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Prenatal testosterone and personality: Increasing the specificity of trait assessment to detect consistent associations with digit ratio (2D:4D)

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ABSTRACT

Prenatal testosterone exposure has been suggested to influence various personality traits including assertiveness/social dominance, aggressiveness, and impulsive sensation seeking (ImpSS). However, correlational work using 2D:4D digit ratio as an indicator for prenatal testosterone only converged on extremely small effects. Here we show that measuring traits with a high degree of specificity by combining extensive personality assessment, factor analysis with oblique rotation and subsequent partialling reveals an association between ImpSS and low 2D:4D (i.e. presumably high prenatal testosterone) in young healthy males. These findings suggest that prenatal testosterone exposure predicts ImpSS in men, that 2D:4D-personality associations are more specific than generally appreciated and that such associations can be more reliably detected using the approach to trait assessment described here.

1. Introduction

Animal studies have demonstrated that prenatal exposure to the sex steroid testosterone strongly influences both sex-related behavior and brain development. In addition, recent evidence suggests that similar influences are also in effect in humans (Hines, 2011). Interestingly, animal research further suggests that the effects of prenatal testosterone are graded and linear – higher levels of exposure lead to more male-typical behavior and brain structure. This suggests that early testosterone levels contribute to individual differences both between and within sexes and that characteristics influenced by prenatal testosterone likely also show sex differences (Hines, 2011). Since small to moderate sex differences exist for almost all facets of personality with similar patterns emerging for self- and observer-ratings (McCrae & Terracciano, 2005), one obvious research question is whether individual differences in prenatal testosterone are associated with human personality.

Because prenatal testosterone levels can be directly measured only in animal studies, researchers depend on indirect markers to investigate this hypothesis in humans. Second-to-fourth digit ratio (2D:4D or the ratio of the lengths of the index finger, 2D, and the ring finger, 4D) is one putative marker of prenatal testosterone that received considerable research attention in the past decade. It has been known for over a century that men tend to have lower 2D:4D than women (Voracek & Loibl, 2009). This sex difference in hand anatomy is established prenatally by the end of the first trimester (Galis, Ten Broek, Van Dongen, & Wijnaendts, 2010) and is already fairly stable in childhood (Trivers, Manning, & Jacobson, 2006). In addition, 2D:4D has been associated with the testosterone to estradiol ratio in amniotic fluid in 2-year olds (Lutchmaya, Baron-Cohen, Raggatt, Knickmeyer, & Manning, 2004), the differentiation of the gonads and the formation of the digits are controlled by the same genes (Kondo, Zakany, Innis, & Duboule, 1997), genetic females exposed to high levels of testosterone in utero due to Congenital Adrenal Hyperplasia (CAH) have lower 2D:4D (Ökten, Kalyoncu, & Yaris, 2002), and genetic males with complete androgen insensitivity develop feminized 2D:4D (Berenbaum, Bryk, Nowak, Quigley, & Moffat, 2009). Furthermore, Zheng and Cohn (2011) recently presented experimental data showing that manipulations of the balance of androgen to estrogen signaling in a narrow window of prenatal digit development causes changes in 2D:4D in mice. Taken together the available data strongly support the utility of digit ratio as a lifelong signature of prenatal testosterone (and estradiol) exposure. Note that although prenatal testosterone as indexed by 2D:4D is not related to circulating adult testosterone levels (Hönekopp, Bartholdt, Beier, & Liebert, 2007), it may nonetheless modulate the sensitivity to testosterone in later life (van Honk et al., 2011).

Much of the research examining the link between personality and both 2D:4D and testosterone broadly maps onto the three

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components of Wilson and Daly's (1985) "young male syndrome": competitiveness, violence, and risk taking, or – phrased in more common trait labels of personality psychology–assertiveness/social dominance, aggression, and impulsive sensation seeking (for examples of 2D:4D studies including traits from other domains, see Evardone & Alexander, 2009; Fink, Manning, & Neave, 2004; Lippa, 2006).

Not only do men tend to score higher in *assertiveness/social dominance* than women (e.g. McCrae & Terracciano, 2005), a number of studies also suggest a link between basal testosterone levels and measures of assertiveness/social dominance (see review by Eisenegger, Haushofer, and Fehr (2011); but see Neave, Laing, Fink, & Manning, 2003) with particularly consistent associations emerging for implicit power motivation (i.e., indirect measure of an individual's dominance disposition, see Stanton & Schultheiss, 2009). Furthermore, Neave et al. (2003) found that males with low 2D:4D were judged as more dominant by females based on facial images and Nelson, Hoffman, Gerald, and Shultz (2010) recently found that in female rhesus macaques low 2D:4D significantly predicted high dominance rank. Conversely, Voracek (2009) did not find a significant association between self-reported assertiveness and 2D:4D mirroring the findings of two previous studies (Hampson, Ellis, & Tenk, 2008; Moore, Quinter, & Freeman, 2005) and only an extremely small negative association of around $r = -.02$ was observed in another study (Manning & Fink, 2008).

On average men also score higher in *aggression* than women (Campbell, 2006) and testosterone has been associated with aggression in animals and humans (Archer, 2006; Book, Starzyk, & Quinsey, 2001). However, a recent meta-analysis by Hönekopp and Watson (2011) only revealed a very small negative association between aggression and 2D:4D ($r \approx -.06$) specifically for males that was further reduced when accounting for the publication bias observed for right hand measurements.

Finally, on average, men score higher in measures of *impulsive sensation seeking* than women (e.g. Zuckerman, Kuhlman, Joireman, Teta, & Kraft, 1993), although it should be noted that this sex difference is pronounced only for the thrill and adventure seeking (TAS) and disinhibition (DIS) subscales of Zuckerman's Sensation Seeking Questionnaire but less so for the experience seeking (ES) and boredom susceptibility (BS) subscales (e.g. Hampson et al., 2008; Zuckerman, Eysenck, & Eysenck, 1978). Whereas females from opposite sex versus same sex twin pairs score higher in TAS and ES suggesting an influence of the higher levels of prenatal testosterone produced by the male co-twin (given that the effects could not be explained by the psychosocial effects of having a close-in-age brother, Slutske, Bascom, Meier, Medland, & Martin, 2011), a recent meta-analysis by Voracek, Tran, and Dressler (2010) did not find any evidence for an association between sensation seeking and low (i.e. male-typical) 2D:4D (in fact, a small but statistically significant association in the opposite direction was observed for the ES subscale, see also Campbell et al., 2010).

Taken together it currently seems that the associations between 2D:4D and each of the three most frequently investigated traits of the "young male syndrome" (i.e., the moderately correlated broad trait domains of assertiveness, aggression, and impulsive sensation seeking in which men typically score higher than women) are negligible. However, the possibility remains that the effects of prenatal testosterone as indexed by 2D:4D are more specific than typically assumed, encompassing not the complete spectrum of the "young male syndrome" but instead a more specific aspect of personality. If true, this would suggest that consistent associations with 2D:4D can only be demonstrated with more specific assessments of potentially relevant personality traits.

As recently argued by Wacker, Mueller, Hennig, and Stemmler (2012), simply using more appropriate personality scales may not achieve an optimal level of specificity due to contaminating influences of variance specific to individual tests and of variance associated with correlated traits. Wacker et al. (2012) therefore suggested (1) using factor analysis of a larger number of tests to derive factors for the dimension of interest as well as for correlated trait dimensions and (2) eliminating variance from correlated dimensions through partialling.

For example, impulsive sensation seeking typically correlates with aggression and extraversion (e.g. Aluja, Garcia, & Garcia, 2002). If 2D:4D is specifically associated with impulsive sensation seeking but neither with aggression nor with extraversion, the association will become stronger, when partialling these other unrelated traits. Only when 2D:4D largely taps into the shared variance between the various facets of the "young male syndrome" will partialling correlated traits reduce the chance of finding a significant association. However, in that case 2D:4D should show associations with all facets, which, as described above, does not seem to be the case. Consequently, removing the variance associated with other trait factors thereby singling out the specific contribution of each individual facet of the "young male syndrome" as well as of other dimensions of personality may be a promising strategy for detecting associations with 2D:4D. In the present study, we aim to probe for the first time, whether the utility of this partialling strategy previously applied to the domain of molecular genetic associations in the same sample (Wacker et al., 2012) extends to the 2D:4D measure.

2. Materials and methods

2.1. Participants

Of the 203 young male volunteers participating in the study $N = 201$ had no missing values in any of the variables of interest here and thus constituted the analysis sample. The participants' average age was $M = 23.8$ years (range 20–35, $SD = 3.0$) and 97% were university students. All participants were right-handed and had no history of mental disorders as assessed with a standardized DSM-IV-based clinical interview. In addition, they described themselves as non-smokers and reported not to have used either prescription drugs or illegal drugs during the past 3 months. The present study was part of a larger study involving various physiological and molecular genetic assessments as well as psychopharmacological challenges (for details and further results obtained in this study see Mueller, Makeig, Stemmler, Hennig, & Wacker, 2011; Wacker et al., 2012). We only investigated male participants, because in females, the possibility of an undetected pregnancy constitutes an additional risk in pharmacological studies and because the menstrual cycle is known to introduce error variance into physiological recordings. All volunteers gave written informed consent before participating and received a monetary compensation of 70 EUR (100 USD) for approximately 7 h involvement in the project. The study protocol was approved by the Ethics Committee of the German Society for Psychology (Deutsche Gesellschaft fuer Psychologie).

2.2. Digit ratio assessment

Digit ratio assessment followed recommendations by Kemper and Schwerdtfeger (2009). The palmar surface of participants' left hand was scanned with an EPSON GT-20000 scanner with a resolution of 300 dpi. We measured digit ratio for the left hand only, because some of the early work seemed to suggest slightly weaker personality associations for the right hand (e.g. Austin, Manning, McInroy, & Mathews, 2002; Neave et al., 2003). Note, however, that more recent studies did not confirm this trend and meta-analysis revealed that the sexual dimorphism of digit ratio is even slightly