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Original Article

Predictions for Sex of First Born Child Reflect Masculine and Feminine Characteristics in Male and Female Undergraduates

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Abstract: Previous research has identified physical and behavioral differences between parents who produce sons and those who produce daughters. However, the possibility that men and women have predictions about the sexes of their offspring based on these differences, or any other interoceptive cues, has not been investigated. We compared the dominance, sociosexual orientation, estradiol, testosterone, and 2D:4D ratios of men and women who predicted they would conceive a boy as their first child with those who predicted a girl. Women who predicted they would have a boy were more dominant and less sociosexually restricted than those who predicted they would have a girl. Men who predicted they would have a girl had higher salivary estradiol and higher (more feminine) 2D:4D ratios than those who predicted they would have a boy. Possible implications of these results are discussed in the context of evolutionary theory.

Keywords: 2D:4D, Testosterone, Estradiol, Dominance, Sociosexual Orientation, Sex-of-offspring Prediction, Masculine, Feminine

Introduction

Variation in offspring sex ratio has been the topic of considerable interest for decades, but the mechanisms through which it occurs, if at all, remains unknown in humans. The Trivers-Willard hypothesis (Trivers and Willard, 1973) proposes that parents should vary their offspring sex ratios toward the sex that maximizes reproductive success. Whereas female reproductive success in populations where males compete for access to mates remains relatively stable, male reproductive success depends on ability to access mates. Males in good condition, or those exhibiting traits that facilitate mating, therefore, should produce more offspring than males in poor condition. Through the production of

sons, then, parents in good condition could ensure more grand-offspring than parents in poor condition. Parents in poor condition, in contrast, could maximize the number of their grand-offspring through the production of daughters. Although the Trivers-Willard hypothesis has received considerable support in the animal literature, the data are not always consistent (reviewed in Brown, 2001; Clutton-Brock and Iason, 1986; Hewison and Gaillard, 1999; Hiraiwa-Hasegawa, 1993). This is likely because researchers have investigated maternal characteristics thought to reflect physical condition (e.g., body size, nutrition, parity), whereas the most convincing evidence comes from studies that focused on behavioral traits, namely, dominance prior to conception (Sheldon and West, 2004). For example, in a population of Barbary macaques (*Macaca sylvanus*), Paul and Kuester (1990) found that females with high dominance rank at conception produced more male offspring than females with low dominance rank. In addition, males born to high ranking females produced more offspring than those born to low ranking females (Paul and Kuester, 1990; Paul, Kuester, and Arnemann, 1992). Reliance of the Trivers-Willard hypothesis on physiological condition as a determinant for sex ratio adjustment, therefore, might be too exclusive. The investigation of heritable environmental influences, such as social rank and resource availability, and their possible associated epigenetic mechanisms, in determining individual offspring sex ratios could be more informative in enhancing our understanding of sex ratio adjustment.

In humans, both physiological and psychological characteristics of parents have been associated with offspring sex ratio. Interestingly, studies have shown a tendency for parents of sons to have characteristics associated with male reproductive success, and for parents of daughters to have characteristics associated with female reproductive success. For example, taller and heavier parents have more sons than shorter and lighter parents (Kanazawa, 2005), and more physically attractive parents have more daughters than less attractive parents (Kanazawa, 2007). Lower (e.g., more masculinized) digit ratios, which are thought to reflect greater exposure to androgens prenatally, have also been associated with higher offspring sex ratios (e.g., more sons than daughters). Manning and associates (2002) found that parents with lower ratios of the 2nd to the 4th digit of their hands (2D:4D) had more sons than daughters. Similarly, Ventura, Gomes, Pita, Neto, and Taylor (2013) found that the 2D:4D ratios of mothers of newborn male infants were significantly higher than those of mothers of newborn female infants, and that testosterone in the amniotic fluid was negatively associated with 2D:4D in the female infants. Lower 2D:4D may indicate dominance and masculinity to others (Neave, Laing, Fink, and Manning, 2003) as well as self-reported physical attractiveness (Manning and Quinton, 2007). Behaviorally, high status males (not females, but see Grant and Yang, 2003) such as billionaires (Cameron and Dalerum, 2009) and past presidents (Betzig and Weber, 1995) have more sons than would be expected by chance. Dominant mothers and less sexually restricted parents (e.g., requiring less commitment before engaging in sex, having more sexual partners) also have more sons than daughters (Akande, 1999; Gangestad and Simpson, 1990; Grant, 1990, 1994; Kanazawa and Apari, 2009).

Specific parental physiological and psychological characteristics could have adaptive value for humans. The Maternal Dominance Hypothesis (Grant, 1998) proposes that the conception of one sex or the other is under the control of the mother, where the

likelihood of an ovum being fertilized by a Y-bearing chromosome is facilitated by higher maternal levels of testosterone. Behaviorally, the Maternal Dominance Hypothesis suggests that testosterone levels fluctuate with dominance, thus more dominant women should conceive sons than daughters. In fact, Grant and France (2001) found that women who scored higher in dominance had higher serum testosterone than those who scored lower. Fewer studies have examined the effects of testosterone in women, but several studies have shown that women with a higher waist-to-hip ratio (WHR), which is indicative of higher circulating testosterone levels and lower ratings of female physical attractiveness (reviewed in Singh, 2002), have significantly more sons than daughters (Manning, Anderton, and Washington, 1996; Trivers, Singh, and Thornhill, 1999; Singh and Zambarano, 1997). In men, testosterone influences a variety of characteristics including facial masculinity (Penton-Voak and Chen, 2004) and dominance (reviewed in Mazur and Booth, 1998) making it plausible that it has similar effects in women. Compared to mothers of daughters, therefore, mothers of sons, could exhibit more masculine or less feminine physical and personality traits, which would in turn influence the manifestation of these traits in their sons. Fathers could exhibit similar sex-of-offspring differences. Specifically, characteristics that enhance male mating success, such as dominance and masculinity, might be more extreme in fathers of sons, which would work to increase their reproductive success by increasing their attractiveness to potential mates and increasing their success in competing with other men for access to mates.

Differences in the expression of masculine or feminine mating characteristics in parents raises the interesting possibility that self-perception of these characteristics, or the presence of some interoceptive cue such as steroid hormone concentration, influences individuals' predictions of their offspring sexes. This possibility remains unknown. In the present study, we investigated the relationship between sex-of-offspring prediction and the hormonal and personality characteristics of men and women. Specifically, within sexes, we hypothesized that individuals who predict a boy for their first child would exhibit higher dominance scores, sociosexual orientation scores, and testosterone levels, as well as lower digit ratios, and estradiol than those who predicted they would have a girl. In contrast, individuals who predict a girl would exhibit lower dominance scores, sociosexual orientation scores, and testosterone levels, as well as higher digit ratios and concentration of estradiol than those who predict a boy.

Materials and Methods

Procedure

Fifty-one male (mean age = 20.60 years, $SD = 2.03$) and 56 female (mean age = 20.88 years, $SD = 2.74$) undergraduates, naïve to both the purpose and hypotheses of the study, completed a questionnaire package and provided a saliva sample and a photocopy of their hands in exchange for course credit. All study procedures were subject to review and prior approval by the Simon Fraser University Research Ethics Board. All participants provided written informed consent.

Measures

Dominance. We assessed self-reported dominance using the Simple Adjective Test (SAT) (Grant, 1998), a brief, 64-item checklist containing 13 items measuring dominance (e.g., influential, strong, powerful) and 53 filler items (e.g., hopeful, shy, depressed). Participants checked off the items that applied to them and a score out of 13, one for each checked dominance item, was calculated.

Sociosexual orientation. Sexual restrictiveness, or the degree to which an individual is comfortable engaging in sex without commitment, was assessed using the sociosexual orientation inventory (SOI) (Simpson and Gangestad, 1991). The questionnaire involves a series of questions (e.g., “How many different partners do you foresee yourself having sex with during the next five years?”), and statements (e.g., “Sex without love is OK”) to which the participant must rate their agreement on a 9-point Likert scale. Overall scores were calculated based on participant responses, with higher scores reflecting less restricted orientations and lower scores reflecting more restricted orientations.

Reproductive ambition and preferences. We created a questionnaire based on questions used by Deady, Law-Smith, Sharp, and Al-Dujaili (2006) to assess reproductive ambition and sex-of-offspring prediction and preferences. We asked: “How broody/maternal (or paternal) do you feel compared to others of your age?”, “How important to you is having children?”, “How important to you is having a career?”, “Ideally, how many children would you like to have?”, and “Ideally, at what age would you like to have your first child?”. The first three questions were answered using 7-point Likert scales, and the remaining two were open-ended. We created an overall score indicative of reproductive ambition by adding the responses from the first three questions (the last was reversed scored). Lower scores reflected a lesser tendency/importance for having family than career. The remaining question was analyzed separately. For 3 females and 1 male who did not want children, we replaced their ideal age response with the mean age for their corresponding sex. To assess the sex-of-offspring prediction, we asked, “What sex of child would you predict that you would have first?”. To ensure that predictions were not reflecting simple preferences, we also asked about sex-of-offspring preferences: “If you could only have ONE child, what sex would you prefer to have?” and “Assuming you have more than one child, if you could choose, what would you prefer for the sex of your first-born child?”. Questions were answered in forced choice, male or female.

Salivary hormones. Participants were asked not to eat, drink, smoke, or brush their teeth for one hour prior to the sample collection. We asked about medication use (including hormonal birth control), chronic health or endocrine problems, and menstrual cycle. We collected 3mL of saliva from each participant into untreated polypropylene tubes via passive drool. Each sample was immediately frozen at -20°C for later analysis. Samples were assayed for testosterone and estradiol using enzyme-linked immunoassay techniques at Yerkes National Primate Research Centre at Emory University. The assay range for estradiol was 1-100pg/mL and the inter-assay coefficient of variation was 4.43% at 1.75 pg/mL, 3.67% at 3.95 pg/mL, 0.18% at 14.17 pg/mL, and 8.16% at 30.43 pg/mL. The intra-assay coefficient of variance was 10.5% at 1.84 pg/mL and 12% at 3.78 pg/mL. For testosterone, the assay range was 6.1-600 pg/mL, the inter-assay coefficient of variance was 13.29% at 166.10 pg/mL, and the intra-assay coefficient of variance was 6.7% at

150.49 pg/mL.

Digit ratio. Following removal of rings and jewelry, a thin line was drawn (similar to Bailey and Hurd, 2005) on the proximal creases of the index and ring fingers of participants' left and right hands. A photocopy was taken of both hands together, palms down. The lengths of the 2nd and 4th digits of each hand were measured twice, by two independent raters, from the center of the tip of the finger to the center of the proximal crease, measuring to the nearest 0.05cm using a standard ruler. Due to power outage, scans for 2 males were not collected. One scan was excluded due to poor quality. Inter-rater reliability was $r = 0.99$ for both the right and left hands. An average of the two measurements were taken for each participant and analyzed.

Data Analysis

Preferences and predictions for sex of offspring were compared using Pearson's chi square tests. Within sexes, we compared personality scores, hormone levels, and 2D:4D measurements of individuals who predicted they would have a boy first to those who predicted they would have a girl first using independent samples t-tests. All hypotheses were directional and one-tailed tests were used. Blood contamination or error was suspected for 3 female and 3 male saliva samples. As their values were greater than 3 standard deviations from the mean for their respective sexes, they were excluded from any hormone analyses.

Results

We found an overall preference for a boy compared to a girl as both an only child ($\chi^2 = 4.57, p < 0.05$) and as a first-born child ($\chi^2 = 8.49, p < 0.01$). In contrast, there was no significant overall difference in prediction between boy and girl for men or women ($p = 0.17$), indicating that predictions did not reflect simple preferences for either sex. There were also no significant differences between dominance and sociosexual orientation scores, testosterone and estradiol concentrations, or digit ratios of males and females who preferred a boy compared to a girl for either their only or first born child ($p > 0.05$), indicating that neither personality or hormone profile influenced general sex of offspring preferences.

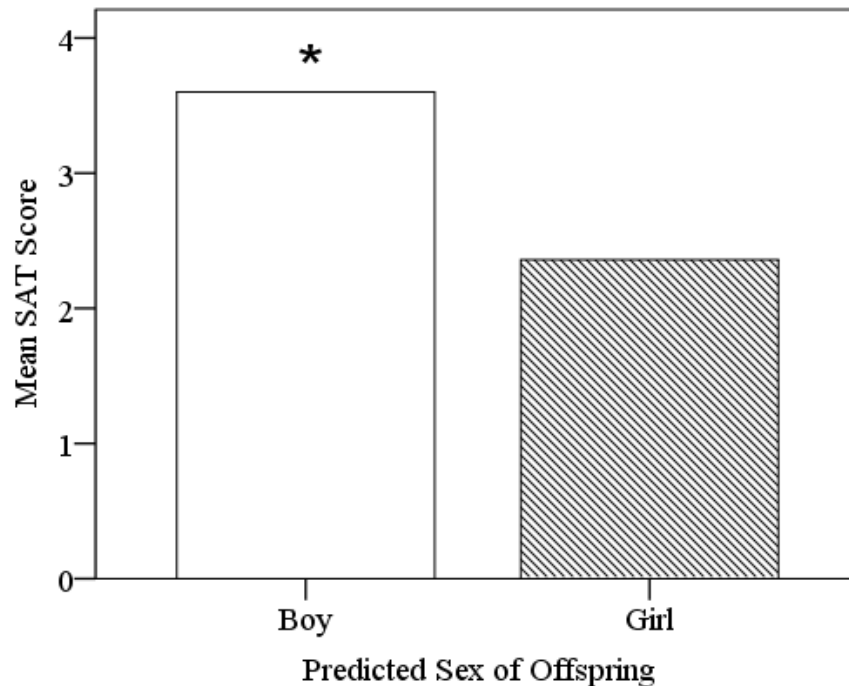
Women

Women who predicted that they would have a boy first (mean \pm SE = 3.60 ± 0.48 , $n = 30$) scored significantly higher than those who predicted a girl first (mean \pm SE = 2.36 ± 0.39 , $n = 25$) on the SAT ($t_{53} = 1.95$, $p < 0.05$, one-tailed) (Figure 1) and this difference approached significance for the SOI (boy: mean \pm SE = 42.97 ± 4.76 , $n = 30$; girl: mean \pm SE = 32.44 ± 4.42 ; $t_{53} = 1.56$, $p = 0.06$, one-tailed). Since hormonal contraceptive use affects both SOI (Oinonen et al., 2008) and dominance (Grant and France, 2001; Stanton and Edelstein, 2009) in females, we explored these differences in users versus non-users. Significantly higher SOI scores were found for users (mean \pm SE = 53.00 ± 6.21 , $n = 16$) compared to non-users (mean \pm SE = 31.85 ± 3.49 , $n = 39$) ($t_{53} = 3.138$, $p < 0.01$). To ensure that predictions were not dependent on contraceptive use, we separately analyzed the SOI scores of users and non-users who predicted sons compared to daughters. No

significant differences were found (Users: $p = 0.31$; Non-users: $p = 0.20$). No significant differences were found between users and non-users for the SAT ($p = 0.74$).

No significant differences were observed between women who predicted they would have a boy first and those who predicted they would have a girl for reproductive ambition ($p = 0.47$), ideal age to have first child ($p = 0.30$), or testosterone ($p = 0.24$), estradiol ($p = 0.14$), or 2D:4D for the right ($p = 0.36$) or left hands ($p = 0.35$).

Figure 1. Dominance scores obtained by women predicting boy compared to girl as first born child

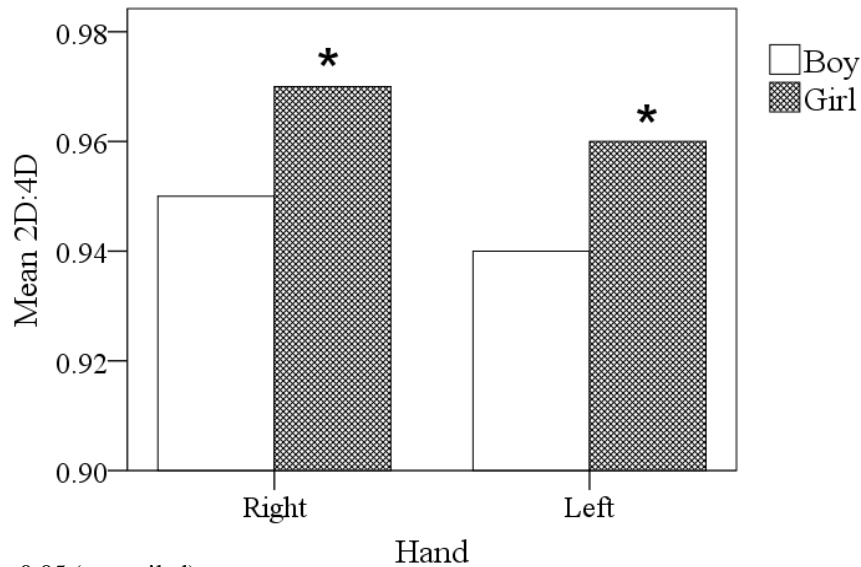


Note: * $p < 0.05$ (one-tailed)

Men

Higher estradiol was found for men who predicted they would have a girl first (mean \pm SE = 4.02 ± 0.18 , $n = 19$) compared to those who predicted they would have a boy (mean \pm SE = 3.60 ± 0.11 , $n = 29$) ($t_{46} = 2.10$, $p < 0.05$, one tailed). Similarly, significantly higher (more feminine) 2D:4D (right hand) ratios were found for men who predicted they would have a girl (mean \pm SE = 0.97 ± 0.01 , $n = 19$) (Figure 2) as their first child compared to those who predicted they would have a boy (mean \pm SE = 0.95 ± 0.01 , $n = 29$) ($t_{46} = 1.77$, $p < 0.05$, one-tailed). The same pattern was observed for the 2D:4D (left hand) (girl: mean \pm SE = 0.96 ± 0.01 , $n = 19$; boy: mean \pm SE = 0.94 ± 0.01 , $n = 29$; $t_{46} = -2.05$, $p < 0.05$, one-tailed) (Figure 2). No differences were observed for testosterone ($p = 0.34$). No differences were observed for the SAT ($p = 0.10$), SOI ($p = 0.21$), reproductive ambition ($p = 0.26$), or age to have first child ($p = 0.82$).

Figure 2. Right and left hand digit ratios for men predicting boy compared to girl as first born child



Note: * $p < 0.05$ (one-tailed)

Discussion

The present study examined the relationship between masculine and feminine psychological and physiological characteristics and an individual's prediction of sex for their first-born offspring. Taken together, our results suggest that whatever the mechanism, individuals are somehow sensitive to their own relative masculinity or femininity, and that this alters the predictions they make about their offspring sexes. We found that women who predicted they would conceive a boy were more dominant and less sexually restricted than women who predicted they would conceive a girl. Although we are unable to confirm the accuracy of these predictions, our results are in line with previous studies showing that more dominant and less sexually restrictive women have more sons than daughters (Akande, 1999; Gangestad and Simpson, 1990; Grant, 1990, 1994; Kanazawa and Apari, 2009). These results also agree with the Trivers-Willard hypothesis, in that mothers who exhibit characteristics associated with high male reproductive success (in this case, dominant and sexually less restrictive) should produce more sons than daughters.

Males who predicted they would have a girl as their first born exhibited higher salivary concentrations of estradiol as well as higher, or more feminine, 2D:4D ratios, suggesting less exposure to androgens prenatally. To our knowledge, no studies have investigated the relationship between offspring sex ratio and parental estradiol; however, 2D:4D and offspring sex ratio were negatively correlated in previous research (Manning et al., 2002). It is unclear what effect, if any, higher estradiol might have upon male reproductive success, but 2D:4D has been negatively associated with facial dominance and masculinity as perceived by others (Neave et al., 2003) as well as physical and behavioral aggression (Bailey and Hurd, 2005; Kuepper and Hennig, 2007) in males, suggesting that individuals with a higher 2D:4D exhibit less male-typical behavior than those with a lower

one. With regard to the Trivers-Willard hypothesis, these results support the idea that fathers who do not exhibit characteristics associated with high male reproductive success (in this case, correlates of high estradiol and 2D:4D ratios) should produce more daughters than sons. In contrast, it could be that fathers of daughters possess characteristics that are more likely to enhance the reproductive success of daughters than sons. Interestingly, women who reported wanting to have more children had higher urinary estrogen levels and more feminine faces than women who reported wanting to have fewer children (Law Smith et al., 2012). Kanazawa (2007) proposed that parental offspring sex ratio should reflect the degree to which parental traits are associated with male or female reproductive success, with parents of sons exhibiting more male-typical traits and parents of daughters exhibiting more female-typical traits. The direct inclusion of femininity measures in future work would enable a test of this hypothesis.

If individuals are able to accurately predict the sex of their offspring prior to ever conceiving a pregnancy, an intriguing possibility that follows is that these predictions affect mating behavior and preferences in line with the Trivers-Willard hypothesis. Specifically, women who anticipate that they will have sons might choose mates with characteristics important for male reproductive success, whereas those who anticipate they will have daughters might choose mates with characteristics important for female reproductive success. One possibility is facial preferences. Facial architecture is thought to reflect hormone levels, with androgens being responsible for bone growth, such as brow ridges and lower jaw development, and estrogens being responsible for the distribution of fats (Johnston Hagel, Franklin, Fink, and Grammer, 2001). In men, high testosterone was associated with a more masculine face, but not necessarily a more attractive one (Penton-Voak and Chen, 2004), highlighting individual differences in women's preferences. No studies have determined whether facial preferences are related to offspring sex ratio, however, our finding that men who predict they will have a girl rather than a boy have higher estradiol and more feminine 2D:4D ratios suggest that they might also have more feminine or less masculine faces. Whereas some studies have identified an overall preference for masculine features (DeBruine et al., 2006; 2010), others have found that women generally preferred faces with feminine features (Perrett et al., 1998; Rhodes, Hickford, and Jeffery, 2000). More attractive women have been found to prefer more masculine faces than less attractive women (Little, Burt, Penton-Voak, and Perrett, 2001; Penton-Voak et al., 2003), and mothers and fathers who were rated as being "very attractive" by an objective third party rater were significantly more likely to have a daughter than a son as their first child (Kanazawa, 2007). The inclusion of measures of the predicted or actual offspring sex ratio of both the individual making choices and the target individual in future studies might help to clarify this issue.

Women who predict they would have a son might prefer more masculine faces. Gangestad and Simpson (1990) proposed that less sexually restricted women would be more receptive to mating with reproductively successful men (e.g., those having many sexual partners), as their genes would be beneficial for enhancing the reproductive success of sons. Interestingly, Waynforth, Delwadia, and Camm (2005) found that women with a less restricted sociosexual orientation preferred more masculine male faces than women with a more restricted one. Similarly, Simpson and Gangestad (1992) found that less

restricted women placed more emphasis on the attractiveness of partners than those who were more restricted. We did not find an association between male offspring prediction and women's salivary testosterone in our study; however, Welling et al. (2007) found that women preferred a masculine male face more often than a feminine one when their salivary testosterone levels were high, which in combination with Grant and France (2001) who found that women with higher dominance also had higher serum levels of testosterone, suggests that mothers of sons prefer more masculine mates. It is unclear why we did not see an association between dominance and salivary testosterone in our study; however, Grant (1998) suggested that state testosterone is the best predictor of offspring sex close to time of conception. Given the exploratory nature of our study, and that our participants were not actively trying to achieve pregnancy, we did not attempt to control for this possibility. Future studies, therefore, should examine the relationship between offspring sex ratio – either predicted or actual – and preferences for facial masculinity in male mates, with specific consideration being given to menstrual cycle phase and time to conception.

It is also important to note the possibility that our findings are actually the result of a general self-perception of an individual's masculinity or femininity relative to their own sex. While we did not directly investigate this, the psychological assessment of one's own expression of masculine or feminine characteristics could be important for mating behavior. Individuals who perceive themselves to be more masculine might believe they *should be* more likely to have a son compared to a daughter whereas those individuals who perceive themselves to be more feminine might believe *they should be* more likely to have a daughter than a son. In turn, they might seek mates that fulfill these perceived roles, namely a more masculine or more feminine mate. This possibility should be tested in future studies.

In sum, we found that the personality and hormone profiles of men and women are related to their prediction for sex of future offspring. Despite our relatively small sample of undergraduate students, these individual differences reflect characteristics that could be important for influencing both the reproductive success and mating behavior and preferences of men and women.

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