Personality and Individual Differences 51 (2011) 367–370

Contents lists available at ScienceDirect

Personality and Individual Differences

journal homepage: www.elsevier.com/locate/paid

Special issue preamble: Digit ratio (2D:4D) and individual differences research

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ARTICLE INFO

Article history:
Available online 23 May 2011

Keywords:
Digit ratio (2D:4D)
Finger length
Journal special issue
Prenatal testosterone
Brain organization
Masculinization
Sex differences
Individual differences

ABSTRACT

The sexually differentiated second-to-fourth digit ratio (2D:4D) is currently frequently utilized in individual differences research as a putative indicator of the masculinizing brain organization effects of prenatal testosterone. This preamble introduces the journal special issue on this theme, entitled "Digit ratio (2D:4D) and individual differences research". Notes regarding the background, history, and recent progress of 2D:4D research are provided, and the background of the special issue and the contents of its 11 research articles are briefly summarized.

Exposure to prenatal androgens (foremost, testosterone) is essential for sexual differentiation. It also has profound, permanently masculinizing effects on human neural circuitry and peripheral tissues, which in turn partly account for a multitude of behavioral, cognitive, and health-related human sex differences seen in later postnatal life (Cohen-Bendahan, van de Beek, & Berenbaum, 2005; Hines, 2009). Fetal sex-hormonal programming is thus an important biological basis and source of sex and individual differences in many human psychological traits, but markedly difficult to study. It is not feasible to directly measure prenatal testosterone in human fetuses, and ethical boundaries clearly forbid any experimentation.

Behavioral endocrinological studies of this kind (i.e., brain organization research) therefore have to rely on a variety of indirect methods (e.g., hormonal studies of umbilical cord blood, mother's blood during pregnancy, and amniotic blood studies) and on certain experiments of nature (i.e., studying effects of early-onset endocrine or sexual differentiation disorders in clinical populations). Animal models and animal experimentation are also increasingly utilized, but may not accurately reflect the conditions relevant for humans. For research progress, it is therefore important to discover straightforward, non-invasive somatic markers of prenatal testosterone, in other words, retrospective windows into the prenatal sex-hormonal milieu (Hines, 2009).

Presumed markers for prenatal sex-hormone action currently under investigation include otoacoustic emissions (fine sounds generated spontaneously from within the inner ear), co-twin sex (i.e., type of dizygotic twinning in humans, which is conceived as analogous to intrauterine position effects seen in rodents), middle-phalangeal hair, onset of puberty, asymmetry in bodily sexual characteristics, dermatoglyphic traits (finger-ridge counts), and anogenital distance (Cohen-Bendahan et al., 2005; Dressler & Voracek, 2011).

One further putative and currently intensely studied prenatal testosterone marker is the second-to-fourth digit ratio (2D:4D), i.e., the ratio of the lengths of the index finger (2D) and the ring finger (4D). 2D:4D is sexually differentiated, such that men tend to have lower 2D:4D than women, owing to men's, as compared to women's, 2D being more frequently shorter than their 4D. This subtle difference in human hand anatomy has been known since the late 19th century (for reviews of the classic literature, see Peters, Mackenzie, & Bryden, 2002; Voracek, Dressler, & Loibl, 2008).

However, it was only in 1998 that this sex effect in human 2D:4D was in a sustained manner popularized by posing a hypothesis about the likely origin of these sex and individual differences: since these already emerge in utero (at the end of the first trimester) and seem fairly stable postnatally, it was suggested that 2D:4D may be a suitable pointer to prenatal testosterone (Manning, Scutt, Wilson, & Lewis-Jones, 1998).

Manning's hypothesis has received great resonance by researchers within and outside psychology. Accordingly, over the past decade, 2D:4D research has developed into a substantial research program, which in early 2009 numbered about 300 published reports (Voracek & Loibl, 2009) and, as of this writing (early 2011), now totals more than 450 reports. Presently, 2D:4D research is published at a rate of about 1–2 journal papers per week.

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doi:10.1016/j.paid.2011.04.018

Ever since the first 2D:4D study appeared on the pages of *Personality and Individual Differences* (Austin, Manning, McInroy, & Mathews, 2002), the journal has taken and maintained a forefront position in 2D:4D research. Interestingly, one forerunner study of modern 2D:4D research had already been published in the journal's first decade (Wilson, 1983; see also Wilson, 1989, pp. 29–31, 36, 80, 109, 116–117, 120; and, for personal recollections related to this early account, Wilson, 2010). With respect to the number of 2D:4D research papers published, the journal now clearly ranks first. This special issue on 2D:4D and individual differences research celebrates these developments. Its background and contents are as follows.

On three occasions, I had the opportunity to organize and invite for internationally staffed symposia on 2D:4D research (with contributing researchers coming from six countries: Austria, Czech Republic, Germany, Italy, Switzerland, and the United Kingdom) at psychology conferences. These were held at the 9th Biennial Conference of the Division of Differential Psychology, Personality Psychology, and Psychological Assessment of the German Psychological Association, September 2007, in Vienna, Austria; at the 8th Biennial Conference of the Austrian Psychological Association, April 2008, in Linz; Austria; and at the conjoint 29th Quadrennial International Congress of Psychology and 46th Biennial Conference of the German Psychological Association, July 2008, in Berlin (see Voracek, 2008)—This is, of course, not an exhaustive list of all conference symposia on 2D:4D research held so far. Preceding international conference symposia on 2D:4D research (all chaired by John T. Manning) include the 13th Annual Human Behavior and Evolution (HBES) Conference, June 2001, in London; the 15th Annual HBES Conference, June 2003, in Lincoln (NE); and the 16th Annual HBES Conference, July 2004, in Berlin (to which latter one my lab was among the contributors; see www.hbes.com/conference for these symposia's contents and further information).

Notwithstanding these and similar efforts of colleagues, at that time it was evident that there were still not many organized, coordinated, collaborative efforts in 2D:4D research. The two existing monographs on the topic are single-authored (Manning, 2002, 2008), as are several overviews in this field (Breedlove, 2010; McIntyre, 2006). As for the counter-examples, Manning et al. (2000), in a collaboration of researchers from nine universities, reported a cross-national analysis of ethnic differences in 2D:4D and relations of 2D:4D with reproductive outcomes; the inter-university collaboration for the BBC Internet Study has generated a number of 2D:4D research papers (as for examples, Manning, Baron-Cohen, Wheelwright, & Fink, 2010; Manning & Peters, 2009; Manning & Quinton, 2007; Manning, Reimers, Baron-Cohen, Wheelwright, & Fink, 2010); five primary studies on sexual orientation differences in 2D:4D have been subjected to a conjoint secondary analysis by their authors (McFadden et al., 2005); one study (Voracek, Manning, & Dressler, 2007) assessed 2D:4D measurement repeatabilities among 17 researchers who contributed to the 2D:4D literature; and, most recently, a substantial number of groupings collaborated in an investigation of hand pattern (a proxy of 2D:4D) and prostate cancer risk (Rahman et al., 2011).

So far, there has been only one special issue of a journal devoted to 2D:4D research (see the editorials of Hennig & Rammsayer, 2007; Rösler, 2007) which came about through a number of manuscript submissions with a common theme close in time. Hence, the current special issue on 2D:4D research is only the second one to appear. Its plan was proposed to and in turn approved and commissioned by Editor-in-Chief Tony Vernon in fall 2009. I invited a range of researchers already well-known for their 2D:4D research as well as newcomers to the field to contribute to this special issue. Articles were expected to focus on progress, consolidation, and integration of 2D:4D research.

The types of articles envisaged and sought for included: (1) broader theoretical integrations of 2D:4D research, novel insights, and theory-driven hypotheses; for instance, thoughts about the future of 2D:4D research, about the broader field wherein it fits in (i.e., brain organization research), and data on alternative proxies for prenatal androgen action (particularly, comparative studies of 2D:4D and such other markers). (2) Specific state-of-the-art systematic quantitative reviews (meta-analyses) of relevant subliteratures of 2D:4D research. This was preferred over traditional (narrative, non-exhaustive) reviews, since, among other objectives, one of the special issue's aims was to provide researchers a resource against the scatter of the literature. (3) Novel empirical findings already demonstrated to be replicable (i.e., multi-study evidence or methodology triangulation and generalization approaches). This was preferred over single-sample findings without replication attempt.

The compilation at hand shows good coverage of all three of these aspects. All invited manuscripts submitted (as well as this Preamble) had Acting Editors assigned and underwent external review. Those surviving peer-review comprise this compilation. In addition, some further regular submissions to the journal have fittingly joined this special issue. One invited paper was inadvertently assigned to a regular issue of the journal and has meanwhile been published (Fisher, Rich, Island, & Marchalik, 2010). It should duly be regarded as part of this special issue. Fisher and her colleagues report on associations between finger-length patterns and dimensions of a new neurochemically based temperament model on the basis of a large online survey.

The themes of the ten remaining papers (this issue) are as follows: (1) Brosnan, Gallop, Iftikhar, and Keogh provide multi-sample evidence for 2D:4D effects on computer-related academic performance and also address computer-related anxiety. (2) Snihur and Hampson revisit the research question of associations between 2D:4D and another putative marker of prenatal androgen action, namely otoacoustic emissions, with novel data. (3) Hell and Päßler investigate correlations of both 2D:4D and absolute finger length with sex-specific dimensions of occupational interests in a large online study. (4) Hönekopp and Watson subject the 2D:4D literature on aggression to a meta-analysis. (5) Manning and Fink utilize data from a very large online survey to assess aggregate-level (nation-based) associations between 2D:4D and personality dimensions, including further contextual and environmental variables. (6) McIntyre, Li, Chapman, Lipson, and Ellison investigate the nexus of 2D:4D, circulating testosterone, masculine identification, and social status according to peer rankings in a residential setting of young men. (7) Millet synthesizes and integrates the emerging branch of the behavioral economics literature within 2D:4D research, deriving potentially fruitful directions for future research therefrom. (8) Quinton, Smith, and Joiner report on 2D:4D differences by eating disorder diagnoses among women. (9) Stenstrom, Saad, Nepomuceno, and Mendenhall explore associations of domain-specific risk-taking behaviors with 2D:4D as well as with an alternative measure of relative finger length. (10) Voracek, Pietschnig, Nader, and Stieger present three new studies on 2D:4D and psychometric measures of sex-role orientation and subject the respective literature to a meta-analysis.

The majority of these papers were prepared in late 2009, submitted in early 2010, and received in revised form during spring 2010. 2D:4D research is a fast-growing line of inquiry, resulting in an ever-changing landscape of accumulating evidence. It is thus worth mentioning some 2010 and 2011 findings in this area, published after this special issue's papers went to press.

To begin with, well-controlled experimental work (using a double-blind, placebo-controlled, crossover, within-subjects design), albeit based on a small sample size (16 women), has found that testosterone administration impairs cognitive empathy (measured