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2D:4D digit ratio and types of adult paranormal belief: An attempted replication and extension of Voracek (2009) with a UK sample

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Highlights

1. Females reported (marginally) stronger beliefs in ESP and life after death.
2. Females also reported higher indirect rater-based 2D:4D ratios.
3. Females' direct self-rated 2D:4D correlated positively with their ESP and PK beliefs.
4. Females' direct self-rated functional asymmetry correlated with their PK beliefs.
5. No significant digit-related × paranormal belief associations existed for males.

Abstract

This study examines the extent to which mean digit length (MDL), second-to-fourth digit ratio (2D:4D), digit asymmetry (DA) and fluctuating asymmetry (FA) correlate with belief in three types of alleged paranormal phenomena (extrasensory perception, psychokinesis, and life after death). An opportunistic sample of 275 undergraduate students completed standard paranormal belief and demographics questionnaires with the absolute length of their 2D and 4D on both hands measured by participants themselves (direct self-based measures) as well as by two independent from hand photocopies (indirect rater-based measures). As hypothesised, females presented a lower MDL (both measurement sources) but higher indirect rater-based 2D:4D ratio than males. Additionally, females' left hand 2D:4D correlated positively with their belief in psychokinesis with their right hand 2D:4D correlating with belief in both extrasensory perception and psychokinesis. Females' direct self-based FA was also associated with stronger PK beliefs. These trends did not exist for male participants. Finally, no significant relationships were found between either MDL or DA and any belief type regardless of measurement source, hand or participant sex. Results are discussed in relation to previous work by Voracek (2009) and their support for genetic bio-markers of adult paranormality. Methodological limitations are also considered.

Keywords: Paranormal belief; 2D:4D digit ratio; Genetic; Hormones; Sex Differences

1. Introduction

Numerous studies suggest women are more likely to believe in paranormal concepts such as extrasensory perception (ESP), psychokinesis (PK), and life after death (LAD) than are men. Early writers claimed these sex differences developed as a reaction to feelings of alienation experienced by those with low or marginal status in society which at the time included women (e.g., Emmons & Sobal, 1981). Others have since argued women's heightened paranormality reflects their preference for intuitive over rational thinking (Aarnio & Lindeman, 2005) else a socially constructed gender role stereotype (Simmonds-Moore & Moore, 2009). At present, empirical support for these arguments is either sparse or mixed (Irwin, 2009). Another possibility is that sex differences in adult paranormal belief have a genetic basis. The present study investigates this possibility by testing the degree to which various digit-related measures - mean digit length, 2D:4D digit ratio, digit asymmetry and fluctuating asymmetry - correlate with specific *types* of adult paranormal belief.

1.1 Digit ratio

As its name implies 2D:4D digit ratio reflects the relative length of a person's second digit (2D) to that of their fourth digit (4D). This ratio develops in utero under the influence of Homeobox genes which determine prenatal levels of male and female hormone both of which exert a permanent thus organising effect on brain physiology. Because 2D:4D remains relatively stable post partum, it acts as a retrospective bio-marker for prenatal exposure to testosterone and oestrogen levels and is directly linked to, not only adult physique and sexual development, but also to adult traits, cognitions and behaviour (Manning 2002; 2008).

Digit ratio is sexually dimorphic with females typically displaying higher 2D:4D than males. In general, higher 2D:4D is associated with characteristics typically deemed more feminine in nature with sex-differences, for the most part, robust to variations in measurement protocol (Manning, 2002; 2008; Voracek, Manning, & Dressler, 2007; although

see Ribeiro, Neave, Morais & Manning, 2016). For example, higher (more feminized) 2D:4D has been shown to correlate with a preference for intuitive over reflective decision-making (Bosch-Domènech, Brañas-Garza, & Espín, 2014).

1.2 Digit ratio, asymmetry, length and paranormal belief

To date only one study has examined the relationship between digit ratio and paranormal belief. Voracek (2009) took palmar-view photocopies of participants' right and left hands from which three trained investigators blind to study aims used digital vernier callipers to measure 2D and 4D lengths to .01 mm. Whilst women had higher 2D:4D and more pronounced paranormal and superstitious beliefs than men, their ratio and paranormal belief scores were uncorrelated. Significant ratio × belief correlations did emerge for men however; men with a higher (more feminized) 2D:4D ratio reported stronger paranormal and superstitious beliefs than men with a lower (less feminized) 2D:4D ratio. This was true for both left and right hands and persisted even after men's age, years of education, birth dimensions (length and weight), and adult dimensions (height and weight at the time of testing) had been partialled out. These trends existed for both positive superstitions (e.g., the efficacy of lucky charms) and to a lesser extent negative superstitions (e.g. unfavourable outcomes associated with the number thirteen) with one exception; men's right hand 2D:4D failed to correlate with their endorsement of negative superstitions.

In the same study Voracek also examined the relationship paranormal and superstitious beliefs had with right minus left hand 2D:4D difference (D_{R-L}) scores - also termed "directional asymmetry" (DA) - and is thought to be an alternative marker of prenatal testosterone and thus sex-dependent characteristics in adulthood. According to Voracek, Offenmüller and Dressler (2008) DA is the likely cause of much 2D:4D variance.

In general, DA scores are larger and thus more "rightward biased" for women than for men, implicating the existence of two entirely different sex-biased growth programmes which

differ in sensitivity to prenatal androgen levels (Voracek et al., 2008). Consequently, positive DA scores should be associated with more pronounced adult paranormality. But, whilst Voracek (2009) found women presented slightly larger (more rightward biased) DA than men, DA was not related to either paranormal or superstitious beliefs for either sex.

Overall, women tend to have shorter 2D and 4D for both left and right hands with their mean digit length (MDL) across these four digits shorter than that of men (e.g., Voracek, 2009). Because sex differences in 2D and 4D are negligible in pre-pubescent children but large in adult populations, MDL is seen as a putative marker of androgen levels following pubertal-adolescent growth spurts (Manning, 2002; 2008). As such, lower MDL should also be associated with more pronounced paranormal and superstitious worldviews. In partial support of this argument, Voracek (2009) found (near) significant negative associations between MDL and both positive and negative superstitious - but not paranormal - beliefs for women but not men. This suggests comparatively low testosterone levels during the female - but not male - pubertal growth spurts heighten adult superstitiousness but not adult paranormality. But in Voracek's study this relationship disappeared when the same demographic and body measures outlined above were controlled for. Voracek conceded that the association between women's MDL and superstitiousness may, in fact, be spurious (p.108).

Finally, Voracek (2009) examined the extent to which "fluctuating asymmetry" (FA) is associated with adult paranormal and superstitious beliefs. Bodily FA reflects the extent to which bilateral body parts (such as 2D and 4D) randomly deviate from perfect symmetry and is thought to reflect the cumulative effect genomic or environmental factors have on development[1]. Voracek reasoned that greater FA should be linked to stronger paranormal and superstitious worldviews because both are also linked with various forms of adult

psychopathology. Contrary to this argument no sex differences in FA were found with FA unrelated to both paranormal and superstitious beliefs for both sexes.

In sum, Voracek's (2009) findings suggest only higher (more feminized) 2D:4D is linked to paranormal and superstitious thinking in adulthood, with sex differences in these beliefs most likely influenced by prenatal testosterone levels rather than pubertal-adolescent androgen spurts and/or developmental instability. However, there are several issues with this work than render replication necessary. First, virtually all significant associations existed for male participants only who, as already noted, are less inclined to uphold paranormal and superstitious worldviews. In other words, Voracek's findings were in the opposite direction to that hypothesised and as such, cannot explain women's preponderance for endorsing paranormal and superstitious concepts (cf. Irwin, 2009). Second, observed associations were generally small (all *r*'s <.15) with < 3% of belief variance explained by digit ratio (Thalbourne, 2010). Finally, Voracek had 2D:4D measured indirectly from hand photocopies rather than directly from participants' actual hands. Indirect 2D:4D is thought to be less accurate and generally lower than corresponding direct 2D:4D, especially for males (Manning, Fink, Neave & Caswell, 2005; Ribeiro et al., 2016), the implication being that cross-sex correlations are unduly influenced by measurement source. These issues, coupled with the widespread inconsistencies and lack of repeatability common in 2D:4D research (Valla & Ceci, 2011) suggests a replication of Voracek (2009), employing both direct and indirect measurement protocols, is warranted.

1.3 Study overview and hypotheses

The current study investigates the extent to which MDL, 2D:4D digit ratio, DA, and FA scores correlate with *specific* beliefs in three "core" paranormal concepts namely extrasensory perception (ESP), psychokinesis (PK) and life after death (LAD). Participants' self-reported ("direct self-based") digit lengths plus digit lengths derived from hand

photocopies and assessed by two independent and trained judges ("indirect rater-based") are included. In general digit-related measures indicative of greater femininity - hence less prenatal testosterone - should correlate positively with all types of paranormal belief. As such, the following hypotheses are proposed.

First, females will report stronger beliefs in ESP, PK, and LAD than males (H01). Second, females will present shorter MDL, larger (more feminized) 2D:4D digit ratios, larger (more rightward biased) DA and more FA than males (H02 to H05 respectively). Third, females with shorter MDL, larger 2D:4D, larger DA, and larger FA scores will have stronger beliefs in ESP, PK, and LAD (H06 to H09 respectively) with fourth, parallel associations less pronounced for male participants (H10 to H13 respectively). Fifth, the above differences and trends should be equally strong for ESP, PK, and LAD beliefs (H14). Finally, larger/stronger relationships will be found for direct self-based over indirect rater-based measures (H15).

2 Method

2.1 Participants

Undergraduate students (N = 344) were recruited from a large university in North-West England. Of these, 275 returned usable data, a response rate of 79.9%. Most participants were female (77.1%) and of Caucasian ethnicity (94.9%), with age ranging from 18 to 44 years (M = 19.74 years; SD = 3.65 years). No other demographic details were collected.

2.2 Materials

2.1.1 Paranormal Belief: This was assessed via the *Australian Sheep-Goat Scale* (ASGS: Thalbourne & Delin, 1993) a psychometrically sound measure of belief in ESP, PK, and LAD across three subscales (Thalbourne, 2010). Participants rate 18 statements on a 7-point Likert scale from 1 'strongly disagree' to 7 'strongly agree' with items (re)coded such that higher scores reflected stronger belief in each paranormal concept.

2.1.2 Demographics: A standard demographics questionnaire assessing participant's age, sex, and ethnicity (16 categories) was also included.

2.1.3 Digit-Related Measures: Both direct self and indirect rater-based digit lengths were measured. For the former, participants were given a photocopy of the ventral surface of a hand on which the base (i.e. the crease where the finger joins the palm) and tip of both 2D and 4D were marked. This served as an instructive sheet. They were then asked to hold out their left hand, establish the 2D base and, using a ruler provided ensuring this ran up the middle of each digit, measure the distance in millimetres from the mid-point of this crease to the tip of that finger (excluding fingernails). This procedure was repeated for right hand 4D, left hand 2D and left hand 4D.

For indirect rater-based measures, the ventral surface of participants' left and right hands were photocopied onto sheets of A4 paper. Participants were asked to press their hands gently on the copier's glass plate ensuring all fingers were straight and laying flat[2]. Landmark locations at the tip and base of each digit were highlighted on the copy, with the distance between these points measured in millimetres by two trained raters blind to each other's calculations. This method of establishing finger length - and thus 2D:4D ratio - is both common and highly reliable (Caswell & Manning, 2009).

2.3 Procedure

Demographic, paranormal belief and digit length data were collected from an opportunistic sample of undergraduate students. The order of photocopying and questionnaire completion was counterbalanced with all digit-related measures computed according to standard protocols (e.g., Voracek et al., 2007). No incentives were provided with adhering to British Psychological Society (BPS) ethical guidelines.

3 Results

3.1 Paranormal belief

Specific beliefs in ESP, PK, and LAD were all internally reliable (see Table 1). That said, removal of one item ("non-hallucinatory visions") improved the internal reliability of the LAD subscale considerably (from α = .64 to α=.73) with this revised measure subsequently computed. Only ESP beliefs were normally distributed with PK beliefs presenting noticeable positive skew and LAD beliefs slight negative skew. No outliers were found in any belief measure.

*** Table 1 here ***

Mann-Whitney tests revealed (near) significant participant sex differences in two of the three belief subscales with females having (marginally) stronger beliefs in both ESP, U = 5679.5; Z = -1.80; p = .072, and LAD, U = 5447.0; Z = -2.23; p = .026, than males. No sex differences were found in PK beliefs. Thus, H01 is partially supported.

Belief in ESP alone correlated with participant age, *tau* = .12; p = .009; two-tailed; n = 274, with no significant associations found between any paranormal belief type and participants' (Caucasian vs. non-Caucasian) ethnicity.

3.2 Digit-related measures: Preliminary analyses

3.2.1 Inter rater Reliability: Highly significant positive intra-class correlations emerged between raters' independent measurements for 2D and 4D on both hands, all r_1's = 1.00; all p's <.001; two-tailed; n = 273 to 275, with perfect inter- rater reliability found in all cases. Mean digit lengths across the two raters were subsequently computed to generate indirect rater-based measurements (cf. Caswell & Manning, 2009).

3.2.2 Descriptive Data: Normality, skew and means data for direct self and indirect rater-based digit-related measures across relevant digit (2D vs. 4D) × hand (left vs. right) combinations were examined, with variance explained (eta^2) figures calculated following guidelines in Fritz, Morris, and Richler (2012). Of the eighteen digit-related measures thirteen were non-normal as follows: direct self-based 2D and 4D lengths for both left and

right hands, all $Z_{K\text{-}S}$ from.12 to.14; p<.001; indirect rater-based 2D and 4D for the right hand, $Z_{K\text{-}S}$ = .07; p = .006 and $Z_{K\text{-}S}$ = .06; p = .012 respectively; direct self-based MDL, $Z_{K\text{-}S}$ = .12; p<.001; direct self-based 2D:4D ratios for both left and right hands, $Z_{K\text{-}S}$ = .36; p<.001 and $Z_{K\text{-}S}$ = .39; p<.001 respectively; indirect rater-based 2D:4D ratio for the right hand, $Z_{K\text{-}S}$ = .06; p = .027; direct self-based DA, $Z_{K\text{-}S}$ = .37; p<.001; and finally, both direct self-based and indirect rater-based FA, $Z_{K\text{-}S}$ = .16; p<.001 and $Z_{K\text{-}S}$ = .07; p = .007 respectively.

With the Kolgomorov-Smirnov (*K-S*) test sensitive to sample size (Field, 2013), index of skew (*IS*) figures were also examined. Direct self-based MDL was negatively skewed (*IS* = -3.16) whereas indirect rater-based MDL (*IS* = .25) was not. Direct self-based 2D:4D ratios for both left and right hands were also negatively skewed (*IS* = -.18 and -1.30 respectively) unlike indirect rater-based ratios (*IS* = .17 and .18 respectively). Similarly, direct self-based but not indirect rater-based, DA presented slight negative skew (*IS* of -.80 and -.25 respectively). In contrast, direct self and indirect rater-based FA presented positive skew; the former noticeably large (*IS* = 2.77 and .70 respectively). No outliers were removed with all data retained. Subsequent analyses employed non-parametric two-tailed tests.

3.2.3 Measurement Source: Wilcoxon signed-ranks tests revealed direct self-based 2D to be higher than indirect rater-based 2D for both left and right hands, T = -8.92; p<.001 and T = -3.81; p<.001 respectively. The same was also true of indirect rater-based 4D for the left, T = -2.51; p = .011, but not right hand. Subsequent analyses confirmed significant cross-source differences in MDL, T = -5.22; p<.001; in both left and right hand 2D:4D, T = -5.66; p<.001 and T = -2.73; p = .006 respectively; in DA, T = -3.64; p = .006 and finally in FA scores, T = -3.64; p<.001. With one exception, direct self-based scores were higher/larger than their indirect rater–based equivalents; only DA was smaller for self than for indirect rater-based measures.

3.3 Sex differences

Table 2 presents means data for digit-related measures across male versus female participants.

*** Table 2 here ***

Unsurprisingly, females presented shorter MDLs than males. This was true of both direct self-based and indirect rater-based measures, $U = 2825.0$; $Z = -6.95$; $p < .001$ and $U = 2993.5$; $Z = -7.01$; $p < .01$ respectively, with H02 thus fully supported. Whilst direct self-based 2D:4D did not differ across participant sex for either hand, indirect rater-based ratios for both left and right hands did, $U = 5479.5$; $Z = -2.11$; $p = .034$ and $U = 5358.5$; $Z = -2.38$; $p = .017$ respectively, with these significantly higher (more feminized) for females over males. As such, H03 is partially supported. In all cases 2D:4D ratios fell just below unity. In contrast, neither direct self nor indirect rater-based ratio difference scores varied significantly across participant sex, with males and females both displaying near zero DA. H04 is not supported. Finally, neither direct self nor indirect rater-based FA differed across males verses females with, in all cases, FA representing < 3.0% of trait size (cf. Voracek, 2009). H05 is not supported either.

3.4 Associations with participant age and ethnicity

All digit-related measures were unrelated to participants' age and (Caucasian vs. non-Caucasian) ethnicity. These two demographics are no longer considered.

3.5 Associations with paranormal belief: Trends for males vs. females

Correlations between all digit-related measures and the three paranormal belief types are presented separately for male and female participants in Table 3. Corresponding variance explained (eta^2) figures - calculated from guidelines in Walker (2003) – are given in the supplementary Appendix.

*** Table 3 here ***

As Table 3 shows, only four (near) significant correlations were found, First, females' belief in ESP correlated positively with their self-rated right hand 2D:4D. Second, females' belief in PK did likewise with self-rated 2D:4D for both hands, with the right hand correlation marginally significant (p = .058). Finally, females' belief in PK also correlated positively with their self-rated FA. No more than 4% of belief variance was explained by these relationships (see Appendix) which were not replicated for male participants. In sum, there was limited support for H07 and H09 with all other hypotheses unsupported.

3.7 Trends for different paranormal belief types

Of these above (near) significant belief × digit associations, one involved ESP with three involving PK beliefs, with all four of comparable magnitude (*tau-b* from .10 to .12). Some support for H14 was therefore found.

3.8 Direct Self vs. Indirect Rater-Based Digit Measurements

Noticeably, these four the (near) significant correlations existed only for females' direct self-based measures. Some support for H15 was also found.

4. Discussion

For the most part, digit-related scores derived from participants' self-judged digit lengths were higher/larger than those measured by two independent and trained raters. Only DA showed the opposite trend. These findings are consistent with previous claims that indirect 2D:4D is generally lower (and less accurate) than direct 2D:4D (Manning et al., 2005; Ribeiro et al., 2016). All subsequent discussion will take this bias into account.

4.1 Sex differences

As expected, females presented (marginally) stronger ESP and LAD beliefs supporting previous claims of robust sex differences in these paranormal belief types (Irwin, 2009). The lack of parallel sex differences for PK beliefs was surprising. It is worth noting that belief in PK is generally less prevalent than belief in either ESP or LAD, in part because PK is

arguably more controversial and easier to dismiss as a misinterpretation of some natural event (Irwin & Watt, 2007). In this sense, PK belief may be considered a more "extreme" paranormal endorsement with the current lack of sex differences perhaps reflecting this apparent extremity.

As hypothesised, females' 2D and 4D lengths for both hands across both measurement sources - and hence their direct self and indirect rater-based MDLs - were shorter than those of their male counterparts. Contrary to hypotheses, MDLs failed to correlate with any paranormal belief type regardless of measurement source or participant sex. These findings are consistent with those reported by Voracek (2009).

Females also presented larger (more feminized) 2D:4D than males. This was true of both hands further highlighting the sexually dimorphic nature of digit ratios (Manning, 2002, 2008) although here, only for those generated from indirect rater-based assessments. As such, they may be less accurate (cf. Manning et al., 2005; Ribeiro et al., 2016)

Surprisingly females' DA scores did not vary significantly from those of males, with both sexes displaying comparatively little directional asymmetry in digit ratios. Whilst contrary to general trends (Manning, 2002; 2008; Voracek et al., 2007) this finding *is* consistent with Voracek (2009), the implication being that males and females experience prenatal growth programmes that are equally sensitive to in utero androgen levels (cf. Voracek et al., 2008).

Finally, the two sexes were equally prone to FA implying females' biopsychological development is just as sensitive to the cumulative effects of genomic and environmental factors as is that of males. This is consistent with Voracek (2009).

4.2 Associations with paranormal belief: Trends for males vs. females

Females with higher (more feminized) self-rated 2D:4D maintained stronger beliefs in both ESP (both hands) and PK (left hand only) - but not LAD - than those with lower (more masculine) ratios. With self-rated ratios less prone to measurement bias (Manning et al.,

2005; Ribeiro et al., 2016), this suggests that at least some of the variance in female's heightened paranormality may be explained by genetic factors, namely sex differences in prenatal exposure to testosterone and/or oestrogen (Voracek, 2009). But, as with Voracek's work, current associations were weak explaining no more than 4% of belief variance, further highlighting the complex nature of adult paranormality (Irwin, 2009). Furthermore, parallel trends did not exist among male participants. As such, current findings are in direct contrast to those of Voracek (2009) who found more feminized 2D:4D was only associated with heightened (global) paranormal and superstitious beliefs among men. Thus, whilst both studies support the idea that prenatal hormone exposure may influence sex differences in adult paranormality, there is considerable disagreement as to whether this is true for just men, just women, or both.

Current findings seem to add to the various inconsistencies characteristic of 2D:4D research (Valla & Ceci, 2011) and further studies are required to clarify this position. That said, the magnitude of correlation coefficients and thus the percentage of belief variance explained by 2D:4D ratios are comparably small in both studies, with current findings suggesting they exist only with direct self-based measurements.

Contrary to hypotheses, directional asymmetry in 2D:4D ratios (as measured by D_{R-L} scores) were unrelated to specific beliefs in ESP, PK, and LAD. With DA being an alternative bio-marker of prenatal testosterone (Voracek et al., 2008), the suggestion is that this particular male hormone has little influence in shaping adult paranormality. This too is consistent with Voracek (2009).

Likewise, MDL averaged across the four digit × hand combinations failed to correlate with any paranormal belief type regardless of measurement source and/or participant sex. These non-significant findings support those of Voracek (2009) who found MDL was unrelated to *global* paranormal beliefs. And whilst Voracek found women with a longer MDL

had more pronounced superstitious beliefs - the implication being that pubertal-adolescent levels of androgen exposure shape adult superstitiousness but not adult paranormality - he subsequently acknowledged this relationship was most likely spurious (p. 108). Current findings should be interpreted the same way.

Finally, FA scores were, for the most part, also unrelated to ESP, PK, and LAD beliefs again regardless of both measurement source and participants' biological sex. These data are largely consistent with those reported by Voracek (2009). The single exception was that in the present study females with higher self-rated FA were more predisposed to PK beliefs than those with lower self-rated FA. The implication here is that genome and environmental factors in human development somehow shape adult acceptance that physical objects can be moved through "mind control" alone. However, the relatively small *tau-b* and associated eta^2 figures, coupled with concerns over measurement biases (cf. Caswell & Manning, 2009) and inflated alpha rates from multiple testing, means a more parsimonious interpretation is that this too is a statistical artefact.

4.3 Methodological limitations and future research

The current study utilised both direct self and indirect rater based digit related measures and thus offers a direct comparison of differing measurement techniques/sources. With the former likely to be more accurate (Manning et al., 2005; Ribeiro et al., 2016) future studies should employ direct-from-hand rather than indirect-from-photocopy protocols. Several other methodological issues are worthy of mention.

First, one anonymous reviewer suggested the current sample size (N = 275) was rather small compared to other digit ratio studies[3]. Subsequently the current study's statistical "sensitivity" was tested via a retrospective power analysis. With N = 275, alpha set at .05, r ranging from .10 to .12 for two-tailed tests and effect sizes (eta^2) of .03 and .04 entered into *G*Power* (Faul, 2008), analysis revealed power (1-β) figures ranging from .9327 to .9988

indicating a very high - over 93% - chance of detecting genuine effects. In short, Type II errors were unlikely (Field, 2013).

Second, current findings are based on an undergraduate rather than general public sample so are less generalizable than those of Voracek (2009) whose (Austrian) participants came from a wide range of domestic, educational and occupational backgrounds. Present data are also restricted to predominately Caucasian participants with a Westernized socio-cultural background who may hold different paranormal beliefs than those from other ethno-cultural groups (see Irwin, 2009).

Third, current trends are limited to just three (core) parapsychological concepts, namely ESP, PK, and LAD. With women more likely to endorse witchcraft and astrology, and less likely to accept extraterrestrial visitation and extraordinary life forms (Irwin, 2009), it seems pertinent to explore the relationship all digit-related measures have with these beliefs.

Fourth, the present study did not include body dimensions such as participants' weight and length at birth or weight and height at the time of testing. This aspect of Voracek's (2009) work requires independent verification.

Finally, direct comparison between biological verses socio-cultural and/or cognitive factors underlying females' heightened paranormality seems warranted. For example, the extent to which 2D:4D and a preference for intuitive thinking independently predict heightened adult paranormality is worth investigating (cf. Aarnio & Lindeman, 2005; Bosch-Domènech et al., 2014). Other factors such as (scientific) education might also be explored as potential moderators of these relationships (see Irwin, 2009).

4.4 Conclusion

At first glance, current findings appear to suggest belief in certain types of paranormal phenomena, notably psychokinesis and to some extent extrasensory perception, may be shaped by higher exposure to testosterone and oestrogen *in utero* and thus, that genetic

372 factors play some role in determining adult paranormality. But current belief × digit
373 associations are relatively weak, emerge only for direct self-based measures and are in the
374 opposite direction to those reported by Voracek (2009). Further work incorporating direct-
375 from-hand measures of finger length is needed to fully understand the veracity and true
376 magnitude of these effects. It is hoped the present study will stimulate such research.

Footnotes

1. FA is calculated as {Rd |Rd – Ld| / [(Rd + Ld)/2]}/2 where d = 2D and 4D, and is expressed as a percentage of trait size (Voracek, 2009; p.107).
2. Second copies were taken if the base and/or tip of any finger was not clearly defined.
3. Voracek (2009) for instance, sampled 1118 individuals comprising 491 men plus 627 women.

5. References

Aarnio, K., & Lindeman, M. (2005). Paranormal beliefs, education, and thinking styles. *Personality & Individual Differences*, **39**(7), 1227-1236. doi: 10.1016/j.paid.2005.04.009.

Bosch-Domènech, A., Brañas-Garza, P., & Espín, A.M. (2014). Can exposure to prenatal sex hormones (2D:4D) predict cognitive reflection? *Psychoneuroendocrinology*, *43*, 1-10. doi:10.1016/j.psyneuen.2014.01.023.

Caswell, N. & Manning, J.T. (2009). A comparison of finger 2D:4D by self-report direct measurement and experimenter measurement from photocopy: Methodological issues. *Archives of Sexual Behavior*, **38**(1), 143-148. doi: 10.1007/s10508-007-9202-3.

Emmons, C.F. & Sobal, J. (1981). Paranormal beliefs: Testing the marginality hypothesis. *Sociological Focus*, **14**(1), 49-56. doi: 10. 1080/00380237.1981.10570381.

Faul, F. (2008). *G*Power Version 3.0.10.* University of Kiel, Germany. Available online via http://download.cnet.com/G-Power/3000-2054_4-10647044.html. (Accessed 06 July 2016).

Field, A. (2013). *Discovering statistics using IBM SPSS statistics (4th ed.).* London: Sage

Fritz, C.O., Morris, P.E., & Richler, J.J. (2012). Effect size estimates: Current use, calculations, and interpretation. *Journal of Experimental Psychology: General*, **141**(1), 2-18. doi:10.1037/a0024338.

Irwin, H.J. (2009). *The psychology of paranormal belief: A researcher's handbook.* Hatfield, Hertfordshire, UK: University of Hertfordshire Press.

Irwin, H.J., & Watt, C. A. (2007). *An introduction to parapsychology* (5th ed.). Jefferson, NC, US: McFarland.

Manning, J.T. (2002). *Digit ratio: A pointer to fertility, behaviour & health*. New Brunswick, NJ, US: Rutgers University Press.

Manning, J.T. (2008). *The finger ratio*. London, UK: Faber and Faber.

Manning, J.T., Fink, B., Neave, N., & Caswell, N. (2005). Photocopies yield lower digit ratios (2D:4D) than direct finger measurements. *Archives of Sexual Behavior*, **34**(3), 329-333. doi:10.1007/s10508-005-3121-y.

Ribeiro, E. Neave, N., Morais, R.N. & Manning, J.T. (2016). Direct versus indirect measurement of digit ratio (2D:4D): A critical review of the literature and new data. *Evolutionary Psychology,* Jan-Mar 2016, 1–8. doi: 10.1177/1474704916632536.

Simmonds-Moore, C.A., & Moore, S.L. (2009). Exploring how gender role and boundary thinness relate to paranormal experiences, beliefs and performance on a forced-choice clairvoyance task. *Journal of the Society for Psychical Research,* **73**(896[3]), 129-149.

Thalbourne, M.A. (2010). The Australian Sheep-Goat Scale: Development and empirical findings. *Australian Journal of Parapsychology,* **10***(1),* 5-39.

Thalbourne, M.A. & Delin. P.S (1993). A new instrument for measuring the sheep-goat variable: Its psychometric properties and factor structure. *Journal of Society for Psychical Research,* **59**(832), 172-186.

Valla, J.M., & Ceci, S.J. (2011). Can sex differences in science be tied to the long reach of prenatal hormones? Brain organization theory, digit ratio (2D/4D), and sex differences in preferences and cognition. *Perspectives on Psychological Science*, **6**(2), 134-146. doi:10.1177/1745691611400236.

Voracek, M. (2009). Who wants to believe? Associations between digit ratio (2D:4D) and paranormal and superstitious beliefs. *Personality & Individual Differences*, **47**(2), 105-109. doi: 10.1016/j.paid.2009.01.051.

Voracek, M., Manning, J.T. & Dressler, S.G. (2007). Repeatability and interobserver error in digit ratio (2D:4D) measurements made by experts. *American Journal of Human Biology,* **19**(1*)*, 142-146. doi: 10.1002/ajhb.20581.

Voracek, M., Offenmüller, D., & Dressler, S.G. (2008). Sex differences in directional asymmetry of digit length and its effects on sex differences in digit ratio (2D:4D). *Perceptual & Motor Skills*, **107**(2), 576-586. doi:10.2466/PMS.107.6.576-586.

Walker, D.A., (2003). JMASM9: Converting Kendall's Tau for correlational or meta-analytic analyses. *Journal of Modern Applied Statistical Methods*, **2**(2), 525-530.

Table 1: Internal reliability, skew, normality and descriptive data for paranormal belief types across participant sex

Belief	Reliability[a]	Skew		Normality[b]			Males		Females		Sig.		*Eta²*
		M	(*SD*)	$Z_{K\text{-}S}$	*p*		*M*	(*SD*)	*M*	(*SD*)	Effects		
	α												
ESP	.89	.04	(.15)	.05	.062	*a*	3.14	(1.17)	3.48	(1.18)	S	*a*	.01
PK	.85	.62	(.15)	.17	<.001	***	2.16	(1.11)	2.38	(1.13)	S		.01
LAD	.73	-.27	(.15)	.11	<.001	***	3.92	(1.62)	4.43	(1.69)	S	*	.02

Key: *Extrasensory Perception* (ESP); *Psychokinesis* (PK) and *Life After Death* (LAD) beliefs. [a]Final Cronbach's alpha (α) coefficients. [b]Kolgomorov-Smirnov (K-S) test where df = 273. Sig. non-normality and Respondent Sex effects (S) at the *p <.05 level; a = approaches significance (two-tailed; n_{males} = 62 to 63; $n_{females}$ = 210 to 212; n_{all} = 273 to 275)

Table 2: Descriptives and effects for digit-related measures across participant sex

Measure	Source	Hand	Digit(s)	Males		Females		Sig.		*Eta*^{2}
				M	(*SD*)	*M*	(*SD*)	Effects		
MDL	Direct self	Both	all	74.85	(7.84)	69.92	(6.80)	S	***	.18
	Indirect rater	Both	all	74.66	(4.54)	69.62	(4.24)	S	***	.18
2D:4D	Direct self	Left	2D:4D	.98	(.07)	.98	(.07)			.00
		Right	2D:4D	.98	(.07)	.99	(.06)			.00
	Indirect rater	Left	2D:4D	.95	(.03)	.96	(.04)	S	*	.02
		Right	2D:4D	.97	(.03)	.98	(.03)	S	*	.02
DA	Direct self	Both	D_{R-L}	.00	(.05)	.01	(.06)			.00
	Indirect rater	Both	D_{R-L}	.02	(.03)	.02	(.03)			.00
FA	Direct self	Both	$f(D_R,D_L)$	2.32	(2.25)	2.22	(1.97)			.00
	Indirect rater	Both	$f(D_R,D_L)$	1.95	(1.13)	2.02	(1.15)			.00

Key: *Mean Digit Length* (MDL); *Second-to-Fourth Digit Ratio* (2D:4D); *Differential Asymmetry* (DA); *Functional Asymmetry* (FA). Respondent Sex effects (S) at the **p* <.05, ***p*<.01 and ****p*<.001 levels (two-tailed; n_{males} = 62 to 63; $n_{females}$ = 210 to 212; n_{all} = 273 to 275).

Table 3: Correlations (*tau-b*) between digit-related measures and paranormal belief types by measurement source, hand, digit type & participant sex

Measure	Source	Hand	Digit(s)	Males			Females				
				ESP	PK	LAD	ESP	PK		LAD	
MDL	Direct self	Both	all	-.04	-.08	-.01	.01	-.01		.02	
	Indirect rater	Both	all	.01	-.03	-.01	-.02	-.06		.06	
2D:4D	Direct self	Left	2D:4D	.11	.02	.05	.07	.12	*	.03	
		Right	2D:4D	.10	.10	.11	.11	* .11	*a*	.05	
	Indirect rater	Left	2D:4D	.12	.16	.13	-.02	.04		.00	
		Right	2D:4D	.07	.07	.14	.00	.04		-.04	
DA	Direct self	Both	D_{R-L}	-.02	.06	.04	.04	-.02		.04	
	Indirect rater	Both	D_{R-L}	.02	-.01	.03	.02	.01		-.07	
FA	Direct self	Both	$f(D_R,D_L)$	-.11	-.08	-.15	.03	.10	*	-.02	
	Indirect rater	Both	$f(D_R,D_L)$	.03	.00	.03	-.02	-.01		.02	

Key: *Mean Digit Length* (MDL); *Second-to-Fourth Digit Ratio* (2D:4D); *Differential Asymmetry* (DA); *Functional Asymmetry* (FA). Sig. at the *p <.05 level; *a* = approaches significance (two-tailed; n_{males} = 62 to 63; $n_{females}$ = 210 to 212).