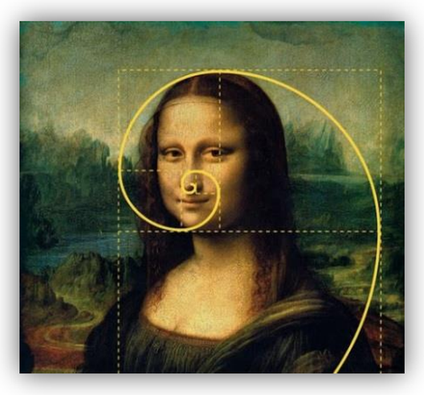
Can photogrammetry measure ugliness?

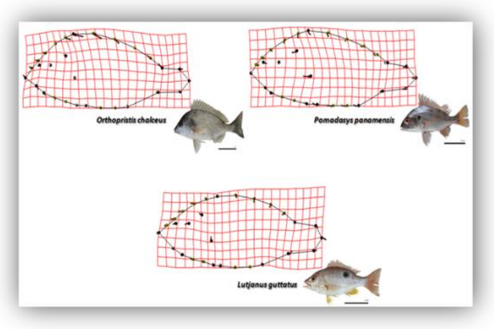
VNIVERSITAT DE VALÈNCIA

Gil English, N.*; Marquez Sapiña, A.; Ponce Ruiz, L. *****

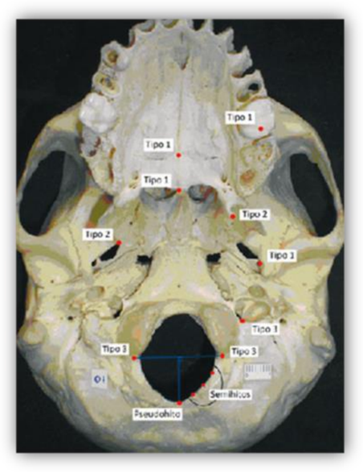
Introduction



- The human form and the canons have drawn the attention of both artists and scientists throughout history, due to its multidimensional nature.



- **Morphometry** is the study of the covariation of shape with underlying factors. Morphometry has achieved great development in the areas of biology and anthropology. For example to differenciate between species and to describe the structures observed, like: cells, shapes, dimensions or organs.



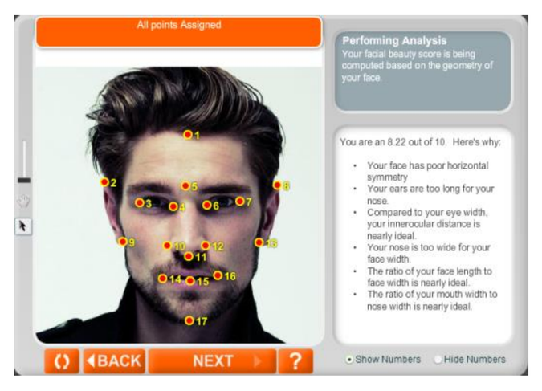
- **Photogrammetry** is the branch of morphometry that analyzes the covariation in photographs. We have based our investigation in this discipline.

- The **objective** of this poster is to investigate if there's a correlation between the ugliness and the morphometry with different statistical methods. This work is purely recreational as it's intended to obtain universal objective relations based on subjective data.

Material and methods

Our study

- We used facial photographs of 62 men from 18-35 years old and different ethnic groups. These pictures were selected from a data set of different web pages.



- Several women evaluated the degree of ugliness (0-10,ugliness-beauty) of the pictures showed. In addition we used an entertainment computer application: Anaface to evaluate the photos.
- We used the tps programme to place 46 **landmarks** following the model of Hayes *et al* (2011).
- We analyzed our data with three methods based on: traditional morphometry, configuration of landmarks and eliptical Fourier analysis of outlines.
- For processing data we used the following statistical software: SPSS v21, R v2.15.2 and tpsDig

Results

Scores

- Figure 1 represents the distribution of our pictures according to women's scores. Figure 2 shows that "Anaface's" scores are higher than women's ones.

Fig. 1. *Women's scores*

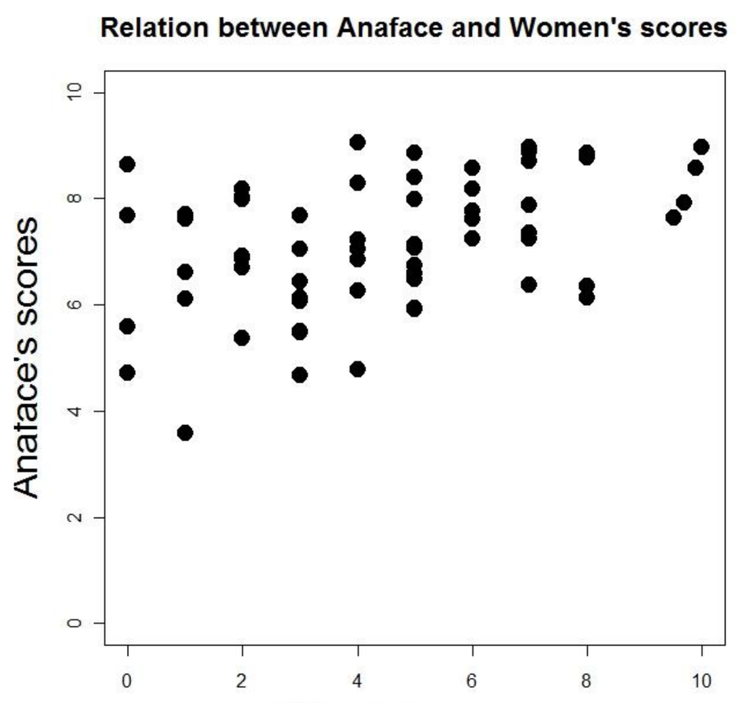


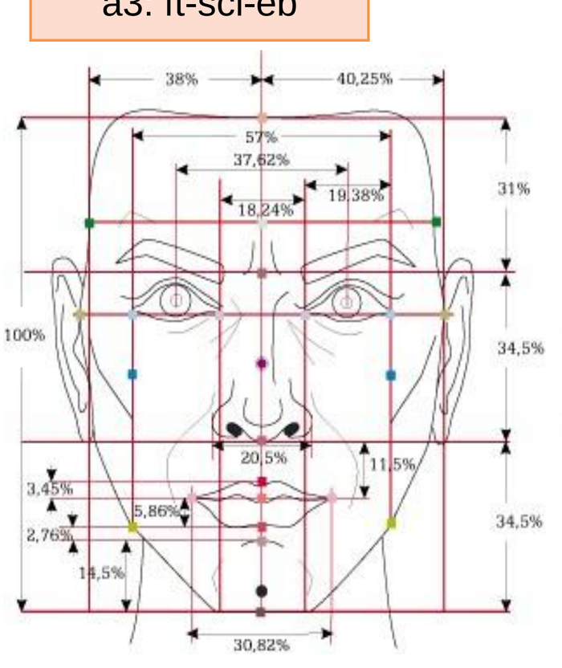
Fig. 2. *Relation Anaface - Women's scores*

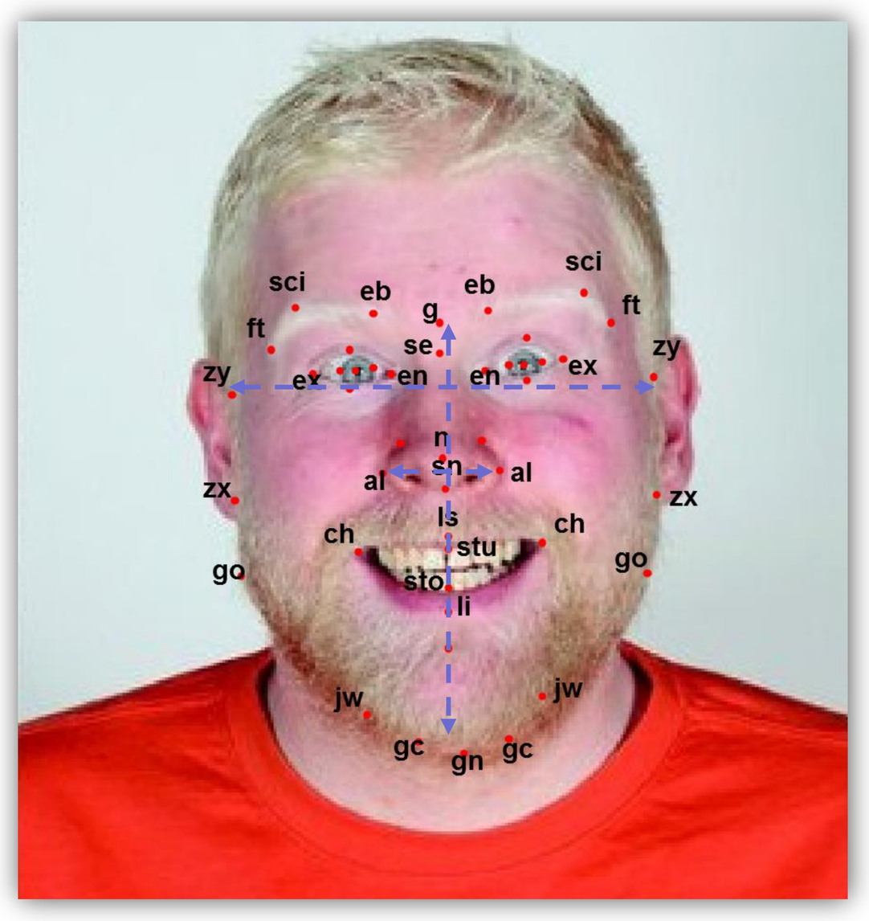
Traditional morphometry

- We calculated standardized distances as Farkas *et al* (1993) and angles to relate them with the beauty canons.

Measurements
d1: en-ex/en-en
d2: al-al/en-en
d3: ch-ch/en-en
d4: ch-ch/al-al
d5: zy-zy/al-al
d6: g-sn/sn-gn
d7: se-n/al-al
d8: sn-sto/g-gn
d9: ls-sto/sn-ls
d10: pu-pu/g-gn
d11: zy-zy/g-gn

Angles
a1: gn-gc-jw
a2: jw-go-zy
a3: ft-sci-eb





- We made a multiple linear regression with the 16 original variables and its squares trying to predict Z ugliness scores corresponding to the estimated cumulative proportion.
- After doing a variable selection using backward-forward AIC, we arrived to the next model (described in table 1).

Table 1. *Summary of adjusted model*

```
Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)   -46.4135    11.4738  -4.045 0.000193 ***
d2             10.5176     6.4044   1.642 0.107211
d4             18.0536     6.9704   2.590 0.012738 *
d5             -8.6697     2.7132  -3.195 0.002496 **
d6             21.9068     7.6906   2.849 0.006497 **
d11            64.3558    22.9313   2.806 0.007267 **
a1             26.2164    19.9604   1.313 0.195417
a3           -117.2901    46.3484  -2.531 0.014794 *
d2 * d2        -4.4562     2.7074  -1.646 0.106453
d4 * d4        -5.8304     2.3555  -2.475 0.016978 *
d5 * d5         1.1658     0.3674   3.173 0.002659 **
d6 * d6       -11.8760     4.2909  -2.768 0.008050 **
d11 * d11     -28.0664    10.2876  -2.728 0.008929 **
a1 * a1       -70.8159    76.3739  -0.927 0.358546
a3 * a3       552.5689   250.5795   2.205 0.032371 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.738 on 47 degrees of freedom
Multiple R-squared: 0.5594,     Adjusted R-squared: 0.4282
F-statistic: 4.263 on 14 and 47 DF,  p-value: 8.607e-05
```

- After transforming predictions with cumulative normal probability, we found a correlation of 0.72 with women's scores (Fig.3) and 0.85 with Anface's scores (Fig.4).
- It's clear that Anaface program uses a model similar to ours, but it doesn't give scores under four.

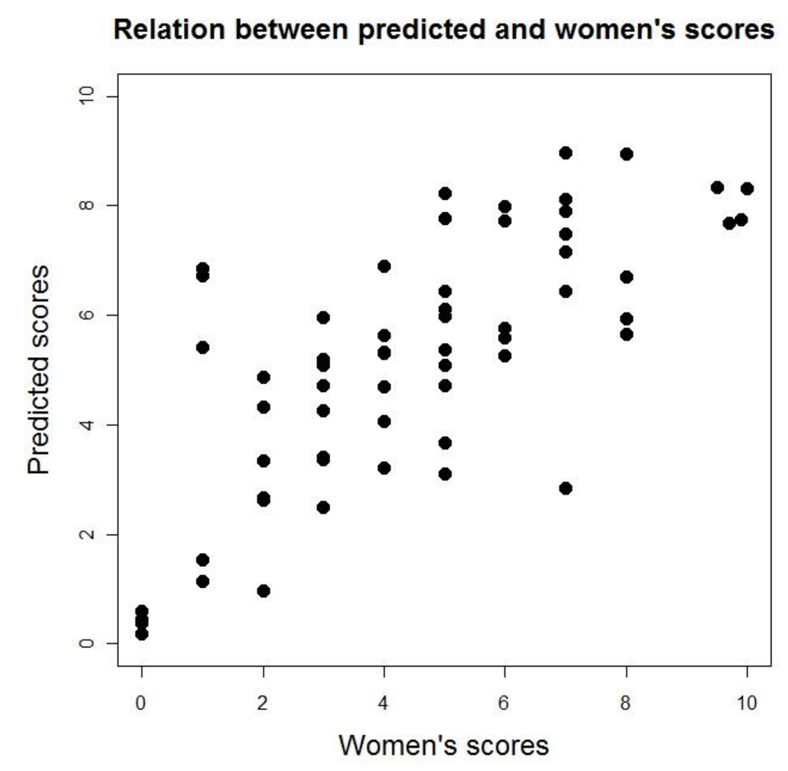


Fig.3. *Relation prediction-women's scores*

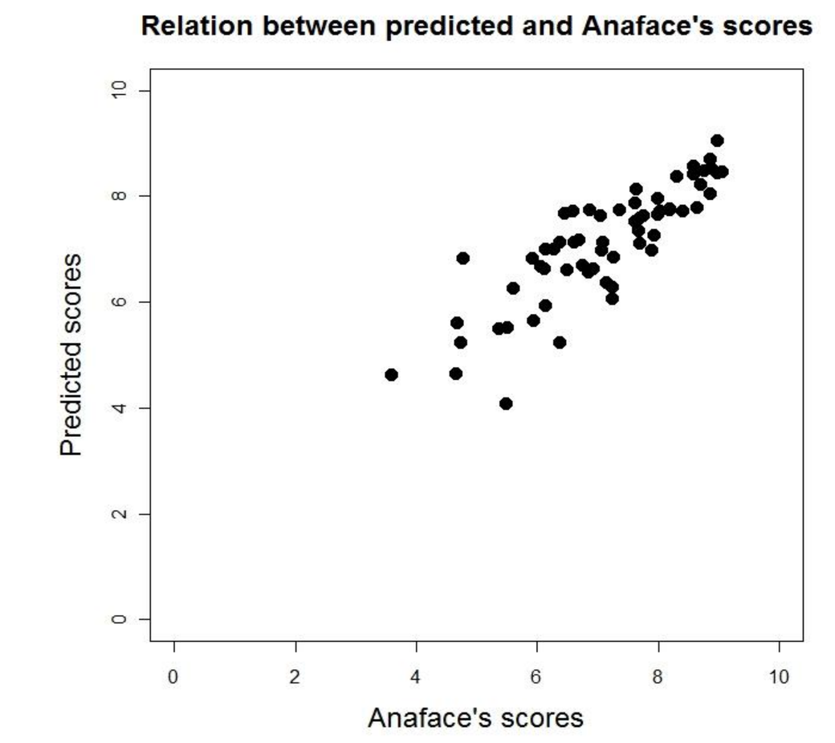
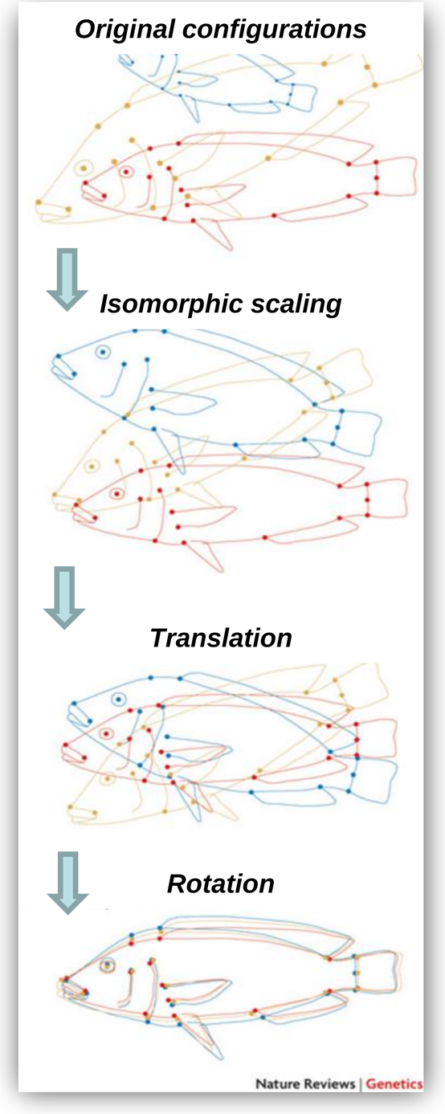


Fig.4. *Relation prediction-Anaface's scores*

Procrustes superimposition

- In the Greek myths of Theseus, Procrustes was an inn owner with a unique "one-size-fits-all" bed. In order for this magical bed to work, Procrustes would chop off the legs of any guests who were too tall and stretch, on the rack, any guests who were too short.
- The Procrustes superimposition is a method to align shapes using isomorphic scaling, translation and rotation (*see Klingenberg, 2010*). This method uses formula 1:

$$d_{F(M1,M2)} = min\|M2 - \beta M1\boldsymbol{\Gamma} - \mathbf{1}_p\boldsymbol{\alpha}'\|$$



Formula 1.*Superimposition of two configuration matrices, M1 and M2, minimizing the quantity dF(M1,M2), where β is a scalar for the size parameter, Γ is a square rotation matrix of k × k dimensions for the orientation parameter, **α** is the location parameter corresponding to a vector of k values, and **1**p is a column vector of p 1.*

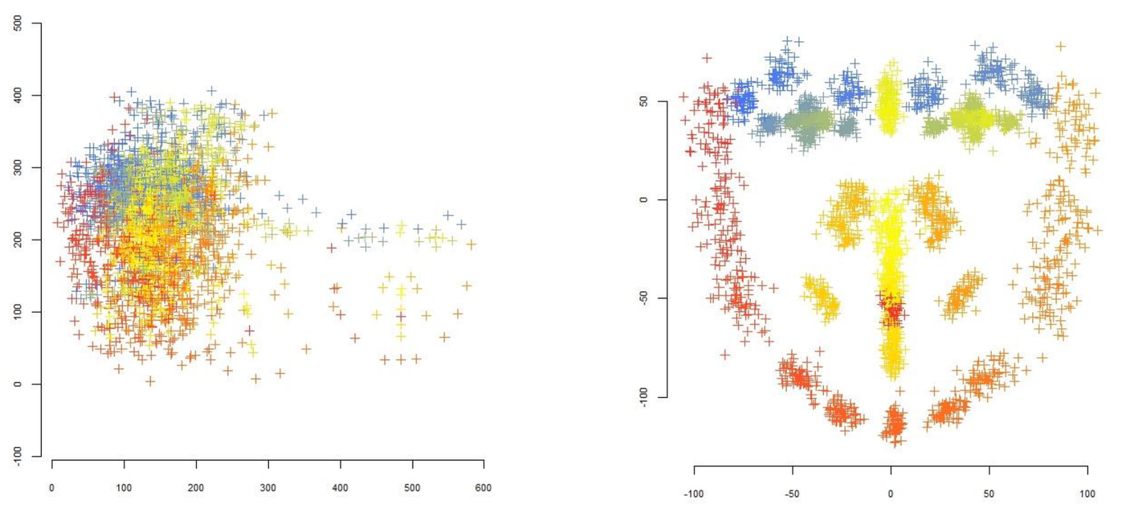


Fig. 5. *Original and transformed configurations*

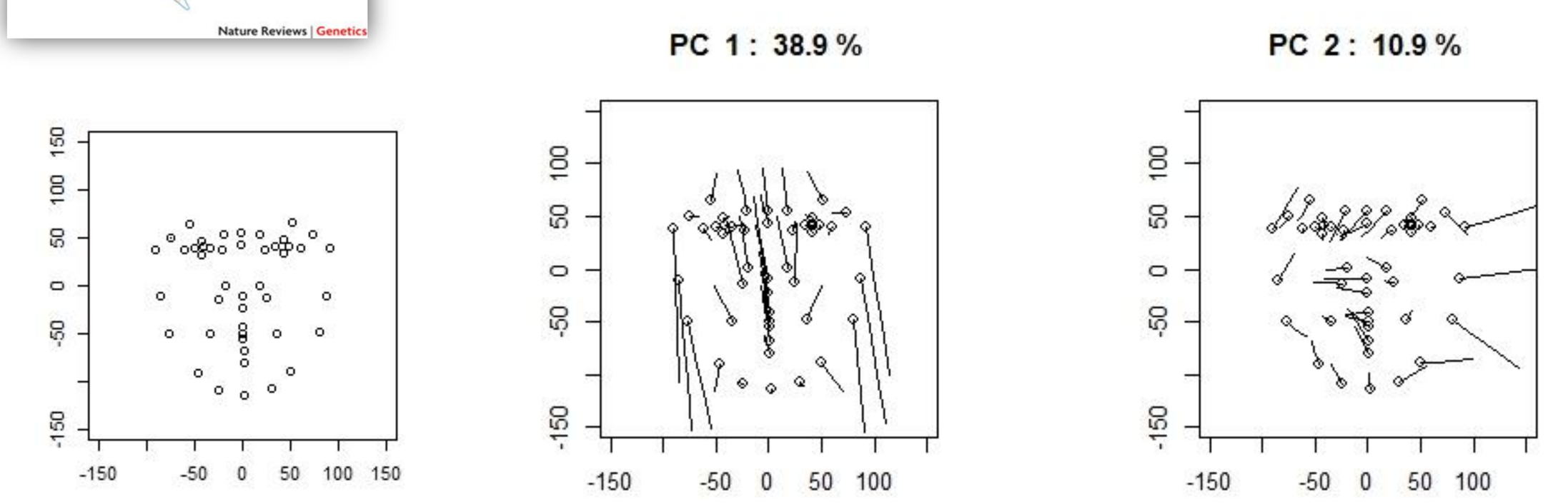


Fig. 6. *The mean and the principal components*

- In Figure 6, the first image represents the mean of all the values. The mean symbolizes the "ideal" distances. The next pictures show how the faces change with the values of the two principal components.

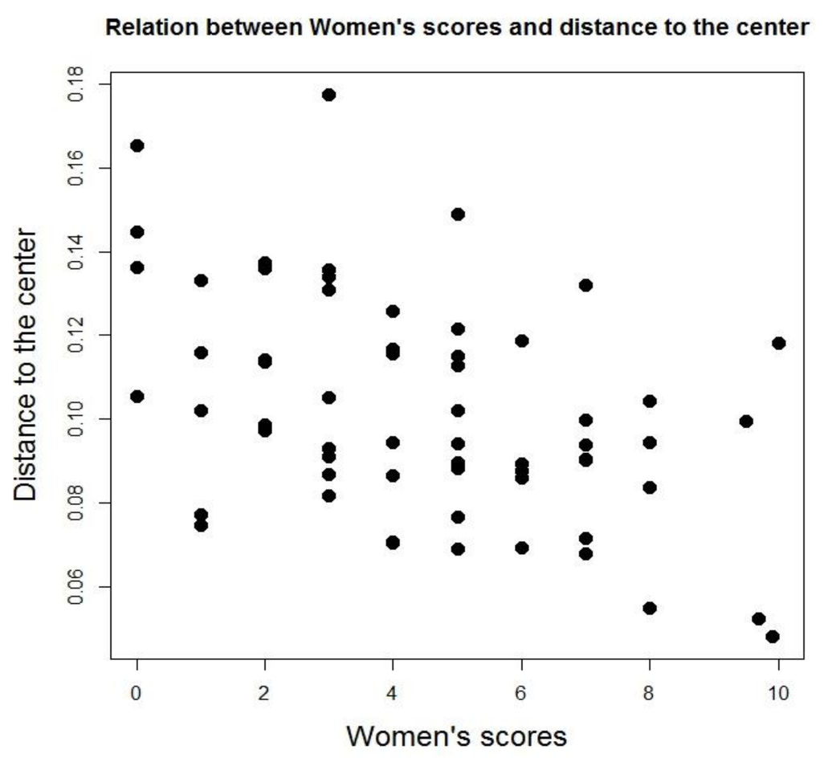
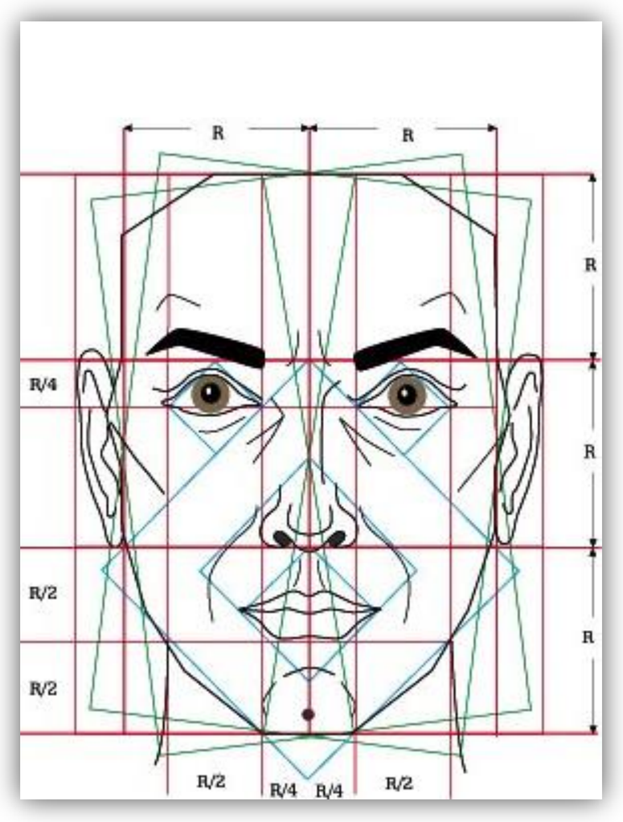


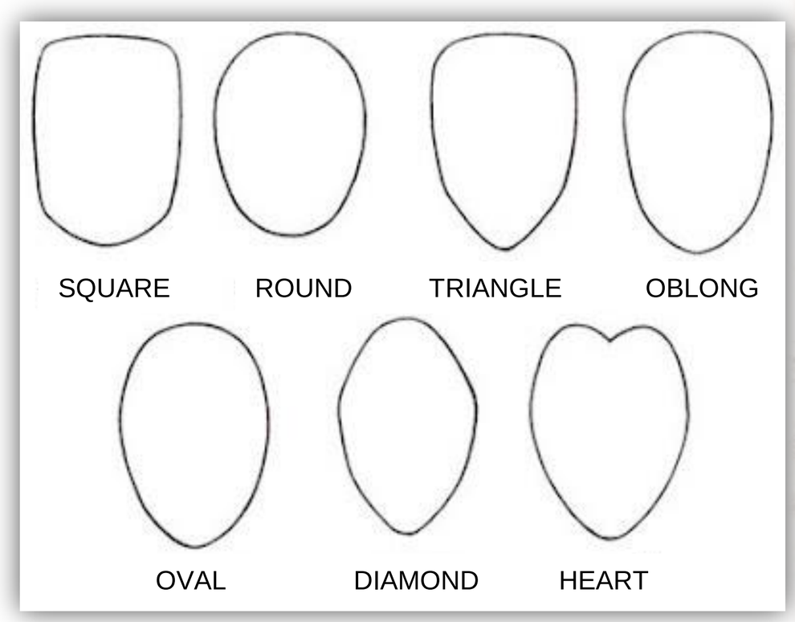
Fig. 7. *Relation women's scores - rho*

- The correlation between women's scores and the PC1 is -0.30 and with the PC2 it's 0.14.
- In Figure 7 appears the relation between women's scores and the Euclidian distances to the mean face, with a correlation of -0.47.
- We repeated the same process searching the distance between our images and the landmarks of the mask. This mask has the "perfect" measures.
- We obtained a correlation between the mask to the distance of ours photos. This is -0,34, and to anaface is -0,22. Maybe, the mask isn't very realistic.



Elliptical Fourier analysis

- The last approach presented here is due to Kuhl and Giardina *et al* (1982) that developed a method for fitting separately *x* and *y* coordinates of an outline projected on a plane, using R-library *Momocs* (Claude, 2008).
- To this method equally spaced points are not required and the coefficients can be made independent of outline position and normalize for size.



- This method uses the formula 2 for axis X:

$$x(t) = \frac{a_0}{2} + \sum_{n=1}^{+\infty} a_n \cos(n\omega t) + b_n \sin(n\omega t)$$

$$a_n = \frac{2}{T} + \int_0^T x(t)\cos(n\omega t)dt$$

$$b_n = \frac{2}{T} + \int_0^T x(t)\ \sin(n\omega t)\ dt$$

Formula 2. *Fourier series for axis X, ω=2π/perimeter. Similar identity for y(t) with c_n and d_n coefficients.*

- We have 18 landmarks. We've interpolated 3 landmarks between every pair, giving us a total of 72 landmarks in each contour (Fig.8). In Fig. 9 the contours are procrusted.

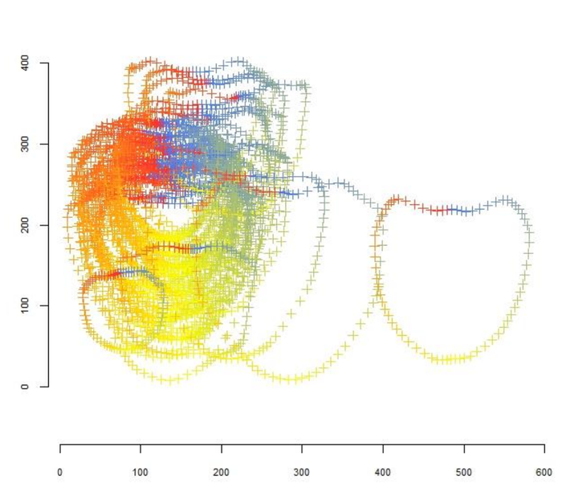


Fig.8. *Original configuration*

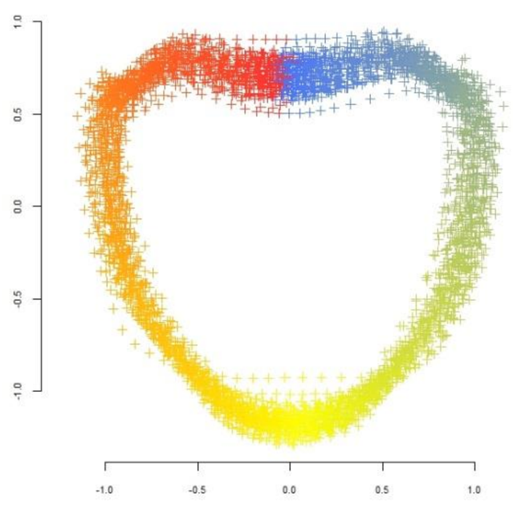


Fig.9. *Procrusted configuration*

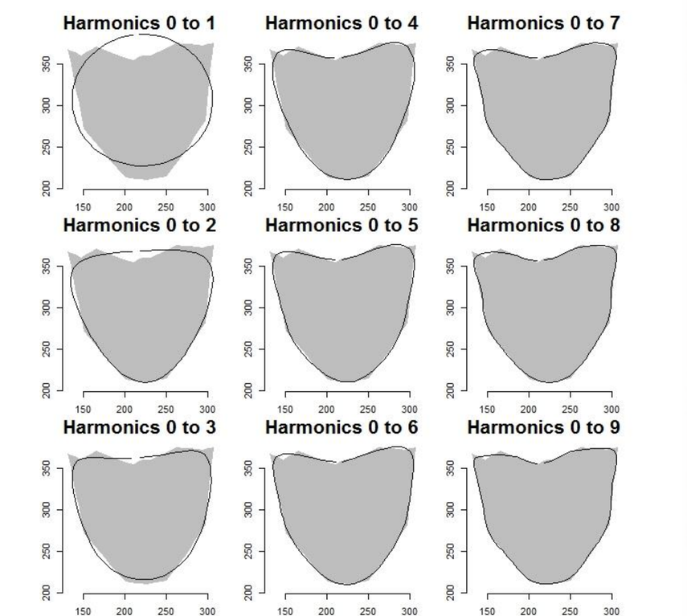


Fig.10. *Reconstructed configuration*

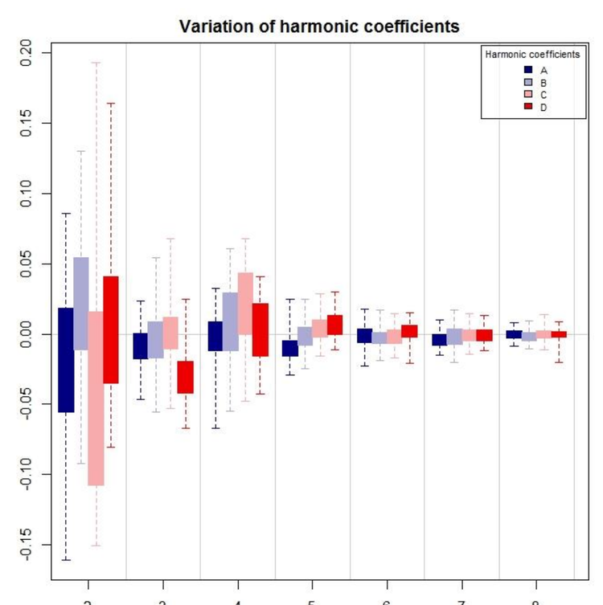


Fig.12. *Boxplot of harmonic coefficients*

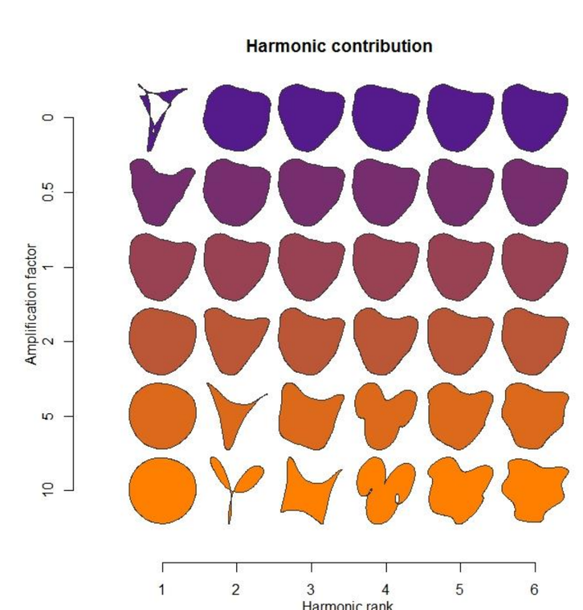


Fig.13. *Harmonic contributions*

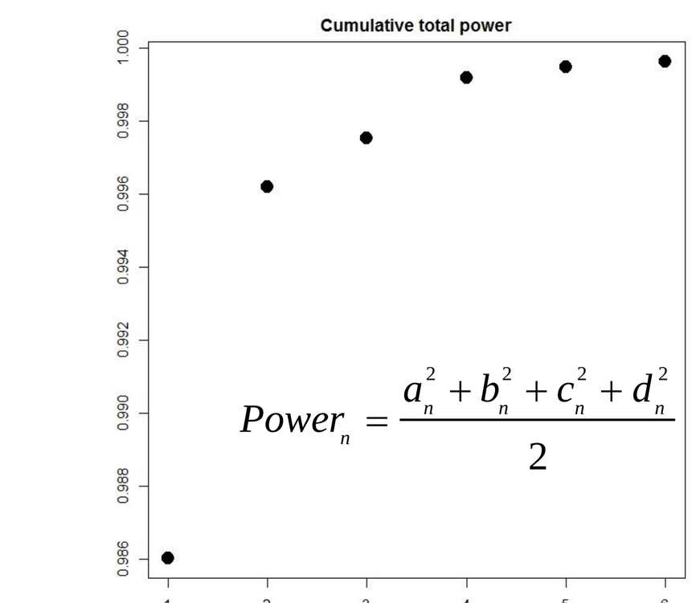


Fig.14. *Cumulative power*

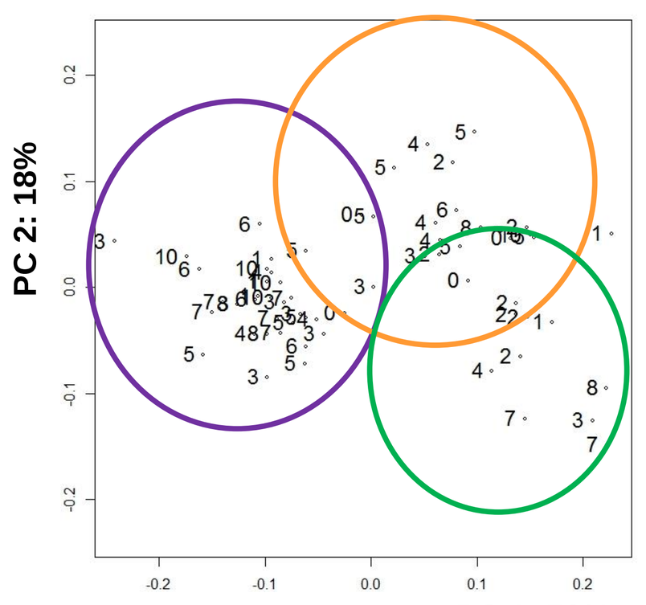


Fig.15. *PC of harmonic coefficients*

- After estimating elliptic Fourier coefficients, we show in fig. 10 the reconstruction of contours with 0:9 harmonics.
- We see the numerical contribution of the harmonic coefficients with boxplot (Fig.12), the shape and the power contribution (Fig.13-14).
- After eliminating the first harmonic, because it contains very little information concerning differentiation between groups, we calculated the PC of harmonic coefficients. Unfortunately it didn't show a clear relation with women's scores (cor.=0.27 and 0.13) (Fig.15).

Conclusions

- We have seen a clear relation between the ugliness scores and the measures obtained with the explored methods. Fortunately this isn't a perfect correlation, because this is a very subjective topic.

- This subject is very popular, like for example the "*Uggly metter*" app. has won 5 millions$ in two years, which is only an entertainment software.
- Photogrammetry nowadays can use data in a 3D color image. With the development of new technologies the morphometry has achieved to be a useful tool to many disciplines.
- Finally, we agree with Bacon's saying: "*there is no excellent beauty that hath not some strangeness in the proportion*" (1561-1626).

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Acknowledgements

- We thank all the sponsors who have financed this meeting: Societat Catalana de Biologia 1912-2012; Servei de Formació Permanent i Innovació Educativa; Col·legi Oficial de Biòlegs de la Comunitat Valenciana; Editorial Medica Panamericana; Pearson; Delegació per a la Incorporació a la Universitat
- We thank the women that have ranked the pictures of the men that we've used in our project.

*nagilen@alumni.uv.es; **amarsa5@alumni.uv.es; ***lopon@alumni.uv.es - *Grade in Biology 1st B 2013*