Is facial width-to-height ratio reliably associated with social inferences?

A large cross-national examination

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Abstract

Previous research suggests that facial width-to-height ratio (fWHR) may be associated with behavioral tendencies and social judgments. Mounting evidence against behavioral links, however, has led some researchers to invoke evolutionary mismatch to explain fWHR-based inferences. To examine whether such an explanation is needed, we leveraged a large cross-national dataset containing ratings of 120 faces on 13 fundamental social traits by raters across 11 world regions ($N = 11,481$). In the results of our preregistered analyses, we found mixed evidence for fWHR-based social judgments. Men's fWHR was not reliably linked to raters' judgments for any of the 13 trait inferences. In contrast, women's fWHR was reliably negatively associated with raters' judgments of how dominant, trustworthy, sociable, emotionally stable, responsible, confident, attractive, and intelligent women appeared, and positively associated with how weird women appeared. Because these findings do not follow from assumptions and theory guiding fWHR research, the underlying theoretical framework may need revising.

Keywords: person perception; facial width-to-height ratio; evolutionary mismatch

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Humans make social judgments and inferences from faces. Identifying the facial features on which these judgments are made is a major objective of the person-perception branch of psychological science. Careful pruning of candidate features can help us better understand proximate and ultimate factors involved in human perception and social behavior. One oft-investigated morphometric is facial width-to-height ratio (fWHR).

Early research suggested that fWHR would be a promising candidate facial feature for deconstructing human perceptions and social behavior. After more than a decade of research, however, the theoretical importance of fWHR is unclear. In this paper, we present findings from a large cross-national dataset pertinent to determining the role of fWHR in person-perception.

Brief overview of fWHR research

The fWHR metric was introduced by Weston et al. (2007). Their measurements of 121 dry human skulls (53 female) suggested that the morphology of faces diverge at puberty such that, in comparison to adult female faces, the bizygomatic width of adult male faces tend to be shorter relative to facial height (i.e., the distance between the brow ridge and top of the upper lip). They interpreted this sexual dimorphism as evidence of sexual selection independent of selection for overall body size.

Based on this initial evidence, Carré and McCormick (2008) proposed that the development of fWHR may be related to other sexually-dimorphic pubertal changes in hormones and behavior. They hypothesized that testosterone may link fWHR to aggressive behavior in men. In support of this hypothesis, they found moderate positive correlations between fWHR and

lab-based reactive aggression in undergraduate men ($n = 38$) but not women ($n = 51$), and between fWHR and in-game penalty minutes accrued by male hockey players at the college level ($n = 21$) and professional level ($n = 112$). Concurrent investigations found that undergraduate students' ($n = 47$) face-based assessments of men's aggressiveness were reliably positively associated with the men's fWHR and manifest aggressive behavior ($n = 37$; Carré et al., 2009). These studies provided initial evidence that fWHR is linked to theoretically-relevant behavioral tendencies and judgments in men; further, they suggested that fWHR could be useful in examining social inferences and behavior more broadly.

The literature is now bursting with apparent links between fWHR, behavioral tendencies, and social inferences. Because the association between fWHR and behavioral tendencies was hypothesized to be influenced by levels of testosterone, most of the research on the relationships between fWHR and behavior examines domains linked to testosterone. For instance, larger fWHR was reported to be associated with more fouls, goals, and assists in soccer players from 32 countries in the 2010 Men's World Cup (Welker et al., 2015); higher achievement drive in former US presidents (Lewis et al., 2012); and more aggressive, Machiavellian traits (Noser et al., 2018). These links to behavioral tendencies appear to influence the way that men with larger fWHR are perceived by others. For example, people purportedly view men with larger fWHR as less trustworthy (Stirrat & Perrett, 2010), more deceitful (Geniole et al., 2014; Haselhuhn, & Wong, 2011), more dominant (Mileva et al., 2014), more aggressive (Lefevre & Lewis, 2014), and having less integrity (Ormiston et al., 2017). Early meta-analyses suggested that the potential links between fWHR, behavioral tendencies, and social-perceptions across studies were small but reliable (Geniole et al., 2015; Haselhuhn et al., 2015).

However, there are several reasons to question the theoretical core of fWHR research and the veracity of ostensible associations between fWHR, behavioral tendencies, and social perceptions. First, while Carré and McCormick (2008) found evidence of sexual dimorphism in fWHR from facial photographs mirroring Weston et al. (2007), subsequent studies offer mixed evidence that fWHR is reliably sexually dimorphic in either human faces or skulls (Kramer, 2017; Kramer et al., 2012; Lefevre et al., 2012; Özener, 2012; Robertson & Kingsley, 2018; Stirrat et al., 2012; but see Köllner et al., 2018). Second, although early research found some support for hypothesized links between testosterone and fWHR (Lefevre, Lewis, Perrett, & Penke, 2013), large-scale studies and meta analyses using a broad range of methodology fail to support associations between testosterone and fWHR (Bird et al., 2016; Eisenbruch et al., 2018; Hodges-Simeon et al., 2016; Kordsmeyer et al., 2019). Third, previous studies examining behavioral links tended to examine lab-based behaviors in relatively small sample sizes, but recent large-scale replications of links between fWHR and behavioral tendencies found no evidence for theoretically-predicted behavioral links (Kramer, 2015; Kosinski, 2017; Wang et al., 2019). Although several studies and a meta-analysis based largely on Western samples find some evidence that fWHR may be linked to social inferences (Geniole et al., 2015), no large-scale, cross-cultural studies have examined these claims. Because meta-analyses are highly susceptible to publication bias and can grossly overestimate effect sizes (Kvarven et al., 2019), it is crucial to reexamine the reliability of social-inference associations in large and diverse samples.

Importantly, even if fWHR is not sexually dimorphic, influenced by testosterone, or associated with behavioral tendencies, social judgments may still be influenced by fWHR. For instance, associations between fWHR and social inferences could reflect *evolutionary mismatch*

(Frankenhuis & Del Giudice, 2012; Li et al., 2018). The mind may be designed to use fWHR to make social inferences because fWHR was probabilistically associated with fitness-relevant information throughout human evolution (Wang et al., 2019). Some forensic-archaeological evidence suggesting that wider-faced males were less likely than narrow-faced males to die from physical conflict between males in the ancestral past (Stirrat et al., 2012) provides initial scaffolding to connect fWHR to fitness-relevant cues in the past. Of course, an explanation for associations between social inferences and fWHR is only necessary if the human mind reliably makes fWHR-based social inferences.

The current study

Although fWHR may not be sexually dimorphic, influenced by testosterone, or reliably linked with behavioral tendencies, an open question in the fWHR literature remains: Is facial width-to-height ratio reliably associated with social inferences? The answer to this question would determine whether research investigating evolutionary mismatch explanations is needed. To inform this outstanding question, we leveraged a large cross-national dataset assembled by Jones et al. (2020). The dataset contains ratings of 120 faces by raters across 41 countries and 11 world regions on 13 fundamental social traits: aggressive, attractive, caring, confident, dominant, emotionally stable, intelligent, mean, responsible, sociable, trustworthy, unhappy, and weird (Oosterhof & Todorov, 2008).

As part of the Psychological Science Accelerator (Moshontz et al., 2018) Secondary Analysis Challenge¹, we first preregistered analyses using an exploratory subset of the Jones et al. (2020) data in November 2019; we then conducted preregistered analyses in the full confirmatory dataset released in March 2020. We did not preregister specific predictions for each

¹ Information about this challenge can be found at <https://psysciacc.org/2019/09/01/introducing-the-psa001-secondary-analysis-challenge/>

of the 13 trait judgments; however, our general research question is preregistered, and several predictions follow logically from the theoretical considerations and seminal research underpinning the fWHR research program. First, in male faces, fWHR should be positively associated with perceptions of aggressiveness and dominance (Geniole et al., 2015). Second, in male faces, fWHR should be negatively associated with perceptions of trustworthiness and attractiveness (Geniole et al., 2015; Stirrat & Perrett, 2010). These associations are predicted to be attenuated or absent in women (Geniole et al., 2015). No firm predictions can be derived from the literature about the associations between fWHR and judgments of how caring, confident, emotionally stable, intelligent, mean, responsible, sociable, unhappy, or weird men and women look. Still, we examined associations between fWHR and these trait judgments because they may be informative in evaluating the discriminant validity and general parameters of fWHR-based social judgments.

Methods

Participants

The full dataset provided by Jones et al. (2020) as part of the Psychological Science Accelerator Secondary Analysis Challenge consists of ratings from 11,481 raters (7,967 women) across 44 countries, representing 11 world regions and 25 languages. Country-level sample sizes range from 27 to 2,273 ($M = 260.93$, $Mdn = 166.50$, $SD = 353.85$). The mean age of participants is 22.56 ($Mdn = 20$, $SD = 6.97$). The exploratory sample that was released prior to the full dataset consists of a random subset of one-third of raters from each lab ($n = 3,851$).

Study Materials and Procedure

Face stimuli. The face stimuli rated in the study are taken from the Chicago Face Database (Ma, Correll, & Wittenbrink, 2015). The stimuli set consists of 60 male and 60 female

faces, with equal numbers of Asian, Black, Latino, and White faces—30 faces each, with 15 male and 15 female faces per group. The ages of subjects range from 18 to 35 ($M = 26.38$, $SD = 3.57$). All subjects displayed a neutral expression, a straight-ahead gaze, and wore a gray t-shirt; the full-color photos were taken under standardized lighting with a uniform background. Facial measurements were taken from each photo, and each subject's fWHR is provided in the norming data associated with the face database (Ma et al., 2015).

Trait ratings. Rating data were collected by a distributed network of 126 labs involved with the Psychological Science Accelerator (Moshontz et al., 2018). All data collection sites obtained approval from their local IRB, unless the task was covered by a pre-existing IRB approval or this type of rating task was classified as exempt by the local IRB.

After providing informed consent and completing a demographic questionnaire, participants were randomly assigned to rate each of the 120 faces on one of 13 trait adjectives. The 13 trait adjectives—aggressive, attractive, caring, confident, dominant, emotionally stable, intelligent, mean, responsible, sociable, trustworthy, unhappy, and weird—were taken from Oosterhof & Todorov (2008). Participants rated the degree to which the adjective applied to each face using a 9-point scale (1 = *not at all*; 9 = *very*). Instructions and rating prompts were presented to each participant in the appropriate language for their site. The same face stimuli were used in each testing site. Faces were presented in a randomized order for each participant. Participants completed the ratings twice and these ratings were averaged for each person prior to the dataset release. Table 1 shows the number of raters for each trait, along with the mean and standard deviation of each trait rating across all 120 faces.

Table 1.

Number of raters rating each trait and descriptive statistics for each trait rating.

Trait Rating	<i>n</i>	<i>M</i>	<i>SD</i>
Aggressive	854	3.96	1.83
Attractive	832	3.97	1.81
Caring	906	4.71	1.70
Confident	975	5.07	1.63
Dominant	896	4.66	1.72
Emotional Stability	896	5.43	1.60
Intelligent	895	5.41	1.56
Mean	839	3.96	1.81
Responsible	880	5.57	1.64
Sociable	958	4.88	1.60
Trustworthy	896	5.16	1.64
Unhappy	897	4.40	1.75
Weird	760	3.87	2.03

Note: Trait ratings from Oosterhof & Todorov (2008). Faces were rated on a 9-point scale (1 = *not at all*; 9 = *very*). *SD* = Standard Deviation; *M* = Mean; *n* = number of raters for trait.

Analytic Methods and Procedure

We conducted all data tidying and analyses in *R* (R Core Team, 2019). All code used to conduct the analyses and create figures presented is publicly available on our associated Open Science Framework project page (<https://osf.io/ykh4c/>). The full Jones et al. (2020) dataset used in our confirmatory analyses is also on the Open Science Framework (<https://osf.io/jfwtr/>).

In November 2019 we preregistered our analyses based on the exploratory data set released by the Psychological Science Accelerator as part of the Secondary Analysis Challenge associated with release of the Jones et al. (2020) dataset. We ran separate multilevel models for ratings of male and female faces (henceforth *targets*) because of theory-driven expectations for sex-differentiated associations (e.g., Carré & McCormick, 2008). Each model examined one of

the 13 trait-rating associations with fWHR, regressing participants' scaled ratings for a given trait on targets' fWHR, resulting in 26 total models (13 trait models for male targets and 13 trait models for female targets).

In the initial exploratory analyses, we specified random intercepts for targets with random slopes and random intercepts for raters, labs, countries, and world regions to account for all levels of nesting within the data. After reproducibility checks conducted by the Psychological Science Accelerator in January 2020, we decided to remove the random intercept and slope specifications for labs, countries, and world regions because the effectively zero variability at these higher-order levels caused convergence issues and often triggered singular fit warnings. We used these simplified models used to conduct the exploratory and confirmatory analyses.

The final random-effects structures in the final preregistered analyses were specified as follows. For all models, we specified random intercepts for targets which allows us to generalize to the wider population of human faces represented by the faces in the face set (Judd et al., 2012). For most models, we specified random intercepts and slopes for raters, allowing for generalization to the greater population of raters, represented by the samples of raters who participated in the study. In exploratory and confirmatory analyses, we removed the random slopes for raters in four models—male attractiveness, male unhappiness, male emotional stability, and male sociability—because these slope specifications caused the models to fail to converge (c.f., Barr et al., 2013; Brauer & Curtin, 2018). In the confirmatory analyses, two more models—male caring and male confidence—failed to converge, so we removed the random slopes specification for raters in these models. We used the lme4 package (Bates et al., 2015) to run the multilevel models and the lmerTest package (Kuznetsova et al., 2017) to obtain *p*-values

for the fixed-effect estimates. We adopted the conventional alpha level of .05 to assess statistical significance of associations.

Results

Figure 1 shows the point estimate, standard error, and statistical significance level for each sex-specific relationship between fWHR and the 13 social adjectives in both the exploratory sample and the full confirmatory dataset. The results were not qualitatively different between exploratory and confirmatory samples. No relationships between male fWHR and the 13 trait ratings were statistically significant in either the exploratory or confirmatory samples ($.066 < ps < .985$; $M_p = .539$). In both the exploratory and confirmatory samples, we found small but statistically significant negative associations between female fWHR and rated dominance, trustworthiness, sociability, emotional stability, responsibility, confidence, attractiveness, and intelligence, as well as a small but statistically significant positive association between fWHR and rated weirdness ($.0001 < ps < .041$; $M_p = .012$); associations between fWHR and ratings of how unhappy, aggressive, mean, and caring the female faces appeared were not statistically significant in either the exploratory or confirmatory sample ($.129 < ps < .485$; $M_p = .322$). Regression tables for each analysis and plots depicting the country-level and participant-level slopes for each of the 13 sex-specific trait associations for both the exploratory and confirmatory samples are provided in the supplemental materials (<https://osf.io/ykh4c/>).

Figure 1. Coefficient plot depicting the standardized estimates for the sex-specific associations between male ($n = 60$) and female ($n = 60$) facial width-to-height ratio (fWHR) and 13 trait inferences in both the confirmatory dataset ($N = 11,481$; solid lines and filled shapes) and in the exploratory sample ($n = 3,851$; dotted lines and empty shapes). Error bars depict the standard error of the point estimates. The transparency of each point estimate and error bar depicts the level of statistical significance, where more transparency is associated with larger p -values and less transparency is associated with smaller p -values.

Discussion

We leveraged a large, relatively diverse dataset containing trait ratings of faces to examine whether fWHR is reliably associated with social inferences foundational in social perception research (Jones et al., 2020; Oosterhof & Todorov, 2008). We found no evidence for theoretically expected associations between men's fWHR and trait ratings. In contrast, women with higher fWHR were reliably rated as weirder, and as less dominant, trustworthy, sociable, emotionally stable, responsible, confident, attractive, and intelligent. These findings do not follow logically from the theoretical assumptions guiding fWHR research, which suggest that fWHR should be positively associated with judgments of testosterone-linked traits in men but not women.

Our null findings contribute crucial evidence needed to evaluate the role of fWHR in social perception. Recent studies have failed to support the hypothesized links between fWHR, testosterone, and behavior (e.g., Kordsmeyer et al., 2019; Kosinski, 2017; Wang et al., 2019). Consequently, Wang et al. (2019) interpreted the assortment of studies showing fWHR-inference links (e.g., Carré et al., 2009; Lefevre & Lewis, 2014) as evidence of evolutionary mismatch; however, the need for this explanation is not clear because the reliability of fWHR-inferences has not previously been rigorously tested in large samples. The lack of support for theoretically expected associations between fWHR and trait judgments from men's faces in the large cross-national sample examined here suggests that fWHR is not a major factor in face-based inferences of men's behavioral tendencies. Evolutionary mismatch explanations are therefore unnecessary.

Our positive findings, however, suggest that fWHR may play a role in social judgments of women. The few extant studies examining links between fWHR and behavioral tendencies in women have found mixed evidence (e.g., Haselhuhn & Wong, 2011; Lefevre et al., 2014; Stirrat

& Perrett, 2010). Large-scale research may be needed to more accurately examine whether fWHR-based judgments are tracking real relationships between fWHR and behavior in women. It may also be worthwhile to rigorously investigate hormonal correlates of fWHR in women, an area which has also been relatively understudied in comparison to men (Kordsmeyer et al., 2019). If fWHR is not associated with behavioral or hormonal variation in women, perhaps the trait judgments reflect general halo effects stemming, for example, from assessments of sex-typicality or body size (Coetzee et al., 2010; Fiala et al., 2020; Kočnar et al., 2019).

Interestingly, fWHR-based inferences do not seem to map cleanly onto the valence-dominance dimensions that appear to be fundamental to face perception (Jones et al., 2020; Oosterhof & Todorov, 2008). For instance, while “dominant”, “aggressive”, and “mean” trait ratings all contribute to the dominance dimension of face perception, only “dominance” ratings appear to track women’s fWHR. Further, the trait judgments “sociable” and “trustworthy” track women’s fWHR, but “caring” trait judgments do not—even though all three traits contribute roughly equally to the valence dimension of face perception. This lack of discrimination suggests that fWHR is not a feature that the human mind uses to place faces along these ostensibly fundamental dimensions.

Several limitations should be considered in interpreting our findings. Some research suggests that body size may confound fWHR associations (e.g., Deaner et al., 2012; Geniole et al., 2015), but we could not examine interactions or control for allometric scaling because no data on body size were available for the faces used as stimuli. Relatedly, no behavioral data were associated with targets, so we could not assess the accuracy of rater judgments. Additionally, minimal data are available on rater characteristics, so we could not examine interactions between potentially relevant rater characteristics and judgments of faces, which may have moderating

effects (e.g., Gruenewald et al., 2006; Tiedens et al., 2007). Finally, although representative of many nations and cultures, the raters in the sample are mostly young college students, so our findings may not generalize well to older adults or to small-scale, nonindustrial societies. Future research is needed to address these limitations.

Identifying the features tracked by face-based social judgments may help us better understand the mechanisms behind person perception. Although fWHR initially appeared to be a promising facial feature for studying person perception, the weight of the contradictory evidence indicates that the underlying theoretical framework needs modification. Our findings suggest that resources could be fruitfully directed towards rigorous examinations of fWHR-links in women and investigations of other morphological features involved in person perception.

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