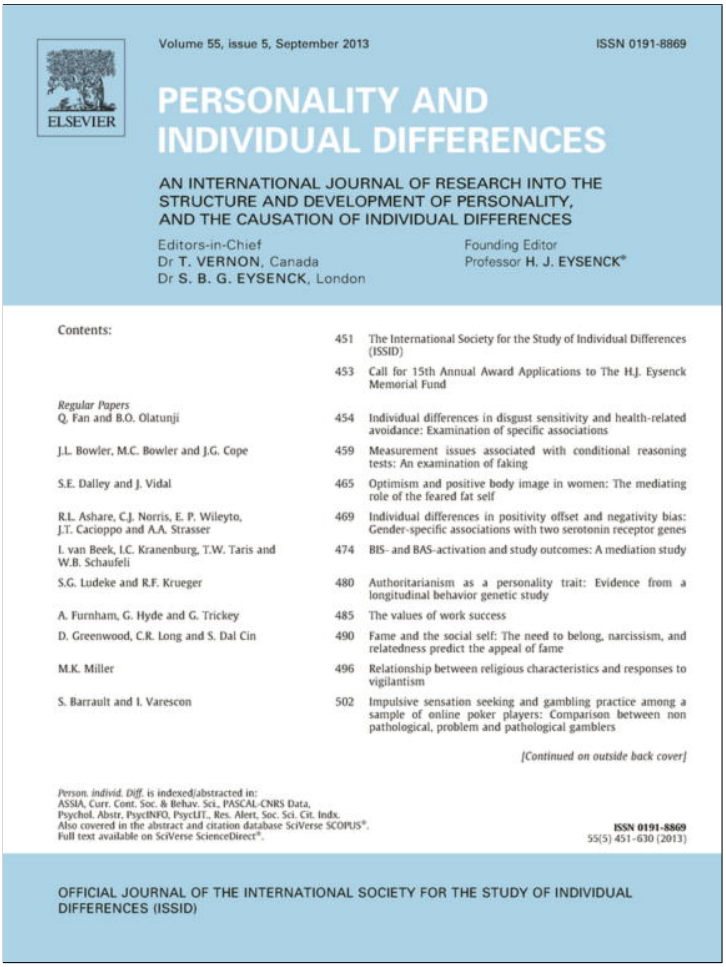

Volume 55, issue 5, September 2013 ISSN 0191-8869

ELSEVIER

PERSONALITY AND INDIVIDUAL DIFFERENCES

AN INTERNATIONAL JOURNAL OF RESEARCH INTO THE STRUCTURE AND DEVELOPMENT OF PERSONALITY, AND THE CAUSATION OF INDIVIDUAL DIFFERENCES

Editors-in-Chief
Dr T. VERNON, Canada
Dr S. B. G. EYSENCK, London

Founding Editor
Professor H. J. EYSENCK*

Contents:

[Continued on outside back cover]

Person. individ. Diff. is indexed/abstracted in:
ASSIA, Curr. Cont. Soc. & Behav. Sci., PASCAL-CNRS Data, Psychol. Abstr, PsycINFO, PsycLIT., Res. Alert, Soc. Sci. Cit. Indx.
Also covered in the abstract and citation database SciVerse SCOPUS®.
Full text available on SciVerse ScienceDirect®.

ISSN 0191-8869
55(5) 451-630 (2013)

OFFICIAL JOURNAL OF THE INTERNATIONAL SOCIETY FOR THE STUDY OF INDIVIDUAL DIFFERENCES (ISSID)

Personality and Individual Differences 55 (2013) 591–594

Contents lists available at SciVerse ScienceDirect

Personality and Individual Differences

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

Digit ratio and risk taking in post-menopausal Finnish women

Minna Lyons [a,*], Samuli Helle [b]

[a] Psychology Department, Liverpool Hope University, Hope Park, Liverpool L16 9JD, UK
[b] Department of Biology, University of Turku, FI-20014 Turun Yliopisto, Finland

ARTICLE INFO

Article history:
Received 5 December 2012
Received in revised form 29 April 2013
Accepted 1 May 2013
Available online 12 June 2013

Keywords:
Digit ratio
Health risk
Nicotine
Alcohol
Sexual risk
Post-menopausal women

ABSTRACT

Although an indicator of prenatal testosterone (PT), 2D:4D ratio, has been extensively studied in the domain of financial risk taking, other domains of risk have received less attention. It is thought that elevated levels of PT relate to more masculinised behaviours, including increased risk taking propensity. In this study, we report negative findings with regards to health (average weekly drinking and daily smoking) and sexual (lifetime number of sexual partners) risk in a sample of post-menopausal Finnish women (N = 146–262). Our results suggest that PT may not masculinise health and sexual risk taking in women, at least at an older age.

1. Introduction

Empirical evidence suggests that elevated levels of pre-natal testosterone (PT) and lower levels of prenatal estrogens, indicated by the ratio of the second to fourth digit (2D:4D), relate to adult risk-taking behaviours in domains such as financial, social and recreational risk (Coates, Gurnell, & Rustichini, 2009; Garbarino, Slonim, & Sydnor, 2011; Hönekopp, 2011; Stenstrom, Saad, Nepomuceno, & Mendenhall, 2011; although see also Apicella et al., 2008), reckless and dangerous driving habits (Schwerdtfeger, Heims, & Heer, 2010), as well as increased number of sexual partners (Clark, 2004; Hönekopp, Voracek, & Manning, 2006). It is thought that exposure to PT during early foetal development masculinises the brain, resulting in more male-like personality traits as an adult, often irrespective of biological sex (Luxen & Buunk, 2005). As risky activities are more common in males than in females, and males are generally exposed to higher amount of PT than women are, PT is a likely candidate for explaining at least some of the sex differences in risk-taking behaviour.

Although PT and financial risk has been widely investigated, there has been less focus on looking at PT as a marker for health-related risks. Health-risks, such as alcohol consumption, are sexually dimorphic behaviours. For instance, there is cross-cultural evidence to suggest that men have higher frequency and intake of alcohol than women have (Wilsnack, Wilsnack, Kristjanson, Vogeltanz-Holm, & Gmel, 2009). Although sex differences in nicotine consumption are of smaller magnitude, men on average smoke more than women do (Byrnes, Miller, & Schafer, 1999). Thus, it is plausible that PT has an organisational effect on propensity to drink and smoke in adulthood. Lenz, Müller, and Kornhuber (2012), for example, found that males who had a male co-twin were more likely to have alcohol dependency than men with a female co-twin, suggesting that pre-natal transfer of testosterone has an effect on adult alcohol consumption. Furthermore, in a recent case–control study, Kornhuber et al. (2011) found that alcohol dependency was, irrespective of sex, related to lower, more masculinised digit ratios. Similar findings were reported by Manning and Fink (2011), who investigated self-measured digit ratios and alcohol consumption in a large-scale internet study. They found that lower, masculinised ratios related to higher alcohol use in a nationally diverse sample of participants, indicating that PT may masculinise alcohol consumption in adulthood.

The evidence for smoking and PT exposure is conflicting. For instance, there is some research suggesting that higher levels of testosterone during pregnancy relate to a higher likelihood of the daughter's smoking as an adult (Kandel & Udry, 1999). However, there is also opposing evidence suggesting that more feminised digit ratios relate to smoking (Manning & Fink, 2011), although the causes for this are not clear. For example, Lynch (2009), using rodent models, found that circulating female hormones reinforce the sensitivity to nicotine, predisposing females to be more addictive than males. However, more research is clearly needed in order to confirm the relationship between markers of PT and nicotine use, as PT does not necessarily function in a way similar to circulating testosterone.

Both alcohol consumption (Jackson, Sweeting, & Haw, 2012) and smoking (Berg et al., 2012) relates to risky sexual behaviour. It is possible that as well as having a relationship with increased

* Corresponding author. Tel.: +44 1512913907; fax: +44 1512913000.
E-mail address: lyonsm2@hope.ac.uk (M. Lyons).

0191-8869/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.paid.2013.05.014

health risk, PT could, potentially, affect risky mating strategies. Clark (2004) found that lower digit ratios in women related to higher scores on unrestricted socio-sexuality, suggesting that PT may partially masculinise female mating behaviour. However, Manning and Fink (2008) reported no such associations in men or women in a large internet-based sample, suggesting that the links between prenatal influences on socio-sexuality are unclear at present. More evidence for prenatal influences on risky mating strategies comes from a study by Scarbrough and Johnston (2005), who found that women with more masculine digit ratios reported having shorter intimate relationships, and higher preference for masculine long-term partners. Other studies have found that in heterosexual men, life-time sexual partners (Hönekopp et al., 2006) and short-term mating orientation (Schwarz, Mustafić, Hassebrauck, & Jörg, 2011) relates to more masculine digit ratios, whereas other studies on both men and women have found no such associations (Charles & Alexander, 2011; Putz, Gaulin, Sporter, & McBurney, 2004; Rahman, Korhonen, & Aslam, 2005). Thus, the relationship between prenatal testosterone and mating strategy is unclear at present, and demands more research to investigate any possible associations.

The present study has several aims. Firstly, as there is remarkable variation in the digit ratio between populations and ethnic groups (Manning et al., 2000), we are investigating the relationship between indicators of PT and health and sexual risk in a nationally and ethnically homogenous sample of postmenopausal Finnish women. Second, the study of Manning and Fink (2011) utilised self-measured digit ratios in a diverse sample, which could, potentially, introduce a confounding factor (McIntyre, 2006). Therefore, we aim to investigate the weekly frequency of alcohol use, the daily average number of cigarettes smoked, and the lifetime number of sexual partners with a more homogeneous sample of participants. Third, most studies looking at the relationship between risk and digit ratio have used relatively young, undergraduate student samples. It is possible that PT exposure affects individuals differently depending on the age or age-related individual attributes. Thus, we are adding to the existing literature by investigating PT effects on risk-taking in an older, postmenopausal female sample.

2. Methods

2.1. Participants

Our data consisted of 262 women who were born in years 1946–58 in Finland and who participated in the study during 2006 (see Helle & Lilley, 2008). For the current study, we recorded the self-reported number of sexual partners during lifetime, how many times in a week, they used alcohol and the number of cigarettes smoked per day. We also recorded women's height, birth area (classified to be born in North-, South- or West-Finland), birth cohort (1946–47, 1951–52 or 1956–58) and education (elementary school, secondary school or university degree). Information on the lifetime number of sexual partners was not asked from the women of the oldest birth cohort and was therefore missing by design. These data have previously been used to associate postmenopausal women's 2D:4D on their offspring sex ratio (Helle & Lilley, 2008), age at menarche (Helle, 2010a), life history traits and fitness (Helle, 2010b) and the latitudinal gradient of their birth place (Helle & Laaksonen, 2009),

2.2. Digit ratio measurements

During the collection of questionnaires, both of the women's hands were scanned (Canon Canoscan D66OU) for 2D:4D measurements. The digits were measured from the tip of the finger to the crease proximal to the palm with computer-program Image-J (http://rsb.info.nih.gov/ij/) by one person. Sixty randomly selected hands were measured twice by the same person in order to estimate repeatability (i.e. intraclass correlation coefficient) of 2D:4D measurements using one-way ANOVA). The 2D:4D measurements showed a repeatability of 0.79 ($F_{1,59} = 8.44$, $p = 0.005$).

2.3. Statistical analyses

We used structural equation modeling (SEM) to examine whether right and left hand 2D:4D were associated with the lifetime number of sexual partners, average weekly alcohol and daily cigarette use while controlling for height, spatial and birth cohort variation and educational differences. The main advantage of using SEM in this study lies with its' multivariate capabilities that take within-women (residual) correlations of response variables into account. Weekly alcohol use was modelled as a continuous outcome, whereas the number of lifetime sexual partners and the daily average number of cigarettes smoked were modelled as count variables using negative binomial error distribution and log link function that automatically includes dispersion parameters to the model. Prior to analysis, left and right hand 2D:4D were rescale by multiplying them by 10 in order to obtain more interpretable regression coefficients for these predictors. The model parameters were estimated by robust maximum likelihood estimator that is insensitive to non-normal data. Missing data were taken into account by using full information maximum likelihood (FIML) estimation that assumes data is at least missing at random and can thus handle missingness by design. The analysis was conducted with MPlus version 7.0 (Muthén & Muthén, 1998–2012).

3. Results

In Table 1, we report descriptive statistics for both left and right hand digit ratio, health risk variables, and number of lifetime sexual partners.

In Table 2, we report the results of the SEM analysis. We found no statistically significant associations suggesting that right and left hand 2D:4D predicted weekly alcohol and daily cigarette use and the number of lifetime sexual partners among these postmenopausal Finnish women. Those women who smoked heavily also reported a higher number of lifetime sexual partners (residual correlation (±SE) = 0.72 (±0.06), $p < 0.0001$), whereas alcohol consumption was not associated with smoking (residual correlation (±SE) = 0.07 (±0.09), $p = 0.46$) and the number of lifetime sexual partners (residual correlation (±SE) = 0.05 (±0.07), $p = 0.46$).

4. Discussion

We found no evidence of a relationship between 2D:4D and sexual and health risk taking in our sample of post-menopausal Finnish women. Our findings largely contradict those few published studies that have investigated digit ratio and alcohol (Kornhuber et al., 2011; Manning & Fink, 2011), digit ratio and smoking (Manning & Fink, 2011), and digit ratio and promiscuous mating orientation (Clark, 2004) in women. Our results add to the

Table 1
Descriptive statistics of the variables considered in this study.

	n	Mean	Median	SD	Min	Max
Right hand 2D:4D	262	0.98	0.97	0.03	0.9	1.08
Left hand 2D:4D	262	0.97	0.97	0.03	0.89	1.08
No. of sexual partners	146	4.32	3.00	4.56	0	25
Alcohol use (times/week)	256	0.87	0.50	1.12	0	7
Cigarette use (*N* per day)	258	2.73	0.00	5.72	0	30
Height	262	164.4	165.00	5.3	149	177

Table 2
Results of SEM estimating the associations between right and left hand 2D:4D and average daily cigarette and weekly alcohol use and lifetime number of sexual partners. Note that standardized estimates (std. β) for continuous covariates are SD-standardized with respect to both dependent and independent variables, while categorical variables are SD-standardized with respect to dependent variables only. 95% Confidence intervals (95% CI) are also given for unstandardized estimates.

	β	95% CI	std. β	z	p
Daily cigarette use					
Right 2D:4D	−0.394	−2.935, 2.148	−0.095	−0.304	0.761
Left 2D:4D	0.232	−1.716, 2.180	0.058	0.233	0.815
Birth area (=north)	−0.650	−2.301, 1.001	−0.503	−0.772	0.440
Birth area (=south)	0.084	−2.212, 2.381	0.065	0.072	0.943
Education (=elementary)	1.096	−1.072, 3.262	0.847	0.991	0.322
Education (=secondary)	1.401	−0.577, 3.379	1.083	1.388	0.165
Birth cohort (=1946–47)	1.427	0.084, 2.769	1.103	2.082	0.037
Birth cohort (=1951–52)	1.206	−0.111, 2.522	0.932	1.795	0.073
Height	0.016	−0.098, 0.131	0.067	0.282	0.778
Weekly alcohol use					
Right 2D:4D	−0.033	−0.563, 0.498	−0.009	−0.121	0.903
Left 2D:4D	0.135	−0.379, 0.649	0.039	0.516	0.606
Birth area (=north)	0.045	−0.389, 0.480	0.041	0.204	0.838
Birth area (=south)	0.665	0.203, 1.127	0.596	2.821	0.005
Education (=elementary)	−0.580	−1.028, −0.132	−0.52	−2.539	0.011
Education (=secondary)	−0.239	−0.653, 0.176	−0.214	−1.129	0.259
Birth cohort (=1946–47)	0.368	0.049, 0.686	0.329	2.263	0.024
Birth cohort (=1951–52)	0.222	−0.102, 0.546	0.199	1.344	0.179
Height	0.006	−0.020, 0.032	0.029	0.466	0.641
No. of sexual partners					
Right 2D:4D	0.034	−0.564, 0.633	0.014	0.113	0.910
Left 2D:4D	0.200	−0.372, 0.772	0.083	0.686	0.493
Birth area (=north)	−0.014	−0.570, 0.541	−0.018	−0.050	0.960
Birth area (=south)	0.790	0.315, 1.264	1.006	3.263	0.001
Education (=elementary)	0.113	−0.209, 0.434	0.143	0.686	0.493
Education (=secondary)	0.207	−0.283, 0.697	0.264	0.827	0.408
Birth cohort (=1946–47)					
Birth cohort (=1951–52)	0.375	0.073, 0.629	0.478	2.432	0.015
Height	0.008	−0.023, 0.039	0.054	0.506	0.614

Ref: Education = University, Birth Area = West, Birth cohort = 1956–58.

literature on research failing to replicate previous, theory-confirming findings (e.g., Apicella et al., 2008). The present results add to the previous patterns of non-replication on digit ratio and reproductive variables using the same dataset (Helle, 2010a, 2010b; Helle & Lilley, 2008). We would like to use our results to highlight the importance of replication in psychological studies (Francis, 2012), as findings in digit ratio research are often inconsistent from one publication to another. Our results indicate that at least in our sample of postmenopausal women, digit ratio is unrelated to risk taking in terms of smoking, drinking, and number of sexual partners. These results obviously need to be verified by further studies, as there currently are not many published researches that have looked at the association between these variables.

One possible explanation for our null-findings is the high age of our sample compared to other studies. Generally speaking, risk-taking, including alcohol consumption (Moore et al., 2005) tends to decline with age. According to the maturity principle (McAdams & Olson, 2010), individuals change with age to assume more responsible social roles, which could attenuate the PT influences when people reach older age. Although this could explain our non-significant findings on alcohol and nicotine use, it does not explain the lack of association between digit ratio and number of life time sexual partners. It is possible that PT does not masculinise female sexual behaviour, in line with Rahman et al. (2005), but contra to Clark (2004).

It is also possible that our null-findings are owed to the limited statistical power to detect small associations between 2D:4D and the outcomes studied here. Because calculating statistical power retrospectively using observed effect sizes is not recommended (Hoenig & Heisey, 2001), we reported 95% confidence intervals for parameter estimates that incorporate the element of power, making it possible to judge from "all the potential results that are supported by the data" (Smith & Bates, 1992). The problem here is to tell what should be considered as a biologically meaningful effect size. For example, our data suggests that increasing right hand 2D:4D by one unit (which owing to rescaling covers almost the whole range of 2D:4D in these women) may either decrease weekly alcohol use by 0.6 times a week or increase it by 0.5 times a week. Therefore, given for example the massive BBC internet digit ratio data (e.g. Manning & Fink, 2008) that has statistical power to detect even very small effect sizes, the field of digit ratio research would benefit from putting these effect size estimates to a relevant biological arena.

It also should be noted that we used an indirect measurement of 2D:4D based on photocopied hands, which may be subjected to elevated measurement bias (see Manning & Fink, 2011). Thus, we would like to see a replication of our study using direct digit ratio measurements. Furthermore, as there are latitudinal effects on digit ratio among these postmenopausal women (Helle & Laaksonen, 2009), it would be useful to replicate the study in samples from different latitudes. Overall, we urge for more research on prenatal influences on risk-taking behaviour in different age groups, as we believe that age is generally an over-looked factor in digit ratio research.

References

Apicella, C. L., Dreber, A., Campbell, B., Gray, P. B., Hoffman, M., & Little, A. C. (2008). Testosterone and financial risk preferences. *Evolution and Human Behavior, 29*, 384–390.

Berg, C. J., Painter, J. E., Sales, J. M., Mays, D., Rose, E., Wingood, G. M., et al. (2012). Smoking as a risk factor for STI diagnosis among African American females. *American Journal of Health Behavior, 36*, 505–512.

Byrnes, J. P., Miller, D. C., & Schafer, W. D. (1999). Gender differences in risk taking: A meta-analysis. *Psychological Bulletin, 125*, 367.

Charles, N. E., & Alexander, G. M. (2011). The association between 2D: 4D ratios and sociosexuality: A failure to replicate. *Archives of Sexual Behavior, 40*, 587–595.
Clark, A. P. (2004). Self-perceived attractiveness and masculinization predict women's sociosexuality. *Evolution and Human Behavior, 25*, 113–124.
Coates, J. M., Gurnell, M., & Rustichini, A. (2009). Second-to-fourth digit ratio predicts success among high-frequency financial traders. *Proceedings of the National Academy of Sciences of the United States of America, 106*, 623–628.
Francis, G. (2012). The psychology of replication and replication in psychology. *Perspectives on Psychological Science, 7*, 585–594.
Garbarino, E., Slonim, R., & Sydnor, J. (2011). Digit ratios (2D: 4D) as predictors of risky decision making for both sexes. *Journal of Risk and Uncertainty, 42*, 1–26.
Helle, S. (2010a). Does second-to-fourth digit length ratio (2D:4D) predict age at menarche in women? *American Journal of Human Biology, 22*, 418–420.
Helle, S. (2010b). Digit length ratio (2D:4D) and variation in key life-history traits and fitness in Finnish women. *Behavioral Ecology, 21*, 1061–1066.
Helle, S., & Laaksonen, T. (2009). Latitudinal gradient in 2D:4D. *Archives of Sexual Behavior, 38*, 1–3.
Helle, S., & Lilley, T. (2008). Maternal 2nd to 4th digit ratio does not predict lifetime offspring sex ratio at birth. *American Journal of Human Biology, 20*, 700–703.
Hoenig, J. M., & Heisey, D. M. (2001). The abuse of power: The pervasive fallacy of power calculations for data analysis. *The American Statistician, 55*, 19–24.
Hönekopp, J. (2011). Relationships between digit ratio 2D:4D and self-reported aggression and risk taking in an online study. *Personality and Individual Differences, 51*, 77–80.
Hönekopp, J., Voracek, M., & Manning, J. T. (2006). 2nd to 4th Digit ratio (2D: 4D) and number of sex partners: Evidence for effects of prenatal testosterone in men. *Psychoneuroendocrinology, 31*, 30–37.
Jackson, C., Sweeting, H., & Haw, S. (2012). Clustering of substance use and sexual risk behaviour in adolescence: analysis of two cohort studies. *BMJ Open, 2*.
Kandel, D. B., & Udry, J. R. (1999). Prenatal effects of maternal smoking on daughters' smoking: nicotine or testosterone exposure? *American Journal of Public Health, 89*, 1377–1383.
Kornhuber, J., Erhard, G., Lenz, B., Kraus, T., Sperling, W., Bayerlein, K., et al. (2011). Low digit ratio 2D:4D in alcohol dependent patients. *PLoS One, 6*, e19332.
Lenz, B., Müller, C. P., & Kornhuber, J. (2012). Alcohol dependence in same-sex and opposite-sex twins. *Journal of Neural Transmission, 119*, 1–4.
Luxen, M. F., & Buunk, B. P. (2005). Second-to-fourth digit ratio related to verbal and numerical intelligence and the Big Five. *Personality and Individual Differences, 39*, 959–966.
Lynch, W. J. (2009). Sex and ovarian hormones influence vulnerability and motivation for nicotine during adolescence in rats. *Pharmacology Biochemistry and Behavior, 94*, 43–50.
Manning, J. T., Barley, L., Walton, J., Lewis-Jones, D. I., Trivers, R. L., Singh, D., et al. (2000). The 2nd:4th digit ratio, sexual dimorphism, population differences, and reproductive success: Evidence for sexually antagonistic genes? *Evolution and Human Behavior, 21*, 163–183.
Manning, J. T, & Fink, B. (2008). Digit ratio (2D: 4D), dominance, reproductive success, asymmetry, and sociosexuality in the BBC Internet Study. *American Journal of Human Biology, 20*, 451–461.
Manning, J. T., & Fink, B. (2011). Digit ratio, nicotine and alcohol intake and national rates of smoking and alcohol consumption. *Personality and Individual Differences, 50*, 344–348.
McAdams, D. P., & Olson, B. D. (2010). Personality development: Continuity and change over the life course. *Annual Review of Psychology, 61*, 517–542.
McIntyre, M. H. (2006). The use of digit ratios as markers for perinatal androgen action. *Reproductive Biology and Endocrinology, 4*, 1–9.
Moore, A. A., Gould, R., Reuben, D. B., Greendale, G. A., Carter, M. K., Zhou, K., et al. (2005). Longitudinal patterns and predictors of alcohol consumption in the United States. *American Journal of Public Health, 95*, 458–464.
Muthén, L. K., & Muthén, B. O. (1998–2012). *Mplus user's guide* (7th ed.). Los Angeles, CA: Muthén & Muthén.
Putz, D. A., Gaulin, S. J., Sporter, R. J., & McBurney, D. H. (2004). Sex hormones and finger length: What does 2D: 4D indicate? *Evolution and Human Behavior, 25*, 182–199.
Rahman, Q., Korhonen, M., & Aslam, A. (2005). Sexually dimorphic 2D: 4D ratio, height, weight, and their relation to number of sexual partners. *Personality and Individual Differences, 39*, 83–92.
Scarbrough, P. S., & Johnston, V. S. (2005). Individual differences in women's facial preferences as a function of digit ratio and mental rotation ability. *Evolution and Human Behavior, 26*, 509–526.
Schwarz, S., Mustafić, M., Hassebrauck, M., & Jörg, J. (2011). Short-and long-term relationship orientation and 2D: 4D finger-length ratio. *Archives of Sexual Behavior, 40*, 565–574.
Schwerdtfeger, A., Heims, R., & Heer, J. (2010). Digit ratio (2D: 4D) is associated with traffic violations for male frequent car drivers. *Accident Analysis and Prevention, 42*, 269–274.
Smith, A. H., & Bates, M. N. (1992). Confidence limit analyses should replace power calculations in the interpretation of epidemiologic studies. *Epidemiology, 3*, 449–452.
Stenstrom, E., Saad, G., Nepomuceno, M. V., & Mendenhall, Z. (2011). Testosterone and domain-specific risk: Digit ratios (2D: 4D) as predictors of recreational, financial, and social risk-taking behaviors. *Personality and Individual Differences, 51*, 412–416.
Wilsnack, R. W., Wilsnack, S. C., Kristjanson, A. F., Vogeltanz-Holm, N. D., & Gmel, G. (2009). Gender and alcohol consumption: Patterns from the multinational GENACIS project. *Addiction, 104*, 1487–1500.