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.

1   **Abstract**

2   This study examines the extent to which mean digit length (MDL), second-to-fourth digit

3   ratio (2D:4D), digit asymmetry (DA) and fluctuating asymmetry (FA) correlate with belief in

4   three types of alleged paranormal phenomena (extrasensory perception, psychokinesis, and

5   life after death). An opportunistic sample of 275 undergraduate students completed standard

6   paranormal belief and demographics questionnaires with the absolute length of their 2D and

7   4D on both hands measured by participants themselves (direct self-based measures) as well

8   as by two independent from hand photocopies (indirect rater-based measures). As

9   hypothesised, females presented a lower MDL (both measurement sources) but higher

10   indirect rater-based 2D:4D ratio than males. Additionally, females' left hand 2D:4D

11   correlated positively with their belief in psychokinesis with their right hand 2D:4D

12   correlating with belief in both extrasensory perception and psychokinesis. Females' direct

13   self-based FA was also associated with stronger PK beliefs. These trends did not exist for

14   male participants. Finally, no significant relationships were found between either MDL or

15   DA and any belief type regardless of measurement source, hand or participant sex. Results

16   are discussed in relation to previous work by Voracek (2009) and their support for genetic

17   bio-markers of adult paranormality. Methodological limitations are also considered.

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24   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

50   see Ribeiro, Neave, Morais & Manning, 2016). For example, higher (more feminized) 2D:4D

51   has been shown to correlate with a preference for intuitive over reflective decision-making

52   (Bosch-Domènech, Brañas-Garza, & Espín, 2014).

53   *1.2 Digit ratio, asymmetry, length and paranormal belief*

54   To date only one study has examined the relationship between digit ratio and paranormal

55   belief. Voracek (2009) took palmar-view photocopies of participants' right and left hands

56   from which three trained investigators blind to study aims used digital vernier callipers to

57   measure 2D and 4D lengths to .01 mm. Whilst women had higher 2D:4D and more

58   pronounced paranormal and superstitious beliefs than men, their ratio and paranormal belief

59   scores were uncorrelated. Significant ratio × belief correlations did emerge for men however;

60   men with a higher (more feminized) 2D:4D ratio reported stronger paranormal and

61   superstitious beliefs than men with a lower (less feminized) 2D:4D ratio. This was true for

62   both left and right hands and persisted even after men's age, years of education, birth

63   dimensions (length and weight), and adult dimensions (height and weight at the time of

64   testing) had been partialled out. These trends existed for both positive superstitions (e.g., the

65   efficacy of lucky charms) and to a lesser extent negative superstitions (e.g. unfavourable

66   outcomes associated with the number thirteen) with one exception; men's right hand 2D:4D

67   failed to correlate with their endorsement of negative superstitions.

68   In the same study Voracek also examined the relationship paranormal and superstitious

69   beliefs had with right minus left hand 2D:4D difference (D_{R-L}) scores - also termed

70   "directional asymmetry" (DA) - and is thought to be an alternative marker of prenatal

71   testosterone and thus sex-dependent characteristics in adulthood. According to Voracek,

72   Offenmüller and Dressler (2008) DA is the likely cause of much 2D:4D variance.

73   In general, DA scores are larger and thus more "rightward biased" for women than for

74   men, implicating the existence of two entirely different sex-biased growth programmes which

75   differ in sensitivity to prenatal androgen levels (Voracek et al., 2008). Consequently, positive

76   DA scores should be associated with more pronounced adult paranormality. But, whilst

77   Voracek (2009) found women presented slightly larger (more rightward biased) DA than

78   men, DA was not related to either paranormal or superstitious beliefs for either sex.

79   Overall, women tend to have shorter 2D and 4D for both left and right hands with their

80   mean digit length (MDL) across these four digits shorter than that of men (e.g., Voracek,

81   2009). Because sex differences in 2D and 4D are negligible in pre-pubescent children but

82   large in adult populations, MDL is seen as a putative marker of androgen levels following

83   pubertal-adolescent growth spurts (Manning, 2002; 2008). As such, lower MDL should also

84   be associated with more pronounced paranormal and superstitious worldviews. In partial

85   support of this argument, Voracek (2009) found (near) significant negative associations

86   between MDL and both positive and negative superstitious - but not paranormal - beliefs for

87   women but not men. This suggests comparatively low testosterone levels during the female -

88   but not male - pubertal growth spurts heighten adult superstitiousness but not adult

89   paranormality. But in Voracek's study this relationship disappeared when the same

90   demographic and body measures outlined above were controlled for. Voracek conceded that

91   the association between women's MDL and superstitiousness may, in fact, be spurious

92   (p.108).

93   Finally, Voracek (2009) examined the extent to which "fluctuating asymmetry" (FA) is

94   associated with adult paranormal and superstitious beliefs. Bodily FA reflects the extent to

95   which bilateral body parts (such as 2D and 4D) randomly deviate from perfect symmetry and

96   is thought to reflect the cumulative effect genomic or environmental factors have on

97   development[1]. Voracek reasoned that greater FA should be linked to stronger paranormal and

98   superstitious worldviews because both are also linked with various forms of adult

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99 psychopathology. Contrary to this argument no sex differences in FA were found with FA

100 unrelated to both paranormal and superstitious beliefs for both sexes.

101 In sum, Voracek's (2009) findings suggest only higher (more feminized) 2D:4D is linked

102 to paranormal and superstitious thinking in adulthood, with sex differences in these beliefs

103 most likely influenced by prenatal testosterone levels rather than pubertal-adolescent

104 androgen spurts and/or developmental instability. However, there are several issues with this

105 work than render replication necessary. First, virtually all significant associations existed for

106 male participants only who, as already noted, are less inclined to uphold paranormal and

107 superstitious worldviews. In other words, Voracek's findings were in the opposite direction to

108 that hypothesised and as such, cannot explain women's preponderance for endorsing

109 paranormal and superstitious concepts (cf. Irwin, 2009). Second, observed associations were

110 generally small (all r's <.15) with < 3% of belief variance explained by digit ratio

111 (Thalbourne, 2010). Finally, Voracek had 2D:4D measured indirectly from hand photocopies

112 rather than directly from participants' actual hands. Indirect 2D:4D is thought to be less

113 accurate and generally lower than corresponding direct 2D:4D, especially for males

114 (Manning, Fink, Neave & Caswell, 2005; Ribeiro et al., 2016), the implication being that

115 cross-sex correlations are unduly influenced by measurement source. These issues, coupled

116 with the widespread inconsistencies and lack of repeatability common in 2D:4D research

117 (Valla & Ceci, 2011) suggests a replication of Voracek (2009), employing both direct and

118 indirect measurement protocols, is warranted.

119 *1.3 Study overview and hypotheses*

120 The current study investigates the extent to which MDL, 2D:4D digit ratio, DA, and FA

121 scores correlate with *specific* beliefs in three "core" paranormal concepts namely

122 extrasensory perception (ESP), psychokinesis (PK) and life after death (LAD). Participants'

123 self-reported ("direct self-based") digit lengths plus digit lengths derived from hand

124   photocopies and assessed by two independent and trained judges ("indirect rater-based") are

125   included. In general digit-related measures indicative of greater femininity - hence less

126   prenatal testosterone - should correlate positively with all types of paranormal belief. As

127   such, the following hypotheses are proposed.

128   First, females will report stronger beliefs in ESP, PK, and LAD than males (H01). Second,

129   females will present shorter MDL, larger (more feminized) 2D:4D digit ratios, larger (more

130   rightward biased) DA and more FA than males (H02 to H05 respectively). Third, females

131   with shorter MDL, larger 2D:4D, larger DA, and larger FA scores will have stronger beliefs

132   in ESP, PK, and LAD (H06 to H09 respectively) with fourth, parallel associations less

133   pronounced for male participants (H10 to H13 respectively). Fifth, the above differences and

134   trends should be equally strong for ESP, PK, and LAD beliefs (H14). Finally, larger/stronger

135   relationships will be found for direct self-based over indirect rater-based measures (H15).

136   **2 Method**

137   ***2.1 Participants***

138   Undergraduate students ($N = 344$) were recruited from a large university in North-West

139   England. Of these, 275 returned usable data, a response rate of 79.9%. Most participants were

140   female (77.1%) and of Caucasian ethnicity (94.9%), with age ranging from 18 to 44 years (M

141    $= 19.74$ years; $SD = 3.65$ years). No other demographic details were collected.

142   ***2.2 Materials***

143   *2.1.1 Paranormal Belief:* This was assessed via the *Australian Sheep-Goat Scale* (ASGS:

144   Thalbourne & Delin, 1993) a psychometrically sound measure of belief in ESP, PK, and

145   LAD across three subscales (Thalbourne, 2010). Participants rate 18 statements on a 7-point

146   Likert scale from 1 'strongly disagree' to 7 'strongly agree' with items (re)coded such that

147   higher scores reflected stronger belief in each paranormal concept.

148   *2.1.2 Demographics*: A standard demographics questionnaire assessing participant's age,

149   sex, and ethnicity (16 categories) was also included.

150   *2.1.3 Digit-Related Measures*: Both direct self and indirect rater-based digit lengths were

151   measured. For the former, participants were given a photocopy of the ventral surface of a

152   hand on which the base (i.e. the crease where the finger joins the palm) and tip of both 2D

153   and 4D were marked. This served as an instructive sheet. They were then asked to hold out

154   their left hand, establish the 2D base and, using a ruler provided ensuring this ran up the

155   middle of each digit, measure the distance in millimetres from the mid-point of this crease to

156   the tip of that finger (excluding fingernails). This procedure was repeated for right hand 4D,

157   left hand 2D and left hand 4D.

158   For indirect rater-based measures, the ventral surface of participants' left and right hands

159   were photocopied onto sheets of A4 paper. Participants were asked to press their hands gently

160   on the copier's glass plate ensuring all fingers were straight and laying flat[2]. Landmark

161   locations at the tip and base of each digit were highlighted on the copy, with the distance

162   between these points measured in millimetres by two trained raters blind to each other's

163   calculations. This method of establishing finger length - and thus 2D:4D ratio - is both

164   common and highly reliable (Caswell & Manning, 2009).

165   **2.3 Procedure**

166   Demographic, paranormal belief and digit length data were collected from an

167   opportunistic sample of undergraduate students. The order of photocopying and questionnaire

168   completion was counterbalanced with all digit-related measures computed according to

169   standard protocols (e.g., Voracek et al., 2007). No incentives were provided with adhering to

170   British Psychological Society (BPS) ethical guidelines.

171   **3 Results**

172   *3.1 Paranormal belief*

173 Specific beliefs in ESP, PK, and LAD were all internally reliable (see Table 1). That said,

174 removal of one item ("non-hallucinatory visions") improved the internal reliability of the

175 LAD subscale considerably (from $\alpha = .64$ to $\alpha = .73$) with this revised measure subsequently

176 computed. Only ESP beliefs were normally distributed with PK beliefs presenting noticeable

177 positive skew and LAD beliefs slight negative skew. No outliers were found in any belief

178 measure.

179   *** Table 1 here ***

180 Mann-Whitney tests revealed (near) significant participant sex differences in two of the

181 three belief subscales with females having (marginally) stronger beliefs in both ESP, $U =$

182 5679.5; $Z = -1.80$; $p = .072$, and LAD, $U = 5447.0$; $Z = -2.23$; $p = .026$, than males. No sex

183 differences were found in PK beliefs. Thus, H01 is partially supported.

184 Belief in ESP alone correlated with participant age, $tau = .12$; $p = .009$; two-tailed; $n =$

185 274, with no significant associations found between any paranormal belief type and

186 participants' (Caucasian vs. non-Caucasian) ethnicity.

187 ***3.2 Digit-related measures: Preliminary analyses***

188 *3.2.1 Inter rater Reliability*: Highly significant positive intra-class correlations emerged

189 between raters' independent measurements for 2D and 4D on both hands, all r_I's = 1.00; all

190 p's <.001; two-tailed; $n = 273$ to 275, with perfect inter- rater reliability found in all cases.

191 Mean digit lengths across the two raters were subsequently computed to generate indirect

192 rater-based measurements (cf. Caswell & Manning, 2009).

193 *3.2.2 Descriptive Data:* Normality, skew and means data for direct self and indirect rater-

194 based digit-related measures across relevant digit (2D vs. 4D) × hand (left vs. right)

195 combinations were examined, with variance explained (eta^2) figures calculated following

196 guidelines in Fritz, Morris, and Richler (2012). Of the eighteen digit-related measures

197 thirteen were non-normal as follows: direct self-based 2D and 4D lengths for both left and

198   right hands, all $Z_{K\text{-}S}$ from .12 to .14; $p<.001$; indirect rater-based 2D and 4D for the right hand,

199     $Z_{K\text{-}S} = .07$; $p = .006$ and $Z_{K\text{-}S} = .06$; $p = .012$ respectively; direct self-based MDL, $Z_{K\text{-}S} = .12$;

200     $p<.001$; direct self-based 2D:4D ratios for both left and right hands, $Z_{K\text{-}S} = .36$; $p<.001$ and

201     $Z_{K\text{-}S} = .39$; $p<.001$ respectively; indirect rater-based 2D:4D ratio for the right hand, $Z_{K\text{-}S} = .06$;

202     $p = .027$; direct self-based DA, $Z_{K\text{-}S} = .37$; $p<.001$; and finally, both direct self-based and

203   indirect rater-based FA, $Z_{K\text{-}S} = .16$; $p<.001$ and $Z_{K\text{-}S} = .07$; $p = .007$ respectively.

204   With the Kolgomorov-Smirnov (*K-S*) test sensitive to sample size (Field, 2013), index of

205   skew (*IS*) figures were also examined. Direct self-based MDL was negatively skewed (*IS* = -

206   3.16) whereas indirect rater-based MDL (*IS* = .25) was not. Direct self-based 2D:4D ratios

207   for both left and right hands were also negatively skewed (*IS* = -.18 and -1.30 respectively)

208   unlike indirect rater-based ratios (*IS* = .17 and .18 respectively). Similarly, direct self-based

209   but not indirect rater-based, DA presented slight negative skew (*IS* of -.80 and -.25

210   respectively). In contrast, direct self and indirect rater-based FA presented positive skew; the

211   former noticeably large (*IS* = 2.77 and .70 respectively). No outliers were removed with all

212   data retained. Subsequent analyses employed non-parametric two-tailed tests.

213   *3.2.3 Measurement Source*: Wilcoxon signed-ranks tests revealed direct self-based 2D to

214   be higher than indirect rater-based 2D for both left and right hands, $T = -8.92$; $p<.001$ and $T =$

215   -3.81; $p<.001$ respectively. The same was also true of indirect rater-based 4D for the left, $T =$

216   -2.51; $p = .011$, but not right hand. Subsequent analyses confirmed significant cross-source

217   differences in MDL, $T = -5.22$; $p<.001$; in both left and right hand 2D:4D, $T = -5.66$; $p<.001$

218   and $T = -2.73$; $p = .006$ respectively; in DA, $T = -3.64$; $p = .006$ and finally in FA scores, $T =$

219   -3.64; $p<.001$. With one exception, direct self-based scores were higher/larger than their

220   indirect rater–based equivalents; only DA was smaller for self than for indirect rater-based

221   measures.

222   **3.3 Sex differences**

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

224   participants.

225   *** Table 2 here ***

226   Unsurprisingly, females presented shorter MDLs than males. This was true of both direct

227   self-based and indirect rater-based measures, $U = 2825.0$; $Z = -6.95$; $p < .001$ and $U =$

228   2993.5; $Z = -7.01$; $p < .01$ respectively, with H02 thus fully supported. Whilst direct self-

229   based 2D:4D did not differ across participant sex for either hand, indirect rater-based ratios

230   for both left and right hands did, $U = 5479.5$; $Z = -2.11$; $p = .034$ and $U = 5358.5$; $Z = -2.38$;

231    $p = .017$ respectively, with these significantly higher (more feminized) for females over

232   males. As such, H03 is partially supported. In all cases 2D:4D ratios fell just below unity. In

233   contrast, neither direct self nor indirect rater-based ratio difference scores varied significantly

234   across participant sex, with males and females both displaying near zero DA. H04 is not

235   supported. Finally, neither direct self nor indirect rater-based FA differed across males verses

236   females with, in all cases, FA representing $< 3.0\%$ of trait size (cf. Voracek, 2009). H05 is

237   not supported either.

3.4 Associations with participant age and ethnicity

239   All digit-related measures were unrelated to participants' age and (Caucasian vs. non-

240   Caucasian) ethnicity. These two demographics are no longer considered.

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

242   Correlations between all digit-related measures and the three paranormal belief types are

243   presented separately for male and female participants in Table 3. Corresponding variance

244   explained (eta^2) figures - calculated from guidelines in Walker (2003) – are given in the

245   supplementary Appendix.

246   *** Table 3 here ***

247   As Table 3 shows, only four (near) significant correlations were found, First, females'

248   belief in ESP correlated positively with their self-rated right hand 2D:4D. Second, females'

249   belief in PK did likewise with self-rated 2D:4D for both hands, with the right hand

250   correlation marginally significant ($p = .058$). Finally, females' belief in PK also correlated

251   positively with their self-rated FA. No more than 4% of belief variance was explained by

252   these relationships (see Appendix) which were not replicated for male participants. In sum,

253   there was limited support for H07 and H09 with all other hypotheses unsupported.

254   *3.7 Trends for different paranormal belief types*

255   Of these above (near) significant belief × digit associations, one involved ESP with three

256   involving PK beliefs, with all four of comparable magnitude (*tau-b* from .10 to .12). Some

257   support for H14 was therefore found.

258   *3.8 Direct Self vs. Indirect Rater-Based Digit Measurements*

259   Noticeably, these four the (near) significant correlations existed only for females' direct

260   self-based measures. Some support for H15 was also found.

261   **4. Discussion**

262   For the most part, digit-related scores derived from participants' self-judged digit lengths

263   were higher/larger than those measured by two independent and trained raters. Only DA

264   showed the opposite trend. These findings are consistent with previous claims that indirect

265   2D:4D is generally lower (and less accurate) than direct 2D:4D (Manning et al., 2005;

266   Ribeiro et al., 2016). All subsequent discussion will take this bias into account.

267   *4.1 Sex differences*

268   As expected, females presented (marginally) stronger ESP and LAD beliefs supporting

269   previous claims of robust sex differences in these paranormal belief types (Irwin, 2009). The

270   lack of parallel sex differences for PK beliefs was surprising. It is worth noting that belief in

271   PK is generally less prevalent than belief in either ESP or LAD, in part because PK is

272   arguably more controversial and easier to dismiss as a misinterpretation of some natural event

273   (Irwin & Watt, 2007). In this sense, PK belief may be considered a more "extreme"

274   paranormal endorsement with the current lack of sex differences perhaps reflecting this

275   apparent extremity.

276   As hypothesised, females' 2D and 4D lengths for both hands across both measurement

277   sources - and hence their direct self and indirect rater-based MDLs - were shorter than those

278   of their male counterparts. Contrary to hypotheses, MDLs failed to correlate with any

279   paranormal belief type regardless of measurement source or participant sex. These findings

280   are consistent with those reported by Voracek (2009).

281   Females also presented larger (more feminized) 2D:4D than males. This was true of both

282   hands further highlighting the sexually dimorphic nature of digit ratios (Manning, 2002,

283   2008) although here, only for those generated from indirect rater-based assessments. As such,

284   they may be less accurate (cf. Manning et al., 2005; Ribeiro et al., 2016)

285   Surprisingly females' DA scores did not vary significantly from those of males, with both

286   sexes displaying comparatively little directional asymmetry in digit ratios. Whilst contrary to

287   general trends (Manning, 2002; 2008; Voracek et al., 2007) this finding *is* consistent with

288   Voracek (2009), the implication being that males and females experience prenatal growth

289   programmes that are equally sensitive to in utero androgen levels (cf. Voracek et al., 2008).

290   Finally, the two sexes were equally prone to FA implying females' biopsychological

291   development is just as sensitive to the cumulative effects of genomic and environmental

292   factors as is that of males. This is consistent with Voracek (2009).

293   *4.2 Associations with paranormal belief: Trends for males vs. females*

294   Females with higher (more feminized) self-rated 2D:4D maintained stronger beliefs in

295   both ESP (both hands) and PK (left hand only) - but not LAD - than those with lower (more

296   masculine) ratios. With self-rated ratios less prone to measurement bias (Manning et al.,

297 2005; Ribeiro et al., 2016), this suggests that at least some of the variance in female's

298 heightened paranormality may be explained by genetic factors, namely sex differences in

299 prenatal exposure to testosterone and/or oestrogen (Voracek, 2009). But, as with Voracek's

300 work, current associations were weak explaining no more than 4% of belief variance, further

301 highlighting the complex nature of adult paranormality (Irwin, 2009). Furthermore, parallel

302 trends did not exist among male participants. As such, current findings are in direct contrast

303 to those of Voracek (2009) who found more feminized 2D:4D was only associated with

304 heightened (global) paranormal and superstitious beliefs among men. Thus, whilst both

305 studies support the idea that prenatal hormone exposure may influence sex differences in

306 adult paranormality, there is considerable disagreement as to whether this is true for just men,

307 just women, or both.

308   Current findings seem to add to the various inconsistencies characteristic of 2D:4D

309 research (Valla & Ceci, 2011) and further studies are required to clarify this position. That

310 said, the magnitude of correlation coefficients and thus the percentage of belief variance

311 explained by 2D:4D ratios are comparably small in both studies, with current findings

312 suggesting they exist only with direct self-based measurements.

313   Contrary to hypotheses, directional asymmetry in 2D:4D ratios (as measured by D_{R-L}

314 scores) were unrelated to specific beliefs in ESP, PK, and LAD. With DA being an alternative

315 bio-marker of prenatal testosterone (Voracek et al., 2008), the suggestion is that this

316 particular male hormone has little influence in shaping adult paranormality. This too is

317 consistent with Voracek (2009).

318   Likewise, MDL averaged across the four digit × hand combinations failed to correlate

319 with any paranormal belief type regardless of measurement source and/or participant sex.

320 These non-significant findings support those of Voracek (2009) who found MDL was

321 unrelated to *global* paranormal beliefs. And whilst Voracek found women with a longer MDL

322   had more pronounced superstitious beliefs - the implication being that pubertal-adolescent

323   levels of androgen exposure shape adult superstitiousness but not adult paranormality - he

324   subsequently acknowledged this relationship was most likely spurious (p. 108). Current

325   findings should be interpreted the same way.

326   Finally, FA scores were, for the most part, also unrelated to ESP, PK, and LAD beliefs

327   again regardless of both measurement source and participants' biological sex. These data are

328   largely consistent with those reported by Voracek (2009). The single exception was that in

329   the present study females with higher self-rated FA were more predisposed to PK beliefs than

330   those with lower self-rated FA. The implication here is that genome and environmental

331   factors in human development somehow shape adult acceptance that physical objects can be

332   moved through "mind control" alone. However, the relatively small *tau-b* and associated *eta²*

333   figures, coupled with concerns over measurement biases (cf. Caswell & Manning, 2009) and

334   inflated alpha rates from multiple testing, means a more parsimonious interpretation is that

335   this too is a statistical artefact.

336   *4.3 Methodological limitations and future research*

337   The current study utilised both direct self and indirect rater based digit related measures

338   and thus offers a direct comparison of differing measurement techniques/sources. With the

339   former likely to be more accurate (Manning et al., 2005; Ribeiro et al., 2016) future studies

340   should employ direct-from-hand rather than indirect-from-photocopy protocols. Several other

341   methodological issues are worthy of mention.

342   First, one anonymous reviewer suggested the current sample size ($N = 275$) was rather

343   small compared to other digit ratio studies[3]. Subsequently the current study's statistical

344   "sensitivity" was tested via a retrospective power analysis. With $N = 275$, alpha set at .05, *r*

345   ranging from .10 to .12 for two-tailed tests and effect sizes (*eta²*) of .03 and .04 entered into

346   *G*Power* (Faul, 2008), analysis revealed power (1-β) figures ranging from .9327 to .9988

347   indicating a very high - over 93% - chance of detecting genuine effects. In short, Type II

348   errors were unlikely (Field, 2013).

349   Second, current findings are based on an undergraduate rather than general public sample

350   so are less generalizable than those of Voracek (2009) whose (Austrian) participants came

351   from a wide range of domestic, educational and occupational backgrounds. Present data are

352   also restricted to predominately Caucasian participants with a Westernized socio-cultural

353   background who may hold different paranormal beliefs than those from other ethno-cultural

354   groups (see Irwin, 2009).

355   Third, current trends are limited to just three (core) parapsychological concepts, namely

356   ESP, PK, and LAD. With women more likely to endorse witchcraft and astrology, and less

357   likely to accept extraterrestrial visitation and extraordinary life forms (Irwin, 2009), it seems

358   pertinent to explore the relationship all digit-related measures have with these beliefs.

359   Fourth, the present study did not include body dimensions such as participants' weight and

360   length at birth or weight and height at the time of testing. This aspect of Voracek's (2009)

361   work requires independent verification.

362   Finally, direct comparison between biological verses socio-cultural and/or cognitive

363   factors underlying females' heightened paranormality seems warranted. For example, the

364   extent to which 2D:4D and a preference for intuitive thinking independently predict

365   heightened adult paranormality is worth investigating (cf. Aarnio & Lindeman, 2005; Bosch-

366   Domènech et al., 2014). Other factors such as (scientific) education might also be explored as

367   potential moderators of these relationships (see Irwin, 2009).

368   *4.4 Conclusion*

369   At first glance, current findings appear to suggest belief in certain types of paranormal

370   phenomena, notably psychokinesis and to some extent extrasensory perception, may be

371   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.

377 **Footnotes**

378   1. FA is calculated as {Rd |Rd – Ld| / [(Rd + Ld)/2]}/2 where d = 2D and 4D, and is

379   expressed as a percentage of trait size (Voracek, 2009; p.107).

380   2. Second copies were taken if the base and/or tip of any finger was not clearly defined.

381   3. Voracek (2009) for instance, sampled 1118 individuals comprising 491 men plus 627

382   women.

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

Belief	Reliability[a] α	Skew		Normality[b]			Males		Females		Sig. Effects	Eta²[2]
		M	(SD)	Z_{K-S}	p		M	(SD)	M	(SD)		
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	(1.1)	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. Effects		Eta^2
				M	(SD)	M	(SD)			
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).

1 **Table 3: Correlations (*tau-b*) between digit-related measures and paranormal belief**
2 **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).

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