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Evidence to Suggest That Teeth Act as Human Ornament Displays Signalling Mate Quality

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Abstract

Ornament displays seen in animals convey information about genetic quality, developmental history and current disease state to both prospective sexual partners and potential rivals. In this context, showing of teeth through smiles etc is a characteristic feature of human social interaction. Tooth development is influenced by genetic and environmental factors. Adult teeth record environmental and traumatic events, as well as the effects of disease and ageing. Teeth are therefore a rich source of information about individuals and their histories. This study examined the effects of digital manipulations of tooth colour and spacing. Results showed that deviation away from normal spacing and/or the presence of yellowed colouration had negative effects on ratings of attractiveness and that these effects were markedly stronger in female models. Whitening had no effect beyond that produced by natural colouration. This indicates that these colour induced alterations in ratings of attractiveness are mediated by increased/decreased yellowing rather than whitening per se. Teeth become yellower and darker with age. Therefore it is suggested that whilst the teeth of both sexes act as human ornament displays, the female display is more complex because it additionally signals residual reproductive value.

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Introduction

Ornament displays convey important information about freedom from developmental adversity/disease and other aspects of mate quality to both prospective sexual partners and potential rivals [1,2,3,4,5,6]. Individuals displaying high quality characteristics through these displays gain considerable advantage [7]. This is demonstrated within species such as the yellow eyed penguin (*Megadyptes antipodes*) where the higher carotenoid levels seen in healthy animals are reflected in eye and head plumage colouration [8] and associated with increased mating success [9,10,11]. Similar effects are seen in a range of other species including house finches *Carpodacus mexicanus* [12,13] although the relationship between ornamental traits and immune competence is not always a straightforward one [14]. In the context of humans, a variety of ornament displays have been proposed including voice quality [15], waist-to-hip ratio [16] and skin tone [17,18]. The importance of symmetry [19,20] and the reproductive advantages associated with height [21] are also well documented.

Several lines of evidence point towards teeth also having function as a human ornament display. Smiling is a common behaviour in our species [22] and this is usually viewed positively by those receiving the smiles [23,24,25]. Smiling is seen in many different social situations, including those involving cooperation [26,27] and affiliation [28]. Importantly, smiling is also one of the first indications of sexual interest in our species [29,30,31,32]. Hence, one of the opening acts of any new sexual partnership is a mutual tooth display.

In further support of this proposal tooth loss is associated with poor general health [33], nutritional deficits [34], cognitive disorder [35,36], cardiovascular disease [37], stroke [38,39] and increased risk of death [40]. Absence of teeth may also be indicative of dental caries and periodontitis [41] which are in turn reflective of poor oral hygiene [42,43] and negative psychological characteristics [44]. Similarly, tooth wear is related to diet, dietary habits [45] and age [46], whilst shape of teeth and spacing may signal the presence of genetic disorders such as Pfeiffer Syndrome [47,48], Robinow's Syndrome [49,50] and Rapp-Hodgkin Syndrome [51].

Tooth colour is also a rich source of information concerning health and genetic quality. Natural colour is mostly determined by the dentine [52]. This is however also influenced by the structural composition/thickness of the enamel and the characteristics of the pellicle layer [53]. Teeth are prone to discolouration from a wide variety of metabolic, inherited and traumatic factors in addition to environmental and dietary causes [54,55]. In the context of ornament displays it is noteworthy that thinning of the enamel, textural changes and secondary/tertiary deposition of dentine [56] leads to teeth becoming darker and yellower with age [57,58,59,60].

In the US in the order of \$1 billion per year is spent on purely cosmetic dental procedures [61] and the desire to improve the appearance of teeth is cross-cultural (e.g. [60,62,63,64]). There are however several components to the tooth display and the relative importance of each of these is not well understood. Therefore the aim of the present studies was to examine the effects of two of these components, spacing and colour. The hypothesis under investiga-

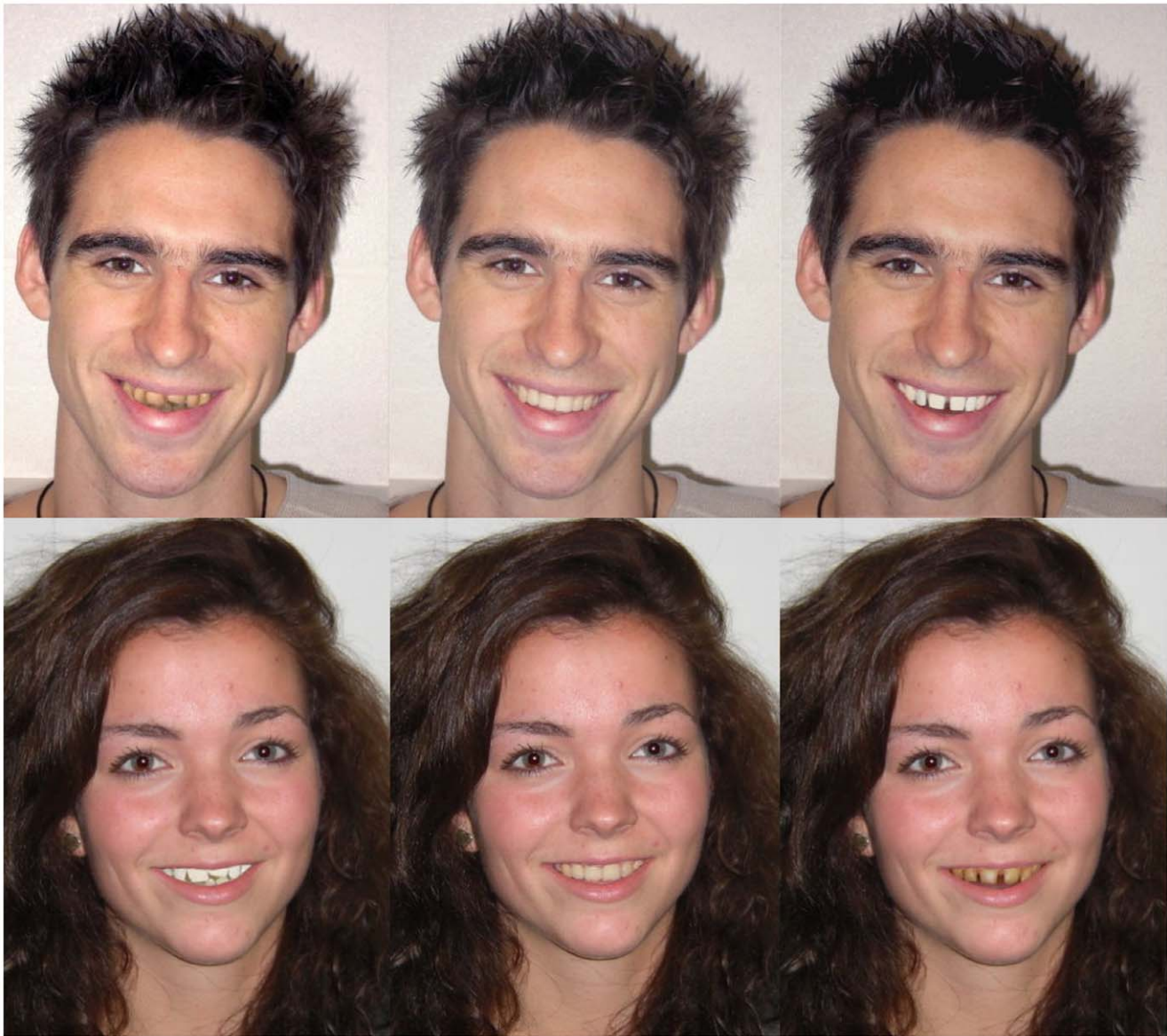


Figure 1. Digital manipulations of tooth spacing and colour. Tooth colour approximated (dark to light) to A4, B1 and OM1 on the Vita Classical shade system whilst naturalistic samples of crowded, normal and widely spaced teeth (shown from left to right) were obtained opportunistically. There were 18 different combinations of tooth colour, spacing and sex of the model. A nested design was used whereby each participant viewed six of these, each shown using a different model (3 of each sex). Stimulus pictures were viewed one at a time and rated independently. See text for further details. doi:10.1371/journal.pone.0042178.g001

tion was that ratings of a model's attractiveness would be influenced by digital manipulations of their teeth.

Methods

One hundred and fifty participants (mean = 21.2 ± 1.1 years) were selected by opportunistic sampling (75 males and 75 females). Each participant was presented with pictures of one of six different models (3 males and 3 females) whose own teeth had been digitally replaced with teeth taken from a standard set manipulated by spacing and colour that had been specifically created for the purposes of this study. Picture presentation was made in accordance with a 2 (sex of participant) $\times$ 2 (sex of model) $\times$ 3 (spacing; crowded, normal and widely spaced) $\times$ 3 (colour; yellow, normal and white) **nested** design with colour nested in spacing.

There were therefore 9 digitally manipulated photographs of each model that together displayed all combinations of spacing and colour. Each participant thus viewed 6 photographs (3 of each sex) that were selected from each model's set in randomised counter-balanced order with care being taken to avoid the possibility of order effects and to ensure that no participant viewed the same model twice. All models were Caucasian in origin and aged 20–22 years. Tooth colour was adapted from the Vita Classical shade system [65] approximating to A4, B1, OM1 and photographs of differently spaced teeth were obtained opportunistically. As these were naturalistic images (i.e. photographs), the supernumerary (crowded) teeth were also unavoidably crooked. Examples of these stimulus materials are illustrated in Figure 1.

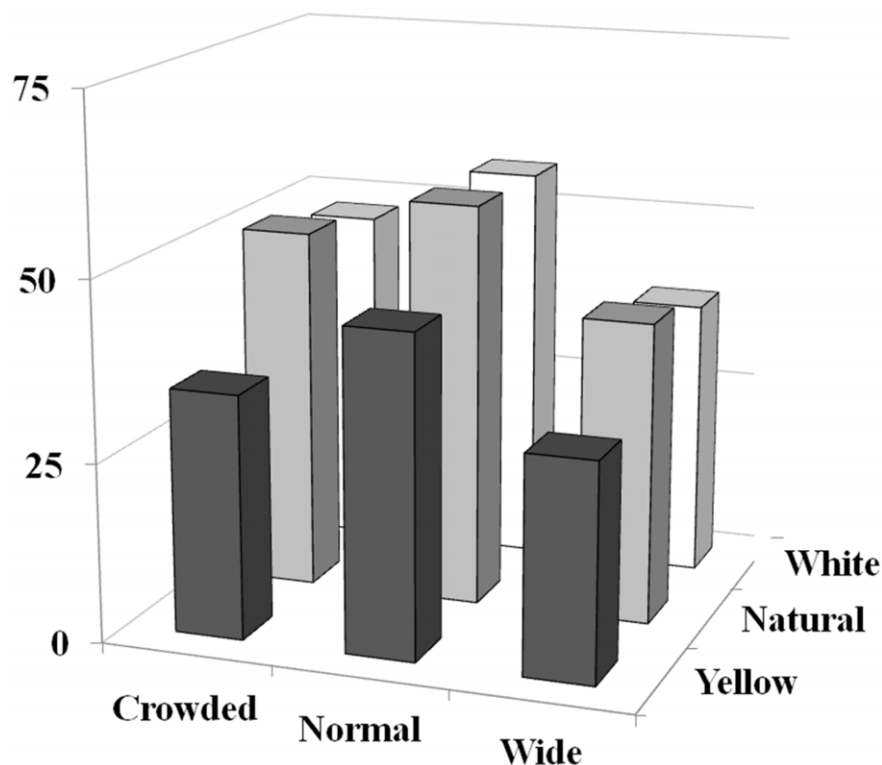


Figure 2. Main effects of digital manipulations of tooth spacing and colour on ratings of attractiveness. Data are expressed as mean ratings of attractiveness given on a 100 mm visual analogue scale. Higher numbers indicate greater attractiveness. Crowded, normal and wide refer to spacing. Yellow, natural and white refer to colour (approximating to A4, B1 and OM1 on the Vita Classical shade scale). Data show that deviations away from normal spacing impact negatively on ratings of attractiveness and that whilst yellowed teeth are rated as least attractive, whitening beyond natural colouration does not further increase ratings of attractiveness. See text for further details.
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A set of 10×10 cm cards were produced, printed to a professional standard, laminated and checked that colour integrity matched the Vita Scale described above. Pictures were shown one at a time under ambient indoor workplace lighting and colour remained clearly differentiated. Participants were asked to rate the attractiveness of the person featured in each of the photographs using a 100 mm visual analogue scale. The negative response (i.e. extremely unattractive) was on the left hand side so that higher numbers indicated increased attractiveness when measured from the left. Data were analysed using Statistica (StatSoft®).

These studies were approved by The University of Leeds Institute of Psychological Sciences Ethics Committee in accordance with British Psychological Society guidelines. In keeping with these guidelines all participants gave their informed consent in writing prior to beginning the study. Written consent was also obtained from the models used in these studies for their photographs to be digitally manipulated for use in the study and to be used in scientific publications. The models shown in Figure 1 signed a further statement indicating their willingness for the photographs shown in that figure to be published in PLoS ONE.

Results

Analysis of Variance showed significant main effects of teeth spacing ($F(2, 863) = 62.07, p < .01$) and colour ($F(2, 863) = 51.96, p < .01$). Interactions were not available in consequence of the nested design. Follow up tests were performed using orthogonal contrasts (with α shifted to 0.01 to accommodate the number of contrasts performed) and these revealed that when males viewed

other males they rated models with widely spaced teeth as being significantly less attractive than those with normally spaced teeth in the yellow ($F(1, 863) = 7.15, p < .01$) and natural ($F(1, 863) = 7.02, p < .01$) colour conditions. Males also rated other males with yellow teeth as being significantly less attractive than those with natural ($F(1, 863) = 8.64, p < .01$) or white ($F(1, 863) = 7.77, p < .01$) teeth in the crowded condition only.

When viewing female models male participants rated those with normally spaced teeth as being significantly more attractive than models with crowded teeth in all colour conditions (yellow ($F(1, 863) = 13.00, p < .01$) natural ($F(1, 863) = 9.55, p < .01$) white ($F(1, 863) = 9.21, p < .01$)). The same effect was seen when comparing normally and widely spaced teeth, again in all colour conditions (yellow ($F(1, 863) = 12.57, p < .01$) natural ($F(1, 863) = 18.21, p < .01$) white ($F(1, 863) = 23.42, p < .01$)). With the focus on colour, yellow teeth were viewed as being significantly less attractive than both naturally coloured and whitened teeth in the crowded (natural ($F(1, 863) = 14.18, p < .01$); white ($F(1, 863) = 11.38, p < .01$)) and normal (natural ($F(1, 863) = 10.51, p < .01$); white ($F(1, 863) = 9.61, p < .01$)) spacing conditions.

Few effects were seen when females rated male models, where only those with widely spaced teeth were rated as being less attractive than those with naturally coloured crowded ($F(1, 863) = 10.73, p < .01$) and normally spaced whitened teeth ($F(1, 863) = 10.38, p < .01$) only.

However, females rating other females viewed models with normally spaced teeth as being significantly more attractive than models with widely spaced teeth in all colour conditions (yellow ($F(1, 863) = 13.01, p < .01$) natural ($F(1, 863) = 8.17, p < .01$) white

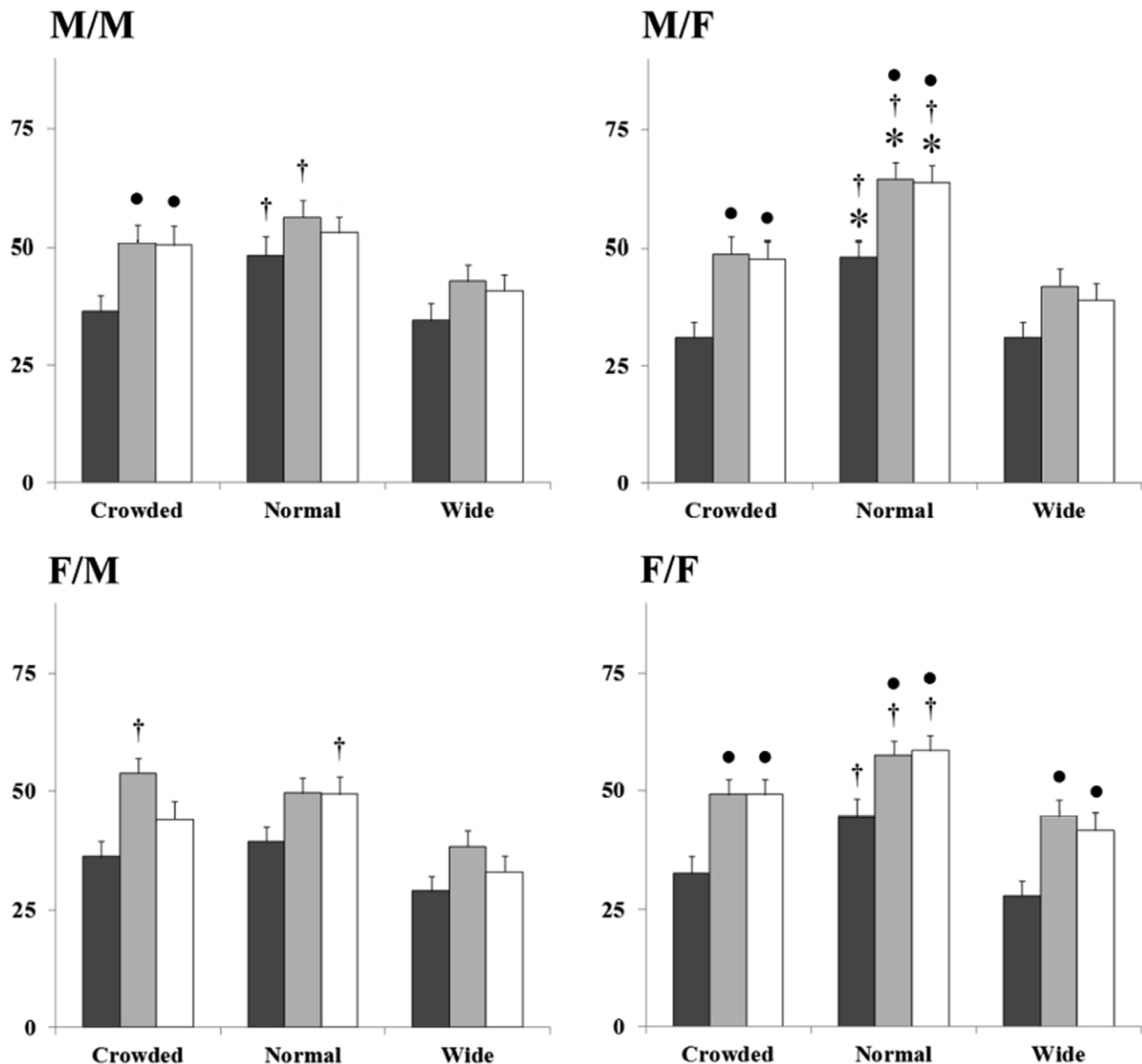


Figure 3. Effects of digital manipulations of teeth on ratings of attractiveness. Data are expressed as mean ratings of attractiveness ($\pm$ SEM) indicated on a 100 mm visual analogue scale. Higher numbers indicate greater attractiveness. Crowded, normal and wide refer to tooth spacing. Yellow, natural and white colour conditions are indicated by the dark, mid-grey and white bars respectively. **M/M** indicates male participants viewing male models; **M/F**, males viewing females; **F/M**, females viewing males and **F/F**, females rating females. Data indicate that ratings of female attractiveness are more sensitive to manipulations of tooth colour and spacing than males' regardless of whether male or female participants were doing the rating. The most marked effects in this sex were produced by deviations from normal spacing and yellow colouration. Attractiveness was not increased by further whitening from natural colour (B1 in the Vita shade scale) in any condition * = $p < 0.01$ from crowded teeth in the same colour condition; † = $p < 0.01$ from widely spaced teeth in the same colour condition; ● = $p < 0.01$ from yellow teeth in the same spacing condition. See text for further details.

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($F(1, 863) = 11.97, p < .01$). This effect was not seen in females with crowded teeth but there was a trend towards this ($p < 0.05$ in both the yellow and white colour conditions). With the focus on colour, female participants rated female models with yellow teeth as being significantly less attractive than those with naturally coloured teeth in all spacing conditions (wide ($F(1, 863) = 14.09, p < .01$), normal ($F(1, 863) = 7.69, p < .01$) crowded ($F(1, 863) = 11.29, p < .01$)). Females with yellow teeth were also rated as being less attractive than those with white coloured teeth, again in all spacing

conditions (wide ($F(1, 863) = 8.57, p < .01$), normal ($F(1, 863) = 8.45, p < .01$), crowded ($F(1, 863) = 11.59, p < .01$)). These data are summarised in Figures 2 and 3.

Discussion

Current data show that digital manipulation of tooth colour and spacing produces significant effects on ratings of attractiveness. Deviation away from normal spacing and/or the presence of

yellow colouration was found to negatively impact on these ratings. Data further suggest that ratings of attractiveness of female faces are more sensitive to digital manipulation than male faces regardless of which sex is doing the rating.

The signals produced by tooth displays in humans are complex. Smile type, duration and sequence are of major significance for social communication in our species [22,24,66,67]. These signals are also of importance because teeth have several key features that make them ideal vehicles with which to convey to both potential mates and rivals information about genetic quality, developmental history and current disease state (i.e. to serve as ornament displays).

Firstly, genetic factors have a clear influence on the expression and incidence of dental anomalies (e.g. [68,69,70]). Secondly, odontogenesis is a multidimensional process that is also sensitive to environmental insults that can then go on to have macroscopic outcomes (for review see [71]). These insults can be reflected in a number of different ways including position along the supernumerary/hypodontia/megadontia/microdontia continuum [72] which is a feature particularly seen in humans in consequence of the dramatic shrinkage of the lower mandible produced by neotony [73] and the changes closely associated with the move towards a soft diet [74]. Finally teeth are sensitive to influences experienced during adult life, particularly those nutritional, metabolic, traumatic events and diseases that lead to changes in colouration (e.g. [54,55]).

Age also has an important influence on the appearance of teeth, with these tending to become yellower and darker as people get older [57,58,59,60]. This may partly explain why females are more concerned about the appearance of their teeth than men [75]. Age-related changes in colour mean that women's teeth are also serving to signal residual reproductive value (e.g. [76]). Hence women smile more than men [77,78,79] and are the only sex to commonly enhance the prominence of their tooth displays by the wearing of lipstick [80].

The lack of effect of whitening teeth on increasing attractiveness beyond that seen in natural tooth colour is in keeping with other findings (e.g. [81]). However in the present study this could be an

artefact of the relatively young age of the participants and the models. The darker and yellower teeth of older women signal lower residual reproductive value than the whiter teeth of younger women. Hence, whilst there may be no advantage in increasing the whiteness of young women's teeth, for whom these are just one of an array of signals indicating their youth and consequent high residual reproductive value, this may not be the case in older women.

Similarly, the generally lower ratings of widely spaced (microdontic) teeth by both sexes when seen in both sexes and in all colour conditions may also be age related. Microdontia is strongly associated with low birth-weight [82] and low normal term birth-weight is strongly associated with increased rates of coronary heart disease, stroke, hypertension, non-insulin dependent diabetes and an early demise [83,84,85,86,87,88,89,90]. Therefore it may be predicted that microdontia will be viewed even more negatively with increasing age of the model, as the poor health outcomes signalled by this tooth array move temporally closer.

In summary, present findings suggest that digital manipulations of tooth colouration and spacing exert an influence over ratings of attractiveness of both male and female faces. The effects were however most strongly seen in female faces. Therefore it is tentatively concluded that the teeth of both sexes do indeed act as human ornament displays but that the female display is more complex because it additionally signals residual reproductive value, although more studies are required to fully confirm this.

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Author Contributions

Conceived and designed the experiments: CAH. Performed the experiments: CAH. Analyzed the data: CAH GB. Wrote the paper: CAH GB.

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