Within-person variability in men's facial width-to-height ratio

Robin S. S. Kramer

Background. In recent years, researchers have investigated the relationship between facial width-to-height ratio (FWHR) and a variety of threat and dominance behaviours. The majority of methods involved measuring FWHR from 2D photographs of faces. However, individuals can vary dramatically in their appearance across images, which poses an obvious problem for reliable FWHR measurement. **Methods.** I compared the effect sizes due to the differences between images taken with unconstrained camera parameters (Studies 1 and 2) or varied facial expressions (Study 3) to the effect size due to identity, i.e., the differences between people. In Study 1, images of Hollywood actors were collected from film screenshots, providing the least amount of experimental control. In Study 2, controlled photographs, which only varied in focal length and distance to camera, were analysed. In Study 3, images of different facial expressions, taken in controlled conditions, were measured. **Results.** Analyses revealed that simply varying the focal length and distance between the camera and face had a relatively small effect on FWHR, and therefore may prove less of a problem if uncontrolled in study designs. In contrast, when all camera parameters (including the camera itself) are allowed to vary, the effect size due to identity was greater than the effect of image selection, but the ranking of the identities was significantly altered by the particular image used. Finally, I found significant changes to FWHR when people posed with four of seven emotional expressions in comparison with neutral, and the effect size due to expression was larger than differences due to identity. **Discussion.** The results of these three studies demonstrate that even when head pose is limited to forward facing, changes to the camera parameters and a person's facial expression have sizable effects on FWHR measurement. Therefore, analysing images that fail to constrain some of these variables can lead to noisy and unreliable results, but also relationships caused by previously unconsidered confounds.

1   **Within-person variability in men's facial width-to-height ratio**

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11   **Abstract**

13   **Background.** In recent years, researchers have investigated the relationship between facial

14   width-to-height ratio (FWHR) and a variety of threat and dominance behaviours. The majority of

15   methods involved measuring FWHR from 2D photographs of faces. However, individuals can

16   vary dramatically in their appearance across images, which poses an obvious problem for reliable

17   FWHR measurement.

18   **Methods.** I compared the effect sizes due to the differences between images taken with

19   unconstrained camera parameters (Studies 1 and 2) or varied facial expressions (Study 3) to the

20   effect size due to identity, i.e., the differences between people. In Study 1, images of Hollywood

21   actors were collected from film screenshots, providing the least amount of experimental control.

22   In Study 2, controlled photographs, which only varied in focal length and distance to camera,

23   were analysed. In Study 3, images of different facial expressions, taken in controlled conditions,

24   were measured.

25   **Results.** Analyses revealed that simply varying the focal length and distance between the camera

26   and face had a relatively small effect on FWHR, and therefore may prove less of a problem if

27   uncontrolled in study designs. In contrast, when all camera parameters (including the camera

28   itself) are allowed to vary, the effect size due to identity was greater than the effect of image

29   selection, but the ranking of the identities was significantly altered by the particular image used.

30   Finally, I found significant changes to FWHR when people posed with four of seven emotional

31   expressions in comparison with neutral, and the effect size due to expression was larger than

32   differences due to identity.

33   **Discussion.** The results of these three studies demonstrate that even when head pose is limited to

34   forward facing, changes to the camera parameters and a person's facial expression have sizable

35   effects on FWHR measurement. Therefore, analysing images that fail to constrain some of these

36   variables can lead to noisy and unreliable results, but also relationships caused by previously

37   unconsidered confounds.

39   **Introduction**

40

41   In the last decade, a great deal of research has focussed on one particular facial measure –

42   width-to-height ratio (FWHR; Weston, Friday, & Liò, 2007) – and its predictive power when

43   considering a variety of human behaviours (for meta-analyses, see Geniole et al., 2015;

44   Haselhuhn, Ormiston, & Wong, 2015). Although originally proposed as evidence that sexual

45   selection played a role in shaping the human skull (Weston et al., 2007), researchers have

46   subsequently found associations between FWHR and aggression, dominance, and threat

47   behaviours in several domains (e.g., Carré & McCormick, 2008; Stirrat & Perrett, 2010; Wong,

48   Ormiston, & Haselhuhn, 2011). Interestingly, evidence suggests that FWHR is correlated with

49   these behaviours, but it also predicts perceptions of faces when observers are asked to make

50   judgements regarding these traits (e.g., Carré, McCormick, & Mondloch, 2009; Stirrat & Perrett,

51   2010). As a result, it has been argued that FWHR is an evolved cue of threat (Geniole et al.,

52   2015).

53   Although FWHR was originally measured directly from skulls (Weston et al., 2007),

54   almost all studies linking this ratio with behaviours have collected measurements from 2D

55   photographs (e.g., Carré & McCormick, 2008; Stirrat & Perrett, 2010). Evidence suggests that

56   measurements taken from images show high agreement with measures taken directly from the

57   face (Kramer, Jones, & Ward, 2012), although the nature of this as a suitable proxy for skull

58   FWHR has not been determined. More importantly for the current work, photographs of the

59   same individual can vary dramatically (Jenkins et al., 2011). Unconstrained images of a face

60   vary in pose, expression, lighting, age, camera settings, and so on. Such variability can

61   significantly decrease face matching performance, i.e., telling if two different images are of the

62   same person (e.g., Megreya & Burton, 2006, 2008). Indeed, this within-person variability

63   strongly argues against the idea that particular facial measures or distances underlie recognition

64   (Burton et al., 2015).

65   If facial measures vary across images of the same person, is it reasonable to assume a

66   reliable measure of FWHR can be obtained from a single 2D photograph? While lighting is

67   unlikely to affect measures of the face (other than shadows preventing accurate measurement),

68   several other variables may significantly alter a person's apparent FWHR. Previous research

69   suggests that FWHR decreases with age (Hehman, Leitner, & Freeman, 2014; cf. Kramer, 2015),

70   although this is not generally controlled for in the literature (but see Alrajih & Ward, 2014). In

71   addition, head pose (tilting upwards/downwards) has a sizable effect on FWHR obtained from

72   photographs (Hehman, Leitner, & Gaertner, 2013). This seems intuitive and, as a result,

73   researchers have tended to include only images that are forward facing, i.e., looking directly at

74   the camera without any noticeable tilting or left-right rotation.

75   In contrast, both facial expression and camera parameters appear less well considered.

76   While many researchers have chosen to exclude images demonstrating expressions other than

77   neutral (e.g., Zilioli et al., 2015), other researchers are less explicit in their inclusion criteria

78   (Haselhuhn & Wong, 2011) or acknowledge that non-neutral images were included (Carré &

79   McCormick, 2008). Regarding camera parameters, no FWHR research appears to have

80   considered their effects. Interestingly, distance between the face and the camera, as well as the

81   camera's focal length, are known to alter facial appearance (Banks, Cooper, & Piazza, 2014;

82   Harper & Latto, 2001; Verhoff et al., 2008), with those photographed closer to the camera

83   appearing thinner and therefore having lower FWHRs (Bryan, Perona, & Adolphs, 2012).

84   In previous studies, researchers have either failed to consider, or have simply avoided

85   (through constraining photographic conditions), the potential influences of both facial expression

86   and camera settings. Importantly, in many situations where images are collected from real-world

87   contexts (e.g., political races, sporting competitions, etc.), no such constraints can be imposed. In

88   the current set of studies, I consider both influences on FWHR measurement. Through the

89   calculation of effect sizes, I aim to determine how influential these factors might be, and hence

90   whether researchers need to constrain or control for these effects in all future work.

91   To my knowledge, no previous research has included measurement of FWHR while

92   systematically varying camera conditions or facial expressions. As such, it is difficult to make

93   predictions regarding how these two factors may influence resulting measures. However, visual

94   inspection of within-person photographic changes in facial expression suggests that these can

95   produce significant alterations to FWHR. Therefore, I hypothesise that varying one's facial

96   expression may have a larger effect on FWHR than differences between individuals. Similarly,

97   with large changes to camera parameters (distance to camera in particular), we see noticeable

98   FWHR differences (Harper & Latto, 2001). Again, I would predict that these camera effects may

99   be larger than the effect on FWHR due to differences between people's faces.

100   In the studies that follow, I focus on within-person variability in White men only (see

101   Haselhuhn et al., 2015). The majority of research has established links between FWHR and

102   various aggressive or competitive behaviours in men, but has generally failed to find such

103   relationships in women (e.g., Carré & McCormick, 2008; Haselhuhn & Wong, 2011; cf. Lefevre

104   et al., 2014). In addition, there may be significant differences in FWHR across ethnicities

105   (Kramer, 2015). For these reasons, I investigated the effects of facial expressions and camera

106   parameters on FWHR measures in White men, while avoiding any noise due to differences

107   between ethnicities, as the results would then be of the most relevance for the current literature.

108

109   **Study 1 – Unconstrained camera parameters**

110

111   In this study, I investigated the influence of variability in camera parameters on resulting

112   FWHR measures. Although all images were taken front-on and with a relatively neutral

113   expression, variables including the camera used, its focal length, and its distance to the subject

114   were unconstrained.

115

116   *Materials & Methods*

117

118   Five White male Hollywood actors were selected based on their ages and their prolific film

119   appearances. For each actor, five films were chosen that were released while the actor was

120   between the ages of 30 and 35 years. This limited age range minimised the possibility that age

121   might influence any variability in FWHR both within and between actors (Hehman et al., 2014).

122   However, this time period does allow for potential fluctuations in body weight, perhaps required

123   for different roles, and this is known to influence FWHR (Coetzee et al., 2010; Geniole et al.,

124   2015). For each film, five screenshots were taken using VLC Media Player in which the actor

125   displayed a relatively neutral expression and was facing front-on to the camera (although gaze

126   was often not directed at the camera). Each screenshot was taken from a different scene in the

127   film, and no images included beards or glasses. As such, 25 images were collected for each actor.

128   Following previous work (e.g., Kramer et al., 2012; Stirrat & Perrett, 2010), images were

129   rotated using custom MATLAB software so that both pupils were aligned to the same transverse

130   plane. The same software was then used to measure the width (the horizontal distance between

131   the left and right zygions) and height (the vertical distance between the highest point of the upper

132   lip and the highest point of the eyelids) of each image. The FWHR was calculated as width

133   divided by height.

134   While every care was taken to include only images that were neutral and front-on, it must

135   be acknowledged that there remained some variability in these two parameters, in particular

136   where actors appeared relatively emotionally neutral but with their mouths open. As such,

137   emotional expression could also be considered to vary here, although this is investigated more

138   systematically in Study 3. Similarly, slight head rotations (both left/right and up/down) may also

139   be present. Importantly, these images were still within the range of head angles that have been

140   analysed in previous publications investigating real-world settings (e.g., Carré & McCormick,

141   2008; Huh, Yi, & Zhu, 2014; Kramer, 2015; Lewis, Lefevre, & Bates, 2012; Loehr & O'Hara,

142   2013; Welker et al., 2014; Wong et al., 2011), which are inherently less constrained than those

143   taken in the laboratory (e.g., Kramer et al., 2012; Özener, 2011).

144

145   *Results*

146

147   The variability in FWHR measures within and between actors can be seen in Fig. 1. It is

148   clear that there is significant variability within actors regarding their FWHRs. As such, ordering

149   these five actors in terms of FWHR would depend greatly on which particular image was

150   considered to represent each man. The effect sizes due to Identity (the differences between

151   actors) and Image (the differences within actors) can be quantified using sums of squares (SS)

152   analyses (Jones & Kramer, 2015; Morrison, Morris, & Bard, 2013). By dividing the SS for each

153   factor (Identity, Image, Identity x Image) by the total SS, I obtained their η^2 effect sizes.

154   Although the five levels for the Identity variable made intuitive sense (each actor is a level), the

155   25 levels for Image were less meaningful since there is no relationship between the orders of

156   images for each actor. Simply, there is no reason why Image 1 is the first image for John Cusack,

157   and this bares no relationship with Image 1 for Ben Affleck. Therefore, in order to obtain an idea

158   of the effect sizes for the two factors and their interaction regardless of image orders, SS were

159   calculated over 10,000 iterations, each time randomising the orders of images within actors. For

160   Identity, the η^2 was 0.41 (and was unaffected by the ordering of the images within actors since

161   this value only takes into account the differences between actors). For Image, the η^2 values over

162   all iterations were $M = 0.12$, $SD = 0.03$, and for the Identity x Image interaction, the η^2 values

163   were $M = 0.48$, $SD = 0.03$.

164   These analyses show that the differences between actors accounted for much more of the

165   variance in FWHR than the differences within actors (due to image variation). This may seem

166   surprising, and highlights the importance of identity differences, irrespective of the particular

167   image chosen, when measuring FWHR. The largest effect size was due to the interaction

168   between Identity and Image, suggesting that the differences between images depended on the

169   actor, and were not equivalent across actors. This is to be expected, given the random selection

170   of images – one actor's images may vary more than another's simply based on the particular

171   images/films used.

172   I repeated this analysis using only one film (and therefore five images) per actor in order to

173   better equate the variability in images within actors. With each actor limited to a shorter time

174   period and a single role, the variability due to camera parameters remains while additional

175   changes due to weight fluctuations and character changes are minimised. Only the first film in

176   the set for each actor was considered, and effect sizes for Identity (0.54), Image ($M = 0.09$, $SD =$

177   0.05), and for the Identity x Image interaction ($M = 0.36$, $SD = 0.05$) mirrored the pattern seen

178   above. However, Identity showed an even great effect here while the interaction effect decreased.

179   By removing the changes in FWHR due to differences across films for a given actor, which

180   perhaps have little equivalence in the real world, I found that FWHR was influenced more by

181   differences between people than within (due to particular images).

182   Another way to quantify the importance of considering (and potentially constraining)

183   camera parameters when selecting images is to model the rank correlation of the five actors

184   irrespective of which image was used. This method more closely resembles analyses in the

185   literature where FWHRs are correlated with behavioural measures, relying on the ordering (and

186   specific values) of the faces. For each iteration, I randomly selected two images for each actor

187   (from the 25 available). I then correlated the FWHRs for the five pairs of images, giving a

188   measure of agreement between the rankings of the actors irrespective of which images were

189   used. After 10,000 iterations, the distribution of rank correlations ($M = 0.41$, $SD = 0.42$) showed

190   relatively low agreement. Even lower agreement was found when this analysis was repeated

191   using only images from the first film for each actor ($M = 0.34$, $SD = 0.45$). Therefore, if

192   researchers fail to constrain camera parameters during image collection, there will be a sizable

193   effect on the orders of their actors according to FWHR.

194

195   **Study 2 – Variation in focal length and distance to the camera**

196

197   It is clear that camera parameters in relatively unconstrained images can have a significant

198   influence on the apparent FWHR of a face. Next, I consider the effect of camera parameters on

199   FWHR under controlled laboratory conditions. By analysing images where focal length and

200   camera distance were systematically varied, I can determine their particular influence on FWHR

201   without additional noise due to head pose, emotional expression, etc.

202

203   *Materials & Methods*

204

205   Photographs of 21 White adult men were taken from the Caltech Multi-Distance Portraits

206   database (Burgos-Artizzu, Ronchi, & Perona, 2014). For each model, front-on images were taken

207   using a Canon Rebel Xti DSLR camera at seven distances: 60, 90, 120, 180, 240, 360, and

208   480cm. Longer focal lengths were used with greater distances in order to equate the sizes of the

209   images. Models were instructed to remain still and maintain a neutral expression throughout the

210   procedure, which lasted 15-20 seconds. No images included beards or glasses. As above, images

211   were rotated using custom MATLAB software so that both pupils were aligned to the same

212   transverse plane, and then FWHRs were measured.

213

214   *Results*

215

216   As in Study 1, SS analyses were carried out on the FWHR values in order to quantify the

217   effect sizes due to Identity (the differences between models), Distance (the differences due to the

218   distance from the camera and its focal length), and their interaction. The results showed that

219   Distance ($\eta^2 = 0.18$) had a much smaller effect on FWHR than Identity ($\eta^2 = 0.80$). This suggests

220   that the particular camera distance–focal length combination had little effect on FWHR measures

221   relative to the general differences between models. Even so, camera distance did have a

222   statistically significant effect on FWHR, $F(6, 120) = 196.23$, $p < .001$, with FWHR increasing

223   with greater distance to the camera (Bryan et al., 2012). Interestingly, the effect size of the

224   Distance x Identity interaction was very small ($\eta^2 = 0.02$), suggesting that the way the camera

225   distance and focal length altered FWHR was equivalent for all models.

226   In addition, I quantified the importance of considering (and potentially constraining)

227   camera distance and focal length when selecting images by modelling the rank correlation of the

228   21 models irrespective of which image was used (see Study 1). After 10,000 iterations, the

229   distribution of rank correlations ($M = 0.75$, $SD = 0.08$) showed high agreement, suggesting that if

230   researchers fail to constrain camera distance and focal length, there will only be a limited effect

231   on the orders or rankings of their models according to FWHR.

232

233   **Study 3 – Variation in facial expression**

234

235   In addition to the influence of camera parameters on FWHR measurement, another source

236   of within-person variability comes from facial expressions. The same face posing different

237   expressions may significantly alter FWHR. In general, researchers utilise neutral expressions and

238   exclude all others (e.g., Welker et al., 2014), but as yet, there has been no investigation into how

239   expressions may systematically alter FWHR measurement.

240

241   *Materials & Methods*

242

243   Photographs of 20 White adult men were taken from the Radboud Faces Database

244   (Langner et al., 2010). For each model, front-on images of eight emotional expressions (based on

245   the Facial Action Coding System; Ekman, Friesen, & Hager, 2002) were included: angry,

246   contemptuous, disgusted, fearful, happy, neutral, sad, and surprised. No images included beards

247   or glasses. As above, images were rotated using custom MATLAB software so that both pupils

248   were aligned to the same transverse plane, and then FWHRs were measured. See Fig. 2 for

249   examples.

250

251   *Results*

252

253   As in Study 1, SS analyses were carried out on the FWHR values in order to quantify the

254   effect sizes due to Identity (the differences between models), Expression (the differences due to

255   posed expression), and their interaction. The results showed that Expression ($\eta^2 = 0.58$) had a

256   much larger effect on FWHR than Identity ($\eta^2 = 0.31$). This suggests that the particular

257   expression a person wears has a large influence on their FWHR, and can alter the rankings of a

258   set of models. Interestingly, the interaction between these two factors was relatively small ($\eta^2 =$

259   0.11), suggesting that particular expressions alter the FWHRs of models in similar ways. For

260   example, disgusted expressions may systematically increase FWHR measures across models

261   while surprised expressions decrease them.

262   By carrying out a repeated measures ANOVA, treating Expression as an 8-level factor that

263   varied within models, I was able to investigate which expressions significantly altered FWHRs in

264   comparison with a baseline neutral expression. As expected, I found a significant effect of

265   Expression, $F(7, 133) = 103.44$, $p < .001$. The results of pairwise comparisons between the

266   neutral expression and the remaining seven expressions are illustrated in Fig. 3.

267   As Fig. 3 shows, models posing with disgusted or happy expressions significantly

268   increased their FWHRs in comparison with neutral (both ps $< .001$). In contrast, posing with a

269   fearful or surprised expression significantly lowered their FWHRs (both ps $< .001$). The

270   remaining three expressions had no significant effect on FWHR (all ps $> .05$).

271   In addition, I quantified the importance of considering (and potentially constraining) facial

272   expression when selecting images by modelling the rank correlation of the 20 models

273   irrespective of which image was used. After 10,000 iterations, the distribution of rank

274   correlations ($M = 0.23$, $SD = 0.20$) suggests that if researchers fail to constrain expression during

275   image selection, there will be a sizable effect on the orders of their models according to FWHR.

276

277   **Discussion**

278

279   Across three studies, I investigated the influences of camera parameters and facial

280   expressions on FWHR measurement. While within-person variability can have a substantial

281   effect on FWHR measurement, this was not always the case.

282   The results of Study 1 suggest that failing to constrain camera parameters, or indeed the

283   camera used, may not be as detrimental to a study's design as one might predict. Differences

284   between identities accounted for a larger proportion of the variation in FWHR than differences

285   within identities (across images). This identity effect became larger still, relative to within-

286   person image differences, when images were limited to only one film per actor, which might be

287   considered more comparable to the variation one might expect in everyday faces. However,

288   correlation analyses highlighted the substantial effect within-person differences could have on

289   the ranking or ordering of faces, an important issue for the majority of articles on this topic.

290   Therefore, collecting images taken by different cameras using different settings (in contrast with

291   the more constrained parameters of Study 2) will add substantial noise to any potential FWHR–

292   behaviour relationship, or on occasion, may even lead to the detection of spurious relationships if

293   these factors are confounded with the variables under investigation. For example, if I were to

294   compare the FWHRs of Democratic and Republican candidates in the US, and these two political

295   parties utilised two different photographers, it may be that the differing camera set-ups result in

296   apparent FWHR differences. Indeed, two sets of White men of approximately the same age,

297   taken using different camera set-ups, produced significantly different FWHRs in previous work

298   (Study 1 vs. Study 2 in Kramer et al., 2012).

299   Here, only five actors were included in Study 1 and so the specific effect sizes may alter

300   with a larger sample. Of course, one could also collect more images for each actor. The

301   important result is not the values themselves but the relative sizes of the effects. Indeed, the

302   FWHR values illustrated in Fig. 1 are comparable with those obtained in previous studies (e.g.,

303   Kramer et al., 2012; Özener, 2011). It is clear that even when relatively neutral, front-on images

304   are used, there can be large variation in FWHR for a single face.

305   While every care was taken to constrain the images used in Study 1, slight head rotations

306   and expressions may have been present. For example, it can be difficult to detect, and therefore

307   control, up/down head tilt in two-dimensional images. Previous research has demonstrated that

308   people may tilt their heads in order to affect perceived FWHR and appear more intimidating

309   (Hehman et al., 2013). In order to control for the noise in FWHR measurement due to head

310   position, researchers might utilise three-dimensional imaging where possible (e.g., Kramer et al.,

311   2012).

312   Study 2 showed that the distance to camera itself, along with alterations to focal length,

313   have only a relatively small effect on FWHR in comparison with between-subject differences.

314   This was also demonstrated when I considered the ranking or ordering of identities by FWHR.

315   Therefore, these factors appear less important when compared with the more unconstrained

316   images used in Study 1. Unfortunately, because camera distance and focal length were both

317   allowed to vary in the particular image set used, further research is needed in order to separate

318   out the influences of these two parameters.

319   Interestingly, I found only a small effect of the interaction between camera parameters and

320   identity in Study 2, suggesting that increasing the camera distance and focal length alters FWHR

321   consistently across different people. Indeed, this result has meant that computer scientists have

322   found some success in estimating camera distance using photographs of unknown people

323   (Burgos-Artizzu et al., 2014; Flores et al., 2013).

324   In Study 3, I found that FWHR changed substantially across different expressions.

325   Therefore, as researchers have already implicitly assumed, it is important to keep this variable

326   constrained when collecting image sets. However, the current results also suggest a caveat – only

327   four of the seven expressions investigated here significantly differed from neutral. As a result,

328   angry, contemptuous, and sad facial expressions may not require exclusion during image

329   collection (assuming the majority of images are neutrals). Importantly, happy expressions (i.e.,

330   smiles) produced significantly larger FWHRs and these are the expressions that tend to appear

331   most in photographic sets (given that people often smile unless instructed otherwise). Therefore,

332   inclusion of these images may lead to potentially spurious results. For example, the recent

333 controversy surrounding sexual dimorphism in FWHR (e.g., Kramer et al., 2012; Özener, 2011)

334 could be unintentionally affected if expression was not tightly constrained during photography,

335 given that women tend to smile more than men in various situations (LaFrance, Hecht, & Paluck,

336 2003). Interestingly, smiling faces are also perceived as more competitive (Mehu, Little, &

337 Dunbar, 2008), which fits well with research whereby faces with larger FWHRs are perceived as

338 more dominant, aggressive, etc. (e.g., Stirrat & Perrett, 2010).

339   Facial height in the current work was measured as the distance from the highest point of

340 the upper lip to the highest point of the eyelids (Kramer, 2015; Kramer et al., 2012; Stirrat &

341 Perrett, 2010). It is worth mentioning that other researchers have instead chosen to use the brow

342 as the upper boundary (e.g., Carré & McCormick, 2008; Özener, 2011). It may be that facial

343 expressions have an even larger effect on FWHR measures if the brow is used, given the sizable

344 shift in the position of the eyebrows for a number of expressions (Ekman et al., 2002).

345   The results presented here are derived from White male faces only. As discussed in the

346 Introduction, the majority of findings to date regarding FWHR and its associations with

347 behaviours are in White men. However, there is no *a priori* reason to believe camera

348 manipulations or changes to facial expression have different sizes of effects in women or other

349 ethnicities. Of course, expressions may alter women's faces in systematically different ways

350 because their face shape, and hence the way they pose expressions, differs from men. As such, I

351 invite future researchers to address this question.

352   The current work focusses on potential issues when measuring FWHR from photographs,

353 given its variability across different images of the same individual. These issues are also relevant

354 when considering the broader topic of social trait inferences. Recently, researchers have been

355 investigating how different images of the same face can produce widely varying social

356 perceptions of that individual (Jenkins et al., 2011). Foreseeing the work presented here,

357 Todorov and Porter (2014) noted that even invariant facial characteristics like FWHR are

358 susceptible to image variation. Combining these topics, there is evidence to suggest that

359 inferences more likely to be based on static cues (like FWHR) may vary less across images of

360 the same face in comparison with inferences based more on dynamic cues like muscle

361 movements (Hehman, Flake, & Freeman, 2015). This growing body of research demonstrates

362 how image variation can have repercussions for several areas of study.

363

364 **Conclusions**

365

366   The current set of studies explores the importance of considering both camera parameters

367 and facial expressions when investigating FWHR. With increasing numbers of researchers

368 downloading images from the Internet in order to explore real-world contexts (e.g., politicians,

369 presidents, professional fighters, football players), the ability to control these factors may be lost.

370 Critically, one must then question whether it is even meaningful to compare images where the

371 camera set-up varies across individuals, for example. To date, there has been no experimental

372 consideration of this particular factor to my knowledge. In conclusion, I recommend that future

373 researchers consider whether both camera parameters and facial expressions can be constrained,

374 and indeed need to be constrained, during image collection before undertaking real-world

375 investigations.

376

377 **Acknowledgments**

378

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380

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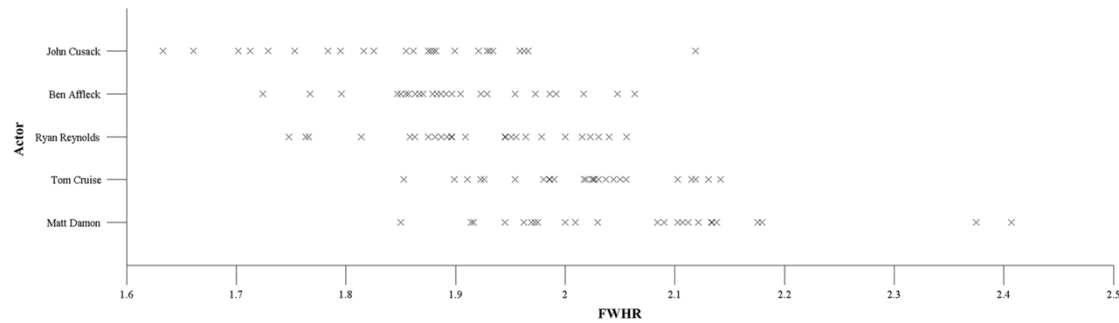
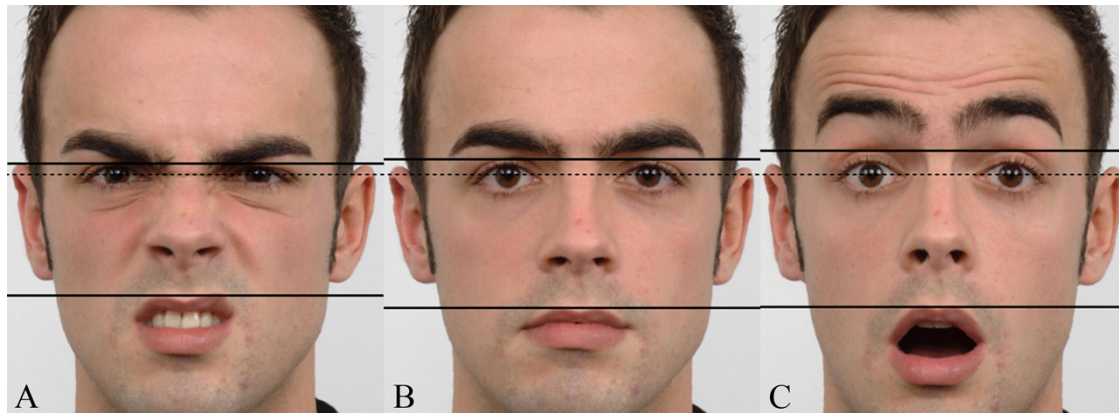

477 **Figure 1.** A scatterplot illustrating the within-person variability in FWHR for each actor. Each

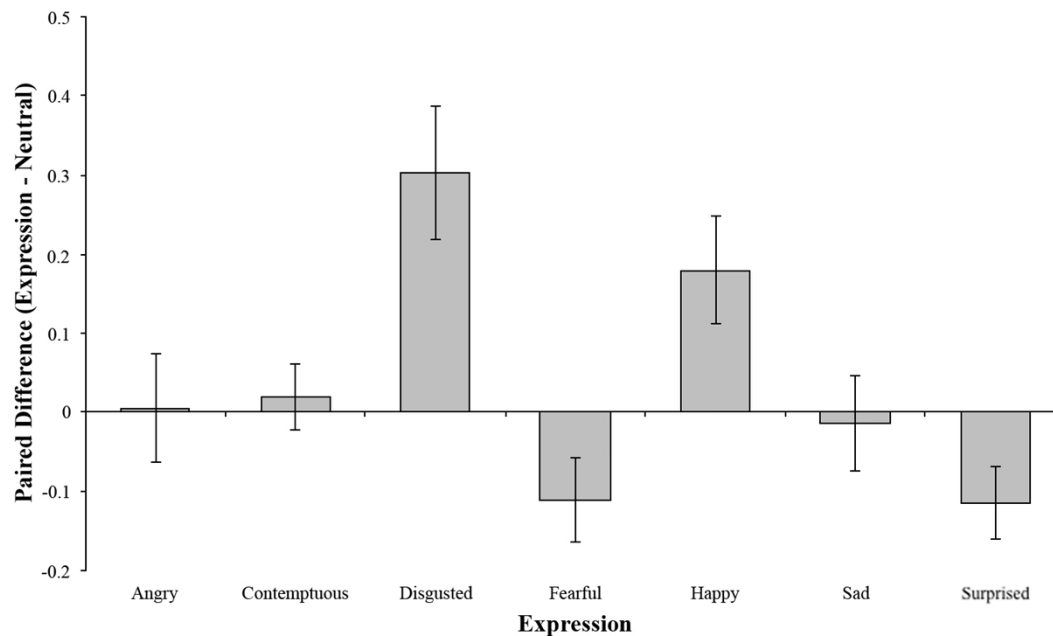
478 cross is a different image.

479

480 A B C

481 **Figure 2.** Example images (after rotation) from the Radboud Faces Database (reproduced with

482 permission). Horizontal lines depict the facial height for disgust (A), neutral (B), and surprise (C)

483 expressions. The dashed line illustrates that the pupils are level.

484

485

486   **Figure 3.** A bar chart illustrating the pairwise comparisons between the neutral expression and

487   the remaining seven expressions. The error bars represent the 95% confidence intervals of the

488   differences, adjusted for multiple comparisons using Bonferroni correction. As such, error bars

489   overlapping the zero line show no difference from neutral.