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Original Article

Sexual dimorphism of facial width-to-height ratio in human skulls and faces: A meta-analytical approach

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ABSTRACT

Facial width-to-height ratio (FWHR), defined as the width of the face divided by the upper facial height, is a cue to behaviour. Explanations for this link often involve the idea that FWHR is sexually dimorphic, resulting from intersexual selection pressures. However, few studies have considered sexual dimorphism in skulls since the original paper on this topic, and it is possible that different explanations may be required if faces show sex differences but skulls do not. Here, meta-analyses of skulls found that men did have larger FWHR than women, although this effect was small. However, after categorising samples by ethnicity and geographical origin, meta-analyses only found evidence of sex differences in East Asians, and again, this effect was small. A re-analysis of previous studies after excluding skull samples found little evidence of sexual dimorphism in faces. Again, considering ethnicities separately, I found no differences for White samples but a medium-sized effect with East Asians, although this was not statistically significant with only three samples. Taken together, I found no reason to consider FWHR as a sexually dimorphic measure in skulls or faces, at least not universally, and so accounts based upon this assumption need rethinking if researchers are to explain the relationship between FWHR and behaviour.
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1. Introduction

The idea that the human face provides social information is not a new one (Darwin, 1872). We can determine the identity (Bruce & Young, 1986), sex (Burton, Bruce, & Dench, 1993), age (Rhodes, 2009), and ethnicity (Montepare & Opeyo, 2002) of a stranger with relative ease, as well as more dynamic and changing information like emotional state (Elfenbein & Ambady, 2002). There is also evidence that trait information like personality, physical and mental health, and even sexual orientation can be perceived with some accuracy from faces alone (Jones, Kramer, & Ward, 2012; Kramer & Ward, 2010; Rule, Ambady, & Hallett, 2009; Scott, Kramer, Jones, & Ward, 2013).

In 2007, researchers provided evidence of one particular facial measure, the width-to-height ratio (FWHR – see Fig. 1; Weston, Friday, & Liò, 2007), which they found to be sexually dimorphic in human skulls, and has since been the subject of intense investigation as a cue to numerous behaviours. While overall size differences play a large role in general skull dimorphism (Calcagno, 1981; Lestrel, 1974; Rightmire, 1970), Weston and colleagues suggested that this ratio difference was instead due to developmental differences in shape trajectories during puberty. Specifically, the height of the upper face (defined as the nasion-prosthion distance) in adults is similar in men and women, while the (bizygomatic) width is larger in men. In other words, while sex differences in skulls are expected simply because men grow to be larger than women, the bizygomatic width in males show additional growth at puberty beyond this predicted increase. The researchers argued that this difference in skull shape might result from intersexual selection pressures, so that a region of the face has evolved which highlights the distinction between men and women.

Why evidence of sexual dimorphism predicts an association between FWHR and behaviour is less clear. If female preferences led to increased facial width in men (although evidence actually suggests that wider faces are judged to be less attractive; Geniole, Denson, Dixson, Carré, & McCormick, 2015), it may not necessarily follow that within-sex differences are correlated with behaviours. More intuitively, intrasexual selection pressures (e.g., male-male competition) could have resulted in increased success for wider-faced men, resulting in an appearance–behaviour link, especially if these two factors have the same underlying mechanism (testosterone, for instance). Might both explanations overlap, whereby a facial cue that highlights 'maleness' to women has become associated with masculinity (both in appearance and behaviour) in men? Of course, there is no reason to assume that the mechanisms underlying sex differences in facial development are the same as those that may drive a within-sex association between appearance and behaviour.

While the precise account and its relationship with sexual dimorphism remain unclear, FWHR does appear to function as a social cue. Levels of masculine characteristics (e.g., aggression, dominance, deception) in men correlate with FWHR, as do perceived levels of these traits

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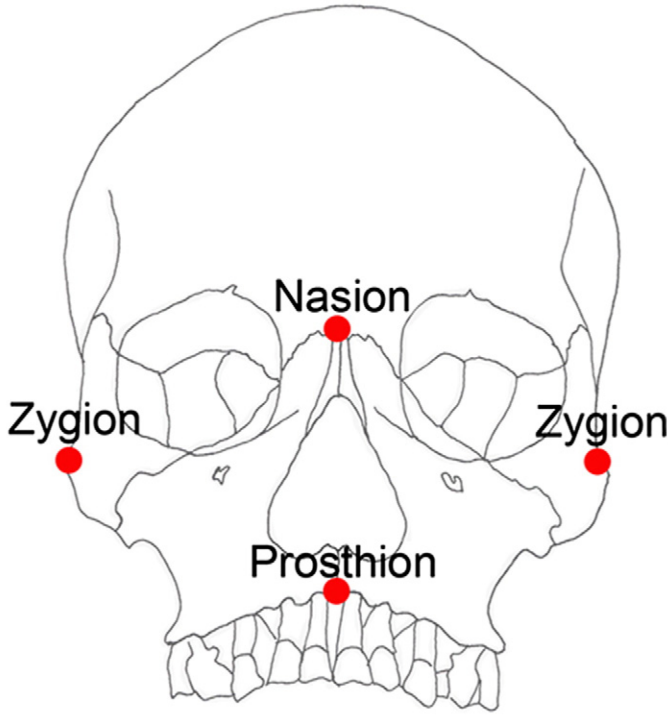

Fig. 1. Craniofacial landmarks used to calculate FWHR. The skull width (the distance between the left and right zygions) is divided by the upper facial height (the distance between the nasion and prosthion) to produce the FWHR.
Figure adapted from Weston et al. (2007).

(for meta-analyses, see Geniole et al., 2015; Haselhuhn, Ormiston, & Wong, 2015). The explanation for this FWHR–behaviour association is thought to involve testosterone (Carré & McCormick, 2008; Sell et al., 2009), which may influence both facial development and behavioural characteristics. Indeed, initial research found significant associations between FWHR in men and baseline levels of testosterone, as well as testosterone changes in response to potential mate exposure (Lefevre, Lewis, Perrett, & Penke, 2013).

Somewhat problematically for this account, FWHR may not actually be sexually dimorphic in faces (Kramer, Jones, & Ward, 2012; Lefevre et al., 2012; Özener, 2012) or skulls (Gómez-Valdés et al., 2013; Stirrat, Stulp, & Pollet, 2012). Of course, it may be that different mechanisms drive facial development in men and women, allowing for testosterone-produced correlates of behaviour in men without differences between the sexes (Lefevre et al., 2013). In a recent meta-analysis of this field, the authors found significant (but small) sex differences when considering studies of both skulls and faces together (Geniole et al., 2015), as well as for subsets of studies (2D photographs versus other materials). However, it is not clear whether differences remain when only skulls are analysed since this distinction was not made in their analyses. It may be that skulls do not show sex differences in FWHR but faces do, perhaps through evolved cues that utilise soft tissue deposits, which differ in men and women (Enlow, 1982). This would be an important caveat when investigating the explanatory mechanisms linking behaviour and facial measures.

One potential issue with previous investigations is that they have not considered populations separately based upon ethnicity or geographical origin. Given evidence of between-population differences in skulls (Gill & Rhine, 2004; İşcan & Steyn, 1999; Ousley, Jantz, & Freid, 2009), the inclusion of all groups into a single analysis will inherently suffer from this additional source of noise. It may be that FWHR dimorphism is present in some ethnicities/populations but not others, and this could account for the mixed results that have previously been found with faces. This would also be an important caveat for theories of dimorphism and signalling.

The other problem for the 'FWHR–testosterone–behaviour' account is that FWHR may not actually be associated with testosterone. In recent research investigating several samples and reporting a combined meta-analysis, no relationship was found between FWHR in adult men and baseline testosterone or competition-induced testosterone reactivity (Bird et al., 2016). Even during adolescence, when testosterone is hypothesised to impact facial growth (Weston et al., 2007), no relationship was found between male FWHR and testosterone levels or other known testosterone-derived traits (Hodges-Simeon, Hanson Sobraske, Samore, Gurven, & Gaulin, 2016). Indeed, FWHR showed no change during adolescence and no growth spurt, contrary to predictions.

In the current work, I focussed specifically on whether FWHR is sexually dimorphic in adult human skulls using a meta-analytical approach. Given that the popular topic of FWHR as an important facial cue originated from this initial finding (Weston et al., 2007), it is worth further examination using multiple large samples. I also considered geographical and ethnic origins as potential factors in order to allow for the likelihood that populations may differ. For this reason, I revisit the topic of FWHR sex differences in faces, again considering ethnicity as a potential influence. Importantly, prior large-scale analyses in this area have yet to consider the distinction between faces and skulls, and the possibility (and evolutionary implications) that there may be FWHR sex differences in one but not the other.

2. Methods

2.1. Previous research

All peer-reviewed and published manuscripts that investigated human skull FWHR separately for men and women were included. This involved searching through all articles that cited Weston et al. (2007), the first paper to propose this measure as a topic of interest. Conveniently, all articles prior to the end of 2014 had already been identified in the recent meta-analysis by Geniole et al. (2015), and no newer research (as of May 2016) or omissions were found. This resulted in the inclusion of three peer-reviewed manuscripts.

In total, these publications described eight separate skull databases: six (Gómez-Valdés et al., 2013), one (Stirrat et al., 2012), and one (Weston et al., 2007). Problematically, the authors reported, and the previous meta-analysis utilised, summary database values for FWHR rather than separating these into specific populations in terms of origin/ethnicity. For example, Stirrat and colleagues provided means and standard deviations for their full sample, which included a mixture of White and non-White skulls. Similarly, Gómez-Valdés and colleagues reported the average FWHR dimorphism for each database, which did not allow for the analysis of separate populations, incorporating different sample sizes, etc. For instance, the Howells (1973, 1989, 1995) database alone contained 26 groups (of varying sizes) originating from almost as many countries.

To address this issue, I contacted the authors (Gómez-Valdés et al., 2013) and obtained summary statistics for their databases, separately for each population. This would allow the calculation of an effect size for each group rather than each database. Unfortunately, the authors were unable to provide data regarding two of their previously reported databases (Hallstat and Mexico City Penitentiary) due to ethical constraints and data property issues, and so these two sets were not included in the current meta-analysis. In addition, several populations were removed before analyses because there was substantial overlap across their databases. For example, the Ourga specimens appeared in both the 2D and Pucciarelli sets. Whenever multiple occurrences were found, the repeated case with the smaller sample size was removed. This was because the second appearance often featured fewer specimens and so was assumed to be a subset of the larger sample, and this was confirmed by the authors through correspondence.

For Weston's original sample (Weston et al., 2007), the set contained individuals from several different southern African populations.

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