Second to Fourth Digit Ratio and the Big Five Aspects and the Externalizing Spectrum of Psychopathology

Yasir Uddin and Jacob Gray

Advisor: Professor Colin DeYoung

University of Minnesota: Undergraduate Research Opportunities Program

Abstract

The ratio of one's second to fourth finger is a marker of prenatal testosterone exposure. The current study seeks to examine this phenomenon as it relates to the Big Five Aspects of personality and certain externalizing behaviors of psychopathology. Participants completed the Big Five Aspects Scale and then had their second to fourth digit ratio measured. Men's left second to fourth digit ratio was significantly correlated with openness and with compassion. Women's right second to fourth digit ratio was significantly correlated with intellect. Consistent with prior literature a negative relationship was found with 2D:4D and physical aggression. Blame externalization was also negatively correlated with 2D:4D, and planful control showed a positive relationship with 2D:4D. In accordance with previous literature, 2D:4D relationships with personality and some antisocial behaviors are weak, but significant.

Second to Fourth Digit Ratio and the Big Five Aspects

The ratio of index to ring fingers (2D:4D) has recently come of interest because of the predictive power the ratio has for hormonal exposure in utero and the subsequent effect that this has on psychological traits (Williams et al., 2000; Lippa, 2006, Putz et al., 2004). Androgen exposure has been the most commonly implicated hormonal difference when discussing the sexual dimorphism of the 2D:4D ratio, causing men to have an aggregate mean ratio lower than that of women (Manning, 2002). In a way, having a higher second to fourth digit ratio can be seen as more "feminine" as the 2D:4D ratio is negatively correlated with prenatal testosterone exposure. Owing to the androgenic nature of the 2D:4D ratio, mean values are lower for males than females (George, 1930). This digit ratio is determined by the fourteenth week of prenatal development and remains stable throughout the life span (Garn, Burdi, Babler, & Stinson, 1975). Significant genetic contributions of the 2D:4D ratio have been shown when comparing monozygotic and dizygotic twins (Paul et al., 2006)

The 2D:4D ratio has been shown to correlate with a variety of physical and psychological characteristics. Manning (2002) found that a higher 2D:4D ratio negatively predicted subjective skiing ability. Endurance running has also been shown to be negatively predicted by the 2D:4D ratio (Manning, Morris & Caswell, 2007). Coates, Gurnell and Rustichini (2009) found that a smaller 2D:4D ratio was also predictive of the success and longevity of high stakes financial traders. Health outcomes, such as infertility, autism, dyslexia, breast cancer and myocardial infarction have also been hypothesized as having

relationships with the 2D:4D ratio (Manning & Bundred, 2000; Fink, Manning & Neave, 2005).

More psychological characteristics have also been associated with the 2D:4D ratio. Females with a higher 2D:4D ratios tend to rate themselves as more attractive and rate themselves as having more self-esteem than females with a lower ratio (Wade, Shanley & Imm, 2004). Male homosexuality is negatively predicted by the 2D:4D ratio, as the amount of prenatal testosterone exposure goes up, males are more likely to be homosexual (Robinson& Manning, 2000). The field of personality psychology has examined this adrogenic phenomenon as it relates to the current Five Factor Model of personality.

Big Five Aspects

Broad trait domains in personality are organized based on a hierarchy in which each domain is composed of lower order facets. These domains are based off the lexicon, and are determined by identifying which traits correlate together. From this method of determining the personality hierarchy, has come forth the Five Factor Model of personality. The Five Factor Model of personality consists of five personality traits: conscientiousness, agreeableness, openness, neuroticism, and extraversion (Digman, 1990). These same five trait domains have been shown to occur across cultures and do not appear to be an artifact of the English lexicon from which they emerged (McCrae & Costa,1997). The Five Factor Model of personality has become widely employed in personality research and has shown to have predictive validity for a variety of long term outcomes, such as neuroticism predicting anxiety disorders (Trull and Sher, 1994), low agreeableness predicting poorer health (Miller et al., 1996), openness predicting mystical or paranormal experiences

(MacDonald, 2000), extraversion predicting subjective well-being (DeNeve & Cooper, 1998) and a study by Paunonen (2003) which found conscientiousness positively correlated with GPA. (See Ozer & Benet-Martinez, 2006 for a detailed review).

Further factor analysis of the facets of the Five Factor Model performed by DeYoung, Quilty and Peterson (2007) brought to light two conceptually different, yet still correlated aspects for each domain of the Five Factor Model. These intermediate aspects of the Five Factor Model are as follows: Conscientiousness is divided into industriousness and orderliness, Agreeableness is divided into politeness and compassion, Openness (referred to as Openness/Intellect) is divided into openness and intellect, Neuroticism is divided into volatility and withdrawal, and the two aspects of Extraversion are enthusiasm and assertiveness.

Second to fourth digit ratio and Personality

The Five Factor Model of personality traits have shown consistent sexual dimorphism with women reporting higher neuroticism and agreeableness and men reporting themselves as being higher in assertiveness (Costa, Terracciano, & McCrae, 2001). Fink, Manning and Neave (2004) examined how the 2D:4D ratio related to the Five Factor Model of personality traits. Neuroticism was the only personality trait that showed a significant, positive relationship with the digit ratio in the entire sample, but this relationship was only significant for females. Agreeableness showed up as significantly and negatively related to right 2D:4D in females, but not in males. Luxen and Buunk (2005) examined how the Big Five hierarchy of personality traits relates to the gonadal androgen exposure as predicted by the 2D:4D ratio. The results Luxen and Buunk obtained indicated

that the only significant association between personality traits and 2D:4D came for

agreeableness and right 2D:4D. Right 2D:4D was positively correlated with self-report

scores of agreeableness. The other four traits of the Five Factor Model were found to be

insignificantly, or unrelated to the 2D:4D ratio. The researchers suggest there is no reason

to believe the other four traits would be predicted by 2D:4D as there is not enough to

predict that androgen exposure would predict such a relationship. However, Lippa (2006)

found contradictory results to this when he measured personality using the Five Factor

Model and personality's relationship with the 2D:4D ratio. Lippa's analysis showed that

2D:4D showed a negative correlation with agreeableness, in disagreement with Luxen and

Buunk's study but in addition found 2D:4D associated with extraversion and openness to

experience. 2D:4D negatively predicted self-report scores of extraversion and was

positively correlated with scores on openness to experience. Neuroticism showed no

relationship.

Fink, Neave, Laughton and Manning (2006) examined the relationship between

second and fourth digit ratio and sensation seeking. Sensation seeking was significantly

and negatively correlated with right hand 2D:4D in males. Female's second to fourth digit

ratio did not show any significant relationship with sensation seeking, nor did the left hand

of males. Cattell's personality traits (Cattell, Bernard, & Eber, 1988) and their relationship

to the second to fourth digit ratio was examined in a study conducted by Lindova et al.

(2008) Using Cattell's first-order factors of personality significant relationships between

2D:4D and personality were found with emotional stability, social boldness and

privateness. Both emotional stability and social boldness were negatively significantly

related to right 2D:4D for women and privateness was positively related to right 2D:4D for

women. No significant relationships were found with either women's left hands or with

digit ratios on either of men's hands. As emotional stability is usually seen as the inverse of

the Five Factor Model's neuroticism, the results are surprising and contradictory to Lippa's

(2006) and Luxen and Buunk's (2005) results but supportive of Fink, Manning and Neave's

(2004) results. Hampson, Ellis and Tenk (2007) further examined how the second to fourth

digit ratio relates to certain personality traits, using assertiveness, emotional empathy,

masculinity and femininity, nurturance, sensation seeking, and aggression. When males

and females were combined, second to fourth digit ratio was significantly and positively

associated with emotional empathy in both left and right hands. Both males and females

showed positive correlations with 2D:4D and nurturance in the left hand. Second to fourth

digit ratio in both males and females was significantly negatively correlated with self-

reported femininity, sensation seeking, and the sensation seeking facets of boredom and

thrill/adventure, and aggression, including the aggression aspects of verbal and physical

aggression, in both hands. A negative correlation was found with left hand 2D:4D in both

sexes were with self-reported masculinity. Both sexes showed significant right hand 2D:4D

correlations with the anger and hostility aspects of aggression. In males, the second to

fourth digit ratio was again negatively correlated with sensation seeking, although this time

the left hand 2D:4D was significantly associated with sensation seeking, and the boredom

facet of sensation seeking in particular. The thrill/adventure aspect of sensation seeking

was negatively related to right hand 2D:4D in males. Females displayed significant right

hand 2D:4D correlations with all four aspects of aggression: verbal, physical, hostility, and

anger; as well as self-reported femininity and sensation seeking (the thrill/adventure

aspect in particular). The only personality traits correlated with exclusively left hand

2D:4D was self-reported masculinity. No traits with correlated with second to fourth digit ratios for both hands in women (Hampson, Ellis, & Tenk, 2007).

Second to fourth digit ratio and antisocial behavior

The individual difference of sensation seeking has been shown to be related to the engagement of risky activities such as risky sexual activity and substance use (Kalichman, Heckman & Kelly, 1996; Wood, Cochran,Pfefferbaum, & Arneklev 1995; Dunlap & Romer, 2010). Given the negative relationship between 2D:4D and sensation seeking (Hampson, Ellis & Tenk, 2007) there is a hypothesized negative relationship between 2D:4D and substance use and abuse. Kornhuber et al. (2011) examined 2D:4D in alcohol dependent patients and found alcoholics had lower second to fourth digit ratios than a control group. This relationship was found for both hands, in both males and females. Another study conducted by Manning and Fink (2011) examined the relationship between alcohol consumption and 2D:4D in nonclinical sample and found that once again alcohol consumption was negatively correlated with 2D:4D. However a replication of this study by Borkowska and Pawlowski (2013) found that alcohol consumption had no relationship with 2D:4D.

Since aggression is a sexually dimorphic trait (Buss & Perry, 1992) with men generally reporting themselves as more aggressive it has been hypothesized that aggression would show a negative relationship with 2D:4D. Hampson, Ellis, and Tenk (2007) found aggression to be negatively correlated with aggression. This finding was consistent by Bailey and Hurd (2005) who found that men with lower digit ratios reported higher levels of physical aggression, but this finding was not generalized to females.

McIntyre et al., (2007) measured aggressive tendencies by a war-like game that used unprovoked attacks as a proxy for aggression. In this 2D:4D was also negatively related to aggression, consistent with previous findings. Indirect (or social) aggression was examine as it relates to the 2D:4D phenomenon (Coyne, Manning, Ringer, & Bailey, 2007) and found that women who had lower 2D:4D ratios reported themselves as higher in this indirect form of aggression.

The results are mixed concerning how the second to fourth digit ratio relates to personality. The Five Factor Model has been inconsistently related to 2D:4D with some studies (Luxen and Buunk, 2005; Lippa, 2006) finding no relationship with neuroticism but others (Fink, Manning and Neave, 2004) finding positive correlations with 2D:4D. Agreeableness has been the only trait to be reliably related to 2D:4D, with every study portraying a negative relationship. Extraversion and openness have also shown to be inconsistently related to second to fourth digit ratio. Other studies (Hampson, Ellis and Tenk, 2007) using personality measures have shown sensation seeking behaviors and aggressive to be negatively correlated with 2D:4D. Bearing in mind that higher second to fourth digit ratios are indicative of increased androgen exposure in utero, we can say that these traits are more "masculinized" as they are more associated with male sexual hormones. The current research is moving beyond the Five Factor Model of personality and is examining the 2D:4D correlates with the Big Five Aspects. This study is driven by a desire to better understand how 2D:4D is related to the Five Factor Model of personality and to examine how this relationship is affected by the lower level aspects of personality.

Relationships between 2D:4D and some antisocial behaviors are more clear. There appears to be a robust, negative relationship with aggression and 2D:4D (Baily & Hurd, 2005, McIntyre et al., 2005), suggesting that sexual dimorphism in aggressive tendencies have a basis in prenatal testosterone exposure, in that increased testosterone exposure in utero is related to increased aggression. The relationship between 2D:4D and alcohol use is less clear as prior studies have found (Kornhuber et al, 2011, Manning, 2011) and failed to find (Borkowska & Pawlowski, 2013) a relationship between alcohol use and 2D:4D. This study also addresses these relationships, as well as other antisocial behaviors.

Method

Participants

The sample used for this study consisted of 154 females (mean age=26.2, S.D.=5.45) and 153 males (mean age=25.9, S.D.=5.03). All the subjects were recruited for the study using an ad placed on Craig's List advertising participation in a paid research study. All participants selected for this study reside in the Minneapolis metropolitan region. Subjects were compensated with $20 for every hour they participated in the study.

BFAS

The Big Five Aspects Scales (BFAS) is a 100-item questionnaire that examines each ten of the aspects of the Big Five Model of personality (DeYoung, Quilty, & Peterson, 2007) with ten questions. Using a five-point Likert scale, the BFAS assessed Industriousness ("I finish what I start"), Orderliness (I keep things tidy"), Volatility ("I get angry easily"),

Withdrawal (I feel threatened easily"), Compassion ("I feel other's emotions'), Politeness ("I

hate to seem pushy"), Intellect ("I have a rich vocabulary"), Openness ("I enjoy the beauty

of nature"), Enthusiasm ("I show my feelings when I'm happy"), and Assertiveness ("I am

the first to act"). Between four and six items for each aspect of the Big Five are reverse

scored to avoid an acquiescence bias. The BFAS is a reliable and valid measure of assessing

the aspects of the Big Five (DeYoung, Quilty, & Peterson, 2007). The BFAS also combines

aspects to create mean trait levels for the Big Five aspects of personality.

ESI

The Externalizing Spectrum Inventory (ESI) is a four-point Likert scale consisting of

160 questions that measure a variety of psychopathological outcomes of antisocial and

drug use pathology (Krueger, Markon, Patrick, & Iacono, 2005). The subscales of the ESI are

Alcohol Use, Alienation, Blame Externalization, Boredom Proneness, Dependability,

Destructive Agression, Drug Problems, Drug Use, Empathy, Excitement Seeking, Fraud,

Honesty, Impatience, Irresponsibility, Marijuana Problems, Marijuana Use, Physical

Aggression, Planful Control, Problematic Impulsivity, Rebelliousness, Relational

Aggression, and Theft. These lower order subscales are then organized into higher factors

of proneness, callous-aggression, and drug use (Venables & Patrick, 2012).

2D:4D Measurements

Every subject's hand was electronically scanned using an Epson 4490 photo scanner and

electronically had their fingers blacked out so as to eliminate fingerprints. Two

independent raters measured the finger lengths, without any prior knowledge of the

subject other than his or her subject ID number. The 2D:4D ratio was then calculated with

the computer program AutoMetric. The computer program then divided the second digit by the fourth digit to give the 2D:4D measurement.

Results

2D:4D

To assess the inter-rater reliability of the 2D:4D, inter-rater correlations were used, .854 for the left 2D:4D (p<.001, Cronbach's alpha=.921) and .852 for right 2D:4D (p<.001, Cronbach's alpha=.918). 2D:4D scores were all normally distributed. The mean 2D:4D ratio was lower for men than for women, an expected finding given that lower ratios are indicative of high prenatal androgen exposure. Men's mean left 2D:4D was .969 (S.D.=.032) and men's right hand mean was .954 (S.D.=.031). Women's mean left 2D:4D was .969 (S.D.=.033) and women's mean right 2D:4D was .982 (S.D.=.035). A one-way analysis of variance was run on the gender differences of the 2D:4D ratio. Both the left (F(1, 305)=12.204, p=.001) and the right hands (F(1, 305)=23.263, p<.001) had significantly lower 2D:4D ratios for men than for women. Thus the conclusion was reached that the 2D:4D measurements were valid and reflected real digit ratios and sexual dimorphism.

2D:4D and the Big Five

The results for the 2D:4D and the big Five traits of personality are presented in Table 1 (Appendix A). Four of the five factors of personality are unrelated to the 2D:4D ratio, but Openness was correlated with the 2D:4D in both men and women. Men had significant correlations with openness and 2D:4D in the left hand, and women showed a significant

relationship between right 2D:4D and openness. No correlations were found with men's

right 2D:4D or women's left 2D:4D.

BFAS and 2D:4D

Internal reliability measures for the Big Five Aspects ranged from $\alpha=.70$ for

orderliness and $\alpha=.90$ for volatility. Table 2 (appendix B) presents the correlations

between with the 2D:4D ratios for left and right hands in both men and women, and the

scores that were calculated from the Big Five Aspects Scale. All correlations run were two-

tailed tests. Intellect was significantly and positively correlated with right 2D:4D in females.

No significant relationship was found with 2D:4D in women's left hands in the Big Five

Aspects. In males; left 2D:4D was significantly and positively correlated with the Big Five

Aspects of openness and compassion. Intellect and withdrawal both have positive

correlations with male's left 2D:4D but the p-values fell just shy of statistical significance.

No negative correlations were found between the Big Five Aspects and 2D:4D ratios for

either men or women.

ESI and 2D:4D

Internal reliability measures for the Externalizing Spectrum Inventory ranged from

$\alpha=.72$ for fraud and $\alpha=.91$ for marijuana use and blame externalization. The subscale for

dependability showed markedly lower reliability than the other subscales ($\alpha=.59$) and so

the decision was made not to use the subscale for dependability in the analysis. Partial

correlations were run showing the relationship between 2D:4D and the subscales of the

ESI, while accounting for the gender of the participant. Table 3 (Appendix C) presents the correlations with 2D:4D and the ESI. All tests run were two-tailed tests. The only significant relationships found with right 2D:4D was a negative correlation with the subscale of blame externalization. Left 2D:4D showed two significant relationships, a negative correlation with physical aggression, and a positive correlation with planful control.

Discussion

Owing to the mixed literature regarding how the 2D:4D ratio relates to personality, no hypotheses were made for most aspects of personality. The results of the relationship between the Big Five Aspects and the second to fourth digit ratio confirms previous findings that the 2D:4D ratio is a valid, but weak predictor of some personality traits. The finding that the compassion aspect of Agreeableness was positively correlated with 2D:4D is in contrast with previous findings on the link between 2D:4D and agreeableness (Fink, Manning& Neave, 2004; Lippa, 2006) but supportive of results obtained by Luxen and Buunk (2005). Openness was significantly correlated with 2D:4D in both men and women, supporting earlier results found by Lippa (2006). The finding that male left 2D:4D is significantly correlated with the openness aspect is in concordance with Lippa's (2006) results. Compounded to those findings is the correlation between women's right 2D:4D and intellect, one aspect of the trait Openness. These three findings support the notion of a significant and positive relationship between Openness and 2D:4D. As the withdrawal

aspect of Neuroticism approached significance in the expected direction it deserves mention that it supports previous findings by Fink et al., (2004) that neuroticism is positively correlated with 2D:4D, although the current study only found this relationship with the left hand in males. This relationship between neuroticism and 2D:4D would be expected given the robust findings of higher levels of neuroticism in females over males (Costa, Terracciano and McCrae, 2001). No consistent relationship exists in the literature between 2D:4D ratio and the Big Five traits of Extraversion and Conscientiousness, and the aspects of neither Conscientiousness nor Extraversion showed any significant relationship to 2D:4D.

The present study supports prior literature that showed a negative relationship between aggression and the 2D:4D (Bailey & Hurd, 2005, Coyne, Manning, Ringer, & Bailey, 2007, McIntyre et al, 2007). This consistent finding suggests that sexual dimorphism when it comes to the individual difference of aggression has a basis in prenatal androgen exposure. Thusly, this finding may serve to illuminate potential treatments for individuals whom are judged to be pathologically high in this particular domain. Further research should be done to discriminate how androgenic factors influence different facets of aggression and where this aggression could present itself (i.e. aggression directed towards relationships vs. strangers).

Another interesting result obtained relates to the relationships between 2D:4D and substance use and abuse. Prior literature has produced mixed results pertaining to how alcohol consumption relates to 2D:4D. The subscales relating to substance use (Alcohol use, Drug use, Drug problems, Marijuana use, and Marijuana problems) showed no relationship

at all with 2D:4D. This finding is consistent with Borkowska and Pawlowski (2013) who found no relationship between alcohol use and prenatal testosterone. Given the ESI measured alcohol use and not necessarily pathological use of alcohol, it could be that the relationship between 2D:4D and alcohol use found by Kornhuber et al. (2011) is found in subjects who are heavier alcohol users. Further research should be done pertaining to how prenatal androgen exposure relates to alcohol use, although both marijuana and drugs included scales pertaining to pathological use of these substances.

The subscale of planful control showed a positive correlation with 2D:4D, implying the less prenatal testosterone exposure is related to more planful control. The individual difference of planful control is similar to the personality trait of conscientiousness in that it refers to a person's ability to inhibit themselves (Meehan, Panfilis, Cain, & Clarkin, 2013). This contradicts findings with the BFAS and 2D:4D (although Industriousness was found to approach significance in women's right hand) that found that the self-regulatory factor of the Five Factor Model and the Big Five Aspects had no relationship with 2D:4D. Further research should be done to explore how self-regulatory behaviors relate to androgen exposure in utero.

Blame externalization is a subscale of the ESI that relates to impulsivity and sensation seeking (Meehan, Panfilis, Cain, & Clarkin, 2013). The negative relationship found between 2D:4D and blame externalization supports previous findings (Fink, Neave, Laughton, & Manning, 2006; Hampson, Ellis, & Tenk, 2007) that increased androgen exposure on the womb is related to increased sensation seeking. These findings can help

identify the root causes of pathological impulsivity and the role hormones play in causing impulsivity and sensation seeking.

The present study confirms the significance of prenatal androgen exposure in the development of personality traits. This hormonal exposure early in life has long term consequential outcomes in personality. By breaking the Five Factor Model down into aspects researchers can get a better grasp on which personality traits are linked to gonadal testosterone. More research should be done on the Big Five Aspects and hormonal influences, especially the aspects of Agreeableness, Neuroticism and Openness. Furthermore, this study could lead a greater understanding of how some externalized psychopathological behaviors arise and possible treatments. Knowing that androgen exposure while a fetus is in the womb can lead to individual differences in personality and externalized psychopathology can help explain some of the variance between men and women and variance within genders.

References

Bailey, A. A., & Hurd, P. L. (2005). Finger length ratio (2D: 4D) correlates with physical

aggression in men but not in women. *Biological psychology*, *68*(3), 215-222. doi:

10.1016/j.biopsycho.2004.05.001

Borkowska, B., & Pawlowski, B. (2013). Alcohol and nicotine intake and prenatal level of

androgens measured by digit ratio. *Personality and Individual Differences*, 55(6), 685-

687. doi: 10.1016/j.paid.2013.05.020

Cattell, R. B., Eber, H. W., & Tatsuoka, M. M. (1988). *Handbook for the sixteen personality factor

questionnaire (16 PF)*. Champaign, Illinois: Institute for Personality and Ability Testing.

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, 106(2), 623-628. doi: 10.1073/pnas.0810907106

Costa, P. T., Terracciano, A., & McCrae, R. R. (2001). Gender differences in personality traits

across cultures: Robust and surprising findings. *Journal of personality and social

psychology*, *81*(2), 322-331. doi: 1O.I037/IO022-3514.XI.2.322

Coyne, S. M., Manning, J. T., Ringer, L., & Bailey, L. (2007). Directional asymmetry (right–left

differences) in digit ratio (2D: 4D) predict indirect aggression in women. *Personality and

Individual Differences*, *43*(4), 865-872. doi: 10.1016/j.paid.2007.02.010

DeNeve, K. M., & Cooper, H. (1998). The happy personality: a meta-analysis of 137 personality

traits and subjective well-being. *Psychological bulletin*, *124*(2), 197. doi: 10.1037/0033-

2909.124.2.197

Digman, J. M. (1990). Personality structure: Emergence of the five-factor model. *Annual review

of psychology*, *41*(1), 417-440.

Dunlop, S. M., & Romer, D. (2010). Adolescent and young adult crash risk: Sensation seeking,

substance use propensity and substance use behaviors. *Journal of Adolescent

Health*, *46*(1), 90-92. doi: 10.1016/j.jadohealth.2009.06.005

Fink, B., Manning, J. T., & Neave, N. (2004). Second to fourth digit ratio and the 'Big

Five'personality factors. *Personality and Individual Differences*, *37*(3), 495-503. doi:

10.1016/j.paid.2003.09.018.

Fink, B., Manning, J. T., & Neave, N. (2005). The 2nd–4th digit ratio (2D: 4D) and neck

circumference: implications for risk factors in coronary heart disease. *International

Journal of Obesity*, *30*(4), 711-714. doi:

Fink, B., Neave, N., Laughton, K., & Manning, J.T. (2006). Second to fourth digit ratio and

sensation seeking. *Personality and Individual Differences 41(7),* 1253-1262. doi:

10.1016/j.paid.2006.05.002

Garn, S. M., Burdi, A. R., Babler, W. J., & Stinson, S. (1975). Early prenatal attainment of adult

metacarpal-phalangeal rankings and proportions. *American Journal of Physical

Anthropology*, *43*(3), 327-332. doi: 10.1002/ajpa.1330430305

George, R. (1930). Human finger types. *The Anatomical Record*, *46*(2), 199-204.

doi: 10.1002/ar.1090460210

Hampson, E., Ellis, C. L., & Tenk, C. M. (2008). On the relation between 2D: 4D and sex-

dimorphic personality traits. *Archives of Sexual Behavior*, *37*(1), 133-144. doi:

10.1007/s10508-007-9263-3

Kalichman, S. C., Heckman, T., & Kelly, J. A. (1996). Sensation seeking as an explanation for the

association between substance use and HIV-related risky sexual behavior. *Archives of*

Sexual Behavior, *25*(2), 141-154. Doi: 10.1007/BF02437933

Kornhuber, J., Erhard, G., Lenz, B., Kraus, T., Sperling, W., Bayerlein, K., Biermann, T., & Stoessel,

C. (2011). Low Digit Ratio 2D: 4D in Alcohol Dependent Patients.*PloS one*, *6*(4), 1-4. doi:

10.1371/journal.pone.0019332

Krueger, R. F., Markon, K. E., Patrick, C. J., & Iacono, W. G. (2005). Externalizing

psychopathology in adulthood: a dimensional-spectrum conceptualization and its

implications for DSM-V. *Journal of Abnormal Psychology*, *114*(4), 537. doi:

10.1037/0021-843X.114.4.537

Lindová, J., Hrušková, M., Pivoňková, V., Kuběna, A., & Flegr, J. (2008). Digit ratio (2D: 4D) and

Cattell's personality traits. *European Journal of Personality*, *22(4),* 347-356.

doi:10.1002/per.664

Lippa, R. A. (2006). Finger lengths, 2D: 4D ratios, and their relation to gender-related

personality traits and the Big Five. *Biological Psychology*, *71*(1), 116-121. doi:

10.1016/j.biopsycho.2005.02.004

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(5),* 959-966. doi:

10.1016/j.paid.2005.03.016

MacDonald, D. A. (2000). Spirituality: Description, measurement, and relation to the five factor

model of personality. *Journal of personality*, *68*(1), 153-197. doi: 10.1111/1467-

6494.t01-1-00094

Manning, J. T. (2002). The ratio of 2nd to 4th digit length and performance in skiing. *The Journal

of sports medicine and physical fitness*, *42*(4), 446-450. Retrieved from:

http://europepmc.org/abstract/MED/12391439

Manning, J. T., & Bundred, P. E. (2000). The ratio of 2nd to 4th digit length: A new predictor of

disease predisposition?. *Medical hypotheses*, *54*(5), 855-857. doi:

10.1054/mehy.1999.1150

Manning, J. T., Morris, L., & Caswell, N. (2007). Endurance running and digit ratio (2D: 4D):

implications for fetal testosterone effects on running speed and vascular health.

American Journal of Human Biology, *19*(3), 416-421. doi: 10.1002/ajhb.20603

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*(3), 344-

348. doi: 10.1016/j.paid.2010.10.016

McCrae, R. R., & Costa Jr, P. T. (1997). Personality trait structure as a human universal.

American psychologist, *52*(5), 509. doi: 10.1037/0003-066X.52.5.509

McIntyre, M. H., Barrett, E. S., McDermott, R., Johnson, D. D., Cowden, J., & Rosen, S. P. (2007).

Finger length ratio (2D: 4D) and sex differences in aggression during a simulated war

game. *Personality and Individual Differences*, *42*(4), 755-764. doi:

10.1016/j.paid.2006.08.009

Meehan, K. B., De Panfilis, C., Cain, N. M., & Clarkin, J. F. (2013). Effortful control and

externalizing problems in young adults. *Personality and Individual Differences*. doi:

10.1016/j.paid.2013.04.019

Miller, T. Q., Smith, T. W., Turner, C. W., Guijarro, M. L., & Hallet, A. J. (1996). Meta-analytic

review of research on hostility and physical health. *Psychological bulletin*, *119*(2), 322.

doi: 10.1037/0033-2909.119.2.322

Ozer, D. J., & Benet-Martinez, V. (2006). Personality and the prediction of consequential

outcomes. *Annu. Rev. Psychol.*, *57*, 401-421. doi:

10.1146/annurev.psych.57.102904.190127

Paul, S. N., Kato, B. S., Cherkas, L. F., Andrew, T., & Spector, T. D. (2006). Heritability of the

second to fourth digit ratio (2d: 4d): A twin study. *Twin Research and Human Genetics*,

9(2), 215-219. doi: 10.1375/183242706776382491

Paunonen, S. V. (2003). Big Five factors of personality and replicated predictions of behavior.

Journal of Personality and Social Psychology, *84*(2), 411. doi: 10.1037/0022-

3514.84.2.411

Robinson, S. J., & Manning, J. T. (2000). The ratio of 2nd to 4th digit length and male

homosexuality. *Evolution and Human Behavior*, *21*(5), 333-345. doi:10.1016/S1090-

5138(00)00052-0

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*(3), 182-199. doi:

10.1016/j.evolhumbehav.2004.03.005

Trull, T. J., & Sher, K. J. (1994). Relationship between the five-factor model of personality and

Axis I disorders in a nonclinical sample. *Journal of abnormal psychology*, *103*(2), 350.

doi: 10.1037/0021-843X.103.2.350

Venables, N. C., & Patrick, C. J. (2012). Validity of the Externalizing Spectrum Inventory in a

criminal offender sample: Relations with disinhibitory psychopathology, personality, and

psychopathic features. *Psychological assessment*, *24*(1), 88-100. doi: 0.1037/a0024703

Wade, T. J., Shanley, A., & Imm, M. (2004). Second to fourth digit ratios and individual

differences in women's self-perceived attractiveness, self-esteem, and body-esteem.

Personality and individual differences, *37*(4), 799-804. doi: 10.1016/j.paid.2003.11.005

Williams, T. J., Pepitone, M. E., Christensen, S. E., Cooke, B. M., Huberman, A. D., Breedlove, N.

J., & Breedlove, S. M. (2000). Finger-length ratios and sexual orientation. *Nature*,

404(67), 455-456. doi: 10.1038/35006555

Wood, P. B., Cochran, J. K., Pfefferbaum, B., & Arneklev, B. J. (1995). Sensation-seeking and

delinquent substance use: An extension of learning theory. *Journal of Drug Issues, 25*(1),

175-193.

Appendix A

Table 1

		Neuroticism	Agreeableness	Extraversion	Openness	Conscientiousness
Male Left 2D:4D	Pearson Correlation	.083	.109	-.067	.223**	-.019
	Sig. (2-tailed)	.306	.177	.405	.005	.816
Male Right 2D:4D	Pearson Correlation	-.042	.109	-.038	.061	.096
	Sig. (2-tailed)	.607	.176	.638	.453	.236
Female Right 2D:4D	Pearson Correlation	-.104	-.070	.074	.173*	.071
	Sig. (2-tailed)	.203	.390	.364	.033	.383
Female Left 2D:4D	Pearson Correlation	.006	-.100	-.003	.135	-.017
	Sig. (2-tailed)	.937	.223	.971	.096	.838

*Indicates significant at p=.05

**Indicates significant at p=.01

Appendix B

Table 2

		Openness	Intellect	Assertiveness	Enthusiasm	Orderliness
Male Left 2D:4D	Pearson Correlation	.210**	.141	-.045	-.042	-.017
	Sig. (2-tailed)	.009	.083	.584	.609	.834
Male Right 2D:4D	Pearson Correlation	.083	.003	-.021	-.026	.059
	Sig. (2-tailed)	.308	.968	.799	.745	.465
Female Left 2D:4D	Pearson Correlation	.114	.112	.071	-.074	-.016
	Sig. (2-tailed)	.157	.164	.377	.359	.846
Female Right 2D:4D	Pearson Correlation	.111	.192*	.103	.002	-.057
	Sig. (2-tailed)	.170	.017	.201	.977	.489

		Industriousness	Politeness	Compassion	Withdrawal	Volatility
Male Left 2D:4D	Pearson Correlation	-.030	-.023	.197*	.158	-.005
	Sig. (2-tailed)	.716	.775	.015	.051	.946
Male Right 2D:4D	Pearson Correlation	.096	.082	.092	.067	-.130
	Sig. (2-tailed)	.236	.311	.257	.414	.110
Female Left 2D:4D	Pearson Correlation	.031	-.097	-.068	.003	.002
	Sig. (2-tailed)	.701	.230	.403	.970	.976
Female Right 2D:4D	Pearson Correlation	.149	-.053	-.036	-.079	-.103
	Sig. (2-tailed)	.064	.515	.657	.332	.203

*Indicates significant at the p=.05 level

**Indicated significant at the p=.01 level

Appendix C

Table 3

Right or Left 2D:4D		Alcohol Use	Alienation	Blame Externalization	Boredom Proneness	Destructive Aggression	Drug Problems	Drug Use
Left 2D:4D	Correlation	-.076	-0.65	-.068	-.056	-.026	.067	.074
	Significance (2-tailed)	.184	.259	.235	.330	.652	.242	.199
Right 2D:4D	Correlation	-.038	-.010	-.118*	-.028	-.042	.020	-.024
	Significance (2-tailed)	.509	.857	.040	.625	.459	.731	.671

Right or Left 2D:4D		Empathy	Excitement Seeking	Fraud	Honesty	Impatience	Irresponsibility	Marijuana Problems
Left 2D:4D	Correlation	.056	-.025	-.087	.053	-.003	-.025	.018
	Significance (2-tailed)	.328	.66	.131	.357	.953	.665	.758
Right 2D:4D	Correlation	.009	-.045	.069	.098	-.033	-.013	-.040
	Significance (2-tailed)	.875	.431	.230	.088	.564	.824	.485

Right of Left 2D:4D		Marijuana Use	Physical Aggression	Planful Control	Problematic Impulsivity	Rebelliousness	Relational Aggression	Theft
Left 2D:4D	Correlation	.063	-.136*	.115*	-.067	.041	-.061	.005
	Significance (2-tailed)	.274	.017	.044	.245	.470	.284	.936
Right 2D:4D	Correlation	-.055	-.043	.086	-.054	-.002	.003	-.026
	Significance (2-tailed)	.337	.450	.133	.343	.977	.955	.652

*Indicates significant at the p=.05 level