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Sex role identity related to the ratio of second to fourth digit length in women

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Abstract

Prenatal gonadal hormones have been implicated as important factors in the development of sex-role identity. The aim of the study reported here was to examine the relationship between adult sex-role preference and the second to fourth digit ratio (2D:4D ratio) in healthy women. There is evidence that the ratio of the length of second and fourth digits associates negatively with prenatal testosterone and positively with prenatal oestrogen. In this study the 2D:4D ratio was measured on a sample of 46 female university students. The subjects completed the form of the Bem Sex Role Inventory (BSRI). It was found that the lower 2D:4D ratios associated significantly with higher, masculinized bias scores in BSRI indicating that 2D:4D ratio predicts the female or male self-reported sex-role identity in females.

Keywords: Second to fourth digit ratio; Sex role; Prenatal steroids

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1. Introduction

The aim of the present study was to investigate the influence of prenatal gonadal hormones on self-reported sex-role identity in women. The hormonal level of the prenatal environment was estimated indirectly using a recently suggested indicator of in utero hormone levels: the second to fourth digit ratio (2D:4D ratio).

Why should in utero levels of sex steroids be reflected in relative finger length? Manning et al. (1998) have pointed out that prenatal exposure to testosterone and estrogen may leave morphological markers (see also Manning, 2002). A fetus is exposed to prenatal testosterone from two sources: the fetal testes and adrenal glands. The main source of prenatal estrogen comes from the adrenal glands and the placenta through the aromatase conversion of testosterone (George et al., 1981). These fetal sources of steroids are highly dependent on the differentiation process of fetal gonads (Lording and De Kretser, 1972). The differentiation of the fetal gonads is controlled by Homeobox or Hox genes (Zákány and Duboule, 1999). In particular, the posterior-most Hoxd and Hoxa genes are strongly expressed in the urinogenital system, including the gonads. However, these genes are also required for the growth and differentiation of digits and toes (Kondo et al., 1997). A common control and similar developmental mechanism of the distal limbs and genital eminence can be illustrated by the progressive removal of the posterior Hox gene function: it results in a concomitant loss of digits and genital bud derivatives (Kondo et al., 1997). The hand–foot-genital syndrome (which typically involves several anomalies of distal limbs and genital buds) is also caused by Hox gene mutation (Manning and Bundred, 2000). Manning et al. (1998) suggested that this sharing of causal factors in digit and gonad differentiation raises the possibility that patterns of digit formation can reflect testis function and, therefore, prenatal sex hormone concentration.

In accordance with the 'Manning hypothesis', the 2D:4D ratio of the human hand is a sexually dimorphic trait. In males the fourth digits tend to be longer than the second (2D:4D ≤ 1) but in females both digits tend to be of equal length (2D:4D ≥ 1) (Manning et al., 2000a). There is evidence that relative digit length is fixed in utero by about the 14th week of pregnancy (Garn et al., 1975). The suggestion that sexual dimorphism in 2D:4D is established early under the influence of testosterone is indicated by the following (a) the waist:hip ratio of mothers (a positive correlate of testosterone) is negatively related to the 2D:4D of their children (Manning et al., 1999). Thus women with a propensity to produce high testosterone concentrations also have a tendency to produce children with low 2D:4D (b) children with congenital adrenal hyperplasia (CAH), a trait which is associated with high concentrations of prenatal androgens, have lower 2D:4D than sex matched controls (Brown et al., 2001) and (c) the 2D:4D ratio of mothers is positively correlated with the 2D:4D of their children, and mothers with low 2D:4D have high testosterone levels in the amniotic fluid of their fetuses (Manning, 2002).

Prenatal testosterone and 2D:4D have been implicated in the development of cognitive abilities. Thus, there is evidence that prenatal testosterone promotes the growth of the right hemisphere increasing the probability of left-handedness, better visual-spatial abilities, music and mathematics (Geshwind and Galaburda, 1987; Kimura and Hampson, 1994; Kimura, 1996; Benbow, 1988; Gotestam, 1990; Grimshaw et al., 1993). Similarly low 2D:4D ratios, indicating a higher testosterone level in utero, are also associated with left-hand preference (Manning et al., 2000b), higher object mental rotation scores (Manning and Taylor, 2001) and male membership of a symphony orchestra (Sluming and Manning, 2000). Furthermore an excess of testosterone has also been implicated in the etiology of developmental disorders including autism. A similar conclusion may be drawn from the finding that 2D:4D ratios of children with autism were significantly lower than population normative values (Manning et al., 2001).

The question of the relation between 2D:4D ratio and sexual behavior has also been investigated recently. Regarding sexual orientation, homosexual men and women have been found to have lower 2D:4D than heterosexuals (Robinson and Manning, 2000; Williams et al., 2000; Brown et al., 2002). This suggests an association between human homosexuality and high prenatal testosterone level (McFadden and Champlin, 2000).

Regarding personality aspects, findings indicate that gonadal steroids are critical in the development of a male and female typical personality (Collaer and Hines, 1995; Ehrhardt et al., 1981). Both male and female typical dimensions of personality can be defined according to scores on self-reported masculine and feminine sex-role identity scales. While males generally exhibit a more assertive and competitive behavior, females possess greater caring attitudes and sociability. These personality characters have been extensively studied in males, especially in their participation in aggressive competition (e.g. Elias, 1981; Gouzalez-Bono et al., 1998). The effects of both pre- and postnatal gonadal steroid concentrations have also been investigated on adult sex-role identities in women. One of the clearest pieces of evidence for the gonadal hormone related basis of sex-roles comes from the study of Baucom et al. (1985). They found a reliable relationship between adult level of testosterone and sex-role identity. In particular, females with high levels of masculinity had somewhat higher testosterone levels than did feminine-sex-typed females. Moreover, their results on the Adjective Checklist indicated that while females with higher level of testosterone perceived themselves as self-directed, action-oriented and resourceful individuals, the women with lower level of testosterone viewed themselves as conventional and socialized individuals. The determining role of prenatal steroids in sex-role identity also appears to be supported by studies utilizing subjects with CAH. CAH women usually showed a masculine bias in indirect aggression and on the scales of different personality inventories (e.g. Detachment and Indirect Aggression Scales, Aggression and Stress Reaction Scales, Reinish's Aggression Inventory; Collaer and Hines, 1995).

The foregoing findings from CAH women strengthen the hypothesized association between prenatal steroids and adult sex-role identity, but they provide less evidence as to hormone dependency of more typical sex-roles shown by normal subjects. The previous studies also indicated that masculinity and femininity might be present in varying degrees in both men and women.

There has been little work on the relationship of 2D:4D to the more typical dimensions of sex-dependent human personality. To our knowledge Wilson (1983) has conducted the only investigation that is of particular interest concerning 2D:4D ratio and masculinity–femininity in women. Testing the subjects, self-reported identity on three adjectives (assertive or competitive, fairly average, and feminine), he found that women with low 2D:4D ratio were more likely to describe themselves as assertive and competitive than women with high 2D:4D. This result supports the association of 2D:4D ratio and sex-role identity. However, because of the small number of gender related items further work is needed to confirm this hypothesis.

In summary, the purpose of the study reported here was to examine the relationship between self-reported sex-role identity and 2D:4D ratio. Few studies on the effects of sex steroids on sex-role identity have focused on female subjects. Therefore, the current investigation was addressed to the hormone–personality relation in females. The sex-role identity was examined on a broad range of masculinity–femininity adjectives provided by the Bem Sex Role Inventory (BSRI). Our prediction was that a low 2D:4D ratio would be related to masculinized self-reported sex role identity.

2. Method

2.1. Participants

Forty-six female participants were recruited from the University of Pécs, Hungary. All subjects were undergraduate or postgraduate students and were paid for their participation. They were aged between 19 and 26 with a mean of 21.24 years. Subjects' height (mean = 166.67 cm) and weight (mean = 60.06 kg) were also recorded.

Volunteers were interviewed to ensure that they had no psychiatric, neurological illness or disordered menstrual rhythm. Their psychiatric symptom status was screened by the Symptom CheckLists (SCL-90-R; Derogatis, 1977). The subjects were within normal range on symptoms factor of SCL-90-R. It is suggested that cerebral lateralization significantly associates with 2D:4D ratio and personal identities (Manning et al., 2000b; Geshwind and Galaburda, 1987). Therefore, we controlled our sample for handedness: all participants were right handed as indicated by the Chapman and Chapman (1987) Handedness Scale.

2.2. Measurement of second to fourth digit ratio (2D:4D)

The length of the second and fourth digits was measured directly on the ventral surface of the right and left hand from the basal crease of the digit to the tip. Where there was a band of creases at the base of the digits, the digit length was measured from the most proximal of these creases (Manning et al., 1998). The digits were measured twice, using a Vernier calliper, measuring to the nearest 0.01 mm. The digit ratio was calculated by dividing the length of the second digit by that of the fourth.

Repeatabilities of similar measurements made directly on digit length have been high in several previous studies (e.g. Manning et al., 2000a; Martin et al., 1999). Individuals who reported injuries to their second and/or fourth digits were not recruited.

We calculated the repeatability of our measurement in the form of intra-class correlation coefficients (r_1). The r_1 values of the 2D:4D ratios were high both for right (2D: $r_1 = 0.99$, 4D: $r_1 = 0.99$, 2D:4D: $r_1 = 0.95$) and left hand (2D: $r_1 = 0.98$, 4D: $r_1 = 0.97$, 2D:4D: $r_1 = 0.81$). In addition there were not significant differences between the first and the second measurement (repeated measures of ANOVA, left hand: 2D: $F(1,45) = 1.11$, $P = 0.3$; 4D: $F(1,45) = 0.5$, $P = 0.48$; 2D:4D: $F(1,45) = 1.27$, $P = 0.34$; right hand: 2D: $F(1,45) = 1.47$, $P = 0.23$; 4D: $F(1,45) = 0.27$, $P = 0.6$, 2D:4D: $F(1,45) = 1.74$, $P = 0.19$). We concluded that our measurements of second and forth digits' length and 2D:4D ratio represented real differences between subjects.

2.3. Measurement of sex-role identity

The subjects completed the BSRI. The BSRI was developed in order to measure masculinity and femininity, respectively (Bem, 1981; Lippa, 1991). There are 60 items in BSRI (20 feminine, 20 masculine and 20 non-gender related items). Using a seven-point Likert scale (ranging from never and almost never true to always or almost always true), respondents indicate how well each characteristic fits their self-perception. Although several scores and classifications can be obtained from the BSRI, only the femininity and masculinity were utilized in this study. Following the suggestion of Bem (1981) the rate of the difference between masculinity and femininity scores was calculated by a t-test. In this way we obtained one masculinity–femininity score for each subject.

In an earlier study, Lippa (1985) reported an internal reliability of 0.75 for the femininity scale and 0.87 for the masculinity scale when using female responses.

3. Results

3.1. The relationship between Bem sex role inventory (BSRI) and second to fourth digit ratio

We obtained the following descriptive statistics for 2D:4D ratio. Right hand: min = 0.92, max = 1.06, mean = 0.99, S.D. = 0.031; Left hand: min = 0.91, max = 1.07, mean = 0.97, S.D. = 0.032. The masculinity–femininity t-value scores ranged between −7.32 (most feminine score in our sample) to 1.39 (most masculine score in our sample) with a mean of −2.35 and S.D. of 2.16. A simple linear regression was performed to analyze the relationship between BSRI and 2D:4D ratio. We obtained the following results.

The associations between BSRI (as dependent variable) and digit traits (as independent variables) are shown in Table 1. The BSRI was negatively related to

Table 1
Results of linear regression analyses of BSRI M–F scores (dependent variable) and second to fourth digit ratio (2D:4D ratio, independent variable)

2D:4D Ratio	Coefficient (*b*)	*F*	*P*
Right hand	−0.29	4.35	0.04
Left hand	−0.26	3.26	0.07
Mean ratio	−0.31	4.82	0.03

$N = 46$.

2D:4D ratio. This relationship was significant with the exception of the ratio for the left hand. The strongest relationship was obtained for the mean 2D:4D ratio.

In addition the sample of BSRI was classified into two classes dividing by the mean t-value score. The subjects with an upper mean value were identified as more masculine sex-role types; the subjects with a lower mean value were identified as more feminine sex-role types. An independent Sample t-test was performed to analyze the relationship between sex-role types and 2D:4D ratio. Lower 2D:4D ratio was associated with the more masculine sex-role type; higher 2D:4D ratio was associated with the more feminine sex-role type. A reliable difference was revealed for the right hand ($t = -2.13$, $P = 0.04$) and mean ratio ($t = -2.26$, $P = 0.03$) but not for the left hand ($t = -1.87$, $P = 0.07$).

An analysis which was preformed to examine whether hand moderates the relationship between 2D:4D and BSRI scores did not give a significant interaction (repeated measures of ANOVA, $F(2,43) = 1.7$, $P > 0.05$). Therefore, the difference in effect size for the right and left hands may be due to sampling variation.

4. Discussion

We have found that a putative indirect measure of prenatal gonadal hormone concentration (2D:4D digit ratio) can be a predictor of self-reported sex role identity in women.

In particular, we found that subjects with lower 2D:4D ratios showed masculinized bias scores in the BSRI adopting more masculine traits on the masculinity scale and less feminine traits on the femininity scale. We interpret this significant relationship in the following way. If 2D:4D digit ratio is an indicator of the intrauterine hormonal milieu relating negatively to prenatal testosterone and positively to prenatal estrogen, then our finding suggests that female subjects who were exposed to higher testosterone and lower estrogen in utero perceive themselves as more masculinized individuals. This interpretation is consistent with findings of some earlier studies that reached similar conclusions. The best evidence for the influence of prenatal steroids on adult personality traits is provided by studies in women with virilization due to CAH. There is evidence that CAH children have lower 2D:4D ratio than sex-matched controls (Brown et al., 2001). Furthermore the group of CAH women usually differs from the group of normal controls on scales of personality inventories. This difference is always in a masculine direction (Collaer and Hines, 1995). For example, in Helleday et al. (1993) study CAH women gave more masculine responses on Detachment and Indirect Aggression scales. In another study, females with CAH showed higher aggression on different personality inventories (Berenbaum and Resnick, 1997). In addition, studies of children born from pregnancies that were treated with a variety of progestogens and/or estrogens also supported the influence of prenatal hormones on personality traits. These children showed a number of hypomasculinization effects on play-behavior (Meyer-Bahlburg et al., 1988). Thus, our results provide further evidence that prenatal steroids can predispose self-reported sex role identity in adulthood. Nevertheless the previous studies utilized CAH women or females from hormonal treated pregnancies as subjects. Therefore, they could not evaluate the influence of prenatal gonadal hormones to the within-sex variations in adult sex role identity. Our results, however, in non-treated, healthy young women lead us to conclude that prenatal steroids can essentially contribute to within-sex variability in human self-reported sex role identity.

Nevertheless it is important to note that the conceptualizations of self-reported sex-roles measuring by BSRI have become a target of expanded discussions in the literature (Lubinski et al., 1983; Klein and Willerman, 1979). Some of the researchers argue that the dimensions of BSRI tap a broad range of personalities, and masculinity may be more accurately clarified in terms of self-ascribed instrumental traits and femininity can be defined in terms of self-ascribed expressive traits (e.g. Lippa, 1991). In the line with this an increasing number of empirical findings indicate intercorrelations of biological gender, self-reported masculinity–femininity, sexual behaviors and other domains of human personality (Lippa, 1991; Whitley, 1983; Feather, 1985; Marsh et al., 1987). More recently Hirschy and Morris (2002) reported reliable associations between self-efficacy, self-esteem and BSRI. Furthermore, researchers in this area often point to a limitation of self-reported sex-role identity: it is difficult to determine how much of a person's self-reported sex-role identity is related to valid self-perception and how much was due to self-report bias (e.g. Hirschy and Morris, 2002).

In the line of the foregoing discussion, the present findings clearly indicate the prenatal hormone related basis of self-reported sex-role identities in women. However, future researches combining self-reported sex-role inventories with questionnaires on self-efficacy and self-esteem may clarify further the complex relationship between fetal steroids and sex-role identity.

Our results did not show a significant relationship between 2D:4D ratio of the left hand and the femininity–masculinity scores. The non-significant interaction between hand (right and left 2D:4D ratio) and BSRI scores, however, indicates that the difference in effect size for the right and left hands may be due to sampling variation. On the other hand, previous studies reported a greater sex difference in 2D:4D ratio on the right hand than on the left hand (Brown et al., 2002; Manning et al., 1998). Therefore, the present results can give a further indication that digit lengths on the right hand could be more sensitive to early androgen exposure than those on the left.

To our knowledge, however, there is not a reliable explanation for the underlying mechanism, which determines a different association of right and left digits with prenatal androgen level.

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