Maternal tendencies in women are associated with estrogen levels and facial femininity

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A B S T R A C T

Previous studies have shown that women with higher maternal tendencies are shorter and have lower testosterone levels than those with lower maternal tendencies. Here we report two studies that investigated the relationships between maternal tendencies and two further measures of physical masculinization/feminization; urinary estrogen metabolite (estrone-3-glucuronide: E1-3G) levels (Study 1) and rated facial femininity (Study 2). In Study 1, nulliparous women reported both their ideal number of children and ideal own age at first child and also provided urine samples. There was a significant positive correlation between measured late-follicular estrogen levels and reported ideal number of children. In Study 2, analyses of facial cues in two independent samples of women showed that the average facial characteristics of women who reported desiring many children were rated as more feminine than those desiring fewer children. Collectively, these results support the proposal that maternal tendencies are related to physical feminization and that this effect may, at least in part, reflect the influence of the hormone estrogen.

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Introduction

The aim of the present study was to explore possible relationships between maternal tendencies in women and two measures of physical feminization; estrogen levels and femininity of facial appearance. Previous research has shown links between physical feminization and psychological feminization in women. Cashdan (2000) showed women with lower (more feminine) waist-to-hip ratios (WHR) have more feminine personality traits as measured by the Bem Sex Role Inventory (BSRI, Bem, 1981). Additionally, women with lower levels of testosterone report possessing less ‘masculine’ traits on personality inventories (Al-Ayadhi, 2004; Baucom et al., 1985; Deady et al., 2006; Grant and France, 2001; Udry and Talbert, 1988), occupy more traditionally feminine occupations (Purifoy and Koopmans, 1979) and tend to achieve lower status in the workplace (Al-Ayadhi, 2004).

One key aspect of sex-specific personality traits are maternal or parental tendencies. Sex differences in parental responsiveness emerge early in life, with females typically spending more time involved in nurturing and caregiving activities (see Berman, 1991). These sex differences may partly result from exposure to differing gonadal hormones (Collaer and Hines, 1995). Recent work also suggests within-sex variation of maternal tendencies in women is related to testosterone levels. Deady et al. (2006) found that women with lower salivary testosterone reported having higher maternal tendencies, such as wanting to have more children and wanting to start having children at a younger age, than did women with higher levels of testosterone. Consistent with a link between feminization and maternal tendencies, shorter women have higher maternal tendencies than taller women (Deady and Law Smith, 2006).

In addition to testosterone, estrogen is another key reproductive hormone in adult women. Although estrogen shows fluctuation over the menstrual cycle, estrogen levels across cycles (at comparable points of cycle) show high stability over time (e.g. across 15 mth period, Chatterton et al., 2004) and therefore can be considered a “trait”, as has been shown for testosterone levels (Sellers et al., 2007). Trait estrogen levels have been shown to relate to physical feminization within females. Women with higher trait estrogen levels have more feminine body shapes (larger breasts, lower WHR, Jasieńska et al., 2004) and more feminine looking faces (Law Smith et al., 2006), as measured by salivary estradiol and urinary estrone levels, respectively. Although no research to date has looked at estrogen levels and...
psychological feminization in humans, studies have investigated relationships between putative markers of prenatal hormone levels and psychological feminization. Two studies have measured women’s digit ratio (2D:4D), a proxy of prenatal ratio of testosterone to estrogen (see Manning, 2002), and found that with a feminine (high) 2D:4D ratio (a sign of high prenatal estrogen, relative to testosterone) are less likely to rate themselves as assertive/competitive (Wilson, 1983) and report more feminine personality traits as measured by the BSRI (Csatho et al., 2003).

No studies to date have investigated how individual differences in estrogen levels relate to maternal tendencies in nulliparous women. In pregnant women, one study found that mothers who had an increase in their blood estrogen levels (relative to progesterone) in the latter half of pregnancy, showed higher postpartum attachment to their infant (Fleming et al., 1997). Similarly, in non-human primates, urinary estrogen metabolite levels in late pregnancy are positively correlated with post-partum maternal behavior in some species (e.g. tamarins, Pryce et al., 1988; macaques, Bardi et al., 2001, 2003). Likewise, the same relationship is seen with plasma estradiol levels in sheep (Dwyer et al., 2004). In one experimental study involving non-pregnant females, Maestripieri and Zehr (1998) showed that exogenous administration of estradiol increased the rate of interaction with unrelated infants in ovariectomized female rhesus macaques.

No animal research has yet looked at how individual differences in estrogen levels during normal cycling periods (i.e. non-pregnant) are related to maternal responsiveness in non-human mammals. However, extensive research in sheep has demonstrated high consistency and repeatability in the expression of maternal behavior within and between parities (e.g. Dwyer, 2008a; Dwyer and Lawrence, 2000), suggesting underlying stable individual differences in determinants (e.g. genetic mediated by hormones) of maternal behavior (e.g. see Dwyer, 2008b for review). In addition, between breed differences in maternal behavior can be predicted by breed differences in circulating estradiol levels in late pregnancy (Dwyer et al., 1999, 2004).

A recent study in humans investigated whether endogenous estrogen levels (in cycling, non-pregnant women) were associated with relationship-relevant personality variables; attachment style and implicit intimacy motivation (Edelstein et al., 2010). The authors found that women with the highest salivary estradiol levels had higher levels of intimacy motivation and low levels of attachment avoidance than others (i.e. children) can also be thought of as an inter-personal variable, and therefore may also be expected to be associated with trait estrogen levels.

In light of the previous research findings, Study 1 investigated how individual differences in estrogen levels, as measured by urinary estrogen metabolite (estrone-3-glucuronide; E1-3G), in nulliparous, non-pregnant (menstrual cycling) women relate to their reported maternal tendencies.

Sexual dimorphism (i.e. femininity/masculinity) in female faces is a measure of physical feminization (see review in Rhodes, 2006). Previous studies have shown personality characteristics to be visible in the face (e.g. extraversion and conscientiousness; Little and Perrett, 2007; Penton-Voak et al., 2006). A recent study found women with more feminine faces to have lower dominance scores (Quist et al., 2011). No studies to date have investigated whether facial femininity in women is related to the psychological feminization variable of maternal tendencies. Because facial femininity in women is positively correlated with estrogen levels (Law Smith et al., 2006), Study 2 investigated the relationship between facial femininity in women and their reported maternal tendencies.

In summary, the current studies investigated whether two measures of physical feminization, estrogen levels and facial femininity, relate to a measure of psychological feminization, reported maternal tendencies, in women. Given that previous research has established a link between estrogen and maternal behavior in non-human primates and non-primate mammals, we predict that women with higher estrogen levels will have higher maternal tendencies than women with lower estrogen levels. Also, given that previous work has linked physical feminization and psychological feminization, we predict that women with high maternal tendencies will have more feminine facial appearance, than women with lower maternal tendencies.

**Study 1: estrogen and maternal tendencies**

**Methods**

**Participants**

Participants were 25 white, nulliparous women from the student undergraduate population at the University of St Andrews (age: M=19.4 years, SD=1.1, range=18–21). No participants were currently using hormonal contraceptives or had been in the last 90 days. All received monetary payment for participation.

**Measurement of maternal tendencies**

All participants completed the following two maternal tendencies questions during their first visit to the lab (for urine collection): 1) ‘Ideally, how many children would you like to have?’ 2) ‘Ideally, at what age would you like to have your first child?’ These items for assessing maternal tendencies have previously been used in other research (Deady and Law Smith, 2006; Deady et al., 2006; Moore et al., 2009).

**Measurement of estrogen levels**

Participants collected urine samples (25 ml midstream urine from first urination of morning) once a week for 4–6 weeks, in order to cover all stages of the menstrual cycle. Urine was frozen at –20 °C until time of analysis. The urinary assays involved a direct competitive ELISA 96-well plate system to assess estrone-3-glucuronide (E1-3G) (major metabolite of estradiol). As urinary creatinine concentration is a measure of urinary excretion rate, E1-3G levels are expressed as E1-3G:creatinine ratios.

Urine samples, diluted in assay buffer, were incubated with labeled antigen (E1-3G conjugated to horseradish peroxidase) in the presence of rabbit anti-steroid antibody (anti-E1-3G antibody (RAB 1) [MRC/AFRC Comparative Physiology Research Group, Institute of Zoology, London]). Bound and free antigens were separated using solid-phase goat anti-rabbit immunoglobulin (IgG). The plates were washed and bound antigen was detected by incubation with the substrate o-phenylenediamine and the developed reaction was detected using a plate reader at 492 nm. Intra- and inter-assay variations (CVs) were assessed by multiple analyses of a number of samples. The samples (low, medium, and high concentrations) were aliquoted and stored at –20 °C, a new aliquot being used for each assay. For intra-assay variation, three samples were assayed 10 times within the same assay. This was repeated on four occasions over a period of 2 weeks. For inter-assay variation, three samples were assayed in 42 assays over a period of 8 weeks. The intra-assay CV was less than 10% on each occasion. At the three levels: low, medium, and high, the inter-assay CVs for E1-3G were 11.0, 6.4, and 4.8%, respectively.

Determination of cycle status was according to established methods used in many previous studies (e.g. Gangestad et al., 2004; Jones et al., 2005; Law Smith et al., 2006). Menstrual cycle information was collected via self-report (i.e. diary data). To determine day of menstruation and length of menstrual cycle, participants reported the number of days since the onset of their last period of menstrual bleeding and their average menstrual cycle length. Date of onset of period following study completion was also collected via email.
Cycle day was calculated by the backwards counting method. All 25 women clearly showed the normal variation of estrogen (peaking at ovulation during late-follicular stage) in their cycles. The levels of estrogen in the late-follicular stage of the menstrual cycle (14–21 days before next period) were used for comparison as this is the stage when estrogen is at its peak and thus shows greatest variation (and as such, represents ‘potential’ estrogen levels for each woman). The late-follicular stage of the cycle has been used in previous studies as a point to measure of individual differences in ‘trait’ estrogen levels, to relate to physical or behavioral variables (e.g. Jasieńska et al., 2004; Law Smith et al., 2006).

Results

Because the personality variables were not normally distributed (Shapiro-Wilk; all p < .002), Spearman’s Rank correlations were used to test for any associations between urinary estroline-3-glucuronide (E1-3G) levels and the two maternal tendency variables. There was no correlation between participant age and E1-3G levels (r = .22, p = .291, n = 25), therefore we did not need to control for age in our main analyses.

E1-3G levels were significantly and positively correlated with reported ideal number of children (r = .436, p = .029, n = 25; withstands Bonferroni correction for 2 comparisons with directional hypothesis as p < .05) (see Fig. 1). This represents a large effect size (as r > .37; Cohen, 1988). There was no significant correlation between E1-3G and ideal age at first child (r = .004, p = .99, n = 25).

Study 2: facial femininity and maternal tendencies

Methods

Creation of stimuli

Composites sample 1: 84 white women from the student population at the University of St Andrews (age 18–22; mean = 19.9, SD = 1.3).

Composites sample 2: 44 white women from the student population at the University of Stirling (age 18–23, mean = 19.6, SD = 1.0).

Both samples of women were photographed with a neutral expression, against the same background and under standardized lighting conditions. Images were captured on a digital camera at a resolution of 1200 x 1000 pixels in uncompressed TIFF format using 24 bit RGB encoding.

All women photographed subsequently completed the maternal tendency questionnaire used in Study 1. The maternal tendencies measure ‘ideal number of children’ was used as the measure of maternal tendencies for the following stimuli. Facial composites were constructed using the methods outlined in Benson and Perrett (1993) and Tiddeman et al. (2001), and used extensively in published research (e.g. Jones et al., 2005). Composites were created from the faces of the St Andrews women with the 18 highest and 18 lowest maternal tendencies (highest and lowest quartiles were used for stability) (see Fig. 2 for composite faces). Mean ‘ideal number of children’ for the women in the St Andrews composites were: High maternal = 4.33 children (SD = .69) vs. Low maternal = 1.39 children (SD = .85).

Thirteen faces were used in the high/low composites in the smaller sample from Stirling, as previous research has shown a minimum of 12 faces is required for composites to minimize the individual differences not associated with the variable of interest (see Tiddeman et al., 2001). Mean ‘ideal number of children’ for the women in the Stirling composites were: High maternal = 3.38 children (SD = .51) vs. Low maternal = 1.31 children (SD = .85).

Age of women contained in the high vs. low composites was not significantly different in either sample: (Sample 1: High maternal = 20.2 years (SD = 1.35); Low maternal = 19.5 years (SD = 1.34); t(34) = −1.61, p = .17; Sample 2: High maternal = 19.2 years (SD = 1.30); Low maternal = 19.8 years (SD = 1.14); t(24) = 1.28, p = .21).

Procedure

Masked composite face pairs were rated in forced-choice interface for femininity: “Which face looks more feminine?” on scale of 1–8 from 1 = ‘Left image is much more feminine’ to 8 = ‘Right image is much more feminine’ by 18 students (aged 18–24) from University of St Andrews (9 men, mean age = 21.6, SD = 0.9; 9 women, mean age = 20.8, SD = 1.7).

Results

In one-sample t-tests comparing preference strengths with what would be expected by chance alone, high maternal composites were rated as significantly more feminine than low maternal composites (Composites sample 1: t17 = 5.3, p < .001; Composites sample 2: t17 = 2.2, p = .045). In one-way ANOVAs, there was no effect of viewer sex on preference strength (Composites sample 1: F1,17 = 2.29, p = .15; Composites sample 2: F1,17 = .45, p = .51), indicating that both male and female viewers rated the high maternal composites as more feminine than low maternal composites.

Discussion

The results of Study 1 demonstrate a statistically significant correlation between women’s urinary estrogen metabolite (E1-3G) levels...
and their reported ideal number of children. Women with higher estrogen levels reported wanting to have more children than those with lower estrogen levels. Consistent with Study 1, Study 2 demonstrated that the average facial characteristics of women with high maternal tendencies are perceived as more feminine than those of women with low maternal tendencies. Since facial feminization is also positively correlated with estrogen levels in women (Law Smith et al., 2006), our findings suggest the possibility that variation in estrogen may be a causal factor in both psychological and physical feminization. Facial feminization is likely to have occurred early in development (in utero) and compounded in puberty; facial femininity is relatively stable from 6 months to 21 years (Perrett, 2010). Therefore current estrogen levels may reflect levels during early and pubertal development which possibly had effects on both appearance and psychology. Maternal tendencies have been previously associated with testosterone in women (Deadly et al., 2006), therefore future research should investigate these hormones simultaneously to determine how they interact in their associations with maternal tendencies.

The lack of the predicted association in Study 1, between ‘ideal age at first child’ and estrogen may be due to the characteristics of our sample. Undergraduate students pursuing a degree might be expected to have a later ‘ideal age’ than the general population, and therefore would be less variance on this measure. Supporting this idea, is the minimum ‘ideal age at first child’ in our sample was 26 years (mean = 28.0, SD = 1.59, range = 26–32) whereas in a general population sample (internet survey of 679 women aged 20–29; Deadly and Law Smith, 2006) the variance was much greater, with a minimum of 16 years (mean = 27.6, SD = 3.52, range = 16–40).

Our finding of an association between estrogen levels and the maternal tendencies measure of ‘ideal number of children’ is also of interest to the literature on maternal motivation in non-human animals. Although most animal studies have looked at correlations between estrogen and maternal behavior in pregnant females, some research has suggested a role of endogenous trait estrogens in explaining consistency in individual differences in maternal behavior (see Dwyer, 2008b).

The results of Study 1 also support the findings of Edelstein et al. (2010) who showed that higher trait estrogen levels in women were associated with higher levels of intimacy motivation and lower attachment avoidance. It suggests the possibility that estrogen levels relate not only to specifically maternal tendencies, but may also generalize to other inter-personal tendencies.

A thorough examination of the proximate mechanism by which estrogen may impact on the maternal tendencies is beyond the scope of this research paper. However, animal research has demonstrated that rats that show higher levels of maternal care have higher estrogen-induced oxytocin receptor levels in several brain areas associated with maternal behavior (e.g. Champagne et al., 2001; Francis et al., 2000). The oxytocin receptor has a functional relationship with maternal behavior, as infusion of an oxytocin receptor antagonist abolishes maternal behavior differences (Champagne et al., 2001). It is therefore possible that oxytocin may be a part of the proximate mechanism which underlies the estrogen/maternal tendencies link.

The results of study 2 have important implications for studies of male preferences for female facial femininity. We have shown that, in addition to cues to fertility (Law Smith et al., 2006), femininity in female faces is a cue to the personality or behavioral characteristic of maternal tendencies. Our results may help explain some of the variation in male preferences for female facial femininity shown in recent studies (Burriss et al., 2011; Fraccaro et al., 2010; Jones et al., 2007). In particular, Moore et al. (2011) showed that men who wanted a higher ‘ideal number of children’ expressed stronger preferences from feminized faces. Men who had lower preferences for resource acquisition in a partner also had stronger femininity preferences. Our findings suggest that these effects might be in part due to an increased preference for females who have higher maternal tendencies; in effect an ‘assortative mating’ on the basis of ‘ideal number of children’. Future research should look to test this interpretation directly.

In summary, our study is the first to demonstrate a positive relationship between maternal tendencies and two measures of physical feminization in women; estrogen levels and facial femininity. Our results extend the finding that women with lower maternal tendencies have higher testosterone levels (Deadly et al., 2006) by implicating the role of the reproductive hormone, estrogen. In doing so, our results lend support to the idea that maternal tendencies in humans may have a biological component related to hormone levels. Importantly, our results demonstrate that female facial feminality is a cue to the behavioral characteristic of maternal tendencies (in addition to the previously established link between femininity and fertility). The results therefore may help explain some of the variation in male preferences for female facial feminality shown in recent studies, in particular preference variation related to men’s own reproductive strategy.

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