosterone), or log (cortisol) transformed to improve distribution normality. Results of the linear mixed models were the same with untransformed hormonal values.

First, the covariates were compared with individual samples Welch's t tests (participant age, income, education years, time of day, relationship duration, and cycle phase) or chi-square tests (oral contraceptive use) between the two groups. The main analysis was conducted with linear mixed modeling using lme4 (Bates et al., 2015) and lmerTest (Kuznetsova et al., 2017) packages. Two separate analyses were performed: one without the hormones as covariates and another with the hormones as covariates. In both models, key presses for viewing time adjustment were the dependent variable. Trial (20 faces), emotion (two-level factor: happy vs. cry), use of hormonal birth control (two-level factor: yes or no), and participant age were added as fixed within-subjects variables. Parity (mothers vs. nonmothers) was added as the grouping factor (between-subjects variable). In the hormonal model, testosterone, estradiol, and cortisol (noncentered) were entered simultaneously to test for independent within-subject effects of these hormones. Finally, the interaction term between emotion and parity was added. The intercept was allowed to vary by participant and random slopes for the repeated factor (trial) were added for each participant. Main effects were interpreted before adding any interactions to the models.

Transparency and Openness

The study hypotheses were preregistered before data analysis but after the data collection (https://osf.io/s3qr5; Sinisalo et al., 2021). The current analysis differs from the original preregistration regarding the hormones: In the preregistration, we planned to have separate correlation analyses for the associations between the hormonal levels and the motivation to view emotional infant faces. However, we decided to include all predictors in the linear model in order to control for the possible effects the hormones might have on each other (Mehta & Josephs, 2010) and also to control for the effect of hormonal contraceptives and age. In addition, originally, we aimed to study oxytocin along with the three other hormones but due to difficulties in analyzing oxytocin from saliva samples resulting in excessive attrition, we decided to exclude it from the analyses. We report how we determined our sample size (see Sinisalo et al., 2022), all data exclusions, all manipulations, and all measures in the study.

An anonymized version of the data and analysis code are available at https://osf.io/s4ezq/. The hormonal data of this study have previously been published as a part of a behavioral and hormonal comparison between the mothers and nonmothers in Sinisalo et al. (2022). In that article, the associations of the hormonal levels were investigated in a different experiment where participants were taking care of an infant simulator, whereas in this study, we combine the hormonal data with a different task from the same lab visit.

Results

Descriptive Statistics

Mothers were significantly older than nonmothers, $t(88.39) = -5.86$, $p < .001$, $d = 1.20$ and their relationships lasted longer, $t(88.22) = -3.20$, $p = .002$, $d = 0.67$. Given a significant correlation between age and relationship duration ($r = .43$, $p < .001$), we only included age as a covariate in the main analysis. There were no differences in the time of day of the lab visit, educational years, or menstrual phase in the two groups.

Nonmothers used hormonal birth control more often than mothers, $\chi^2(2) = 23.25$, $p < .001$, and thus hormonal birth control use was added as covariate to the main analysis. In nonmothers, hormonal birth control users had lower testosterone levels, $t(20.67) = 2.67$, $p = .014$, $d = 0.94$, and lower estradiol levels, $t(28.21) = 2.39$, $p = .024$, $d = 0.81$, than nonusers. Other hormonal levels did not differ in hormonal birth control users and nonusers in either group. Similarly, there were no differences between breastfeeding mothers and nonbreastfeeding mothers in any of the three hormonal levels. The descriptive statistics of the hormonal levels are presented in Table 1. Descriptive statistics of the viewing times are presented in Table 1 and Figure 2.

Effects of Parity, Infant Emotions, and Hormones on Motivation to View Infant Faces

The first linear mixed model analysis, without the hormonal data, showed no main effect of parity, $t(92) = 0.21$, $p = .832$. A main effect of emotion on the viewing times was found: Happy infant faces were generally viewed longer than crying faces, $t(666) = 20.20$, $p < .001$. Finally, there was a marginal interaction between parity and emotion, $t(669) = 1.91$, $p = .056$. This model is presented in Table 2.

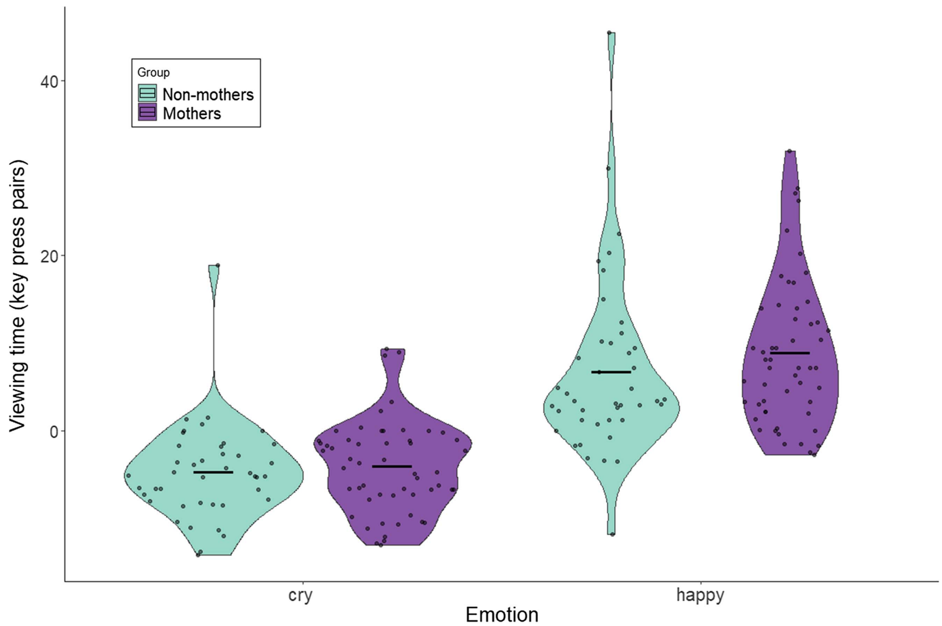
After adding the hormonal levels to the mixed model analysis (Table 3), we found a main effect of emotion, $t(443) = 18.20$, $p < .001$, again meaning that happy infant faces were viewed longer than crying infant faces. In addition, the Emotion × Parity interaction was significant, $t(432) = 2.24$, $p = .025$, illustrated in Figure 3. This interaction was explored by repeating the same analysis separately for crying and happy faces. According to these analyses, nonmothers viewed the happy faces for a shorter amount of time and the crying faces longer than mothers, although the main effects of parity were not significant in these separate models (happy infant faces: $p = .113$; crying infant faces: $p = .266$). From the three

Table 1

Descriptive Statistics of the Viewing Times for Both Emotions and Hormonal Levels (Winsorized Raw Values) by Parity Group

	Nonmother				Mother					
Variable	*n*	*M* (*SD*)	Minimum	Maximum	*n*	*M* (*SD*)	Minimum	Maximum	*t*(*df*)	*p*
Viewing time adjustment										
Happy	42	6.68 (10.01)	−11.80	45.42	54	8.86 (8.36)	−2.70	31.98	−1.14 (79.45)	.259
Crying	42	−4.76 (5.45)	−14.20	31.98	54	−4.07 (5.28)	−13.00	9.40	−0.62 (86.93)	.537
Estradiol (pg/mL)	32	2.55 (1.73)	0.05	6.27	47	2.38 (2.02)	0.09	9.49	0.52 (68.4)	.607
Testosterone (pg/mL)	42	24.06 (15.69)	1.01	76.92	53	23.74 (11.85)	6.61	67.19	−0.32 (74.94)	.751
Cortisol (nmol/L)	33	4.47 (3.40)	1.18	16.72	53	5.33 (5.52)	0.67	27.97	−0.41 (90.02)	.680

Figure 2
Violin Plot of the Mean Viewing Times by Emotion and Parity



Note. See the online article for the color version of this figure.

hormonal covariates, only testosterone had a main effect on the viewing times, $t(72) = -2.90$, $p = .004$. Higher testosterone levels were associated with overall shorter viewing times. This association is illustrated in Figure 4.

Discussion

In this study, we examined whether mothers and nonmothers differ in their motivation to exert effort to view emotional infant faces and whether such motivation is associated with salivary levels of hormones related to parenting behavior and the transition to parenthood (testosterone, estradiol, and cortisol). We measured motivational responses to emotional infant faces with an approach–avoidance key-press task. We expected mothers to exert more effort to view infant faces than nonmothers, but there was no difference between the two groups in overall viewing times. To our knowledge, this is the first study to compare mothers and nonmothers in a motivational task with infant emotions and based on our results it seems that mothers and nonmothers have similar approach and avoidance behavior toward unknown infants. In addition, both groups were more eager to view happy infant faces than crying infant faces. This is in line with our expectations and with earlier studies in which positive infant temperament (Parsons et al., 2014) and cuteness (Hahn, DeBruine, Fisher, & Jones, 2015) have been associated with the reward value of infant faces, and sad infant faces have triggered a tendency for avoidance behavior (De Carli et al., 2017).

Mothers and nonmothers did differ in their motivation to view smiling versus crying infant faces when controlling for hormonal levels. After exploring the two emotion categories separately and taking hormonal levels into account, we found that mothers exerted more effort to view the happy infant faces and to shorten the viewing time of the crying infant faces to a greater extent than nonmothers, although these differences were small. While our results should be replicated in larger samples, they suggest that mothers might be more motivated to avoid crying unknown infant faces. However, an alternative interpretation is that mothers might be more emotionally reactive toward infant emotions in general, in which case negative infant emotions could trigger a greater tendency to intervene, that is, to stop the crying. Using a balance board to record approach–avoidance movements, Hiraoka et al. (2019) found that mothers started making approach-related movements after hearing infant cries and that such movements were related to the perceived urgency of the cry sounds. Relatedly, when viewing emotional infant faces mothers have shown greater activation in mentalizing-related brain areas compared to nonmothers (Zhang et al., 2020). Moreover, studies measuring brain activation to infant stimuli with EEG have found more pronounced attention-related cortical

Table 2
Mixed Model Analysis Without the Hormonal Levels as Covariates

	Model 1: Effects of parity and infant emotion on the motivation to view infant face		
Predictor	Estimate	95% CI	*p*
(Intercept)	−13.27	[−22.83, −3.72]	.006*
Age	0.29	[−0.06, 0.64]	.099
Hormonal birth control	0.26	[−2.12, 2.65]	.830
Parity	0.28	[−2.27, 2.82]	.832
Emotion (happy)	12.45	[11.24, 13.66]	<.001*
Parity × Emotion	2.38	[−0.06, 4.81]	.056

Note. CI = confidence interval.
* $p < .05$.

Table 3
Mixed Model Analysis Including Hormonal Levels as Covariates

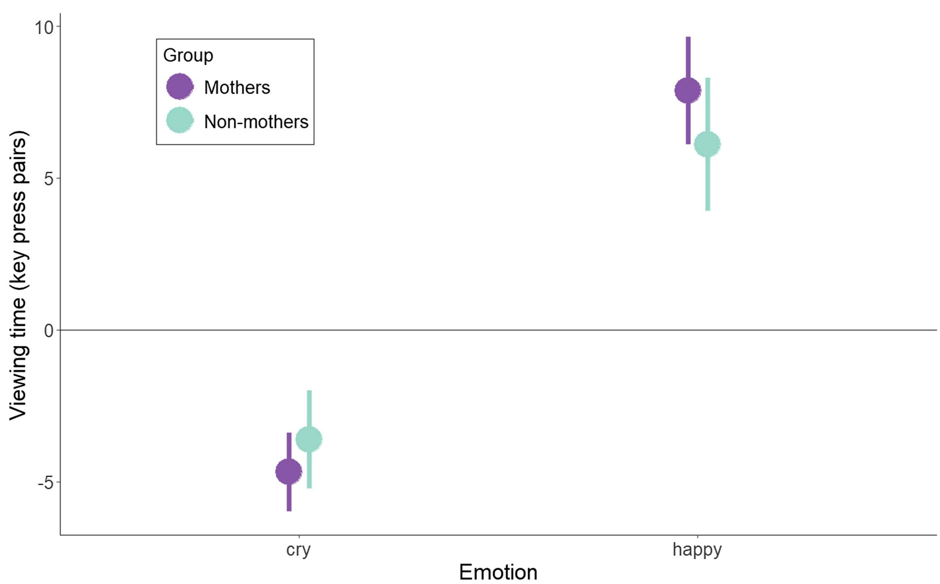
	Model 2: Effects of parity, infant emotion and participant hormonal levels on the motivation to view infant face		
Predictor	Estimate	95% CI	*p*
(Intercept)	−7.37	[−15.98, 3.19]	.157
Estradiol	1.10	[−0.51, 2.71]	.183
Testosterone	−1.00	[−1.67, −0.32]	.005*
Cortisol	−2.08	[−5.04, 0.89]	.170
Age	0.26	[−0.04, 0.57]	.090
Hormonal birth control	−1.08	[−3.27, 1.10]	.334
Parity	−0.49	[−2.68, 1.71]	.665
Emotion (happy)	11.41	[10.18, 12.64]	<.001*
Parity × Emotion	2.85	[0.36, 5.34]	.025*

Note. CI = confidence interval.
* $p < .05$.

responses to distressed infant faces in parents than in nonparents (Peltola et al., 2014; Proverbio et al., 2006). Taken together, these results suggest that mothers may be more tuned to actively put an end to infant distress when exposed to crying infants, and that positive infant emotions might be particularly motivating to mothers. However, we acknowledge that this interpretation is tentative and the factors underlying mothers' seemingly greater tendency to shorten the viewing times of crying infant faces in the current paradigm are not clear. In addition, it must be noted that mean viewing times for crying infant faces were shorter for nonmothers than for mothers when hormonal levels were not controlled, but when taking the hormonal levels into consideration, the viewing time difference between the groups was reversed. Therefore, we hesitate to draw strong conclusions. Replicating the results with measures that provide greater insight into the factors associated with viewing time differences is important. Furthermore, for mothers, the motivational responses to infant faces might be more prominent if they were to view their own infants. For example, Strathearn et al. (2008) found that in mothers, reward-related brain areas were activated more strongly when viewing their own infant's smiling face compared to an unknown infant's smile. Future studies should thus compare motivational responses to own versus unfamiliar infant stimuli.

In our study, we had no specific hypotheses for the effects of hormonal levels on motivation toward infant emotions. Salivary testosterone levels were inversely associated with the motivation to view emotional infant faces across the whole sample. van Anders et al. (2011) argued in their steroid/peptide theory that testosterone has different associations depending on the social context. In our study, smiling and crying infant faces represent two very different social contexts and the function of testosterone in those two contexts might be different. In the context of smiling faces, low testosterone might be related to approach motivation and nurturance (i.e., longer viewing times). This would align with earlier studies investigating associations between testosterone and caregiving behavior, as lower testosterone levels have been associated with faster orientation toward infant faces when competing for attentional resources with adult stimuli (Holtfrerich et al., 2016) and with higher parental sensitivity (Bakermans-Kranenburg et al., 2022; Bos et al., 2018; Meijer et al., 2019; Sinisalo et al., 2022; Weisman et al., 2014). However, in the context of crying infant stimuli, higher testosterone levels being related to shorter viewing times could reflect infant negative emotions triggering protective behavior. Therefore, the efforts made to shorten the viewing time for crying infants could be seen as protection instead of avoidance. In one earlier study, infant cuteness was more rewarding (i.e., looking times were longer) when women's salivary testosterone levels were high (Hahn, DeBruine,

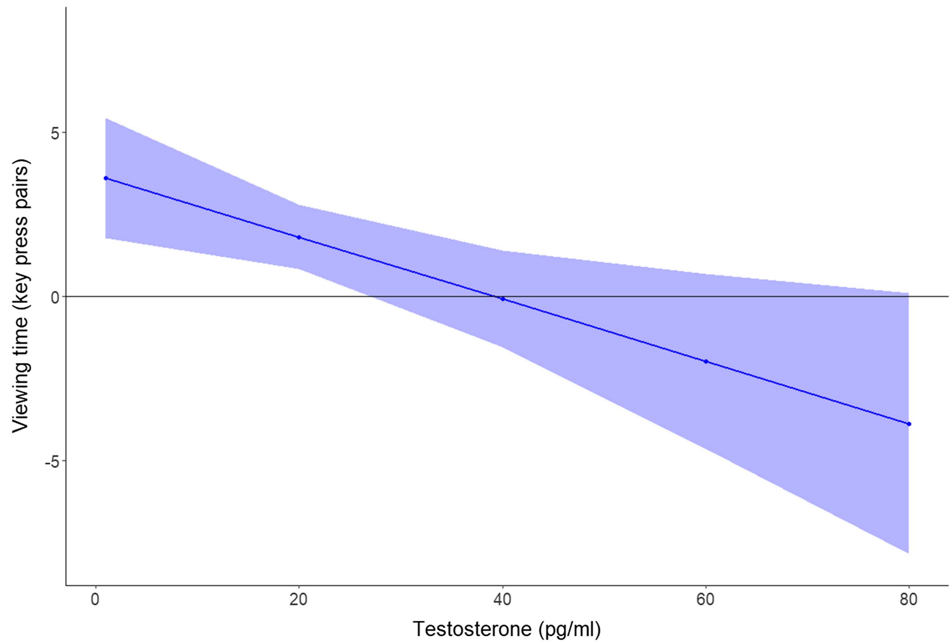
Figure 3
Interaction (p = .025) Between Parity and Infant Emotion on Viewing Times When Controlling for Testosterone, Cortisol, and Estradiol Levels



Note. See the online article for the color version of this figure.

Figure 4

The Association Between Testosterone and Overall Viewing Times for Both Happy and Sad Faces From Model 2, With Winsorized but Untransformed Values



Note. The colored area represents the 95% confidence interval. See the online article for the color version of this figure.

Fisher, & Jones, 2015). Based on the current results and those of Hahn, DeBruine, Fisher, and Jones (2015), the association between testosterone and motivation to view infant faces could be different depending on stimuli and valence (i.e., variation in cuteness vs. emotions). However, it should be noted that Hahn, DeBruine, Fisher, and Jones (2015) had a different study population (only nulliparous women) and study design (participants were tracked several times during their menstrual cycle). It is possible that testosterone is related to motivation toward babies and other people in general, but in a complex manner depending on contextual factors.

Estradiol and cortisol had no significant associations with viewing times in our sample. It is possible that these two hormones are not directly related to motivation toward babies. This would be in line with the earlier reward value paradigm study which also found no association between salivary estradiol levels and motivation to view cuteness-manipulated infant faces (Hahn, DeBruine, Fisher, & Jones, 2015). Recent findings also point to potential validity issues related to salivary estradiol measurements given that salivary estradiol levels only poorly correlated with menstrual cycle phase (Arslan et al., 2023). It is also possible that estradiol's association with social information processing might be dependent on progesterone levels because there is earlier evidence that the estradiol-progesterone ratio is associated with maternal behavior at 1 year postpartum (Glynn et al., 2016), and that changes in the estradiol-progesterone ratio across pregnancy are associated with later feelings of bonding toward one's own infant (Fleming, Ruble, et al., 1997). In future studies, measuring progesterone levels together with estradiol is thus important. It is also important to investigate the hormonal trajectories of the participants, because hormonal levels fluctuate notably during the menstrual cycle (Gandara et al., 2007; van Anders et al., 2014), and tracking them at several time points would give more insight on hormone–behavior associations. In this study, we measured women in the same phase of their cycle. Finally, the associations between cortisol and social motivation might be more apparent during threatening or stressful situations (Joëls, 2018; von Dawans et al., 2021) which may explain why there was no linkage between cortisol and motivation toward emotional infant faces in our study.

This study is the first to compare mothers and nonmothers in a task measuring motivational responses to infant stimuli. Comparing these two groups in a motivation-related behavioral task provides insight into how previously observed differences in brain activation toward infant stimuli between mothers and nonmothers (e.g., Peltola et al., 2014; Plank et al., 2022; Vuoriainen et al., 2022; Zhang et al., 2020) might also be reflected in behavior. In the future, modifying the paradigms measuring motivational responses to address the factors underlying viewing times in more detail (i.e., whether decreases in looking at crying infant faces are due to willingness to act, aversion to infant crying, or other factors) will be important. Measuring psychophysiological responses, for example, frontal EEG asymmetry and arousal-related heart rate variability together with the behavioral outcomes may enhance insight in how the emotional infant stimuli trigger the approach and avoidance motivational systems (Harmon-Jones & Gable, 2018). Furthermore, it must be noted that the participants in our study were all women with relatively high socioeconomic status in terms of household income and years of education (Sinisalo et al., 2022), and thus, it is recommended to replicate this study with more heterogenous populations in the future.

Based on our results, mothers and nonmothers differ in their motivation to exert effort to view emotional infant faces when levels of key hormones are considered. In addition, testosterone seems to be negatively associated with motivation toward emotional infant faces, in line with other evidence pointing to negative associations between testosterone levels and nurturant parenting behaviors and attention to infant stimuli (Deady et al., 2006; Edelstein et al., 2017; Hermans et al., 2006) although such associations could be more pronounced in fathers (Beijers et al., 2022; Bos et al., 2018; Meijer et al., 2019). In the future, studying fathers in a similar setting is essential. Longitudinal designs following the same participants (both gestational and nongestational parents) from pregnancy to postpartum would be informative on how the association between hormones and approach motivation might change during the transition to parenthood. The current literature on social motivation is unclear regarding the impact of hormones on maternal motivation. Our results underline the importance of measuring and controlling the levels of key hormones associated with parenting when studying social motivation and cognitive processes related to caregiving, not only in parents but also in nonparents.

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