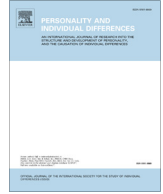




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Short Communication

Associations between digit ratio (2D:4D) and locus of control



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ABSTRACT

The relative lengths of the index and ring fingers (2D:4D), as well as the directional asymmetry between the right and left hands [D(R–L)], are putative measures of prenatal sex hormone exposure. The 2D:4D ratio has been associated with a number of personality traits including neuroticism, agreeableness, extraversion, and openness to experience. The current study therefore aimed to build on these findings by investigating 2D:4D in relation to Rotter's (1966) Locus of Control Questionnaire (LoCQ). Significant positive correlations were observed between LoCQ scores in females and right hand 2D:4D and D(R–L), though no such relationships emerged in males. The findings suggest that differences in concentration and/or sensitivity to prenatal sex hormones may play a role in the development of an individual's locus of control.

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1. Introduction

The relative lengths of the second (index) and fourth (ring) fingers (2D:4D) have been proposed as a biomarker of prenatal sex hormone exposure (Manning, Scutt, Wilson, & Lewis-Jones, 1998; Wilson, 1983). The 2D:4D ratio is a sexually dimorphic trait (males on average displaying relatively longer ring fingers than index fingers compared to females; Manning et al., 1998), emerges prenatally (Malas, Dogan, Evcil, & Desdicoglu, 2006), and shows little plasticity thereafter (Trivers, Manning, & Jacobson, 2006). It has been proposed that 2D:4D is determined by the ratio of testosterone to oestrogen during a critical period of gestation, and that this effect occurs because the frequency of androgen and oestrogen receptors in the fourth finger is greater than in the second finger (Zheng & Cohn, 2011). Due to complications associated with obtaining direct measurements of prenatal testosterone and oestrogen, researchers commonly employ 2D:4D to indirectly assess their influence on cognitive processes and the development of personality traits.

It has been reported that a greater sex difference in 2D:4D occurs in the right hand (Grimbos, Dawood, Burriss, Zucker, & Putz, 2010; Williams et al., 2000). Males, on average, display lower right hand ratios (R2D:4D) than left hand ratios (L2D:4D), though the evidence appears to be less clear in females (Hönekopp & Watson, 2010). However, as directional asymmetry also appears to be related to prenatal androgen action, the difference between

R2D:4D and L2D:4D [D(R–L)] is sometimes used as an additional predictor variable (Manning, 2002).

An area of considerable interest is how 2D:4D may relate to individual differences in personality. Wilson (1983) was the first to investigate such relationships by considering self-measurement of fingers for women and using a qualitative scale of 2D:4D to test links to assertiveness. This study reported that women with low self-measured digit ratios were more likely to describe themselves as assertive and competitive compared to women with high digit ratios – although it should be noted that this result was not significant using a two-tail test. A larger self-report study using continuous-scale finger measurement found a negative correlation between 2D:4D and dominance for both sexes (Manning & Fink, 2008).

Austin, Manning, McInroy, and Mathews (2002) observed negative correlations between 2D:4D and sensation-seeking, thrill seeking, and disinhibition. These authors also reported relationships between 2D:4D and neuroticism and psychoticism as measured by the Eysenck Personality Questionnaire-Revised (Eysenck, Eysenck, & Barrett, 1985). Fink, Manning, and Neave (2004) then investigated relationships between 2D:4D and the 'big five' personality factors, finding R2D:4D in females to correlate positively with neuroticism and negatively with agreeableness. A large-scale study by Lippa (2006) reported 2D:4D to correlate positively with extraversion and negatively with openness to experience. Luxen and Buunk (2005) have also reported positive relationships between R2D:4D and agreeableness in both men and women.

As well as the big five, digit ratios have been related to a number of other personality variables. For instance, high 2D:4D has been associated with 'celebrity worship' in females (Huh, 2012),

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and with superstitious and paranormal beliefs in males (Voracek, 2009); whereas low 2D:4D has been associated with aggression (Bailey & Hurd, 2005; Hönekopp & Watson, 2011), and social, recreational, and financial risk-taking in males (Stenstrom, Saad, Nepomuceno, & Mendenhall, 2011).

The current study aimed to develop this line of research and investigate whether 2D:4D is also associated with a person's locus of control. Locus of control refers to the extent to which an individual believes they can control events affecting them, and is conceptualised as either internal, whereby a person feels that they are in control of their life, or external, by which a person feels that their decisions are controlled by external forces (Rotter, 1966). Locus of control shows marked sexual dimorphism, with females, on average, demonstrating a more external locus of control than males; an effect that has been demonstrated to be stable across cultures (McGinnies, Nordholm, Ward, & Bhanthumnavin, 1974). Locus of control is also known to be associated with a diverse range of behaviours and outcomes, such as stress and depression, (Benassi, Sweeney, & Dufour, 1988), religious belief (Kahoe, 1974), and job satisfaction and performance (Judge & Bono, 2001), suggesting that it is an important and far-reaching dimension of an individual's personality.

Due to the sexually dimorphic nature of locus of control, it is considered likely that differential exposure and/or sensitivity to prenatal sex hormones may influence its development. As females are typically shown to exhibit a higher external locus of control than males, it is suggested that such an external locus reflects high prenatal oestrogen exposure, whereas a high internal locus reflects high prenatal testosterone. It was therefore predicted that scores on Rotter's (1966) Locus of Control Questionnaire would be positively correlated with 2D:4D and D(R–L).

2. Method

2.1. Participants

Two hundred and eleven (106 male, 105 female) students volunteered to participate. The majority of participants were studying at undergraduate level and were opportunity sampled from a university library in the United Kingdom. All participants in the study were Caucasian (White British), and their ages ranged from 18 to 28 ($M = 20.84$, $SD = 1.86$) in males and 18–35 ($M = 20.62$, $SD = 2.43$) in females. Ethical approval was granted by the Psychology Department's Ethics Committee.

2.2. Materials

The Locus of Control Questionnaire (LoCQ; Rotter, 1966) is a 29-item scale designed to measure individual differences in attribution style. Each item is comprised of two statements (one relating to an internal attribution style, the other to an external attribution style) of which the participant is required to endorse the one they agree with more (note that six filler items were excluded from analysis). Low scores indicate an internal attribution style whereas high scores indicate an external attribution style. Cronbach's α for the whole scale was .7.

2.3. Design and procedure

The study utilised a correlational design, with relationships between locus of control and 2D:4D being examined using Pearson's (two-tailed) correlations. Participants were provided with an information sheet prior to consent being recorded, and a small bag of sweets was offered as an incentive to participate.

Demographic information was recorded (age, sex, and ethnicity) prior to completion of the LoCQ.

Each finger relevant to the 2D:4D ratio was measured twice, directly from the palmar (ventral) surface of the hand using vernier callipers (measuring to 0.1 mm). Finger measurement was direct as it has been suggested that indirect finger measurement distorts 2D:4D downwards (Manning, Fink, Neave, & Caswell, 2005). Before recording finger lengths, small ink dots were made at a mid-point on the basal crease (proximal to the palm) of the second and fourth digits in order to increase reliability and repeatability of measurements. Fingers were measured in the following order: R2D, R4D, L2D, L4D, as this method has been demonstrated to give high repeatability (Manning, 2002; Manning et al., 1998). All data collection was conducted on campus or in the researcher's or participants' own homes, and participants were debriefed regarding the nature of the study upon completion.

3. Results

3.1. Representativeness of the sample

Of the 211 participants, 191 completed the LoCQ (the requirement being that all non-filler items were completed), giving a response rate of 90.52%. No differences were observed between those who completed the LoCQ and those who did not in regards to age, $t(209) = .69$, $p = .491$; sex, $\chi^2(1, N = 211) = .201$, $p = .654$; R2D:4D, $t(206) = 1.01$, $p = .313$; L2D:4D, $t(207) = .68$, $p = .497$; or D(R–L), $t(205) = 1.49$, $p = .137$.

3.2. Relationships between 2D:4D and locus of control

The 2D:4D ratio was calculated for each hand by dividing the length of the index finger by the length of the ring finger. Directional asymmetry was then calculated as $D(R-L) = R2D:4D - L2D:4D$. The intraclass correlation coefficient (ICC) was employed to determine the repeatability of measurements (two-way mixed, single measures ICCs with absolute agreement definition were used). Repeatability was high for R2D:4D, $ICC = 0.92$, $F = 23.08$, $p < .001$, L2D:4D, $ICC = 0.89$, $F = 17.29$, $p < .001$, and D(R–L) $ICC = 0.91$, $F = 22.81$, $p < .001$.

Mean R2D:4D was significantly lower in males than in females, $t(206) = 2.08$, $p = .038$, though such an effect was only marginally significant for L2D:4D, $t(207) = 1.87$, $p = .063$. No sex difference was observed for D(R–L), $t(205) = .89$, $p = .377$, and LoCQ scores were significantly higher in females than in males, $t(189) = 2.50$, $p = .013$. For descriptive statistics for all study variables see Table 1.

Pearson's correlations (two-tailed) were conducted in order to determine whether 2D:4D was related to LoCQ scores in males and females. As six separate tests were conducted, Bonferroni

Table 1
Descriptive statistics for 2D:4D variables and LoCQ scores for males and females.

	N	Min	Max	Mean	SD
<i>R2D:4D</i>					
Males	105	.894	1.071	.97	.033
Females	103	.883	1.053	.98	.032
<i>L2D:4D</i>					
Males	104	.903	1.075	.975	.033
Females	105	.896	1.055	.983	.031
<i>D(R–L)</i>					
Males	104	–.048	.05	–.006	.021
Females	103	–.058	.043	–.003	.024
<i>LoCQ</i>					
Males	95	2	21	11.179	3.981
Females	96	5	20	12.563	3.673

adjustment was used to determine the critical value to be $p < .008$. After this correction, significant positive correlations were observed between LoCQ scores and R2D:4D and D(R–L) in females, though no such effects were observed in males. For all correlations see Table 2.

The difference between the correlation coefficients for each hand, and for the right–left 2D:4D difference, were tested. In all cases, even when the correlations were not statistically reliable (such as for L2D:4D), the female effect size was significantly larger than the male effect size: L2D:4D, $z = 2.16$, $p = .02$; R2D:4D, $z = 2.41$, $p < .008$; D(R–L), $z = 2.63$, $p < .004$.

4. Discussion

The current study aimed to investigate relationships between 2D:4D, a putative marker of prenatal sex hormone exposure, and locus of control, a sexually dimorphic personality construct that indicates the extent to which an individual believes they are in control of events that affect their life. Results observed provide evidence to suggest that the development of locus of control may be influenced by exposure and/or sensitivity to prenatal sex hormones.

In accordance with the literature, females exhibited higher 2D:4D (though for the left hand this effect was only marginally significant), and also exhibited more external attribution styles than males. It was predicted that 2D:4D would be positively associated with LoCQ scores. Support for the hypothesis was provided as significant positive correlations were observed between LoCQ scores and both R2D:4D and D(R–L) in females. Though similar relationships were not observed in males, Voracek (2009) suggests that such results may be explainable in terms of ceiling effects. It could be, for instance, that prenatal testosterone influences locus of control up to a certain level, but beyond this point any additional testosterone has little effect. If this is the case, it is possible that any relationship between 2D:4D and locus of control may be negligible or non-existent in males. It should be noted that 2D:4D effects can be influenced by ethnicity, although not explicitly planned, all participants in the study were Caucasian, meaning that these data are not confounded by this factor, but might also be limited to individuals of this ethnic background.

The findings from this study are in line with previous research that has reported relationships between digit ratios and personality traits (e.g. Austin et al., 2002; Fink et al., 2004; Lippa, 2006; Wilson, 1983). However, a feature of the current results was that the findings were restricted to the right hand 2D:4D ratio, and were not noted in the left hand. It is unclear why this should be the case, but this pattern has been previously noted with some personality traits (e.g., Hampson, Ellis, & Tenk, 2008), although is not universally found (see Manning et al., 2005). The main implication of the findings is that not only may prenatal sex hormones directly affect an individual's locus of control, but that they may also indirectly affect a great number of other behavioural and personality traits that rely on locus of control as an underlying mechanism.

Table 2
Person's (two-tailed) correlations between 2D:4D variables and locus of control scores.

	DF	R	p
<i>Males</i>			
R2D:4D	93	.011	.915
L2D:4D	93	.011	.918
D(R–L)	93	.0	.998
<i>Females</i>			
R2D:4D	92	.332	.001
L2D:4D	94	.03	.77
D(R–L)	92	.349	.001

A limitation of the current study is that an undergraduate population is unlikely to be truly representative. It is therefore recommended that future work should utilise a more representative sample. Furthermore, Judge, Erez, Bono, and Thoresen (2002), have suggested that locus of control is not a unidimensional concept, and that it should instead be considered as one of the four dimensions of core self-evaluations (one's fundamental appraisal of one-self; the other three dimensions being neuroticism, self-efficacy, and self-esteem). As previous research (e.g. Fink et al., 2004) has reported associations between high 2D:4D and neuroticism, it is suggested that future work should investigate relationships between digit ratios and self-efficacy and self-esteem.

The current study provides evidence to suggest that phenotypic variance in locus of control may be influenced by differential exposure and/or sensitivity to prenatal sex hormones. Though it is necessary to point out that such effects are likely to be small, and only a single contributing factor amongst many others, due to the far-reaching effects of an individual's locus of control, such an influence should be considered important when discussing the origins and development of personality.

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