The enigma of facial asymmetry: Is there a gender specific pattern of facedness?

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Abstract:

Although facial symmetry correlates with facial attractiveness human faces are often far from symmetrical with one side frequently being larger than the other (Kowner, 1998). Smith (2000) reported that male and female faces were asymmetrical in opposite directions, with males having a larger area on the left side compared to the right side, and females having a larger right side compared to the left side. The present study attempted to replicate and extend this finding. Two databases of facial images from Stirling and St Andrews Universities, consisting of 180 and 122 faces respectively, and a third set of 62 faces collected at Abertay University, were used to examine Smith's findings. Smith's unique method of calculating the size of each hemiface was applied to each set. For the Stirling and St Andrew's sets a computer program did this automatically and for the Abertay set it was done manually. No significant overall effect of gender on facial area asymmetry was found. However, the St. Andrews sample demonstrated a similar effect to Smith, with females having a significantly larger mean area of right hemiface and males having a larger left hemiface. In addition, for the Abertay faces handedness had a significant effect on facial asymmetry with right handers having a larger left side of the face. These findings give limited support for Smith's results but do also suggest that finding such an asymmetry may depend upon some as yet unidentified factors inherent in some methods of image collection.

Introduction

Facial symmetry is an important aspect of facial attractiveness with more symmetrical faces being judged as more attractive (Grammer, & Thornhill, 1994; Perrett et al., 1999). However, Smith (2000) published a study showing somewhat surprisingly, that males and females have significantly asymmetrical faces. Smith (2000) also found that the direction of these asymmetries differed between males and females. He measured a frontal photograph of each participant and measured each side of the face (hemiface) in square centimetres. It was found that females were right faced (larger right hemiface) whereas males had a larger left hemiface, with 89% of males showing left-facedness and 73% of females showing right-facedness.

Smith interpreted this finding as being caused by the brain's hemispheres having different levels of involvement, in males and females, in certain types of thinking. For example, studies have suggested that on average females perform better than males on tasks predominantly controlled by the left hemisphere, such as verbal tasks (Graves, Goodglass, & Landis, 1982; Hausmann et al., 1998; Loring, Meador, Allison, & Wright, 2000) and males perform better on tasks predominantly controlled by the right hemisphere, such as visuo-spatial tasks (e.g. Voyer, 1996).

According to Smith, cognitive tasks that involve one hemisphere more than the other may result in greater muscular activity, and muscle size, on the side of the face controlled by that hemisphere. Smith suggests that because on average females and males rely on verbal and visuospatial thinking to different extent this affects the facial musculature of males and females. As a result males tend to have a larger left face, which is under the control of the right hemisphere, and females tend to have a larger right face, which is controlled by the left hemisphere (Smith, 2000). This was supported through earlier work on facial asymmetry and facial muscle activity (Smith, Smith, & Smith, 1991) suggesting hemiface size may be influenced by muscular activity. Moreover, the direction and extent of facial asymmetry appears related to cognitive aptitudes (Smith, 1984) and academic vocations (1998). Thus, Smith (1998) found academics in the humanities, who arguably have highly developed verbal skills, have larger right hemifaces whereas academics in math-physics have larger left hemiface areas.

To our knowledge Smith's research is the only demonstration that facial asymmetry systematically differs between males and females. Other studies, using a variety of different techniques to measure facial asymmetry, have failed to find a relationship between gender and facial asymmetry (see Borod, Haywood, & Koff , 1997; Borod, Koff, Yecker, Santschi, & Schmidt, 1998 for recent reviews of the literature). For example, Farkas and Cheung (1981), measured facial asymmetry by anthropometry and found no effect of gender. Similarly, Shaner, Peterson, Beattie, and Bamforth (2000) also found no relationship between gender and asymmetry when they measured the asymmetry by stereophotogrammetry. Therefore, while there is considerable evidence that faces are asymmetrical, from studies using measures such as dental occlusion (Namano, Behrend, Harcourt, & Wilson, 2000), musculature (Ferrario, Sforza, Ciusa, Dellavia, & Tartaglia, 2001), and skeletal x-rays (Keles, Diyarbakirli, Tan, & Tan, 1997), there is little additional evidence for systematic gender differences in facial asymmetry. Interestingly, however, Keles et al.'s (1997) results revealed differences regarding sex, handedness and their interactions. For example, right-handed males were significantly left faced (97%), and were more consistent than left-handers who tended to be right faced (68%). In partial support of Smith (2000) a reanalysis of these results revealed that males had a significantly larger left hemiface, while females showed no clear difference (X^2 (1, $\underline{N}$=80) = 11.2, $\underline{p}$= <0.001). However, it is also clear that the definition of facedness used by Smith (2000) is somewhat different from that in other studies and it may be the case that differences in facial asymmetry may only emerge when hemifaces are measured in the same way as Smith. Therefore, the specific purpose of the present study was to examine and extend Smith's (2000) original findings.

Method

Three sets of face images; each gathered under different but self-consistent conditions were used. Stimuli sets were best possible frontal views, as this was a requirement for the original purposes of each set. The Abertay sample was collected specifically to test the findings of Smith (2000) and to add the variable of handedness (as part of a wider programme of handedness research) and so was carried out in accordance with the published methodology of Smith (2000). The other two samples were taken specifically for facial recognition (Stirling) and facial measurement (St. Andrews) studies and so good frontal poses were needed for each set.

Abertay Facial Images (N=62, 24 male, 38 female)

An Olympus Camedia digital camera on a medium resolution setting (images of 1280 x 1024 pixels) was used, and participants (2.5m away) were instructed (with feedback from photographer) to hold their head as straight as possible. The image was viewed immediately after it was taken, and if necessary the process was repeated. Pictures were downloaded onto a PC and were then suitable for measurement.

Stirling Facial Images (N=180, 110 male, 70 female)

Faces were collected by the UK Home Office for the purpose of creating a set for use in researching issues to do with identification and consisted largely of young adult police cadets together with some from the army and support staff. The age range was not recorded and they were provided courtesy of Bob Nicholls, now of PITO. The photos were taken in a consistent way, with a colour chart and measuring stick present in each image and models arranged to look straight at the camera. The photographs were originally captured on film, at a set distance and using consistent diffuse lighting, and transferred to Photo-CD. Each face was resized to 800x600 pixels and a total of 236 points were manually located around major features and the boundary of the face (Frowd, Hancock and Carson, submitted). Subsequent analysis of the pictures, including a principal component analysis of the face shapes, revealed that there were small variations in head pose, but nothing systematic between the sexes. Animations of the principal components of the face shapes may be seen at www.stir.ac.uk/psychology/Staff/pjbh1/.

St. Andrews Facial Images (N=122, 69 male, 53 female)

Sitters (average age 21 for both male and female) were photographed under diffuse flash lighting from two flashguns (one left and one right of the sitter), preventing shadows falling on sitters' faces. Sitters removed glasses and facial jewellery and pushed their hair back from the forehead. Sitters were asked to assume a neutral expression with a closed mouth for the photographs, and keep the their head as level as possible. To ensure that sitters were looking neither up nor down into the camera lens, an adjustable stool was used in combination with a very narrow mirror (14*1.5cm) mounted above the camera. The stool's position was controlled and central to the lens of the camera. Sitters were instructed to look themselves directly in the eye in the mirror. A Fujix DS-300 digital camera was used, and several images of each individual were taken, allowing the selection of the 'best' image in terms of expression

and head orientation. The images were stored uncompressed at 1000 x 1280 pixel resolution, before transfer to PC for key features to be marked, using a total of 172 points.

Measures

In order to check our interpretation of Smith 's (2000) methods, 20 images (10 male, 10 female) were measured. All facial images were measured using CANVAS 7, which enabled the experimenter to calculate area, perimeter and other measurements based upon markers placed on the image. For each image, guiding lines and markers were placed onto the image. Initially the distance between the two pupils was measured, and an interpupillary line was drawn. Next, a line perpendicular to this line was drawn from the exact middle of the first line, carrying down the length of the face, dividing it into 2 hemifaces. Then a series of 30 to 40 marker points (as per Smith, 2000) were added to the image, starting at the midpoint between the pupils and then following this line towards one side of the face. When the side was reached, marker points were placed along the contour of the face, until the line bisecting the midpoint was reached. The markers were then joined together by placing a final marker at the midpoint of the interpupillary line. This created a polygon within the CANVAS 7 application and defined the hemiface area, which could then be calculated using a function within the application. The process was repeated for the other hemiface. Two experimenters (SH + PR) independently measured the images and achieved a significant correlation between their measures (Pearson Correlation, $r(20) = 0.93$, $p<0.01$). This was taken as evidence that the procedures defined by Smith (2000) allow a reliable and accurate measurement of hemiface area.

Automated Measurement Program

A program was written in Matlab to analyse the face shape files. It was written to draw the equivalent lines and measure the equivalent areas as the CANVAS 7 measurements (as per Smith, 2000 and described above) and to give near identical measures. The rationale for doing this was due to the outline of the face being already marked by points in both the Stirling and St. Andrews samples, thus allowing an effective basis for making similar calculations to the CANVAS 7 version. This was confirmed by independently measuring 36 images on the Matlab programme and CANVAS 7 and it was found that the results from the two methods were highly significantly correlated (Pearson Correlation, $r (36) = 0.94$, $p<0.001$). Therefore, the two methods gave similar facedness results.

Results

The entire database of faces was amalgamated for the overall analysis, however each separate set was also compared with each other and sex differences were compared within each set. Finally, the Abertay sample had data on handedness and this was included as a factor for this set. Faces were compared on measures similar to those used by Smith (2000) and so both parametric and non-parametric analyses were done. However, one additional difference was that the hemifaces were compared with each other in terms of their relative size differences. This was expressed as of R-L area difference; meaning that a positive area indicated a larger right hemiface, while a negative area indicated a larger left hemiface.

Table 1 about here

Overall Dataset

The overall dataset had 364 faces (203 males, 161 females), with the mean area of right faces being 66369.8 (S.D. 22150.7) square pixels, and left area being 66101.6 (S.D. 221375.5) square pixels (Table 1). A comparison of these means showed no overall difference between the areas of the two sides of the face ($t(363) = 1.115$, $p=0.265$)). In order to examine potential sex differences, a 2x3 between subjects ANOVA was conducted, with sex and dataset as factors and R-L differences as the dependent variable (Table 2). There was no main effect of sex on facedness ($F_{(1,358)} = 0.819$, $p=0.366$) and no effect of dataset ($F_{(2,358)} = 0.774$, $p=0.462$), but there was a significant dataset by sex interaction ($F_{(2,358)} = 3.786$, $p=0.024$). Individual analyses of the datasets showed no significant difference between the sexes for the Abertay sample ($F_{(1,60)} = 2.236$, $p=0.140$) or the Stirling sample ($F_{(1,178)} = 0.003$, $p=0.960$). The St. Andrews sample showed a significant sex difference ($F_{(1,120)} = 4.859$, $p=0.029$), with females showing a larger mean area of right hemiface and males having a larger mean left hemiface.

Table 2 about here

Categorical Data

As was the case in Smith (2000) a chi-square analysis was conducted (Table 3). Initially, the number of right faced vs. left faced individuals was compared (regardless of sex) and given the almost identical numbers it is unsurprising this was not significant (X^2 (1, $N=364$) = 0.01, $p=0.917$). In addition, males

examined separately did not have a significant asymmetry in face size (X^2 (1, N=203) = 0.044, p= 0.833), nor did females (X^2 (1, N=161) = 0.006, p= 0.937).

Table 3 about here

A 2x 2 x 3 (facedness x sex x Dataset) analysis (VassarStats, 2004) was carried out and was found to be significant (G^2 (7, N=364) = 15.88, p=0.027). Individual two-way Chi-square analyses showed that facedness x sex was non-significant X^2 (1, N=364) = 0.01, p= 0.923), but facedness x data set approached significance (X^2 (2, N=364) = 5.25, p= 0.073). However, analysis carried out on differences for males only (X^2 (2, N= 203) = 2.70, p= 0.258) and females only (X^2 (2, N=161) = 3.71, p=0.156) failed to reach significance. Comparing sex x dataset there was a significant effect, (X^2 (2, N= 364) = 9.38, p= 0.009), suggesting that the 3-way interaction was related to differences between datasets rather than sex-specific facedness. Looking within each of the individual sets of data, none showed a significant difference in the pattern of larger hemifaces, although not all data sets showed the same direction of difference (Table 3). When individual patterns within conditions were examined, there were some directional differences between them (e.g. UAD both sexes left faced, Stirling both right faced). Only the St. Andrews dataset showed a pattern of results similar to those found by Smith (2000) although this effect of sex on facedness was non-significant when analysed using categorical data.

Handedness

As handedness was previously found to influence facedness (Keles, et al., 1997), then this variable was investigated for the single set of data that had such information (Table 4). A 2x2 between subjects ANOVA was conducted, with sex and handedness as factors and R-L differences as the dependent variable. There was no main effect of sex on facedness ($F_{(1,58)}$ = 2.743, p=0.103), no effect of handedness ($F_{(1,58)}$ = 0.137, p=0.713), and no sex by handedness interaction ($F_{(1,58)}$ = 1.633, p=0.206). However, if the samples are compared as categorical data, in terms of facedness (as per Smith, 2000), a different pattern emerges (Table 4). It is clear that there was an overall effect of handedness on the degree of facedness (X^2 (1, N=62) = 8.22, p=0.008) with right-handed individuals being significantly left faced (X^2 (1, N=27) = 10.7, p=0.001), while left-handers showed no lateral effects (X^2 (1, N=35) = 0.257,p=0.612).

Table 4 about here

Discussion

This study investigated the extent to which it is possible to generalize the gender difference in facial asymmetry reported by Smith (2000). While the pooled results did not support the findings of Smith findings, rather intriguingly, the St Andrews database (N= 122) offered some support for the effect. In line with what Smith found, female faces were significantly more right faced and male faces were significantly more left faced. However, in contrast to Smith's results, the magnitude of the difference was very small. Indeed, following the procedures outlined by Coe (2000), an analysis of this data indicated an effect size of 0.4. Drawing on the conventions set by Cohen (1988) this can be interpreted as a weak to medium effect. The finding derived from the Abertay database (N=62), although not significant, was of a similar magnitude (effect size = 0.39), though interestingly, in the opposite direction to the findings derived from the St Andrews database. With the Abertay set, the males tended to be slightly more right faced and the females more left faced. The largest of the three databases, Stirling (N=180), provided no evidence at all for a gender difference in facial asymmetry with the male and female faces providing almost identical measurements (effect size = 0.01). Based on these varying results and the fact that the much larger pooled database (N=352) provided little evidence for a gender-based effect (effect size = 0.12) we conclude that it is surprisingly difficult to replicate the effect shown by Smith (2000). This failure to find a reliable effect concurs with most previous studies (e.g. Ferrario et al., 2001) that indicated a lack of systematic facial asymmetry and is further supported by several findings on asymmetry, which are inconsistent between studies and often contradictory in nature (e.g. Bruyer & Craps, 1985; Burke, 1992; Keles et al., 1997).

The elusive nature of this effect may be explained by the fact that the three independent research groups had broadly similar but crucially non-identical procedures for capturing their images. One the other hand, it can be argued that consistent with Smith (2000), each had a controlled process that was known to provide consistent results. Equally true, it is also clear that unlike previous studies (e.g. Keles et al., 1997) facedness was measured according to the particular definition and methods used by Smith (2000), and importantly, was the same for all three of the databases. So it is not at all clear why the effect was not found in all three of the datasets.

In conclusion, it is possible that some currently unknown part of the photography process may subtly influence the orientation of heads (e.g. gender of poser /photographer (Schirillo, 2000) or even handedness, this study) but at this point in time we do not know the exact nature of such an influence and cannot say why the gender effect is sometimes found and sometimes not.

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Table 1: Mean area in square pixels for the right and left hemiface measures.

		Mean	Std. Deviation	N
Males	Right face area	70435.4	19436.2	203
	Left face area	70413.7	20388.6	203
Females	Right face area	61243.5	24265.8	161
	Left face area	60664.7	23616.3	161
Overall	Right face area	66369.8	22150.7	364
	Left face area	66101.6	22375.5	364

Table 2: Mean area in square pixels for the right and left hemiface measures, separated by dataset.

		Mean	Std. Deviation	N
Abertay				
Males	Right face area	38440.0	7102.7	24
	Left face area	38019.2	7426.8	24
Females	Right face area	29916.1	10459.9	38
	Left face area	30469.2	10798.0	38
Stirling				
Males	Right face area	64627.6	4376.9	110
	Left face area	63972.8	5010.8	110
Females	Right face area	58468.6	5678.2	70
	Left face area	57843.2	5680.1	70
St Andrews				
Males	Right face area	90823.2	15387.4	69
	Left face area	91949.5	16366.6	69
Females	Right face area	87369.8	16367.4	53
	Left face area	86040.7	16030.7	53

Table 3: Categorical data for all three samples and for the combined dataset. Faced refers to the hemiface with the largest mean area, while facedness refers to the side with the highest total.

	Sex	**Right Faced**	**Left Faced**	**Facedness**	**Total**	
Abertay	Male	10	14	Left	24	
	Female	14	24	Left	38	$X^2 = 0.144$, df = 1, p= 0.791
Stirling	Male	60	50	Right	110	
	Female	39	31	Right	70	$X^2 = 0.024$, df = 1, p= 1.000
St Andrews	Male	30	39	Left	69	
	Female	28	25	Right	53	$X^2 = 1.05$, df = 1, p= 0.362
Combined	*Male*	*100*	*103*	*Left*	*203*	
	Female	*81*	*80*	*Right*	*161*	*X^2= 0.40, df = 1, p =0.463*

Table 4: Effect of handedness on facedness

	Left Faced	Right Faced	Total	
Right Handed	22 (81.5%)	5 (18.5%)	27	$X^2 = 10.7$, df = 1, p = 0.01
Left Handed	16 (45.7%)	19 (54.3%)	35	$X^2 = 0.257$, df = 1, p = 0.612
Total	*38*	*24*	*62*	$X^2 = 8.22$, df =1, p= 0.008