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Sexually dimorphic traits (digit ratio, body height, systemizing–empathizing scores) and gender segregation between occupations: Evidence from the BBC internet study

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ABSTRACT

The proportion of women (PW) across occupations shows considerable variation. Here we hypothesize that occupational segregation could be moderated by the effect of testosterone (T), leading individuals to gender-typical choice of occupation. To test this, we examined the relationship between PW across 22 occupations and three putative correlates of T (the 2nd to 4th digit ratio [2*D*:4*D*], a supposed correlate of prenatal T [PT]; body height, a possible correlate of adult T [AT]; and a systemizing–empathizing score [SQ–EQ], a putative behavioural correlate of PT and AT) in a large internet survey. PW varied from 17% (Engineering/R&D) to 94% (Homemaker) per occupation. Compared to participants in female-typical jobs, participants in male-typical jobs tended to have low right hand 2*D*:4*D* and low right–left hand 2*D*:4*D* [Dr-l] (higher PT, women only), were taller (higher AT, men and women), and had higher SQ–EQ scores (higher PT and AT, men and women). With regard to women, the relationships for Dr-l and SQ–EQ (but not body height) remained significant when Whites only were considered. We conclude that in women Dr-l, and SQ–EQ are related to occupational segregation, suggesting that high PT and AT are found in women who are in male-typical occupations.

1. Introduction

Some occupations have an excess of women and others an excess of men. Thus the proportion of women per occupation (PW) may vary considerably from male-typical occupations such as engineering to female-typical occupations such as homemaker. Gender segregation between occupations may have its roots in social factors that lead to discrimination or absence of female role models, and this may be one influence that leads to variation in PW (Petersen & Morgan, 1995).

In the last two decades there has been movement in the US and UK towards a more even sex ratio (PW = 0.5) in many occupations (Weeden, 1998; Wells, 1999), but in some such as the female-dominated caring professions and in male-dominated engineering there has been little change (Govier, 2003). This situation may in part arise because of the influences that determine women's individual choices. For example many women are obliged to take time out to have children. Consequently they may choose an occupation that has little or no financial penalty for breaks in employment, that is flexible in the provision and accommodation of maternity leave, one in which the work is not so physically demanding as to affect pregnancy, or even one in which injury is unlikely to affect their role of caregiver to children. Such hypotheses have been tested, but with mixed results (DeLeire & Levy, 2004; England, 1982, 1985; Polachek, 1981, 1985).

In this present study we stress a biological explanation by arguing that the occupational sex segregation could arise because men and women differ biologically, even prenatally. Testosterone (T) is a sex steroid hormone and males produce twice as much as females, even in the womb. Prenatal T (PT) has been shown in animal research to cause organisational changes in the brain while adult T (AT) may have activational effects, such that high PT is associated with higher systemising (Auyeung et al., 2006) and lower empathizing ability (Baron-Cohen, Lutchmaya, & Knickmeyer, 2004; Chapman et al., 2006). Both PT and AT influence an individual's 'brainsex' and the resulting variation in brain masculinization/feminization could, at least in part, explain gender segregation across occupations (Baron-Cohen, 2003; Govier, 2003). Here we test this model by relating PW per occupation to (i) the ratio of the length of the 2nd and 4th digits (2*D*:4*D*), a putative correlate of PT, (ii) height, a possible correlate of AT, and (iii) a measure of the relative strength of systemizing and empathizing (systemizing–empathizing scores), a putative correlate of PT and AT.

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Digit ratio shows sex differences such that males have, on average, lower 2D:4D ratios than females. This sexual dimorphism is highly conserved and is found not only in humans but throughout the primates (Manning, 2002, 2008; Manning, Scutt, Wilson, & Lewis-Jones, 1998; Nelson & Shultz, 2010). In humans it has been suggested that 2D:4D, and particularly right hand 2D:4D and the difference of right minus left hand 2D:4D (Dr-l), are negatively related to PT (Manning, 2002; Manning et al., 1998). Across populations both 2D:4D and Dr-l are sexually dimorphic (Manning, Churchill, & Peters, 2007; Manning, Stewart, Bundred, & Trivers, 2004). The sex difference is seen in young children (Manning et al., 2004), arises in utero as early as nine weeks (Galis, Ten Broek, Van Dongen, & Wijnaendts, 2010; Malas, Dogan, Evcil, & Desdicioglu, 2006), and the strength of the sexual dimorphism in infants is strongly related to the sex difference in adults (McIntyre, Ellison, Lieberman, Demerath, and Towne, 2005; Trivers, Manning, & Jacobson, 2006). Children with congenital adrenal hyperplasia, a condition in which high PT is produced, have lower 2D:4D than typical controls (Brown, Hines, Fane, & Breedlove, 2002; Ciumas, Linden Hirschberg, & Savic, 2009; Okten, Kalyoncu, & Yaris, 2002; but see Buck, Williams, Hughes, & Acerini, 2003). Right hand 2D:4D and Dr-l are positively correlated with complete or partial T insensitivity as determined from the structure of the androgen receptor gene (Berenbaum, Bryk, Nowak, Quigley, & Moffat, 2009; Manning, Bundred, Newton, & Flanagan, 2003) and right hand 2D:4D was found to be negatively correlated with foetal testosterone:oestrogen ratios obtained from amniocentesis (Lutchmaya, Baron-Cohen, Raggatt, Knickmeyer, & Manning, 2004).

With regard to AT, body height is strongly sexually dimorphic across all human groups such that males are on average taller than females (Gray & Wolfe, 1980). The sexual dimorphism in height is not strongly developed until puberty and is largely dependent on growth of the long bones (Antoszewska & Wolański, 1992). It is known that androgen receptors are present in osteoblasts and androgen is metabolised in bone (Lorentzon, Swanson, Andersson, Mellström, & Ohlsson, 2005). Furthermore, observations in androgen-resistant animals show the sex differences in bone are dependent on functional androgen receptors (Vanderschueren & Bouillon, 1995).

Finally, men, on average, score higher than women in understanding and building systems, while women are better able to identify other people's emotions than are men. Thus men score higher on the Systemizing Quotient (SQ) and women score higher on the Empathizing Quotient (EQ) (Baron-Cohen, Richler, Bisarya, Gurunathan, & Wheelwright, 2003) and the same pattern of sex differences is seen on the child versions of these psychological measures (Auyeung et al., 2009). There is evidence that PT (as measured from amniotic fluid) is positively related to systemizing (Auyeung et al., 2006) and negatively related to empathizing (Chapman et al., 2006; Knickmeyer, Baron-Cohen, Raggatt, Taylor, & Hackett, 2006).

Based on the reported associations of PT, 2D:4D and SQ–EQ and AT and body height, we examined the relationship between these sexually dimorphic traits and PW across a number of occupations in participants in a large internet sample. Our prediction was that measures of PT and AT would be negatively correlated with PW. With regard to our correlates of T this would mean that right hand 2D:4D (but not left hand 2D:4D) and Dr-l would be positively correlated with PW, while body height and SQ–EQ would be negatively related to PW.

2. Methods

Participants were drawn from a large Internet survey (the BBC Internet study) of cognitive and behavioural sex differences, hosted by the BBC Science and Nature Website. Details of the study and patterns of 2D:4D within the study are given in Reimers (2007) and Manning et al. (2007), respectively. Data were collected between January and May 2005. Briefly, the study took 30–40 min to complete, and comprised questions about demographics, personality, sexuality and sexual behaviour, social attitudes and behaviours, along with cognitive tests and physical characteristics such as the 2D:4D ratio. There were six blocks, taking between 3 and 6 min each to complete. Participants completed the blocks in sequence and were able to stop and return to the study at any point later.

The first questions in the study were gender (male/female) and age (0–99) for which a value had to be entered in order to continue. Responses to all other questions were optional. Occupation and ethnicity appeared on the first page with gender and age, both with dropdown menus, from which participants could choose one of 25 categories for occupation and one of seven categories for ethnicity (Asian/Asian British, Black/Black British, Black other, Chinese, Middle/Near Eastern, Mixed ethnic, White).

In the second part participants provided self-measured finger lengths following the methodology of Manning et al. (1998); see also Caswell and Manning (2009). After viewing a diagram of the hand, they were given instructions as to how to measure their index finger and ring finger on the palm-side of the right and left hand. The participants were asked to measure finger lengths with a ruler and to report lengths to the nearest millimetre using dropdown menus, with values between 10 and 100 mm in 1 mm increments (Reimers, 2007). Participants were also asked to report their body height.

In the third part there were 10 questions selected from the full EQ and ten from the full SQ (Baron-Cohen et al., 2003). The selected questions had the highest sex difference in the control data reported in Wheelwright et al. (2006). The scoring options were from left to right: definitely agree (DA), slightly agree (SA), slightly disagree (SD), and definitely disagree (DD). This was scored positively or negatively (positively: DA and SA = 0, SD = 1, DD = 2). An SQ and EQ score was calculated by summing across the 10 questions. Full details of the items and the scoring were given in Manning, Baron-Cohen, Wheelwright, and Fink (2010).

Web studies often attract a large sample. However, there are disadvantages. Participants in Web studies usually have higher levels of education than non-participants and this was the case for the Study with high proportions of participants reporting they had post-graduate degrees (13.5%) or had attended a University (35.5%) (Reimers, 2007). Inaccurate self-measurement may also be of concern. However in the case of the Study, tests of consistency of 2D:4D with that of experimenter-measured studies gave similar results (e.g., in the sex-dependent and ethnicity-dependent patterns of 2D:4D; Manning et al., 2007).

3. Results

There were 255,116 participants who completed the entire study of whom 47.3% were female. White participants made up the greatest proportion (84.%), followed by Asian (6.3%), mixed ethnicity (3.9%), Chinese (2.2%), Middle/Near Eastern (1.2%), Black/Black British (0.8%), Black (0.8%). The analysis was restricted to respondents who were 18 years and older. Inspection of the 2D:4D data showed extreme values varying from 0 to 10. We excluded such outliers by considering a range from 0.80 to 1.20, as recommended from a comparison of self- and experimenter-measured 2D:4D (Caswell & Manning, 2009). There were a total of 199,021 participants (89,506 women) available with occupational choices. The occupations are arranged in ascending order of PW in Table 1. PW varied from 17% for male-dominated Engineering/