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ORIGINAL ARTICLE

The slant of the forehead as a craniofacial feature of impulsiveness

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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

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 physiognomy[2] 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 neuroimaging 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 disorders[9] 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 construct[15] 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

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of the forehead and impulsiveness.[6] 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.[20] It is considered a normalized and stable head position[21] representing the natural real-life posture of human beings.[22] 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[23] or medical[24] purposes, we followed the view employed in a cosmetic treatment report.[25] Two anthropometric landmarks were used[26]: 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

Table 1 Descriptive analysis of participant profile and impulsiveness measures (n=131)

	Total sample			Men	Women	
	Mean (SD)	Minimum	Maximum	Mean	Mean	p-value
Age	36.7 (10.2)	18	60	36.9	36.0	0.673
Forehead inclination in degrees (FID)	19.0 (5.0)	8	33.5	19.5	16.9	0.017
UPPS-P						
Total	43.1 (8.9)	24	69	43.2	42.5	0.727
Negative Urgency	9.9 (2.7)	5	16	9.7	10.7	0.086
Positive Urgency	9.9 (2.7)	4	16	9.9	9.8	0.818
Sensation-Seeking	9.5 (2.9)	4	16	9.7	8.7	0.097
Lack of Premeditation	7.3 (2.4)	4	15	7.3	7.1	0.742
Lack of Perseverance	6.6 (2.5)	4	16	6.6	6.3	0.533
BIS-11						
Total	45.4 (14.4)	21	91	45.0	46.9	0.551
Attentional Impulsiveness	14.0 (4.3)	4	27	13.9	14.3	0.667
Motor Impulsiveness	16.1 (6.6)	3	33	15.9	16.9	0.503
Non-planning Impulsiveness	15.3 (6.2)	1	34	15.2	15.7	0.706
SSS-V						
Total	20.3 (6.7)	5	34	20.7	18.7	0.172
Thrill and Adventure Seeking	5.3 (2.9)	0	10	5.5	4.4	0.064
Experience Seeking	6.4 (2.0)	1	10	6.4	6.5	0.818
Disinhibition	4.3 (2.2)	0	9	4.4	3.9	0.308
Boredom Susceptibility	4.3 (2.2)	0	9	4.4	3.9	0.345

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

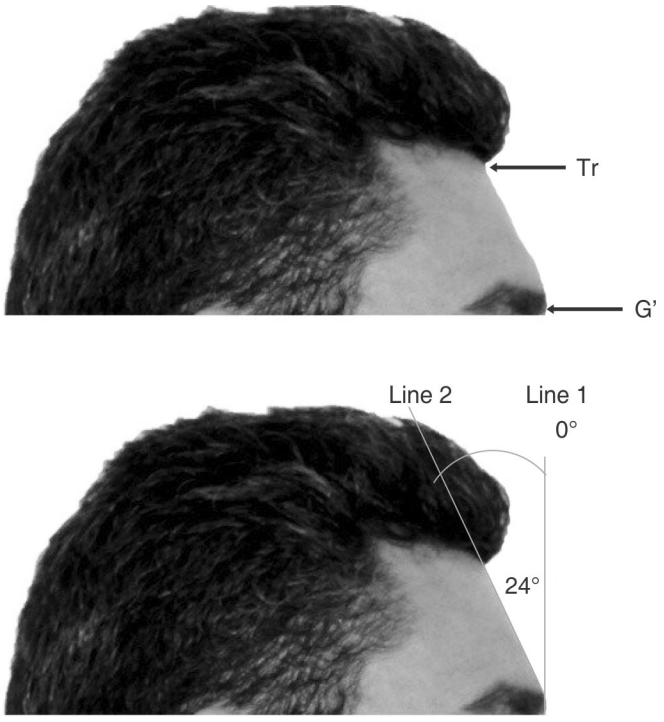

Figure 1 Measurement of the angle of the forehead slant. G' = glabella; Tr = trichion.

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-P[28] 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-11[30] 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

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 asses 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 ($\alpha \leqslant 0.10$) 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*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 UPPS-P, total														
2 UPPS-P, Negative Urgency	0.68													
3 UPPS-P, Positive Urgency	0.77	0.62												
4 UPPS-P, Sensation-Seeking	0.62	0.23	0.37											
5 UPPS-P, Lack of Premeditation	0.73	0.27	0.35	0.29										
6 UPPS-P, Lack of Perseverance	0.61	**0.15**	0.25	**0.12**	0.65									
7 BIS-11, total	0.76	0.50	0.58	0.43	0.63	0.46								
8 BIS-11, Attentional Impulsiveness	0.57	0.34	0.44	0.29	0.51	0.37	0.79							
9 BIS-11, Motor Impulsiveness	0.67	0.49	0.54	0.42	0.52	0.32	0.88	0.59						
10 BIS-11, Non-planning Impulsiveness	0.66	0.40	0.46	0.36	0.56	0.48	0.85	0.53	0.57					
11 SSS-V, total	0.54	0.30	0.43	0.52	0.37	0.21	0.48	0.31	0.49	0.38				
12 SSS-V, Thrill and Adventure Seeking	0.25	**0.04**	0.19	0.42	0.18	**-0.01**	0.24	0.17	0.28	**0.14**	0.74			
13 SSS-V, Experience Seeking	0.43	0.25	0.25	0.38	0.31	0.25	0.25	**0.11**	0.27	0.23	0.70	0.34		
14 SSS-V, Disinhibition	0.53	0.26	0.46	0.43	0.37	0.26	0.48	0.33	0.45	0.42	0.82	0.44	0.52	
15 SSS-V, Boredom Susceptibility	0.42	0.38	0.37	0.28	0.23	**0.16**	0.45	0.29	0.46	0.35	0.64	0.20	0.27	0.45

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.

Table 3 Regression of FID on impulsiveness measures

	b	Beta	R^2	p-value	95%CI (B)
UPPS-P					
Total	0.770	0.432	0.194	< 0.001	0.464-1.076
Negative Urgency			0.086		
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	0.193	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.

as well as high inter-rater reliability in the objective measurement of FID.

With respect to specific instruments, the lowest associations were found when UPPS-P Sensation Seeking is associated with BIS-11, which can be explained by the biological model on which Zuckerman's theory is based.[33] This model includes the Thrill and Adventure Seeking factor as a non-impulsive form of Sensation Seeking.

Given the multidimensional nature of impulsiveness, and for a major representation of the construct, three self-report instruments widely used in both clinical and theoretical research were employed in this study. Research has found that impulsiveness may influence errors of commission in drivers.[34] On this basis, we expected to find higher impulsiveness scores in our sample than in the general population. However, our data were very similar scores to those reported in the adaptations of the SSS-V[31] and UPPS-P[28] instruments; indeed, we even found an identical mean score for positive urgency (9.9).

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[6] 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.[8] Conversely, women scored higher on negative urgency.[8] 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, forehead 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 inclination in men, as previously reported elsewhere.[6-23] On this topic, craniofacial surgeons suggest that people with greater development of the frontal bone (bulging supraorbital 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 opercula, which correlated positively with the frontal protrusion (superciliary arches).[4]

Some limitations of this study must be mentioned. Our work focused on subjective measures of impulsiveness. Although this has been described as the most efficient

method,[39] 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.[40]

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 and after cosmetic surgical correction of a protrusive forehead.[25] The method of Oh et al.[23] was not used because they chose the Frankfort horizontal plane as a landmark. This plane extends from the upper edge of the auditory meatus (porion) to the lower edge of the orbital ridge, and its original purpose was to orient the skull in an approximation of NHP (the actual landmark used in our study). As other authors have suggested, location of the defining landmarks of the Frankfort horizontal plane can be rather difficult, both on cephalometric and photometric analyses, which predisposes to certain errors.[41] A particularly common one consists of assuming that the Frankfort plane is parallel to a true horizontal (TH), which can lead to measurement errors.[40] 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.[21,22]

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.

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Disclosure

The authors report no conflicts of interest.

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