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The effect of the functional asymmetry of the brain on face morphometry in the university students of mathematics and painting department

K. Karacan[1], V. Sabancıoğulları[2], M.İ. Koşar[3], A. Karacan[4]

[1]Departmant of Anatomy, Faculty of Medicine, University of Sakarya, Sakarya, Turkey
[2]Departmant of Anatomy, Faculty of Medicine, University of Cumhuriyet, Sivas, Turkey
[3]Departmant of Anatomy, Faculty of Medicine, University of Sıtkı Koçman, Muğla, Turkey
[4]Departmant of Radiology, Faculty of Medicine, University of Sakarya, Sakarya, Turkey

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Background: *The face is a complicated structure configurations of which are originated and components integrated during the developmental stages. Almost the whole of face is formed by neural crest cells migrating from the edge of the cranial neural folds to the pharyngeal arcus. Brain is an asymmetric organ both functionally and anatomically. While the left hemisphere is dominant in processing the verbal, mathematical and logical information, the right hemisphere is dominant in processing the perceptual, visible, spatial and artistic information. The functional differences in the left and right brain hemispheres might also cause differences in facial regions developing from the same centres as telencephalon during embryonic period. Therefore; we aimed to perform linear anthropometric measurements and determine whether functional asymmetry of brain creates any change in facial linear measurements, on the faces of students of painting and mathematics departments whose skills are different from each other.*

Materials and methods: *This study was performed on 212 students. A total number of 22 measurements from 17 anthropometric points for each student were done. Measurements were carried out between November 2011 and February 2012.*

Results: *Our findings revealed that there were statistically significant differences between two student groups in the face width, intercanthal distance, mandibular width, nose width, upper lip height and philtrum length. The comparison of genders revealed that there were statistically significant differences between all measured parameters. In addition, all students from both departments had euryprosopic face type when face type points were compared.*

Conclusions: *Those differences might be related to the functional asymmetry of brain. Therefore it could be suggested that the functional asymmetry of brain could cause an asymmetry in the face as well as in the linear anthropometric measurements.* (Folia Morphol 2019; 78, 3: 508–516)

Key words: ability, brain asymmetry craniofacial anthropometry, face

INTRODUCTION

The face is a complex structure that derives from many structures developing and integrating with each other during the embryonic period [24]. Almost all of the face is formed by the crest cells which migrate to the pharyngeal arch from the edge of the cranial neural

Address for correspondence: Associate Prof. Dr. V. Sabanciogullari, MD, Department of Anatomy, Cumhuriyet University School of Medicine, 58140 Sivas, Turkey, tel: +90 346 2191010, fax: +90 346 2191284, e-mail: vsabanci@yahoo.com.tr

crimp [1]. Neural crest cells are derived from neuroectoderm in the forebrain, midbrain, and hindbrain regions. They migrate into pharyngeal arch toward the front and to the face from the periphery of the forebrain and the optic cup. Facial development is under the influence of the inductive effect of the centres organising the prosencephalon and rhombencephalon. Prosencephalon; is formed by the telencephalon which forms cerebral hemispheres and the diencephalon which forms the optic cup, optic stalk, pituitary gland, thalamus, hypothalamus and pineal gland [20, 21]. Prosencephalic development is a process by which the forebrain takes its shape. Although cerebral hemispheres, that develop under the influence of the prosencephalic centres, are substantially symmetrical structures, they are known to be functionally distinct [5].

Accordingly, it is known that the left brain that controls the right side of the body organises verbal competencies such as reading, writing, speaking, remembering names and events. While left brain, which has logical and analytical mode of operation, processes the information sequentially, understands numbers and symbols in the mathematical sense and, accordingly, allows advanced mathematical calculations and operations [22].

On the other hand, the right brain, which controls the left side of the body and whose principle of operation is holistic; benefits from images and dreams rather than words. The right brain, which has competence to see and evaluate different types of information in a holistic way, is the main source of creativity and imagination. In short, while right hemisphere is playing a dominant role in the creative, intuitive, emotional, auditory and holistic perception, the left hemisphere is more rational, analytical, reductive and is related to oral functions [4, 22].

Right and left halves of the brain are functionally distinct and the face develops from the same centre as telencephalon during embryonic period; these reasons lead to differences in the facial area. Therefore, in our study, we aimed to determine the reference range and facial types in this section by performing linear anthropometric measurements of the face of the students in the departments of painting and mathematics.

MATERIALS AND METHODS

Participants

In the study, a total of 212 students from the Faculty of Education at the University of the Cumhuriyet were included. Eighty and one hundred thirty-two of these students were selected from the department of painting and mathematics teaching for secondary school, respectively. The students of painting department were placed by special aptitude test; the students of department of mathematics were placed according to the results of the university entrance exam. The students aged 18 to 26 were included in the study group. Before starting the study, ethics committee report (31.05.2011-140) and inter-agency necessary permits were received. Volunteering was taken into account in individuals who participated in the study. At the same time, individuals with a facial or nasal disorder, a history of facial or nasal surgery, neurological disorders, chronic drug use were excluded from the study.

Methods and measurements

Measurements were carried out between November 2011 and February 2012. The anthropometric landmarks had been identified and direct measurements were performed using a millimetre compass.

Craniofacial parameters used in measurements classified as horizontal and vertical are shown in Figures 1 and 2. For each subject, 22 measurements were taken utilising 17 anthropometric landmark points. The craniofacial landmarks [15] used in this study and the determinations of landmark localisations were as follows:

- **alare (al):** the most lateral point on the nasal ala;
- **cheilion (ch):** the outer corner of the mouth where the outer edges of the upper and lower vermilions meet;
- **crista philtri (cph):** the point on the crest of the philtrum, the vertical groove in the median portion of the upper lip, just above the vermilion border;
- **endocanthion (en):** the inner corner of the eye fissure where the eyelids meet, not the caruncles (the red eminences at the medial angles of the eyes);
- **exocanthion (ex):** the outer corner of the eye fissure where the eyelids meet;
- **frontotemporale (ft):** the most medial point on the temporal crest of the frontal bone;
- **glabella (g):** the most prominent point in the median sagittal plane between the supraorbital ridges;
- **gnathion (gn):** the lowest point in the midline on the lower border of the chin;
- **gonion (go):** the most lateral point at the angle of the mandible;
- **labiale superius (ls):** the mid point of the vermilion border of the upper lip;

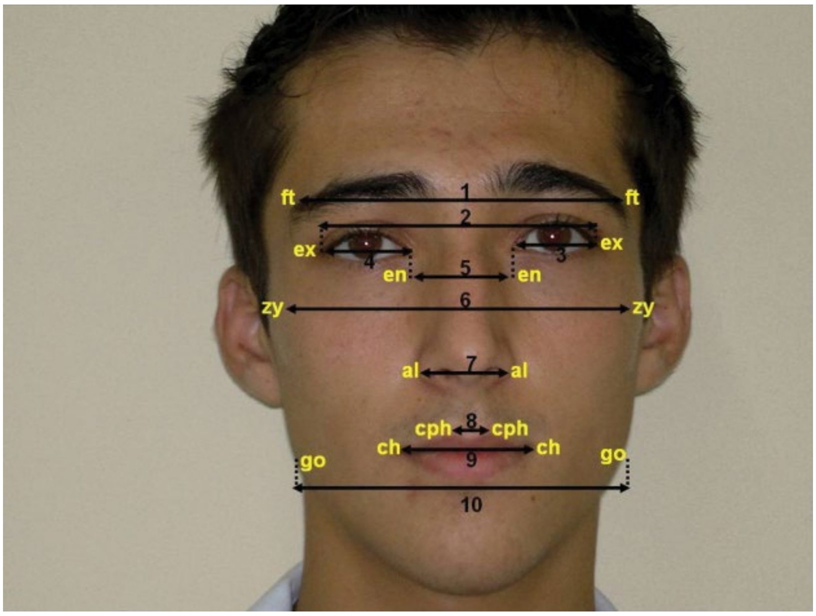

Figure 1. Linear horizontal distances measured in this study: 1 — forehead width = ft-ft; 2 — binocular width = ex-ex; 3 — left eye width = ex-en; 4 — right eye width = ex-en; 5 — intercanthal distance = en-en; 6 — face width = zy-zy; 7 — nose width = al-al; 8 — philtrum width = cph-cph; 9 — mouth width = ch-ch; 10 — mandibular width = go-go.

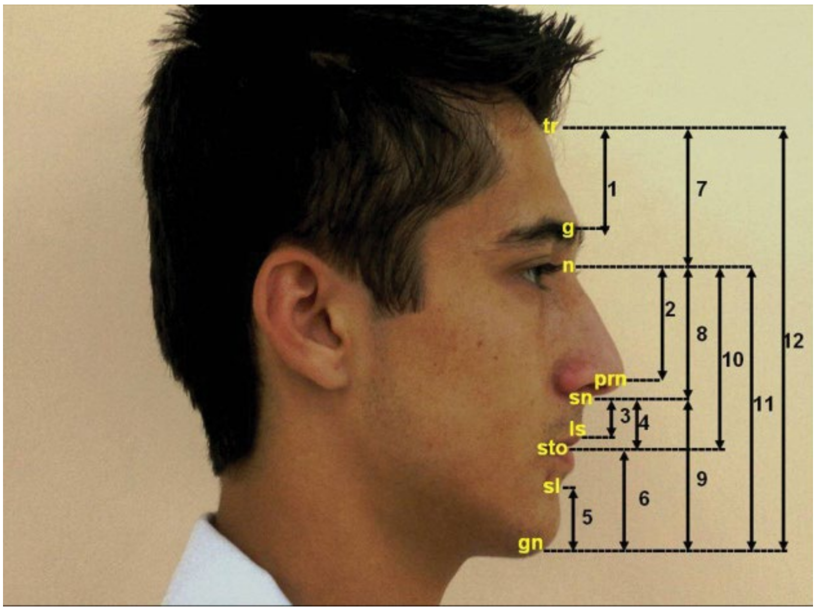

Figure 2. Linear vertical distances measured in this study: 1 — forehead height I = tr-g; 2 — nasal bridge length = n-prn; 3 — philtrum length = sn-ls; 4 — upper lip height = sn-sto; 5 — chin height = sl-gn; 6 — mandibular height = sto-gn; 7 — forehead height II = tr-n; 8 — nose height = n-sn; 9 — lower face height = sn-gn; 10 — upper face height = n-sto; 11 — total face height = n-gn; 12 — physiognomic face height = tr-gn.

- **nasion (n):** the midpoint of the nasofrontal suture;
- **pronasale (prn):** the most protruded point of the nasal tip;
- **stomion (sto):** the midpoint of the labial fissure when the lips are closed naturally;
- **sublabiale (sl):** the midpoint of the labiomental sulcus;
- **subnasale (sn):** the junction between the lower border of the nasal septum, the partition that divides the nostrils, and the cutaneous portion of the upper lip in the midline;

Table 1. The results of the craniofacial anthropometric measurements according to gender without department distinction

Measurements	Female (n = 137)	Male (n = 75)	Mean difference (t)	P
ft-ft	111.30 ± 5.40	117.37 ± 6.13	7.44	0.001*
tr-g	56.98 ± 6.34	58.51 ± 8.14	1.40	0.162
tr-n	65.34 ± 6.82	66.95 ± 8.61	1.39	0.164
zy-zy	129.90 ± 12.80	141.60 ± 10.20	7.26	0.001*
go-go	99.50 ± 8.09	105.65 ± 9.93	4.86	0.001*
sn-gn	60.28 ± 5.06	65.53 ± 5.47	7.01	0.001*
n-sto	68.84 ± 4.45	73.64 ± 4.47	7.48	0.001*
n-gn	109.23 ± 6.34	117.73 ± 6.33	9.33	0.001*
sto-gn	41.22 ± 4.72	44.74 ± 5.11	5.03	0.001*
tr-gn	174.02 ± 10.83	184.21 ± 11.23	6.45	0.001*
sl-gn	35.71 ± 3.73	39.00 ± 4.20	5.86	0.001*
en-en	31.94 ± 2.46	32.73 ± 2.87	3.80	0.001*
right ex-en	34.81 ± 2.34	33.36 ± 2.81	3.07	0.003*
left ex-en	35.30 ± 2.33	35.93 ± 2.67	1.78	0.210
ex-ex	101.34 ± 5.22	104.33 ± 6.99	3.23	0.002*
al-al	30.35 ± 2.93	34.22 ± 3.68	7.89	0.001*
n-prn	49.18 ± 4.08	52.08 ± 4.43	4.80	0.001*
n-sn	48.60 ± 3.82	51.83 ± 4.33	5.60	0.001*
cph-cph	11.85 ± 2.00	13.70 ± 2.25	6.14	0.001*
ch-ch	49.65 ± 4.22	53.67 ± 3.95	6.77	0.001*
sn-ls	15.05 ± 2.17	16.81 ± 2.39	5.46	0.001*
sn-sto	20.17 ± 3.40	22.19 ± 3.52	4.06	0.001*

*p < 0.05 significant; abbreviations — see text

— **trichion (tr):** midpoint of the hairline;
— **zygion (zy):** the most lateral point on the zygomatic arch.

In addition, each subject's facial index [23] was determined using the following formula: Facial index = Maximum vertical length of face (n-gn) / Maximum horizontal width of the face (zy-zy)) × 1.

On the basis of the facial index, the faces were classified as euryprosopic (short and broad), mesoprosopic (medium), or leptoprosopic (long and narrow).

In addition, Oldfield handedness questionnaire modified by Geschwind ve Behan was administered to participants [9, 18]. Thus, handedness, that is the most important indicators of the functional hemispheric specialisation, was compared between mathematics and painting students.

Statistical analysis

The study data were analysed using the SPSS 14.0 (SPSS Corp., Chicago, Illinois, USA) statistical package programme. The t-test and χ^2 test was used in the statistical evaluation of variance. Descriptive statistics (mean, standard deviation, and standard error of mean) for each measurement were computed for each sex and department (Painting Department and Mathematics Department). The tables of data reported the arithmetic mean (x) ± standard deviation (S) with an error level of 0.05.

RESULTS

In our study, 67.5% and 32.5% of the students from painting department who participated in our study were female and male, respectively; 62.9% and 37.1% of the students from mathematics department were female and male, respectively.

In the evaluation by gender without department distinction; all measurements except tr-g (forehead height I), tr-n (forehead height II) and right ex-en (right eye width) were found to be significantly different between genders. In addition, all measured values except right ex-en (right eye width) were higher for males (Table 1).

In the comparison of measurement results between departments, there was a significant difference in the measurements of zy-zy (facial width), go-go

Table 2. The comparison of measurement results between the departments

Measurements	Departments		Mean difference (t)	P
	Painting (n = 80)	Mathematics (n = 132)		
ft-ft	112.36 ± 5.35	114.11 ± 6.83	1.95	0.052
tr-g	57.55 ± 7.28	57.51 ± 6.94	0.03	0.970
tr-n	65.31 ± 7.88	66.27 ± 7.30	0.89	0.370
zy-zy	137.00 ± 14.60	132.30 ± 11.90	2.56	0.011*
go-go	104.46 ± 7.98	99.99 ± 9.58	3.49	0.001*
sn-gn	61.71 ± 5.58	62.40 ± 5.89	0.84	0.400
n-sto	70.43 ± 5.23	70.60 ± 4.89	0.23	0.811
n-gn	111.69 ± 7.13	112.57 ± 7.76	0.82	0.408
sto-gn	41.92 ± 4.86	42.80 ± 5.29	1.21	0.227
tr-gn	176.75 ± 13.01	178.16 ± 11.34	0.82	0.410
sl-gn	36.26 ± 4.00	37.25 ± 4.29	1.66	0.097
en-en	31.96 ± 2.26	32.73 ± 2.87	2.05	0.040*
right ex-en	34.81 ± 2.34	34.40 ± 2.37	1.22	0.223
left ex-en	35.54 ± 2.37	35.52 ± 2.54	0.04	0.965
ex-ex	102.35 ± 5.08	102.42 ± 6.61	0.08	0.932
al-al	32.53 ± 3.53	31.22 ± 3.73	2.51	0.013*
n-prn	50.48 ± 4.88	50.03 ± 4.13	0.71	0.474
n-sn	50.45 ± 4.03	49.32 ± 4.39	1.88	0.061
cph-cph	12.17 ± 2.19	12.72 ± 2.29	1.71	0.088
ch-ch	50.81 ± 3.71	51.23 ± 4.99	0.64	0.517
sn-ls	16.18 ± 2.48	15.36 ± 2.30	2.43	0.016*
sn-sto	19.89 ± 3.65	21.49 ± 3.39	3.23	0.001*

*$p < 0.05$ significant; abbreviations — see text

(mandibular width), en-en (intercanthal distance), al-al (nose width), sn-ls (philtrum length) and sn-sto (upper lip height). From these measurements, zy-zy, go-go, al-al and sn-ls were higher in the painting department (Table 2).

In the comparison of measurement results between female students of painting and mathematics departments, there was a significant difference in the measurements of tr-n (forehead height II), zy-zy (face width), go-go (mandibular width), al-al (nose width), sn-ls (philtrum length) and sn-sto (upper lip height). From these measurements, zy-zy, go-go, al-al and sn-ls were higher in the painting department (Table 3).

In the comparison of measurement results between male students of painting and mathematics departments, there was a significant difference only in the measurements of n-sn (nose height). This measurement was higher in the painting department (Table 4).

In the comparison of face types between departments, euryprosope face type was dominant for each of these departments. In the painting department, the percentage of the leptoprosope face type was higher than in the mathematics department. In the mathematics department, the percentage of the euryprosope face type was higher than the painting department. These results were statistically significant (Table 5).

In the comparison of handedness between departments, left handedness and ambidextrous in students of painting department was higher than in mathematics students. But it was statistically insignificant (Table 6).

DISCUSSION

Craniofacial soft tissue analysis and variations are very important in reconstructive and plastic surgery, orthodontics and maxillofacial surgery; therefore, there are many studies on the subject. The anthropometric analyses try to reveal the standard parameter values for of the human face and usually evaluate the reflection of the difference of gender or ethnic

Table 3. The comparison of measurement results between female students of painting and mathematics departments (n = 54, n = 83, respectively)

Measurements	Departments		Mean difference (t)	P
	Painting	Mathematics		
ft-ft	110.82 ± 5.09	111.62 ± 5.60	0.84	0.401
tr-g	56.27 ± 6.60	57.44 ± 6.17	1.05	0.293
tr-n	63.82 ± 7.29	66.32 ± 6.35	2.11	0.036*
zy-zy	133.50 ± 14.20	127.60 ± 11.20	2.66	0.009*
go-go	102.73 ± 7.66	97.41 ± 7.71	3.95	0.001*
sn-gn	60.12 ± 5.05	60.38 ± 5.10	0.28	0.775
n-sto	68.49 ± 4.57	69.07 ± 4.39	0.73	0.462
n-gn	109.02 ± 6.12	109.37 ± 6.52	0.31	0.753
sto-gn	41.22 ± 4.51	41.22 ± 4.89		
tr-gn	172.33 ± 11.46	175.13 ± 10.32	1.48	0.140
sl-gn	35.47 ± 3.49	35.87 ± 3.89	0.61	0.543
en-en	31.52 ± 1.82	32.21 ± 2.78	1.59	0.113
right ex-en	34.43 ± 2.19	33.99 ± 1.95	1.21	0.227
left ex-en	35.30 ± 2.35	35.31 ± 2.34	0.02	0.982
ex-ex	101.21 ± 4.10	101.42 ± 5.86	0.22	0.821
al-al	31.23 ± 2.54	29.77 ± 3.03	2.93	0.004*
n-prn	49.32 ± 4.40	49.08 ± 3.88	0.32	0.747
n-sn	49.12 ± 3.33	48.27 ± 4.10	1.27	0.206
cph-cph	11.71 ± 2.15	11.95 ± 1.90	0.69	0.489
ch-ch	49.61 ± 3.08	49.68 ± 4.84	0.08	0.931
sn-ls	15.55 ± 2.30	14.72 ± 2.03	2.20	0.029*
sn-sto	19.27 ± 3.51	20.76 ± 3.22	2.54	0.012*

*$p < 0.05$ significant; abbreviations — see text

differences to the face. The studies performed to evaluate the anthropometric measurements of face are shown in Table 7.

The head contains not only the central nervous system, eyes, the inner ear structures, the first parts of digestive and respiratory organs, but also it is a place where the face is located. The face is important in communication and interaction with the environment and also is the most important anatomical region containing information for recognition of people [11]. The face develops in embryonic period by integrating many structures. Therefore its development is complex [16]. The facial abnormalities or differences in the morphology may indicate an underlying brain pathology due to they develop from the same centre [12].

The brain is asymmetric in both functional and anatomical aspects. It has been revealed in a study conducted by Keles that the body asymmetry was caused by the brain asymmetry, and also the brain asymmetry resulted in facial asymmetry [14]. However, it is not clear what kind of impact the brain's functional asymmetry has on the face.

As seen in Table 7, the studies usually include the results of anthropometric measurements obtained in a community and those based on gender factors. It is evident that ethnic differences may alter the measured values of some parameters. The study conducted by Farkas et al. [7] on African-American and North American white males and females is a good example that can show the results of ethnic differentiation. In addition, another important factor changing the measurements is gender. In this context, many studies such as the studies conducted by Ozdemir et al. [19] and Ngeow et al. [17] examined the differences based on gender factor. However, it is not clear how much the measurements are affected by different abilities and it is

Table 4. The comparison of measurement results between male students of painting and mathematics departments (n = 26, n = 49, respectively)

Measurements	Departments		Mean difference (t)	P
	Painting	Mathematics		
ft-ft	115.56 ± 4.46	118.33 ± 6.70	1.89	0.063
tr-g	60.19 ± 8.02	57.62 ± 8.15	1.30	0.195
tr-n	68.40 ± 8.30	66.18 ± 8.75	1.06	0.292
zy-zy	144.40 ± 12.60	140.20 ± 8.5	1.71	0.091
go-go	108.06 ± 7.53	104.37 ± 10.85	1.54	0.126
sn-gn	64.99 ± 5.28	65.81 ± 5.60	0.61	0.540
n-sto	74.46 ± 4.16	73.20 ± 4.61	1.16	0.248
n-gn	117.23 ± 5.84	118.00 ± 6.62	0.49	0.622
sto-gn	43.36 ± 5.32	45.47 ± 4.90	1.72	0.090
tr-gn	185.94 ± 11.23	183.29 ± 11.24	0.97	0.334
sl-gn	37.89 ± 4.53	39.58 ± 3.94	1.67	0.098
en-en	32.86 ± 2.79	33.62 ± 2.82	1.11	0.269
right ex-en	35.60 ± 2.47	35.09 ± 2.83	0.77	0.443
left ex-en	36.03 ± 2.36	35.88 ± 2.84	0.22	0.821
ex-ex	104.71 ± 6.10	104.12 ± 7.47	0.34	0.732
al-al	35.21 ± 3.83	33.69 ± 3.53	1.73	0.088
n-prn	52.91 ± 5.02	51.64 ± 4.08	1.18	0.242
n-sn	53.23 ± 4.01	51.09 ± 4.35	2.08	0.041*
cph-cph	13.12 ± 1.99	14.01 ± 2.34	1.64	0.104
ch-ch	53.31 ± 3.72	53.87 ± 4.09	0.58	0.563
sn-ls	17.50 ± 2.36	16.45 ± 2.35	1.84	0.069
sn-sto	21.17 ± 3.67	22.73 ± 3.35	1.85	0.067

*$p < 0.05$ significant; abbreviations — see text

Table 5. The comparison of face types between the departments

Departments	Face types			Total
	Euryprosope	Mesoprosope	Leptoprosope	
Painting	41 (51.3%)	5 (6.3%)	34 (42.5%)	80 (100%)
Mathematics	119 (90.2%)	12 (9.1%)	1 (0.8%)	132 (100%)
Total	160 (75.5%)	17 (8.0%)	35 (16.5%)	212 (100%)

$\chi^2 = 63.06$; $p = 0.001$; $p < 0.05$ significant

Table 6. The comparison of handedness between the departments

Departments	Handedness			Total
	Right handed	Left handed	Ambidextrous	
Painting	70 (87.5%)	4 (5.0%)	6 (7.5%)	80 (100%)
Mathematics	124 (93.9%)	3 (2.3%)	5 (3.8%)	132 (100%)
Total	194 (91.5%)	7 (3.3%)	11 (5.2%)	212 (100%)

$\chi^2 = 2.67$; $p = 0.263$; $p > 0.05$

Table 7. Facial measurements in the literature

Measurements	Farkas [7]		Özdemir [19]	Negow [17]	Arslan [2]	Karaca [13]	Bozkır [3]	Ferrario [8]	Evereklioğlu [6]	He [10]
	African--American M/F	North American White M/F	M/F	M/F	M/F	M/F	M/F	M/F		
ft-ft	116.3/111.3	115.9/111.5	109.6/102.9		122.1/114.6	118.34/113.59				
tr-g			53.0/53.5		52.0/56.1	52.72/51.25	55.6/52.1			
tr-n	72.0/67.1	67.1/63.0	64.7/63.3		61.3/65.7	68.80/66.93	65.3/61.6			
zy-zy	139.0/130.5	139.1/130.0	123.1/116.8	132.5/140.1	120.7/113.5	129.06/127.20				
go-go	104.2/96.7	105.6/94.5	116.3/110.2		116.5/110.5	111.55/107.43				
sn-gn	78.7/71.5	72.6/64.3	69.4/61.0	68.5/63.2	68.0/63.0	70.54/63.44	68.4/62.6			
n-sto	78.0/72.7	76.6/69.4	73.5/70.8	76.7/72.6	76.2/72.2					
n-gn	125.6/116.5	124.7/111.4	121.1/112.4	119.3/111.8	122.6/113.4					
sto-gn	57.5/52.1	50.7/43.4	47.8/42.1							
tr-gn	192.6/179.9	187.2/173.3	185.8/174.4							
sl-gn			28.5/24.4							
en-en	35.5/34.4	33.3/31.8		33.9/32.5	30.4/30.2	33.17/31.86	30.7/30.0	30.68/28.55	30.87/30.22	37.45/35.99
R ex-en	32.9/32.4	31.3/30.7			34.9/33.9	33.89/33.50		32.87/31.64		
L ex-en	32.9/32.2	31.3/30.7		29.5/28.7	34.4/33.5	33.91/33.39	32.6/31.0	34.09/32.79		
ex-ex	96.8/92.9	91.2/87.8		92.3/89.6		99.74/96.51		94.25/89.73	88.92/86.32	
al-al	44.1/40.1	34.9/31.4	38.4/34.8	41.0/37.3	37.0/32.7	35.15/32.32	35.9/32.3			39.30/34.75
n-prn	45.6/42.6	50.0/44.7	40.3/40.1							51.80/50.54
n-sn	51.8/48.8	54.8/50.6	51.9/51.7	51.6/54.1	56.3/52.8	53.14/50.36	52.4/49.7			60.33/58.23
cph-cph			13.9/12.1							
ch-ch	54.6/53.6	54.5/50.2	47.1/44.0	48.8/47.1	50.0/47.3	51.55/48.88	49.4/45.4			
sn-ls	16.4/14.0	15.9/13.8	24.4/22.4	13.1/12.2						
sn-sto	26.1/24.5	22.3/20.1	21.6/19.3	22.7/21.1	21.2/19.6					

F — female; M — male

not included in the studies of literature. Our study shows the reflection of different abilities on craniofacial measurements.

When comparing our results between two departments which are different from each other in terms of talent, the measurements of face width (zy-zy), mandibular width (go-go), nose width (al-al) and philtrum length (sn-ls) were higher in the students from the painting department, while the measurements of upper lip height (sn-sto) and intercanthal distance (en-en) were higher in the students from the mathematics department.

Arslan et al. [2] have sought to determine the facial types according to facial indices and the leptoprosope face type was found to be more common in their study group. In our study, the euryprosope face type was more common in both mathematics and painting department. In addition, the leptoprosope face type had a very low rate in the students from the department of mathematics.

CONCLUSIONS

These differences that we observed in our study may be related to the brain's functional asymmetry. Therefore, we suggest that the functional asymmetry of the brain causes a facial asymmetry as well as may lead to a difference in the linear anthropometric measurements and accordingly facial types in individuals that are different in terms of abilities.

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