

## Testing the prenatal androgen hypothesis: measuring digit ratios, sexual orientation, and spatial abilities in adults

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### Abstract

The present study examined whether the following variables putatively associated with prenatal androgens are inter-related in women: spatial abilities, sexual orientation, and 2nd to 4th finger (digit) length ratio (2D:4D). Participants were 99 healthy premenopausal women tested in the menstrual phase of the ovarian cycle between 0800 and 0930 hr. Women completed the Kinsey scales of sexual orientation, and were either strictly heterosexual (HS;  $N = 79$ ) or not-strictly heterosexual (NHS;  $N = 20$ ). Photocopies of the two hands were collected, and participants completed the revised Vandenberg Mental Rotations test, the Paper Folding test, and a short version of the Guilford-Zimmerman Spatial Orientation Test. Results showed that NHS women exhibited superior spatial ability relative to HS women. No significant difference was found between the HS and NHS women in the 2D:4D digit ratio. There was no association between the digit ratio and spatial performance. These results support an association between increased spatial abilities and heteroflexible sexual orientation, which may possibly be mediated by high prenatal androgens.

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There are various physiological markers in humans that are sexually dimorphic. One is the ratio of the second digit to fourth digit (2D:4D) on the hand, which is significantly higher in women than in men (Manning et al., 1998, 2000; Peters et al., 2002; Lippa, 2003). Manning et al. (1998) found that the sex difference was visible in two-year olds (the youngest group sampled), and suggested that the ratios were probably established in utero. This sex difference is thought to be due to differences in prenatal androgen exposure, and studies of individuals with congenital adrenal hyperplasia (CAH), a disorder in which the fetus is exposed to excess androgens, have provided some support. For example, two studies have shown that females with CAH exhibit lower digit ratios than female controls (Brown et al.,

2002b; Ökten et al., 2002). One other study, however, failed to find this difference (Buck et al., 2003).

High prenatal androgens have been associated with an increase in ‘heteroflexible’ (i.e. non-strictly heterosexual) or lesbian orientation in women. For example, women with CAH exhibit lower rates of exclusively heterosexual fantasy than unaffected female relatives (Zucker et al., 1996) and higher rates of bisexual or homosexual fantasy or experience (Dittmann et al., 1992; Ehrhardt et al., 1968; Money et al., 1984). Conversely, a heteroflexible or lesbian orientation has been associated with putative markers of high prenatal androgens. Click-evoked otoacoustic emissions are believed to be sensitive to prenatal androgens (McFadden, 1998), and lesbians and bisexual women show a pattern that is intermediate to heterosexual men and women (McFadden and Champlin, 2000; McFadden and Pasanen, 1998).

A lesbian orientation has also been linked with high androgens in women using the 2D:4D marker. Lesbians exhibit smaller digit ratios than heterosexual women

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(McFadden and Shubel, 2002; Rahman and Wilson, 2003b; Williams et al., 2000; *c.f.* Lippa, 2003) and self-identified butch lesbians have smaller ratios than femme lesbians (Brown et al., 2002a). In a study of monozygotic twin pairs, Hall and Love (2003) found that lesbian co-twins had significantly lower ratios than their heterosexual co-twins, suggesting a non-genetic contribution to both sexual orientation and 2D:4D.

Spatial ability is another characteristic that has been associated with prenatal androgens. Men outscore women on tests of mental rotation and spatial perception (Voyer et al., 1995). Part of the sex difference seems to be attributable to circulating steroids at the time of testing (Hampson, 1990a, 1990b; Hausmann et al., 2000), but studies of girls with CAH suggest there is an additional, organizational, component. For example, CAH girls outperformed controls on tests of spatial ability, but not other tests (Hampson et al., 1998; Resnick et al., 1986). Helleday et al. (1994) did not find superior spatial ability in CAH women compared to controls, but the groups were not matched in overall intelligence, rendering a comparison of abilities difficult. Although research on CAH has produced inconsistent findings (Hines et al., 2003), Grimshaw et al. (1995) found that androgen concentrations in amniotic fluid were significantly and positively correlated with subsequent mental rotation ability in girls.

Based on the hypothesized common link of prenatal androgens between 2D:4D, sexual orientation, and spatial abilities, some research has examined inter-correlations among these markers. Two studies found evidence for a link between low digit ratios (*i.e.* male-typical) and superior spatial performance in women (Csathó et al., 2003) and men (Manning and Taylor, 2001). Another study found a significant negative correlation between 2D:4D on the right hand and mental rotations performance in men, but not women (McFadden and Shubel, 2003). Finally, two studies failed to find a significant association between 2D:4D and mental rotations performance in men or women (Austin et al., 2002; Coolican and Peters, 2003).

An association between a lesbian orientation and higher mental rotations ability has been hypothesized but is controversial. In a large sample of lesbians and heterosexual women, a significant difference in favor of lesbians was seen (Rahman and Wilson, 2003a), while two other studies failed to find significant differences though means were in the expected directions (Neave et al., 1999; Wegesin, 1998). Earlier studies found no significant differences between lesbians and heterosexual women, even with large samples (Gladue and Bailey, 1995; Tuttle and Pillard, 1991).

It is unclear why the results are conflicting, but better control of extraneous variables known to affect spatial performance in women (*e.g.* phase of the menstrual cycle; time of day, Moffat and Hampson, 1996), and use of large sample sizes, might reduce error variation and allow underlying relationships to be more clearly evaluated.

Previous literature has found associations between high prenatal androgens and low digit ratios, lesbian or heteroflexible orientation, and increased spatial ability. To the extent that these variables are associated with high prenatal androgen exposure at the same point in gestation, we would expect significant correlations between them to exist. The purpose of the present study was to investigate whether individual differences in spatial ability, lesbian or heteroflexible orientation, and in digit ratios were associated, as would be predicted by the prenatal androgen hypothesis.

## Materials and methods

### Participants

Participants were 99 healthy premenopausal women (mean age = 23.76 yrs; SD = 5.66, range = 18–42 yrs), who were neither pregnant nor breastfeeding, and had not used oral contraceptives for at least 4 months. Participants were classified as strictly heterosexual (HS,  $n = 79$ ) or non-strictly heterosexual (NHS,  $n = 20$ ) (see below for details), but were not recruited based on orientation. There were no significant differences between the HS and NHS women in age ( $M = 23.27$  vs.  $25.89$  yrs), weight ( $M = 63.81$  vs.  $63.68$  kg), height ( $M = 166.29$  vs.  $167.28$  cm), or body mass index ( $M = 23.08$  vs.  $22.87$ ). Participants were recruited through posters and newspaper advertisements at the University of Western Ontario. A reimbursement was provided for participation.

### Procedure

Sessions began at 0800 hr and lasted approximately 1.5 hrs. This controlled for variations in cognitive performance associated with time of day. Women have been shown to perform better on spatial tests in early morning (Moffat and Hampson, 1996). For each woman, testing took place in the first seven days of the menstrual cycle when estrogen levels are lowest. This allowed us to minimize and control effects of estrogen on spatial performance (Hampson, 1990a; 1990b; Hausmann et al., 2000). A specimen of saliva was collected at the beginning and end of the test session to verify that there were no group differences in circulating testosterone that could account for differences in spatial ability.

### Digit ratios

Photocopies of the two hands were made for later calculation of the 2D:4D ratio. Second copies were made if the landmarks used for measuring were lacking in quality. Despite this, digit ratios could not be measured in five women because landmarks could not be clearly identified. The lower landmark was the most basal crease on each finger and the upper landmark was the most distal point on

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