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Facial Structure Predicts Sexual Orientation in Both Men and Women

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Abstract Biological models have typically framed sexual orientation in terms of effects of variation in fetal androgen signaling on sexual differentiation, although other biological models exist. Despite marked sex differences in facial structure, the relationship between sexual orientation and facial structure is understudied. A total of 52 lesbian women, 134 heterosexual women, 77 gay men, and 127 heterosexual men were recruited at a Canadian campus and various Canadian Pride and sexuality events. We found that facial structure differed depending on sexual orientation; substantial variation in sexual orientation was predicted using facial metrics computed by a facial modelling program from photographs of White faces. At the univariate level, lesbian and heterosexual women differed in 17 facial features (out of 63) and four were unique multivariate predictors in logistic regression. Gay and heterosexual men differed in 11 facial features at the univariate level, of which three were unique multivariate predictors. Some, but not all, of the facial metrics differed between the sexes. Lesbian women had noses that were more turned up (also more turned up in heterosexual men), mouths that were more puckered, smaller foreheads, and marginally more masculine face shapes (also in heterosexual men) than heterosexual women. Gay men had more convex cheeks, shorter noses (also in heterosexual women), and foreheads that were more tilted back relative to heterosexual men. Principal components analysis and discriminant functions analysis generally corroborated these results. The mechanisms underlying variation in craniofacial structure—both related and unrelated to sexual differentiation—may thus be important in understanding the development of sexual orientation.

Keywords Sexual orientation · Sexuality · Faces · Facial structure · Sexual differentiation

Introduction

The most commonly cited biological models of the origins of sexual orientation implicate variations in fetal androgen signaling on sexual differentiation (Bao & Swaab, 2011; Breedlove, 2010; Rice, Friberg, & Gavrilets, 2012). Nevertheless, there is only modest evidence of physical differences between gay/lesbian and heterosexual individuals suggestive of atypical sexual differentiation (e.g., Schwartz, Kim, Kolundzija, Rieger, & Sanders, 2010). The physical differences that have been found are not found consistently and have weak effect sizes, thus accounting for little of the variance in sexual orientation (Hines, 2011; LeVay, 2010). For example, in a meta-analysis investigating the relationship between sexual orientation and the ratio of the second to fourth digit (2D:4D ratio; tends to be larger in women than in men and is a putative marker of variation in prenatal androgen signaling), there was a small effect of sexual orientation on 2D:4D ratios for women (heterosexual women > lesbian women; Hedge's $g = 0.29$ for the right hand and 0.23 for the left hand), but no effect for men (Grimbos, Dawood, Burriss, Zucker, & Puts, 2010; see also Williams et al., 2000). Further, despite a marked sex difference in height, which is influenced by both prenatal and postnatal factors including androgens, the difference in height between gay and heterosexual men is small in effect (e.g., $d = 0.21$ in Bogaert, 2010). There is also little or no difference in height between lesbian

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and heterosexual women (e.g., Bogaert, 2010; Bogaert & Liu, 2013).

In addition, when other physical characteristics have been associated with sexual orientation, this association has not always been interpreted in light of fetal androgens. For example, although handedness was originally conceptualized as being associated with sexual orientation due to sexual differentiation processes, the relationship between handedness and sexual orientation has more recently been argued to be influenced by a number of factors other than fetal androgens (Lalumiere, Blanchard, & Zucker, 2000). Based on a sex difference in handedness, such that men are more likely to be non-right-handed than women, a meta-analysis indicated that gay men were 34 % more likely than heterosexual men to be non-right-handed, and lesbian women were 91 % more likely than heterosexual women to be non-right handed (Lalumiere et al., 2000). This corresponds to $d = 0.16$ in men and $d = 0.36$ in women, conventionally small and moderate effect sizes (Tabachnick & Fidell, 2007). Overall, gay/lesbian individuals were 39 % more likely than heterosexual individuals to be non-right handed (Lalumiere et al., 2000), which corresponds to $d = 0.18$, a small effect size. Although other explanations exist, developmental instability, or deviations from perfect development influenced by environmental or genetic factors, was forwarded as the most plausible explanation for the findings of the relationship between sexual orientation and handedness. Left-handedness has been associated with markers of developmental instability. The increased likelihood of non-right-handedness in gay and lesbian compared to heterosexual individuals suggests that gay/lesbian individuals were under increased instability in early development compared to heterosexual individuals (Lalumiere et al., 2000). In sum, other mechanisms beyond androgen signaling have been proposed to explain variation in sexual orientation related to physical characteristics (e.g., developmental instability, genetic variation, maternal immune response), and these mechanisms may not always be mutually exclusive or independent of one another (Blanchard, 2008; Bogaert, 2007; Williams et al., 2000).

One physical characteristic, facial structure, has not been extensively studied in relation to sexual orientation. Facial structure is also affected by factors beyond sexual differentiation mechanisms, including developmental instability and genetic variation (Greene & Pisano, 2010; Jelenkovic, Poveda, Susanne, & Rebato, 2010). Sexual differentiation, however, is a common mechanism used to explain the development of facial structure because men and women differ in facial structure. Male faces generally have longer jaws, wider jaws, smaller eyes, larger noses, and more prominent brow ridges, whereas female faces generally have larger eyes, smaller brow ridges, smaller jaws, smaller chins, and fuller lips (Burke & Sulikowski, 2010; Rhodes, 2006). The development of the sexual dimorphism of faces is guided by both prenatal and postnatal factors (Bulygina, Mitteroecker, & Aiello, 2006; Enlow, 1982; Meindl, Windhager, Wallner, & Schaefer, 2012; Verdonck, Gaethofs, Carels, & de Zegher, 1999).

Hughes and Bremme (2011), who conducted one of two known studies of the relationship between sexual orientation and facial structure, reported reduced masculinity in gay relative to heterosexual men, but they were unable to identify the specific facial features underlying the reduced masculinity. Further, they did not find any significant differences between lesbian and heterosexual women. Specifically, gay and heterosexual men, as well as lesbian and heterosexual women, did not differ on seven separate proportional measures of sexually dimorphic facial characteristics (eye size, lower face/face height, cheekbone prominence, face width/lower face height, mean eyebrow height, forehead height, and lip/jaw width). After calculating a composite measure using these seven facial characteristics in an attempt to tap into overall facial masculinity/femininity, gay men had reduced facial masculinity relative to heterosexual men, but the composite masculinity/femininity measure was not associated with sexual orientation in women (Hughes & Bremme, 2011). Their study was limited, however, due to a small sample of photographs ($n = 15$ per group) that were obtained from websites and in the number of facial features examined.

In another study in Czech men that involved geometric morphometric analyses, significant differences were found between the shape of the faces of gay men compared to the shape of the faces of heterosexual men (Valentova, Kleisner, Havlicek, & Neustupa, 2014). In a qualitative follow-up analysis, it was found that gay men had shorter noses, a longer distance between the nose and mouth (i.e., philtrum), and a shorter distance between eyes and mouth compared to heterosexual men. Also, gay men had corners of the mouth oriented downwards, the shape of the oral cleft was convex, and gay men had a rounded and wider chin compared to heterosexual men. These characteristics suggest that gay men have a wider, shorter, and more globular facial form compared to the longer and narrower facial form of heterosexual men. In addition, these characteristics seem to reflect a mixture of both masculine (e.g., wider faces; rounded jaws) and feminine (e.g., shorter noses, shorter faces) facial features in gay men. This study was limited, however, by examining a small sample of men only, and by conducting only qualitative analyses to delineate the specific facial features that differ between gay and heterosexual men.

Examination of the facial features that differ between gay/lesbian and heterosexual individuals is partially fuelled by several studies providing empirical support for sex-based heuristics or stereotypes that guide judgement of sexual orientation based on the face (e.g., men's faces perceived to be more feminine in terms of face shape and texture were more likely to be judged as gay) (Freeman, Johnson, Ambady, & Rule, 2010; Stern, West, Jost, & Rule, 2013; Valentova et al., 2014). In addition, there is evidence of accuracy in judgements of sexual orientation based on facial photographs (which has been termed "gaydar") (Rule & Ambady, 2008; Rule, Ambady, Adams, & Macrae, 2007, 2008; Rule, Ambady, & Hallett, 2009). A meta-analysis found that the overall effect size for accurately categorizing targets based on sexual orientation was $r = .29$, with about 64.5 % of targets that would be correctly categorized. Further, accuracy in judgments of sexual orientation has been associated with sex-based heuristics (Freeman et al., 2010). Valentova et al. (2014), however, found that while ratings of homosexuality were associated with ratings of femininity, the gay men in their sample were rated as more masculine, so ratings of sexual orientation did not predict the actual sexual orientation of targets.

In several of these gaydar studies, the photographs of faces were obtained from dating websites, similar to Hughes and Bremme (2011; cf. Valentova et al., 2014). Examining facial features from photographs obtained from websites may reveal more about presentation of the self or the types of partners being sought than about the facial morphology that is associated with sexual orientation, although Rule and Ambady (2008) and Rule et al. (2008) attempted to address the self-presentation issue. An additional concern present in the gaydar studies is that hairstyle is not cropped out of the photographs of targets for rating of sexual orientation (e.g., Rule & Ambady, 2008; Rule et al., 2007, 2009). Given that hairstyle does play a role in judgements of sexual orientation (Rule et al., 2008), it is difficult to tease apart effects of hairstyle from effects due to perception of *only* facial cues in the studies that limited their photographs to ones solely with hairstyle. Nevertheless, faces with hairstyle occluded were still judged with some accuracy for sexual orientation, albeit less than just hairstyle alone, and less than a face with hairstyle together (Rule et al., 2009). Thus, sampling and standardization of photographs must be taken into account to determine whether there are actual differences in the facial characteristics of gay/lesbian and heterosexual individuals.

In summary, there may be sexually dimorphic facial features that differ between heterosexual and gay/lesbian individuals in the direction supported by androgen signalling theory (e.g., gay men have more feminine facial features) that cue judgements of sexual orientation, such as face shape, width of jaw, and length of face (Freeman et al., 2010; Tskhay & Rule, 2013; Valentova et al., 2014). Further, there may be sexually dimorphic facial features that differ between heterosexual and gay/lesbian individuals that cannot be explained by androgen signalling theory (e.g., gay men have more masculine facial features) that cue judgements of sexual orientation, such as width of face and length of nose (for evidence of this in men, see Valentova et al., 2014). Also, it is theoretically possible that there may be facial features that differ between heterosexual and gay/lesbian individuals that are independent of sex, although this has not been demonstrated in previous research.

We tested these possibilities—i.e., sexual orientation is related to facial structure via sexual differentiation mechanisms (e.g., androgen signalling) or via non-sexual differentiation mechanisms (although we did not test the mechanisms directly)—through the use of a facial modelling program that provided 63 facial metrics from photographs of a sample of both men and women. The subjects also completed extensive demographic information, including completion of several measures for classification of sexual orientation. The current study extended the work previously done on the relationship between sexual orientation and facial structure by: (1) Utilizing a sample of men somewhat larger than that examined by Valentova et al. (2014) and by Hughes and Bremme (2011); (2) including a sample of women (women were not included in Valentova et al. and our sample was somewhat larger than the sample of women examined by Hughes and Bremme); (3) utilizing more standardized photographs, similar to Valentova et al., but unlike the photographs examined by Hughes and Bremme which were collected from online websites; (4) utilizing a quantitative approach to deducing the facial features related to sexual orientation, which expands on the quantitative approach used by Hughes and Bremme and extends the qualitative approach used by Valentova et al.; and (5) capitalizing on the quantitative approach offered by our methodology to utilize different data reduction techniques to deduce the facial features related to sexual orientation.

Method

Subjects

Photographs were selected from a database including 906 subjects. Only those fitting the definition of gay/lesbian and heterosexual based on questionnaire responses were included. Subjects indicated their sexual attraction on a 1–7 Likert scale (exclusively homosexual/gay/lesbian to exclusively heterosexual/straight). Specifically, subjects rated themselves on the following question: "In terms of my sexual thoughts and feelings, I am…" on the Likert scale. Subjects also indicated their identity by checking whether they were homosexual/gay, homosexual/lesbian, bisexual, heterosexual/straight, asexual ("lack of attraction to either sex"), or other, with a space to specify what they referred to as other. Subjects were selected if their Likert score was ≤ 2 (i.e., exclusively or near exclusively homosexual) and they self-identified as "homosexual/gay/lesbian" or if their Likert score was ≥ 6 (i.e., exclusively or near exclusively heterosexual) and they self-identified as "heterosexual/straight." Only White subjects were included to remove variation in facial structure attributable to ethnicity (Fang, Clapham, & Chung, 2011). Some were excluded because they were not posed in neutral expressions, were not facing the camera directly, or the face was obscured. An additional three women were removed from final analyses when identified as multivariate statistical outliers (Cohen, Cohen, West, & Aiken, 2003). Thus, the final sample consisted of 390 facial photographs (52 lesbian women, 134 heterosexual women, 77 gay men, 127 heterosexual men).

Procedure

The photographs were taken with a Nikon D3100 digital SLR camera in RAW format by the first author. Each photograph was converted to TIFF format prior to inputting into the FaceGen program (a facial modelling program) (Singular Inversions, 2010). Once inputted into the FaceGen program and after receiving training, the third author, who was blind to the sexual orientation of the subjects in the photographs, fitted each face to the points on the face required by FaceGen to compute the necessary numerical values. Subjects were instructed to pose with a neutral facial expression, to remove glasses, and to wear a hair net or hold back any hair that was obstructing their face if a hair net was unavailable. Subjects were recruited at Brock University or at various Pride or sexuality events across Canada (e.g., Toronto Pride, Montreal Pride, Vancouver Pride, Everything to do with Sex Show Toronto) to participate in a larger study on Sexuality and Physical Development. Note that not all subjects recruited on campus were heterosexual and not all subjects recruited at Prides were gay/lesbian. For photographs taken at Brock University, the camera was placed on a tripod, approximately 2 m away from each subject, as they stood straight against a wall. The height of the camera was adjusted so that the lens of the camera was at the same height of the subject's face. For photographs shot off campus, the camera was held in hand when shooting and an attempt was made to stand 2 m away from each subject, although this distance was not always possible due to the conditions at the various events. A hairline to chin distance of 400 pixels was used to standardize the photographs to control for any variation in distance from the camera to the face. Subjects were paid or given course credit for participation, and provided consent to participating in the study and to having their photograph taken for structural analyses only. See Table 1 for descriptive statistics related to this sample. The original data collection and the current study were approved by the Brock University Research Ethics Board.

Measures

FaceGen utilizes statistical algorithms derived from 3D laser scans of a sample of human faces. From these algorithms, 62 facial metrics are provided in standardized units, which range on a continuum from high to low. Sixty-one of these facial metrics have numerical values and can be grouped into 10 featural categories (e.g., cheeks, nose). An additional shape metric, not associated with a numerical value, consisted of an analogue sliding scale along a masculine-feminine dimension (see also Carpinella & Johnson, 2013; Yang, Shen, Chen, & Fang, 2011). We placed a ruler on the scale to obtain a numerical value that corresponded with the degree to which a face was masculine or feminine. That is, the ruler was placed on the computer screen to measure the distance that the slider was at on the scale, which was anchored by 100 % male on one end and 100 % female on the other end (inter-rater reliability: $r = .99, p < .01$). It is important to note that the shape metric is not an average measure of other facial metrics that FaceGen provides that are related to sex. While sex is correlated with several of the facial metrics, the shape metric is a separate metric provided by FaceGen that globally assesses differences in the shape of the face between men and women. Also, the shape of the face has been found to discriminate strongly between male and female faces (Yamaguchi, Hirukawa, & Kanazawa, 1995). The 63rd metric, facial width-to-height ratio (bizygomatic width divided by upper face height) was also measured (Carré & McCormick, 2008).

Data Analysis

Overview of Facial Metrics in the Main Analyses

First, among heterosexual subjects (127 men, 134 women), we examined partial correlations (controlling for age, weight, and height) between each facial metric and sex (see Table 2) to determine which of the facial metrics, used in the final model to predict sexual orientation, differed for the sexes. Further, facial metrics that shared significant ($ps \leq .05$) partial correlations (controlling for age, height, and weight) with sexual orientation within each sex were selected for the main analyses (see Table 2). When two or more metrics (e.g., cheekbones high and

Table 1 Descriptive statistics for the sample

Predictors	Gay men ($n = 77$) *M* (*SD*)	Heterosexual men ($n = 127$) *M* (*SD*)	Heterosexual women ($n = 134$) *M* (*SD*)	Lesbian women ($n = 52$) *M* (*SD*)
Age (years)	31.08 (12.55)	22.87 (8.28)	20.66 (4.81)	27.69 (10.95)
Height (cm)	177.28 (8.16)	177.60 (7.15)	164.32 (6.75)	164.93 (6.51)
Weight (kg)	79.39 (16.20)	77.87 (12.77)	64.96 (11.71)	72.09 (16.54)
BMI	25.19 (4.37)	24.69 (3.81)	24.03 (4.03)	26.53 (6.03)

Table 2 Partial correlations between the facial metrics, sex, and sexual orientation

Facial metrics	Sex	Sexual orientation	
		Men ($n=204$)	Women ($n=186$)
Shape: feminine	−**.42**	.03	−**.23**[c]
Facial width-to-height ratio	.05	.00	−.07
Brow category			
Brow ridge: low	.09	.05	−.03
Brow ridge inner: up	.01	−.09	.05
Brow ridge outer: down	.11	.05	−.06
Cheek category			
Cheekbones: high	**.12**	−**.21**[a]	.00
Cheekbones: pronounced	−.10	.02	−.10
Cheekbones: wide	−.02	.00	−.07
Cheeks: convex	.10	**.22**	**.27**
Cheeks: gaunt	**.16**	.05	.12
Chin category			
Chin: backward	.03	−.03	.08
Chin: recessed	.05	−.02	−.07
Chin: jutting	−.02	.01	.05
Chin: deep	−**.18**	−.01	−**.19**[c]
Chin: large	.08	−.09	.12
Chin: short	.09	.02	−.03
Chin: thin	.08	.02	−.06
Eyes category			
Eyes: up	**.20**	.10	**.19**[c]
Eyes: large	−**.27**	.03	−.12
Eyes: tilt outward	.08	**.15**	.00
Eyes: together	−.02	−.09	.04
Face category			
Face: brow-nose-chin ratio	**.23**	.06	**.23**[c]
Face: forehead-sellion-nose ratio	−.07	.04	−.06
Face: light	.03	.04	−.05
Face: gaunt	−**.15**	.13	.14
Face: short	−**.13**	−.04	−.13
Face: down	.04	−.07	−.07
Face: thin	−.07	−.08	−.10
Forehead category			
Forehead: large	−**.12**	−.13	−**.36**[c]
Forehead: short	.04	.10	.13
Forehead: tilt back	.03	**.16**	**.19**
Head category			
Head: thin	−.10	.06	.09
Temples: wide	−.01	−.08	−.10
Jaw category			
Jaw: jutting	−.02	.01	.06
Jaw: thin	−**.16**	.00	−.08
Jaw-neck-slope: low	.00	.02	.08
Jawline: convex	.01	.04	.09
Mouth category			
Mouth: pursed	.11	.02	−.10
Mouth: sad	**.18**	−.06	.07
Mouth: lips inflated	.07	.13	**.28**
Mouth: lips small	−**.18**	−**.16**[b]	−**.31**[c]
Mouth: lips retracted	.03	−**.18**	−**.30**
Mouth: lips thick	**.18**	.13	.01
Mouth: retracted	−.07	−**.24**	−**.42**
Mouth: tilt down	−**.24**	−.11	−**.33**[c]
Mouth: overbite	−**.32**	−.05	**-.28**[c]
Mouth: down	**.27**	.00	.08
Mouth: thin	−**.15**	−.03	−**.20**[c]
Mouth-chin distance: long	−**.25**	−.03	−.04
Nose category			
Nose: bridge deep	**.24**	−**.28**[a]	−.09
Nose: bridge long	−**.19**	.03	−.12
Nose: up	**.21**	.01	**.15**[c]
Nose: pointed	**.21**	−**.24**[a]	−**.15**[d]
Nose: nostril tilt up	.11	−.05	.06
Nose: nostrils large	**.25**	−**.17**[a]	−.14
Nose: nostrils thin	−**.20**	−.08	−.11
Nose: region convex	−.11	.08	.06
Nose: sellion up	−**.12**	−.07	−.04
Nose: sellion deep	.10	−.01	.07
Nose: sellion deep	**.23**	.13	.13
Nose: sellion wide	**.14**	−.02	−.01
Nose: long	**.21**	−**.30**[a]	−**.23**[d]
Nose: tilt up	.05	−.04	−.03

The numbers represent partial correlations between the facial metrics and sex (0 = heterosexual women, 1 = heterosexual men; positive correlations indicate heterosexual men have more of the metric than heterosexual women, whereas negative correlations indicate they have less), and between the facial metrics and sexual orientation (0 = heterosexual, 1 = gay/lesbian; positive correlations indicate gay/lesbian individuals have more of the metric than heterosexual individuals, whereas negative correlations indicate they have less), statistically controlling for age, height, and weight. Correlations in bold are significant ($p \leq .05$)

[a] Metric is more feminine in gay than in heterosexual men

[b] Metric is more masculine in gay than in heterosexual men

[c] Metric is more masculine in lesbian than in heterosexual women

[d] Metric is more feminine in lesbian than in heterosexual women

cheeks convex) within the same featural category (e.g., cheeks) were associated with sexual orientation, they were included in the first model only if they uniquely predicted sexual orientation in a logistic regression with age, height, and weight on Step 1 and the relevant facial metrics on Step 2. This approach is somewhat conservative, but given the high number of predictors, this approach minimized the likelihood of making Type I errors and reduced multicollinearity issues in the main analyses. Standardized residuals were created within each sex, to control for age, weight, and height, for each of the facial metrics to be included in the main analyses. Thus, in the main analyses, within each sex, the residuals of unique metrics *within a featural category* (based on partial correlations and/or logistic regressions, as outlined above) were entered as simultaneous predictors in a binary logistic regression to determine which shared unique associations with sexual orientation. Of these, only the residuals of unique metrics predicting sexual orientation (i.e., $p \leq .10$) were included in the final model.

Overview of Analyses Using Alternative Data Reduction Techniques

Although the logistic regression allowed us to pinpoint specific unique facial metrics that differed between individuals that were gay/lesbian or heterosexual, it did not allow for the identification of linear combinations of features that may better discriminate between gay/lesbian and heterosexual individuals. For example, although a retracted mouth may differentiate lesbian and heterosexual women, a mouth that involves a combination of having thin lips and being retracted may be an even better correlate of sexual orientation. Thus, we utilized two different analyses—principal components analysis (PCA) and discriminant function analysis (DFA)—to examine linear combinations of facial metrics.

In the PCA, the total set of facial metrics was reduced into a smaller number of components. The components represented linear combinations of facial metrics that were arranged and combined such that they accounted for the most amount of variability possible in the total set of facial metrics. For ease of component interpretation, this analysis was conducted using varimax rotation, which reduces variable loadings that are weak and strengthens variable loadings that are strong, therefore minimizing the cross-loading of facial metrics on multiple components (Tabachnick & Fidell, 2007). First, standardized residuals were created for each of the facial metrics in the entire sample, to control for age, weight, and height. Then, the PCA reduced the total set of facial metrics into a smaller number of components and the component scores were saved for each subject. The component scores were then used as independent variables in two logistic regressions conducted within each sex, to predict sexual orientation. To determine which components differed for men and for women (i.e., were sexually dimorphic), we conducted point-biserial correlations within heterosexual subjects ($n = 261$) between the component scores for each component and sex.

In the DFA, group membership (heterosexual women, lesbian women, heterosexual men, gay men) was predicted by linear combinations of variables called discriminant functions. Specifically, the discriminant functions are created to allow for the best separation between the groups. If the groups differ on more than one linear combination of variables, an additional discriminant function will form. The maximum number of discriminant functions that can be formed is equal to the lesser of the number of predictors minus one or the number of groups minus one (Tabachnick & Fidell, 2007). Therefore, in the current analysis, which involved four groups, a maximum of three discriminant functions were able to form. First, standardized residuals were created for each of the facial metrics in the entire sample to control for age, weight, and height. Then, the 63 facial metrics were entered as independent variables in a DFA with group membership (0 = heterosexual women, 1 = lesbian women, 2 = heterosexual men, 3 = gay men) as the dependent variable.

DFA is more robust against the violation of certain assumptions if there are as many subjects in the smallest group as there are predictors in the model. Although we had 63 predictors, 9 of these predictors (nose bridge: short long, nose: down up, nose region: concave convex, nose sellion: down up, nose sellion: shallow deep, nose sellion: thin wide, nose: short long, nose tilt: down up, temples: thin wide) were removed from the analysis because they failed to pass the tolerance test (i.e., they shared substantial overlap with other predictors). Thus, 54 of the 63 facial metrics were included as independent variables in the final DFA with group membership (0 = heterosexual women, 1 = lesbian women, 2 = heterosexual men, 3 = gay men) as the dependent variable.

Results

Group Differences

There were group differences in age (ANOVA, $n = 390$: $F(1, 386) = 8.53$, $p = .004$, men > women; $F(1, 386) = 63.32$, $p < .001$, gay/lesbian individuals > heterosexual individuals; $ps < .01$), weight (ANOVA, $n = 390$: $F(1, 386) = 45.63$, $p < .001$, men > women; $F(1, 386) = 8.36$, $p = .004$, gay/lesbian individuals > heterosexual individuals, $ps < .01$), and height (ANOVA, $n = 390$: $F(1, 386) = 270.09$, $p < .001$, men > women, $p < .001$; see Table 1 for descriptive statistics). There were also associations between age ($-.34 \leq r \leq .33$, $ps \geq .001$), weight ($-.35 \leq r \leq .41$, $ps \geq .001$), and height ($-.33 \leq r \leq .32$, $ps \geq .001$) and facial structure.[1] Thus, age, weight, and height were controlled statistically in all analyses (details provided when each analysis is described below).[2]

[1] For more details, contact the corresponding author.

[2] Note that an alternative strategy would be to statistically control for body mass index (BMI) and age in the analyses. Given that height ($B = -0.29$, $SE = .003$, $t = -88.48$, $p < .001$) and weight ($B = .34$, $SE = .002$, $t = 161.22$, $p < .001$) predicted 98.5 % of the variance in BMI ($R = .99$, $R^2 = .98$, $F(2) = 13008.27$, $p < .001$), and there continue to be conceptual problems with the use of BMI (e.g., BMI takes weight into account

Partial Correlations Between Sex and Facial Metrics

Partial correlations (controlling for age, weight, and height) between each facial metric and sex in heterosexual subjects only are shown in Table 2. There were differences between heterosexual men and heterosexual women for 30 of the 63 facial metrics. The metric of shape (masculine–feminine dimension) showed the largest effect size, such that heterosexual women had more feminine face shapes than heterosexual men, consistent with the literature (Yamaguchi et al., 1995).

Partial Correlations Between Sexual Orientation and Facial Metrics in Women

Partial correlations between each metric and sexual orientation, within each sex, are shown in Table 2. In women, the partial correlations indicated that there were significant differences between lesbian and heterosexual women for 17 of the 63 facial metrics (see Table 2). The greatest difference between lesbian and heterosexual women was on the mouth retracted metric, such that heterosexual women had a more retracted mouth than lesbian women. With respect to the shape metric's partial correlation with sexual orientation, heterosexual women had more feminine face shapes than lesbian women. Ten of the 17 facial metrics were in the direction of more masculine in lesbian than in heterosexual women, whereas two were in the direction of more feminine in lesbian than in heterosexual women. Five of the 17 facial metrics that were associated with sexual orientation within women were unrelated to sex differences.

Partial Correlations Between Sexual Orientation and Facial Metrics in Men

In men, the partial correlations indicated that there were significant differences between gay and heterosexual men for 11 of the 63 facial metrics (see Table 2). The greatest difference was on the nose long metric, such that heterosexual men had longer noses than gay men. With respect to the shape metric's partial correlation with sexual orientation, there was no significant difference in the shape of the face between gay and heterosexual men. Five of the 11 facial metrics were in the direction of more feminine in gay than in heterosexual men, whereas one was in the direction of more masculine in gay than in heterosexual men. Five of the 11 facial metrics that were associated with sexual orientation within men were unrelated to sex differences.

Footnote 2 continued
more than height) (Anderson, 2012; Ernsberger, 2012), we chose to conduct our analyses with our original plan of controlling for height and weight (in addition to age).

Selection of Facial Metrics in Women and Men for Main Analyses

Of the 17 facial metrics that were partially correlated with sexual orientation within women, 11 were included in the main analyses (see "Method" section for a description of how the facial metrics were selected within each featural category). These 11 facial metrics were: shape, cheeks: convex, chin: deep, eyes: up, face: brow nose chin ratio, forehead: large, mouth: lips inflated, mouth: lips retracted, mouth: retracted, mouth: thin, and nose: up. Seven differed between heterosexual men and women (shape, chin: deep, eyes: up, face: brow nose chin ratio, forehead: large, mouth: thin, and nose: up); all seven were in the direction of more masculine for lesbian women (see Table 2).

Of the 11 facial metrics that were partially correlated with sexual orientation within men, six were included in the main analyses (see "Method" section). These six facial metrics were: cheekbones: high, cheeks: convex, eyes: tilt outward, forehead: tilt back, mouth: retracted, and nose: long. Two differed between heterosexual men and women (cheekbones: high and nose: long); both were in the direction of more feminine for gay men (see Table 2).

Main Analyses in Women

When the residuals of the 11 facial metrics were entered into a binary logistic regression as simultaneous predictors of sexual orientation in women ($n = 186$), the first model significantly predicted sexual orientation; $\chi^2 = 50.10, p < .001$, Nagelkerke $R^2 = .34$ ($d = 1.44$). The model accurately predicted sexual orientation in 81 % of the cases. The strongest unique predictors were shape ($B = -0.49$, Wald $= 3.98, p = .05, OR = 0.61$, $d = 0.27$), nose: up ($B = 0.58$, Wald $= 4.23$, $p = .04$, $OR = 1.78$, $d = 0.32$), mouth: retracted ($B = -0.76$, Wald $= 3.66$, $p = .06, OR = 0.47, d = 0.42$), and forehead: large ($B = -0.46$, Wald $= 3.21$, $p = .07$, $OR = 0.63$, $d = 0.26$). All other predictors were non-significant ($ps > .16$). When only these four predictors were used, the overall final model was significant ($\chi^2 = 43.50$, $p < .001$, Nagelkerke $R^2 = .30$, $d = 1.31$), the model accurately classified 81 % of cases, the nose: up ($B = 0.49$, Wald $= 5.56, p = .02, OR = 1.63, d = 0.27$), mouth: retracted ($B = -0.86$, Wald $= 11.64$, $p = .001$, $OR = 0.42$, $d = 0.48$), and forehead: large ($B = -0.45$, Wald $= 4.37, p = .04, OR = 0.64, d = 0.25$) predictors were significant, and the shape predictor was marginally significant ($B = -0.40$, Wald $= 3.39$, $p = .07$, $OR = 0.67$, $d = 0.22$).

Thus, lesbian women had noses that were more turned up, had mouths that were more puckered, had smaller foreheads, and had marginally more masculine face shapes than heterosexual women. Recall that in terms of features that showed evidence of typical sex differentiation, heterosexual women had more feminine face shapes, had noses that were more turned down, and had smaller foreheads than heterosexual men

Table 3 Summary of results of correlational analyses and logistic regressions (final models)

Facial metric	Results (versus heterosexual counterparts)
Women: unique facial metrics	
Shape: feminine	Lesbian women had marginally more masculine face shapes[a]
Nose: up	Lesbian women had noses that were turned up[a]
Mouth: retracted	Lesbian women had mouths that were puckered[c]
Forehead: large	Lesbian women had small foreheads[b]
Women: additional facial metrics significant at univariate level	
Cheeks: convex	Lesbian women had convex cheeks[c]
Chin: deep	Lesbian women had shallow chins[a]
Eyes: up	Lesbian women had eyes that were up[a]
Face: brow-nose-chin ratio	Lesbian women had a large ratio[a]
Forehead: tilt back	Lesbian women had foreheads that were tilted back[c]
Mouth: lips inflated	Lesbian women had lips that were inflated[c]
Mouth: lips small	Lesbian women had lips that were large[a]
Mouth: lips retracted	Lesbian women had lips that were protruding[c]
Mouth: tilt down	Lesbian women had a mouth that was tilted up[a]
Mouth: overbite	Lesbian women had an underbite[a]
Mouth: thin	Lesbian women had a mouth that was thick[a]
Nose: pointed	Lesbian women had a rounded nose[b]
Nose: long	Lesbian women had a short nose[b]
Men: unique facial metrics	
Nose: long	Gay men had a short nose[a]
Cheeks: convex	Gay men had convex cheeks[c]
Forehead: tilt-back	Gay men had foreheads that were tilted back[c]
Men: additional facial metrics significant at univariate level	
Cheekbones: high	Gay men had low cheekbones[a]
Eyes: tilt outward	Gay men had eyes tilted outward[c]
Mouth: lips small	Gay men had large lips[b]
Mouth: lips retracted	Gay men had protruding lips[c]
Mouth: retracted	Gay men had a protruding mouth[c]
Nose: bridge deep	Gay men had a shallow nose bridge[a]
Nose: pointed	Gay men had a rounded nose[a]
Nose: nostrils large	Gay men had small nostrils[a]

[a] Atypical sexual differentiation

[b] Typical sexual differentiation

[c] Unrelated to sexual differentiation

(see Table 2). Thus, the facial structure of lesbian women demonstrated some atypical sexual differentiation (i.e., had metrics in the same direction as heterosexual men) for two out of the four metrics (shape and nose). The facial structure of lesbian women also exhibited some typical sexual differentiation for one metric (forehead) and exhibited differences that were unrelated to sexual differentiation for one metric (mouth) (for a summary of the results in women, see Table 3). The four metrics in the final logistic regression were used to generate a facial model of women's sexual orientation (see Fig. 1a for the facial model with these four structural differences in women).

Main Analyses in Men

For men ($n = 204$), when the residuals of the six metrics were entered into a binary logistic regression as simultaneous predictors, the first model significantly predicted sexual orientation; $\chi^2 = 34.60$, $p < .001$, Nagelkerke $R^2 = .21$ ($d = 1.03$). The model accurately predicted sexual orientation in 72 % of the cases. The strongest unique predictors were nose: long ($B = -0.51$, Wald $= 7.76$, $p < .01$, $OR = 0.60$, $d = 0.28$), cheeks: convex ($B = 0.38$, Wald $= 3.47$, $p = .06$, $OR = 1.46$, $d = 0.21$), and forehead: tilt-back ($B = 0.31$, Wald $= 3.36$, $p = .07$, $OR = 1.37$, $d = 0.17$). When only these three predictors were used, the final model was again significant ($\chi^2 = 29.10$, $p < .001$, Nagelkerke $R^2 = .18$, $d = 0.94$), the model accurately classified 67 % of cases, and each predictor was significant (nose: long, $B = -0.63$, Wald $= 13.74$, $p < .001$, $OR = 0.53$, $d = 0.35$; cheeks: convex, $B = 0.46$, Wald $= 7.39$, $p = .007$, $OR = 1.58$, $d = 0.25$; forehead: tilt-back, $B = 0.35$, Wald $= 4.76$, $p = .029$, $OR = 1.42$, $d = 0.19$).

Thus, gay men had more convex cheeks, shorter noses, and had foreheads that were more tilted back relative to heterosexual men. Recall that in terms of features that showed evidence of typical sex differentiation, heterosexual men had longer noses than heterosexual women (see Table 2). Thus, the facial structure of gay men demonstrated some evidence of atypical sexual differentiation (i.e., had metrics in the same direction as heterosexual women) for one out of the three metrics (nose). The facial structure of gay men also exhibited differences that were unrelated to sexual differentiation for two metrics (cheeks and forehead) (for a summary of the results in men, see Table 3). The three metrics used in the final logistic regression were used to generate a facial model of men's sexual orientation (see Fig. 1b for the facial model with these three structural differences in men).

Principal Components Analysis (PCA)

When a PCA was conducted ($n = 390$) on the 63 facial metrics (again after partialling age, height, and weight), 19 components were extracted (see Table 4 for a list of the components and their loadings), which accounted for 85.45 % of the variability in the facial metrics. Point-biserial correlations between sex and the component scores for the 19 components revealed six components on which heterosexual women differed from heterosexual men (as indicated by superscripts in Table 4). These were Components 1 ($r = .20$, $p = .001$), 6 ($r = .26$, $p < .001$), 12 ($r = .14$, $p = .02$), 13 ($r = .20$, $p = .001$), 14 ($r = -.12$, $p = .05$), and 16 ($r = -.25$, $p < .001$). The greatest difference between heterosexual men and heterosexual women was on Component 6, which was comprised of several nose

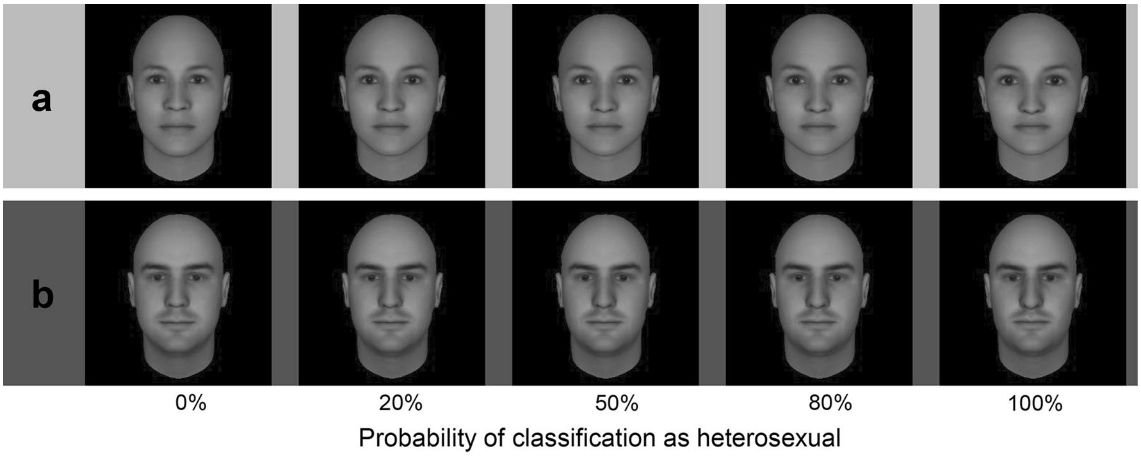

Fig. 1 Facial models of sexual orientation. A female (**a**) and a male (**b**) face were generated randomly using FaceGen and adjusted based on the statistical models predictive of sexual orientation for each sex. The faces in the centre were adjusted on the relevant metrics identified in the second regression analyses (4 metrics in women, 3 in men) to resemble faces that were most ambiguous with respect to predicted sexual orientation. Faces to the right of centre were adjusted to exaggerate features predictive of a heterosexual orientation whereas those to the left were adjusted to minimize these features. The numbers below the faces represent the statistical probability of being classified as heterosexual by the model for each sex. Faces within the 20–80 % range are difficult to discriminate among, indicating that features predictive of sexual orientation may be subtle and that classification accuracy likely depends on structural differences between faces located at the extreme ends of the distribution

metrics, and on Component 16, which was comprised of the face shape metric.

When the scores for the 19 components were entered as simultaneous predictors of sexual orientation in women ($n=$ 186) in a binary logistic regression, the model was significant ($\chi^2 = 61.96$, $p < .001$, Nagelkerke $R^2 = .41$, $d = 1.67$) and accurately predicted 83 % of cases; Component 1 ($B = 0.83$, Wald $= 8.90$, $p = .003$, $OR = 2.29$, $d = 0.46$), Component 5 ($B = -1.06$, Wald $= 14.60$, $p < .001$, $OR = 0.35$, $d = 0.58$), Component 6 ($B = -0.48$, Wald $= 5.02$, $p = .03$, $OR = 0.62$, $d = 0.26$), Component 15 ($B = -0.58$, Wald $= 6.64$, $p = .01$, $OR = 0.56$, $d = 0.32$), and Component 16 ($B = -0.46$, Wald $=$ 3.72, $p = .05$, $OR = 0.63$, $d = 0.26$) were significant predictors (all other $ps > .05$). With only these five components as simultaneous predictors of sexual orientation in women, the model was again significant ($\chi^2 = 46.72$, $p < .001$, Nagelkerke $R^2 =$ .32, $d = 1.37$) and accurately predicted 83 % of cases; Component 1 ($B = 0.72$, Wald $= 8.79$, $p = .003$, $OR = 2.06$, $d =$ 0.40), Component 5 ($B = -0.94$, Wald $= 15.86$, $p < .001$, $OR =$ 0.39, $d = 0.52$), Component 6 ($B = -0.43$, Wald $= 4.54$, $p =$ .03, $OR = 0.65$, $d = 0.24$), and Component 15 ($B = -0.69$, Wald $= 9.79$, $p = .002$, $OR = 0.50$, $d = 0.38$) were significant, but Component 16 ($B = -0.32$, Wald $= 2.41$, $p = .12$, $OR =$ 0.73, $d = 0.17$) was no longer significant. Thus, linear combinations of several facial metrics discriminated between heterosexual and lesbian women. Heterosexual women had higher component scores than lesbian women on Components 5, 6, and 15, and had lower scores than lesbian women on Component 1. Component 1 was defined by mouth, cheek, depth of chin, and length of face metrics. Component 5 was defined by several mouth metrics and Component 6 was defined by several nose metrics. Component 15 was defined by the size of the forehead and width of the nostrils. Recall that heterosexual women had lower scores on Component 1 and 6 than heterosexual men. Thus, the facial structure of lesbian women was consistent with atypical sexual differentiation for Component 1 (i.e., more masculine), some typical sexual differentiation for Component 6 (i.e., more feminine), and exhibited differences that were unrelated to sexual differentiation for Components 5 and 15.

When the 19 components were entered as simultaneous predictors of sexual orientation in men ($n = 204$) in a binary logistic regression, the model was significant ($\chi^2 = 30.78$, $p = .04$, Nagelkerke $R^2 = .19$, $d = 0.97$) and accurately predicted 70 % of cases; only Component 6 ($B = -0.75$, Wald $=$ 18.25, $p < .001$, $OR = 0.47$, $d = 0.42$) was a significant predictor (all other $ps > .05$). With only Component 6 as a predictor of sexual orientation in men, the model was again significant ($\chi^2 = 21.39$, $p < .001$, Nagelkerke $R^2 = .14$, $d = 0.81$), the model accurately predicted 67 % of cases, and Component 6 ($B = -0.71$, Wald $= 18.49$, $p < .001$, $OR = 0.49$, $d = 0.39$) was a significant predictor. Thus, linear combinations of some (but less than in women) facial metrics discriminated between heterosexual and gay men. Gay men had lower scores than heterosexual men on Component 6, which was defined by several nose metrics. Recall that heterosexual men had higher scores on Component 6 than heterosexual women. Thus, the facial structure of gay men suggested some atypical sexual differentiation for Component 6 (i.e., more feminine).

Discriminant Functions Analysis (DFA)

The analysis on the 54 facial metrics (again after partialling out age, height, and weight from each metric) revealed three functions (see Table 5). The test of functions revealed that Functions

Table 4 Varimax-rotated component matrix from the principal components analysis for the total sample ($n = 390$)

Facial metrics	Component																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Component 1 (11.05 %)[b]																			
Mouth-chin distance: long	−**.87**																		
Mouth: tilt down	−**.86**																		
Mouth: overbite	−**.85**																		
Mouth: down	**.79**	.33											−.39						
Mouth: pursed	**.68**				.57														
Face: short	−**.63**			.52						−.42									
Cheeks: gaunt	**.63**																		
Mouth: Lips thick	**.52**		−.33											.34	.32				
Cheeks: convex	**.49**			−.37											−.31	−.32			
Chin: deep	−**.41**																.37	.41	
Component 2 (7.30 %)																			
Nose: nostril tilt up		**.89**																	
Nose: bridge long		−**.88**																	
Nose: up		**.83**																	
Nose: tilt up		**.80**				.31		−.35											
Component 3 (6.77 %)																			
Jaw: jutting			**.96**																
Chin: jutting			**.96**																
Chin: backward			−**.68**						−.36										
Chin: thin			**.64**														−.40		
Chin: recessed			−**.64**						.61										
Component 4 (6.31 %)																			
Brow Ridge: low				**.95**															
Brow Ridge Inner: up				−**.91**															
Brow Ridge Outer: down				**.77**															
Face: down				**.61**						−.59									
Component 5 (5.98 %)																			
Mouth: Lips inflated					−**.96**														
Mouth: Lips small	−.41				**.85**														
Mouth: sad	.35				**.65**									−.40					
Mouth: thin					**.55**			−.40						.41					
Mouth: retracted	−.40				**.51**	.35		.41											

Table 4 continued

Facial metrics	Component																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Component 6 (5.51 %)[b]																			
Nose: long						**.91**													
Nose: bridge deep						**.75**		.31											
Nose: pointed		.51				**.75**		−.36											
Nose: nostrils large		.55				**.64**													
Component 7 (5.06 %)																			
Face: thin							**.81**												
Eyes: together							**.80**												
Cheekbones: wide			.32				**.62**												
Temples: wide							**.58**												
Forehead: tilt back							**−.57**											.39	
Component 8 (4.66 %)																			
Nose: region convex								**−.78**											
Nose: sellion deep								**.64**											.33
Nose: sellion deep								**.60**				.39							
Component 9 (4.19 %)																			
Jawline: convex									**.78**										
Chin: short	.37								**.77**										
Component 10 (3.72 %)																			
Eyes: up	.45									**.73**									
Forehead: short										**.67**									
Cheekbones: high										**.50**		.31							
Component 11 (3.59 %)																			
Head: thin											**.86**								
Facial Width-to-height Ratio											**.78**								
Face: light	.36										**−.47**								
Component 12 (3.54 %)[b]																			
Nose: sellion wide												**.83**							
Eyes: large							.36					**−.66**							
Nose: sellion up		−.32										**−.66**							
Component 13 (3.17 %)[b]																			
Face: brow-nose-chin ratio											.34		**.78**						
Mouth: Lips retracted			.42		.40	.31							**−.65**						
Jaw-Neck-Slope: low									.32				**.36**						−.30

Table 4 continued

Facial metrics	Component																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Component 14 (2.94 %)[a]																			
Cheekbones: pronounced														**.66**					
Face: gaunt						−.31								**.44**		−.36			
Jaw: thin	−.31													**−.36**					
Component 15 (2.54 %)																			
Forehead: large															**.67**				
Nose: nostrils thin			−.39												**.49**	.30			
Component 16 (2.50 %)[a]																			
Shape: feminine																**.86**			
Component 17 (2.47 %)																			
Chin: large	.30																**.78**		
Component 18 (2.09 %)																			
Face: forehead-sellion-nose ratio																		**.77**	
Component 19 (2.09 %)																			
Eyes: tilt outward																			**.75**

Numbers in parentheses indicate the proportion of variance accounted for by each component. Boldface font is used to indicate which variables belong to each component. For simplification of display, loadings < .30 are not shown

[a] Heterosexual women had significantly higher scores on this component than did heterosexual men ($ps < .05$)

[b] Heterosexual men had significantly higher scores on this component than did heterosexual women ($ps < .05$)

Table 5 Structure matrix showing the discriminant functions and corresponding loadings from the discriminant functions analysis for the total sample ($n = 390$)

Predictors	Discriminant functions		
	1	2	3
Function 1 (43.2 %; canonical $r = .55$)			
Mouth: retracted	**−.48**	.17	.03
Mouth: lips retracted	**−.37**	.05	.07
Forehead: large	**−.34**	.25	.07
Nose: pointed	**−.33**	−.19	−.09
Nose: bridge deep	**−.32**	−.21	−.14
Nose: nostrils large	**−.31**	−.22	.06
Mouth: lips inflated	**.30**	−.15	−.10
Mouth: lips small	**−.29**	.28	−.02
Cheeks: convex	**.27**	−.19	.22
Forehead: tilt back	**.24**	−.14	.05
Face: gaunt	**.23**	.10	−.01
Head: thin	**.18**	.08	−.13
Forehead: short	**.15**	−.15	.01
Jawline: convex	**.11**	.00	−.05
Face: down	**−.10**	.04	−.01
Jaw-neck-slope: low	**.08**	−.05	−.06
Facial width-to-height ratio	**−.06**	.00	.06
Function 2 (36.7 %; canonical $r = .52$)			
Shape: feminine	.01	**.54**	−.10
Mouth: overbite	−.14	**.43**	.03
Mouth: tilt down	−.24	**.35**	.03
Mouth: down	−.06	**−.32**	.14
Eyes: up	.15	**−.31**	.02
Eyes: large	.00	**.30**	.04
Mouth-chin distance: long	.07	**.30**	−.20
Face: brow-nose-chin ratio	.12	**−.26**	.04
Mouth: thin	−.14	**.24**	.05
Chin: deep	−.08	**.24**	.04
Mouth: sad	−.05	**−.23**	−.02
Face: short	−.06	**.23**	−.04
Cheeks: gaunt	.08	**−.22**	.02
Nose: sellion deep	.11	**−.20**	.15
Cheekbones: pronounced	−.02	**.18**	.02
Jaw: thin	.03	**.17**	−.08
Nose: nostril thin	−.08	**.16**	−.08
Nose: nostril tilt up	−.03	**−.15**	−.02
Face: thin	−.12	**.15**	−.02
Chin: short	−.02	**−.09**	.04
Face: forehead-sellion-nose ratio	.05	**.08**	.05
Chin: recessed	−.05	**−.07**	.02
Function 3 (20.1 %; canonical $r = .41$)			
Mouth: lips thick	.01	−.23	**.29**
Cheekbones: high	−.11	−.10	**−.28**
Mouth: pursed	−.12	−.10	**.23**

Table 5 continued

Predictors	Discriminant functions		
	1	2	3
Chin: large	.00	−.10	**−.19**
Chin: thin	−.11	−.06	**.17**
Brow ridge outer: down	−.05	−.07	**.15**
Eyes: tilt outward	.06	−.07	**−.13**
Chin: backward	.05	−.07	**−.12**
Cheekbones: wide	−.08	.07	**.11**
Eyes: together	−.03	.04	**−.10**
Jaw: jutting	.06	.05	**−.10**
Chin: jutting	.06	.05	**−.09**
Face: light	−.03	.03	**.08**
Brow ridge inner: up	−.04	−.05	**−.08**
Brow ridge: low	.01	−.05	**.07**

Values represent correlations between each predictor and the corresponding function. Values in boldface font represent the predictor's largest absolute correlation. Numbers in parentheses indicate the proportion of variance accounted for by each function

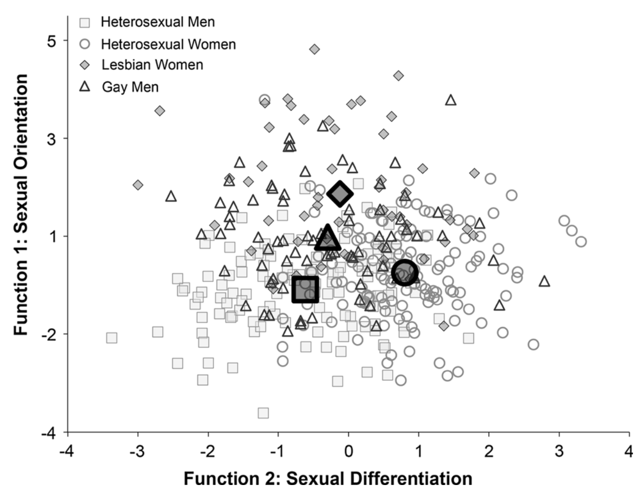

Fig. 2 Discriminant functions plot of gay men ($n = 77$), lesbian women ($n = 52$), heterosexual men ($n = 127$), and heterosexual women ($n = 134$). Large data points represent group centroids (the mean value of each groups on each function) from the discriminant functions analysis. Function 1 appears to represent a linear combination of features that differentiate heterosexual men and women from gay men and lesbian women, or a sexual orientation dimension of facial variation that is unrelated to sexual differentiation. Function 2 appears to represent a linear combination of features that best differentiate heterosexual women from heterosexual men, with lesbian women and gay men in between the two heterosexual groups, or a dimension of sexual differentiation. Lesbian women are shifted toward the masculine end of Function 2, and gay men are slightly shifted toward the feminine end of Function 2

1 and 2 were significant, whereas Function 3 was marginally significant: Functions 1 through 3 (Wilks' Lambda = .43, $\chi^2 = 308.05$, $df = 162$, $p < .001$); Functions 2 through 3 (Wilks' Lambda = .61, $\chi^2 = 178.69$, $df = 106$, $p < .001$); and Function

3 (Wilks' Lambda = .83, $\chi^2 = 65.95$, $df = 52$, $p = .09$). For function interpretation, researchers typically consider loadings above .33 meaningful (i.e., 10 % of variance) (Tabachnick & Fidell, 2007). Based on this convention, Function 1 appeared to represent the extent to which the face had a mouth and lips that were protruding or retracted, a small or large forehead, and a pointed or flat nose. Higher scores indicate less retracted mouth and lips, a smaller forehead, and a flatter nose. From the discriminant functions plot (see Fig. 2), it is clear that Function 1 was effective at separating heterosexual men and women from gay men and lesbian women, indicating that it may represent a sexual orientation dimension of facial variation that is unrelated to sexual differentiation.

Function 2 seemed to represent the extent to which the shape of the face is masculine or feminine, and the extent to which the mouth has an overbite or an underbite and is tilted up or down. Higher scores indicate a more feminine shape, a mouth with overbite, and a mouth that is more tilted down. When subjects' scores on Function 2 were plotted along with their scores on Function 1 (see Fig. 2), it is clear that Function 2 strongly discriminated heterosexual women from heterosexual men, with lesbian women and gay men in between the two heterosexual groups. Note that lesbian women were shifted toward the masculine end of Function 2 (i.e., as close to heterosexual men as they were to heterosexual women). Gay men were slightly shifted toward the feminine end of Function 2. Thus, Function 2 seems to relate to sexual differentiation. In sum, the two functions provide evidence that is consistent with the results from our main analyses: facial metrics both related to and unrelated to sexual differentiation allow for the discrimination between individuals with gay/lesbian versus heterosexual sexual orientations.

Given Function 3 was not significant ($p = .09$) and the loadings on Function 3 were less than .33, we did not plot subjects' scores on this function. Overall, the classification rates for the discriminant functions analysis was 66.4 % for heterosexual women, 60.6 % for heterosexual men, 59.6 % for lesbian women, and 46.8 % for gay men. The proportion of between-group variance for which each function accounted is shown in Table 5.

Discussion

We observed significant relationships among sex, sexual orientation, and facial structure. Within heterosexual subjects, there were significant differences between men and women for 30 of the 63 facial metrics in the univariate analyses, with the metric of overall face shape showing the greatest difference. In the PCA, of the six components on which heterosexual women differed from heterosexual men, the greatest difference was on Component 6 (comprised of several nose metrics) and on Component 16 (comprised of the face shape metric). In the DFA, the largest difference was on Function 2, defined by the nose region and by the shape of the face.

In women, at a univariate level, there were significant differences between lesbian and heterosexual women for 17 of the 63 facial metrics, with 10 of the 17 in the direction of more masculine in lesbian than in heterosexual women (for a summary, see Table 3). The greatest difference between lesbian and heterosexual women was on the mouth retracted metric, and lesbian women had more masculine face shapes than heterosexual women. Eleven of the 17 facial metrics were included in the main analyses, and four of these uniquely discriminated between lesbian and heterosexual women. Lesbian women had noses that were more turned up, had mouths that were more puckered, had smaller foreheads, and had marginally more masculine face shapes than heterosexual women. The results from the PCA generally corroborated the main analyses. Heterosexual women had higher component scores than lesbian women on Components 5 (defined by several mouth metrics), 6 (several nose metrics), and 15 (size of the forehead and width of nostrils), and had lower scores than lesbian women on Component 1 (mouth, cheek, depth of chin, and length of face metrics). Thus, the faces of lesbian women and heterosexual women differed in regions of the face related to the nose, mouth, forehead, and to a lesser extent, the shape of the face. Finally, the results of the DFA generally corroborated the results of the logistic regressions and the PCA, with lesbians shifted away from heterosexual women and heterosexual men on Function 1 (defined by mouth, forehead, and nose regions), and shifted toward the masculine end of Function 2 (the nose region and the shape of the face).

In men, at a univariate level, there were significant differences between gay and heterosexual men for 11 of the 63 facial metrics, with 5 of the 11 in the direction of more feminine in gay than in heterosexual men (for a summary, see Table 3). The greatest difference was on the nose long metric, and there was no significant difference in the shape of the face. Six of the 11 facial features were included in the main analyses, and three of these uniquely discriminated between gay and heterosexual men. Gay men had more convex cheeks, shorter noses, and had foreheads that were more tilted back relative to heterosexual men. In addition, the results from the PCA generally corroborated the main analyses. Gay men had lower scores than heterosexual men on Component 6 (defined by several nose metrics). Thus, the faces of gay and heterosexual men differed in regions of the face related to the nose and, to a lesser extent, the cheeks and forehead. Finally, the results of the DFA generally corroborated the results of the logistic regressions and the PCA, with gay men shifted away from heterosexual women and heterosexual men on Function 1, and shifted somewhat toward the feminine end of Function 2.

Our results that gay and heterosexual men differ in facial structure were convergent with the results of Hughes and Bremme (2011) and Valentova et al. (2014). We extended these two studies by including a somewhat larger sample size of men, by including a sample of women, and providing quantitative analyses of facial structure using photographs that were not obtained from websites. Our quantitative results were partially in line with Valentova et al.'s (2014) qualitative results. In both our quantitative analysis of unique predictors and their qualitative follow-up analysis, it was found that gay men had shorter noses and convex shapes around the mouth or cheek region (i.e., oral cleft in Valentova et al.'s study, cheeks in the current study). Thus, these effects were cross-cultural (i.e., found in Canada and Czech Republic) and were found by independent researchers.

Further, in contrast to other physical differences examined in past research, our results suggest facial structure has a substantial association with sexual orientation, particularly in women. In the current study, the effect sizes for *unique facial metrics* or *components* were similar in size or larger in size than the effect sizes for other physical differences examined in past research (e.g., effect of sexual orientation on height for men [e.g., $d = 0.21$ in Bogaert, 2010]; effect of sexual orientation on handedness for women [$d = 0.36$ in Lalumiere et al., 2000]). The effect sizes for the *overall models* examining sexual orientation and facial structure, however, were substantially larger than the effect sizes for other physical differences examined in past research (i.e., in women, $d = 1.31$ in the main analyses, $d = 1.37$ in the PCA; in men, $d = 0.94$ and $d = 0.81$, respectively). Facial structure may be a relatively important physical difference related to sexual orientation. Thus, the mechanisms underlying variation in facial structure may be particularly important in understanding the development of sexual orientation.

Some of the facial differences between gay/lesbian and heterosexual subjects were consistent with the notion that variation in processes of sexual differentiation is a factor in the formation of sexual orientation (i.e., a feature was more "feminine" in gay men and more "masculine" in lesbian women) (see also Valentova et al., 2014) (see also Table 3). Sex differences in facial structure are shaped by surges in sex steroidal hormones at the time of puberty (Enlow, 1982; Verdonck et al., 1999). Thus, it is plausible that pubertal sex hormones may contribute to variation in facial structure according to sexual orientation, although we know of no evidence to support the notion that pubertal hormones are implicated in the development of sexual orientation. Specifically, pubertal fluctuations in hormones may cause the faces of gay and lesbian individuals to differ from heterosexual individuals, but they may not be implicated in the basic neural mechanisms of attraction associated with sexual orientation. Nevertheless, any link between pubertal gonadal function and variation in the face linked to sexual orientation may involve a third factor, such as the greater exposure to stressors of gay men and lesbian women compared to heterosexual men and women (e.g., Saewyc, 2011). Prenatal sex hormones are also considered a basis of sex differences in facial structure (Bulygina et al., 2006; Meindl et al., 2012) and are implicated in the development of sexual orientation (Bao & Swaab, 2011; Hines, 2011). For example, higher prenatal testosterone exposure was related to more masculine faces in terms of the shape of the face in boys (Meindl et al., 2012). Prenatal testosterone levels may be lower in the fetuses of men that are gay as adults, and higher in the fetuses of women that are lesbian as adults, compared to their same-sex heterosexual counterparts, which may affect their facial structure in a sex atypical way.

Some of the facial differences between lesbian and heterosexual subjects were consistent with the possibility that (heightened) typical sexual differentiation is a factor in the formation of sexual orientation (i.e., a feature was more "feminine" in lesbian women) (see also Table 3). Prenatal hormones fluctuate during gestation and their effects have been shown to operate during critical/sensitive periods of development (Hines, 2011); however, we know of no other studies on the development of female sexual orientation showing additional evidence of a feminization effect in lesbian women. Also, while there was some evidence of feminization of lesbian women, there was more evidence of masculinization than of feminization of lesbian women in the current study. For example, at the univariate level, 10 of the 17 facial metrics related to sexual orientation in women were in the direction of more masculine in lesbian than in heterosexual women (versus two in the feminine direction).

In men, there was only one difference between gay and heterosexual subjects that was consistent with the possibility that heightened typical sexual differentiation is a factor in the formation of sexual orientation (i.e., a feature was more "masculine" in gay men) (see also Valentova et al., 2014) and it was at the univariate level only (see Table 3). Thus, one possibility is that prenatal testosterone levels may be higher in the fetuses of men that are gay as adults during a certain critical period of development, although evidence to support this assertion is limited (cf. Bogaert & Hershberger, 1999). Future studies are required to replicate the current findings and to fully understand the mechanisms involving sex hormones responsible for the differences in facial structure found between gay/lesbian and heterosexual individuals.

The facial features predicting sexual orientation in men were not identical to the facial features predicting sexual orientation in women. Also, stronger effects were exhibited in women than in men. These findings reinforce the idea that sexual orientation develops differently in men and women (e.g., Bogaert & Skorska, 2011; Williams et al., 2000) and that biological factors related to facial structure may be particularly relevant to variation in women's sexual orientation (e.g., Grimbos et al., 2010; Singh, Vidaurri, Zambarano, & Dabbs, 1999).

Other facial differences between gay/lesbian and heterosexual subjects involved features for which there was no significant sex difference (see Table 3). These results suggest the importance of additional etiological factors beyond variations in androgen signalling related to prenatal and pubertal sexual differentiation. Such a suggestion is in keeping with growing evidence of the limitations in the ability of prenatal androgens to produce sexual dimorphisms, and evidence that sex chromosomes moderate the influence of androgens (Rice et al., 2012). Further, the development of sexual orientation has been shown to involve factors other than variations in androgen signalling related to sexual differentiation, such as developmental instability, maternal immune response to a fetus, epigenetic, and genetic factors (e.g., Blanchard, 2004; Blanchard & Bogaert, 1996; Bogaert & Skorska, 2011; Hamer, Hu, Magnuson, Hu, & Pattatucci, 1993; Lalumiere et al., 2000; Rice et al., 2012). Facial structure too is affected by factors beyond those related to prenatal and pubertal sexual differentiation, including both genetic and epigenetic factors (Greene & Pisano, 2010; Jelenkovic et al., 2010). The possibility of shared developmental mechanisms in craniofacial growth and in sexual orientation that are not rooted in prenatal and pubertal hormones suggests new research directions.

Another explanation for the finding that some facial differences between gay/lesbian and heterosexual subjects involved features for which there was no significant sex difference could be due to Type II error. For example, previous research has identified that male faces generally have longer and wider jaws, whereas female faces generally have smaller jaws and fuller lips (Burke & Sulikowski, 2010; Rhodes, 2006), but the heterosexual women in our sample had smaller lips, thinner lips, and a thinner mouth than heterosexual men. The mouth region was one of the regions that differed between lesbian and heterosexual women, and we cannot rule out the Type II error explanation conclusively. Future research using the FaceGen program to examine sex differences in facial features of heterosexual individuals may be needed to resolve this discrepancy.

Our evidence of featural differences between gay/lesbian and heterosexual individuals provides insight into the cues that may be used for accurate perceptions of sexual orientation by observers (cf. Valentova et al., 2014). Several studies provide empirical support for sex-based heuristics or stereotypes that guide judgements of sexual orientation (e.g., men's faces perceived to be more feminine were more likely to be judged as gay) (Freeman et al., 2010; Stern et al., 2013) (see also McDermid, Zucker, Bradley, & Maing, (1998) for use of sex-based heuristics/stereotypes in the perception of boys and girls with gender identity disorder). Nevertheless, reliance upon sex-based heuristics in guiding sexual orientation judgements may lead to misjudgements of sexual orientation. For example, judgements of sexual orientation are below chance accuracy for counter-stereotypical faces (e.g., gay men with masculine faces and lesbian women with feminine faces) (Freeman et al., 2010). Thus, our finding that the facial features that are related to sexual orientation may not be solely dependent on sexually dimorphic facial features aligns with the finding in the face perception literature that the use of sex-based heuristics partially leads to errors in judgements of sexual orientation. In addition, the better prediction of sexual orientation in women than in men by our statistical model parallels the greater accuracy of observers in determining the sexual orientation of women than of men (Lyons, Lynch, Brewer, & Bruno, 2014; Tabak & Zayas, 2012). Future studies may be able to determine whether the facial metrics identified here and in Valentova et al. (2014) are the basis for judgements of sexual orientation by observers.

The present study was limited in that it did not examine observers' perceptions of sexual orientation based on the facial photographs. Another limitation is our use of a deductive statistical approach. Although we were relatively conservative with selection of facial metrics, we did not have a priori predictions for the specific facial metrics that would differentiate gay/lesbian individuals from heterosexual individuals, which increases the chance of Type I errors. As such, future studies are required to replicate these effects. Future studies should replicate with equal sample sizes across the groups, as unequal sample sizes across groups could introduce bias toward groups with greater dispersion, particularly in discriminant function analysis (Tabachnick & Fidell, 2007). Future studies should also replicate using FaceGen and other facial measuring techniques. For example, error could be introduced when using FaceGen because the faces have to be fitted to the points on the face required by FaceGen to compute the numerical values for each facial metric. We attempted to avoid this source of error by having only the third author fit the faces. Nevertheless, utilizing other techniques that do not require fitting of faces by an individual would be beneficial. Also, future studies are required to further corroborate which facial features are sexually dimorphic, especially using FaceGen. Further, the results cannot generalize to individuals of various ethnicities, given that we only examined White individuals in this study. Also, the results cannot directly address questions of causality or mediating variables in the relationship between sexual orientation and facial structure.

Nevertheless, the findings presented here provide additional evidence for the association of a largely biological factor, facial structure, with sexual orientation. The faces of lesbian and gay individuals differed from their heterosexual counterparts in a number of ways (see Table 3). In addition, the overall facial effects associated with sexual orientation (e.g., *d*s associated with the overall models) were large. Thus, this research complements and extends other research on biological factors implicated in the development of sexual orientation, whether these factors are based in fetal androgen signalling or other mechanisms.

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