The slant of the forehead as a craniofacial feature of impulsiveness

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Introduction

Methods used to assess individual differences have arisen as a direct consequence of historical context and technological improvements. Questions about perception, memory, and thinking were framed in Antiquity in order to find answers about how human beings perceive the world.

Apart from introspective methods, the possibility that the human figure might reflect individual character and personality traits did not go unnoticed. Theophrastus (372-287 B.C.) was the first to conduct systematic observations in the field that has become known as the psychology of individual differences.1 In this regard, the craniofacial structure was of special interest as shown in treatises on physiognomy2 and phrenology.3 The technological advances of the 20th century have discredited the aforementioned treatises, contributing to the subsequent scarcity of research into the craniofacial structure and its associations with personality. A neuro-imaging study showed a pattern of clenching of the frontal sinuses which correlated positively with the underlying brain tissue in 101 patients with obsessive-compulsive disorder.4 Another study found an association between bizygomatic width and personality traits.5 Recently, a positive association between forehead inclination and impulsiveness has been observed.6 Overall, however, little or no research at all has been carried out with present-day scientific methodologies; very few studies have directly addressed the possible relation between craniofacial structure and personality traits, let alone impulse behavior.

It is well documented that impulsiveness is a significant psychological construct, represented in most explanatory models of personality.7 Impulsiveness includes a complex association of subordinate traits, such as lack of response inhibition, swift processing of information, sensation-seeking, and lack of self-control.8 It is also of great clinical interest, because it is a risk factor for several psychiatric disorders9 and a major symptom of attention deficit/hyperactivity disorder,10 borderline personality disorder,11 antisocial behavior,12 substance abuse,13 and addiction to online games.14 In short, impulsiveness is a hard-to-tackle heterogeneous construct15 that results from the complex interaction of multiple underlying neurobiological factors.16

All this seems to have contributed to a lack of specificity and controversies concerning its etiology and operational definitions.17 Furthermore, impulsiveness has been studied mostly as a clinical symptom,18 albeit from different theoretical approaches,19 which has contributed to the development of diverse instruments for its assessment. On the other hand, despite some reluctance in finding creative solutions, methodological innovation could promote a better understanding of this construct.18 The main aim of this study, using a larger sample of volunteers and more specific instruments, is to replicate the conclusions of previous research on the association between the slant

Objective: Impulsiveness has been the subject of much research, but little is known about the possible relationship between craniofacial anatomy and impulsiveness. The present study was designed to investigate the relationship between one aspect of craniofacial structure (the angle of inclination of the forehead) and impulsiveness.

Method: Photographs in profile were obtained from 131 volunteers who had been fined for driving at high speed and were undergoing a court-mandated driving license point-recovery course. They completed the Barratt Impulsiveness Scale (BIS-11), the Impulsive Behavior Scale (UPPS-P), and Zuckerman’s Sensation Seeking Scale (V). The angle of the slant of the forehead was measured with a photographic support and a protractor.

Results: High positive concordance was found between forehead inclination and 14 out of the 15 impulsiveness factors studied.

Conclusions: The angle of inclination of the forehead was significantly associated with self-reported impulsiveness in this sample of traffic violators.

Keywords: Craniofacial anatomy; impulsiveness; forehead; BIS-11
of the forehead and impulsiveness. Our study thus addresses impulsiveness as a trait in a healthy population to test the hypothesis that the frontal arch of the cranial structure is an anatomical marker of said trait. Considering individual differences in the forehead inclination in degrees (FID), we propose that people whose forehead is backward-slanted to a greater degree will score higher in impulsiveness than people with a lesser degree of forehead slant.

**Methods**

**Participants**

To ensure wide variability in measures of impulsiveness, the sample was recruited from a traffic training center among offenders who had to complete an official course to recover points in their driving licenses as a result of having been fined for speeding. The final sample consisted of 131 participants, of whom 105 (80.2%) were male. Educational attainment was primary in 31 subjects (23.7%), secondary in 48 subjects (36.6%), and higher in 52 subjects (39.7%). The mean (SD) age of males and females did not differ statistically (36.7 ± 10.2 years).

Table 1 shows the descriptive statistics of the total sample split by sex. Significant differences were only found in FID, with greater inclinations for men. As for impulsiveness measures, men scored higher on nine of 15 scales, although the differences were small and failed to reach significance in all cases.

**Digital photographs**

Photographs were taken in profile, using a Canon EOS 1100D digital single-lens reflex (DSLR) camera with a standard zoom lens (EF-S 18-55 mm, Canon) and a tripod with adjustable height. The distance from subject was set at 1.6 m, the focal length at 50 mm, and the focal ratio at f/5.6. To minimize optical distortions, participants remained seated on a chair that had been bolted to the ground. All were trained to slant their heads upwards and downwards until they felt relaxed and adopted a natural head position (NHP). NHP is defined as an innate, physiological, and reproducible position achieved when a person is in a relaxed sitting or standing position, looking at the horizon or at an external reference point (a mirror, a point on the wall) at eye level. It is considered a normalized and stable head position representing the natural real-life posture of human beings. The edge of each photograph was regarded as the true vertical (TV) reference for FID measurement.

**Measurement of forehead inclination in degrees (FID)**

The digital photographs were printed in black and white in DIN-A4 format, in the portrait orientation. The FID was measured by using a set square with semicircular protractor (Staedtler Mars 568) and a 10-cm ruler.

Although some methods have been reported for measurement of forehead slant variability for descriptive or medical purposes, we followed the view employed in a cosmetic treatment report. Two anthropometric landmarks were used: the trichion, which is the point of intersection between the midline of the forehead and the hairline, and the glabella, or the most prominent point of a midline drawn between both eyebrows. The vertex of the angle was fixed on the glabella, from which two lines were drawn. Line 1 was drawn vertically, parallel to the edge of the photograph (TV), and was set as 0°. Line 2 was drawn from the glabella to the trichion. The FID was measured by using a semicircular protractor and a 10-cm ruler.
then defined as the angle formed between Line 1 and Line 2 (Figure 1).

Each participant’s FID was independently measured on the printed photographs by two experts in craniofacial morphology. The agreement reached between them was high (intraclass correlation coefficient [ICC] = 0.99); therefore, the average of the FID from both raters was used as the predictor variable for subsequent analyses.

**UPPS Impulsive Behavior Scale, short form (UPPS-P)**27

The Spanish version of the UPPS-P28 measures five dimensions of impulsiveness: negative and positive urgency, lack of intent, lack of perseverance, and sensation-seeking. Several psychometric properties have been demonstrated as similar to the original English scale, including convergent validity, reliability, and internal consistency, with a Cronbach’s alpha ranging between 0.61 and 0.81 for the five dimensions. The UPPS-P consists of 20 items scored on four-point Likert-type scales (1 = fully agree; 2 = partially agree; 3 = partially disagree; 4 = totally disagree). Higher scores reflect more impulsiveness.

**Barratt Impulsiveness Scale (BIS-11)**29

The Spanish version of the BIS-1130 measures impulsiveness as a personality trait. It contains three subscales: attentional impulsiveness (tendency to fast decision-making), motor impulsiveness (tendency to act on the spur of the moment), and non-planning impulsiveness (more interested in the present than in the future). The BIS-11 consists of 30 items scored on Likert-type scales ranging from 0 (rarely or never) to 4 (always or almost always), with higher scores reflecting more impulsiveness. The Spanish version has suitable psychometric properties, with an internal alpha consistency of 0.75 and good test-retest reliability after 2 months (ICC = 0.89).

**Zuckerman’s Sensation-Seeking Scale (form V), Spanish version**31,32

Zuckerman’s Sensation-Seeking Scale-V consists of 40 items, and provides both a total score and separate scores for its four 10-item factors: Thrill and Adventure Seeking, Experience Seeking, Disinhibition, and Boredom Susceptibility. Each item is simply scored as true or false; true answers are assigned 1 point. The test-retest reliability for the validates Spanish version is 0.90 for the total score and 0.68-0.94 for the individual factors.31 The alpha coefficient is 0.82 for men and 0.77 for women. There are no cutoff points, but standard scores and deviations have been obtained from a representative Spanish population: 21.3 (6.4) for men and 17.7 (5.3) for women.

**Procedure**

A non-probabilistic strategy was used to recruit the sample. The principal investigator attended the center once a week to select the study participants. A total of 225 participants were suggested, of whom 154 volunteered. Each volunteer was given three self-report inventories to complete and had their picture taken in profile. This was followed by a brief interview to exclude those who were receiving psychoactive drugs or had received

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**Figure 1** Measurement of the angle of the forehead slant. G’ = glabella; Tr = trichion.
a diagnosis of a severe mental or neurological disorder. Incorrect or incomplete self-reports were excluded. In all, 23 participants were left out of the study. The data collection process lasted 7 months.

The study was approved by the local ethics committee of Universitat Autònoma de Barcelona (UAB). Each participant signed an informed consent form before entering the study and agreed to the use of data for research purposes. None of them received financial compensation.

**Statistical analysis**

Statistical analyses were carried out in Stata 14. Student’s t test was used to assess significant differences between sexes. The ICC was calculated for interobserver agreement. Bivariate Pearson’s correlation coefficients were calculated among the 15 impulsiveness measures to gauge the association between them.

The association between FID and impulsiveness was examined through independent linear regression models for each measure by taking impulsiveness as the response variable and FID as the predictor variable. For each model, interactions of FID with sex and age were assessed. Nonsignificant interactions were deleted, assuming a conservative p-value of 0.10 (aiming at detecting moderate, albeit weak effects), but the main effects of sex and age remained in the models and adjusting terms. In the interaction between FID and sex, the effects of FID were estimated separately for each sex. In the interaction between FID and age, the effects of FID were obtained for three ages: minimum (18-year-olds), rounded mean (37-year-olds), and maximum (60-year-olds). Nonstandardized and standardized regression coefficients (beta) are reported, the latter as an effect-size measure. Linearity and homogeneity of variances was verified for each regression model through visual inspection of predicted-residual plots and with the Breusch-Pagan test.

Type I error was set at the usual level (0.05, two-tailed). With the aim of not hiding possible relevant effects, no correction of the Type I error was applied to the results presented in tables. Nevertheless, the false discovery rate was calculated to estimate how much results would change; all statistically significant results remained so after correction.

With a sample of 131 participants and a minimum statistical power of 80%, significance testing would detect correlations of at least 0.30.

**Results**

**Correlation between measures of impulsiveness**

Both total and scale impulsiveness measures obtained with the three above-mentioned instruments showed high Pearson correlation coefficients. As shown in Table 2, only 14 out of 105 correlations did not reach statistical significance. Lack of perseverance, negative urgency, and emotion seeking were the least-correlated scales among them. In general, correlations for total and scale scores were higher between the UPPS-P and BIS-11, and lower when correlating the UPPS-P or BIS-11 with the SSS-V (Table 2).

**Effects of FID on impulsiveness**

Table 3 presents the results of linear regression analysis of the association between FID and different measures of impulsiveness. The only statistically significant interaction (α ≤ 0.10) between FID and sex was found in the prediction of UPPS-P: negative urgency (p = 0.071), with a positive association in men but not in women, as well as between FID and age in the SSS-V: disinhibition (p = 0.089), with positive associations for 18-year-olds and 37-year-olds, but no relation in 60-year-olds.

As for the other impulsiveness measures, positive and statistically significant associations were systematically found, except for Zuckerman’s Thrill and Adventure Seeking.

**Discussion**

Our results support the hypothesis of an association between forehead inclination and impulsiveness. We observed a substantial association between forehead inclination and 14 out of 15 factors of impulsiveness,

**Table 2 Correlation between impulsiveness measures**

<table>
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<th>Measure 1</th>
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<tr>
<td>1 UPPS-P, total</td>
<td>0.68</td>
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<td>2 UPPS-P, Negative Urgency</td>
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<td>3 UPPS-P, Positive Urgency</td>
<td>0.62</td>
<td>0.37</td>
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<td>4 UPPS-P, Sensation-Seeking</td>
<td>0.73</td>
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<td>5 UPPS-P, Lack of Premeditation</td>
<td>0.61</td>
<td>0.12</td>
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<td>6 UPPS-P, Lack of Perseverance</td>
<td>0.76</td>
<td>0.58</td>
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<td>7 BIS-11, total</td>
<td>0.57</td>
<td>0.44</td>
<td>0.29</td>
<td>0.51</td>
<td>0.37</td>
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<td>8 BIS-11, Attentional Impulsiveness</td>
<td>0.67</td>
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<td>0.42</td>
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<td>9 BIS-11, Motor Impulsiveness</td>
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<td>10 BIS-11, Non-planning Impulsiveness</td>
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<td>11 SSS-V, total</td>
<td>0.61</td>
<td>0.34</td>
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<td>0.29</td>
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<tr>
<td>12 SSS-V, Thrill and Adventure Seeking</td>
<td>0.61</td>
<td>0.34</td>
<td>0.44</td>
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<td>0.51</td>
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<tr>
<td>13 SSS-V, Experience Seeking</td>
<td>0.53</td>
<td>0.26</td>
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<td>0.43</td>
<td>0.37</td>
<td>0.26</td>
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<td>0.45</td>
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<td>0.82</td>
<td>0.44</td>
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<td>14 SSS-V, Disinhibition</td>
<td>0.42</td>
<td>0.38</td>
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<td>0.28</td>
<td>0.23</td>
<td>0.16</td>
<td>0.45</td>
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<td>0.46</td>
<td>0.35</td>
<td>0.64</td>
<td>0.20</td>
<td>0.27</td>
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</table>

BIS-11 = Barratt Impulsiveness Scale; SSS-V = Zuckerman’s Sensation-Seeking Scale, form V; UPPS = Impulsive Behavior Scale.

* All the coefficients remained statistically significant after applying false discovery rate correction.

Pearson correlations with p > 0.05 are set in bold.
scores to those reported in the adaptations of the SSS-V 31
general population. However, our data were very similar
find higher impulsiveness scores in our sample than in the

All of these findings are consistent with our results,
Conversely, women scored higher on negative urgency. 8
association between BIS-11 and FID.
used. In this regard, however, our study also found a major
sample was smaller than ours and of a different nature, and
followed a similar approach; in that study, however, the

Our study indicates that forehead inclination reflects the
different subordinate constructs that underpin self-reported
impulsiveness. It is difficult to compare our results with
those of other investigators, as only one preliminary study 5
followed a similar approach; in that study, however, the
sample was smaller than ours and of a different nature, and
except the BIS-11, different self-report instruments were
used. In this regard, however, our study also found a major
association between BIS-11 and FID.

In the UPPS-P model, men showed higher levels of
sensation seeking and positive urgency than women.4
Conversely, women scored higher on negative urgency. 3
All of these findings are consistent with our results,
although forehead inclination was not related to negative
urgency in women in our study.

Regarding the SSS-V, its total scores had the lowest
association, and no association at all with the Experience
Seeking or Disinhibition factors were found in 60-year-
olds. The Disinhibition and Boredom Susceptibility scales
were those most related to impulsiveness. 33 In this regard,
the modulating effect of age on impulsiveness is known and,
consequently, the mean age of our sample has probably
modulated our findings in these dimensions, as we can see in
the Disinhibition factor. In this scale, at the age of 60, fore-
head inclination did not exert any influence, although it seems
that assuming risky behaviors is not a direct consequence of
age but of the grey-matter volume of the brain. 35

Our study found a greater degree of forehead inclina-
ction in men, as previously reported elsewhere. 6-23 On this
topic, craniofacial surgeons suggest that people with
greater development of the frontal bone (bulging supraor-
bital ridge) have a greater forehead inclination, 36 as well
as a more masculine appearance. 25 Additionally, those
people with greater development of the eyebrow muscles
generally report greater obstinacy 25 and express some
difficulty in interpersonal relationships, as well as greater
subjective discomfort. 37 This is consistent with another
study which found that more compulsive subjects, who
are more impulsive a priori, 38 exhibited enlargement of
the cerebrospinal fluid spaces around the frontal oper-

60-year-olds -0.001 -0.002 0.991 -0.179-0.177
37-year-olds 0.141 0.316 0.001 0.099-0.417
18-year-olds 0.258 0.579 0.002 0.099-0.417
Men 0.152 0.282 0.006 0.044-0.260
Women -0.076 -0.141 0.511 -0.304-0.152
Positive Urgency 0.159 0.296 0.129 0.001 0.063-0.254
Sensation-Seeking 0.173 0.300 0.179 0.001 0.073-0.273
Lack of Premeditation 0.133 0.408 0.142 < 0.001 0.109-0.276
Lack of Perseverance 0.133 0.267 0.064 0.005 0.041-0.225

BIS-11
Total 1.405 0.487 0.217 < 0.001 0.917-1.893
Attentional Impulsiveness 0.389 0.454 0.240 < 0.001 0.246-0.531
Motor Impulsiveness 0.579 0.438 0.166 < 0.001 0.348-0.809
Non-planned Impulsiveness 0.438 0.354 0.111 < 0.001 0.215-0.661

SSS-V
Total 0.418 0.311 0.208 < 0.001 0.190-0.646
Thrill and Adventure Seeking 0.130 0.226 0.228 0.009 0.033-0.226
Experience Seeking 0.043 0.109 0.043 0.252 -0.031-0.117
Disinhibition 0.167
18-year-olds 0.258 0.579 0.002 0.099-0.417
37-year-olds 0.141 0.316 0.001 0.063-0.219
60-year-olds -0.001 -0.002 0.991 -0.179-0.177
Boredom Susceptibility 0.107 0.247 0.067 0.009 0.027-0.187

95%CI = 95% confidence interval; BIS-11 = Barratt Impulsiveness Scale; FID = forehead inclination in degrees; SSS-V = Zuckerman's
Sensation-Seeking Scale, form V; UPPS = Impulsive Behavior Scale.
Regression coefficients adjusted by sex and age. Significant interaction if p < 0.10.
* All coefficients remained statistically significant after applying false discovery rate correction.
method, it would be convenient to replicate or refute our findings with objective measures. These concerns notwithstanding, the BIS-11 instrument is regarded as one of the most useful tools to measure impulsiveness, both for research purposes and in everyday clinical practice.

Another aspect that may generate some controversy is the method of FID assessment. Our method followed a study in which forehead inclination was measured before the method of FID assessment. Our method followed a plane parallel to a true horizontal (TH), which can lead to measurement errors. To circumvent these limitations, we used NHP, which has been used as a reference in research purposes and in everyday clinical practice.

Cautious interpretation of our results, taking the aforementioned limitations into account, could pave the way for further modern research into the possible association between craniofacial shape and impulsiveness.

Acknowledgements
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Disclosure
The authors report no conflicts of interest.

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7 Whiteside SP, Lynam DR. The five factor model and impulsivity: defining landmarks of the Frankfort horizontal plane can be rather difficult, both on cephalometric and photometric analyses, which predisposes to certain errors. A particularly common one consists of assuming that the Frankfort plane is parallel to a true horizontal (TH), which can lead to measurement errors. To circumvent these limitations, we used NHP, which has been used as a reference in extra-cranial orthodontics since the 1950s and is usually employed in profile pictures to control landmark placement on lateral cephalograms. The authors report no conflicts of interest.

Read more about the references at the end of the paper.


