Journal of Anatomical Sciences

Email:anatomicaljournal@gmail.com

J Anat Sci 12 (1)

Quantification and Preference of Facial Asymmetry of the Sub- Saharan Africans' 3D Facial Models

[*]Anas IY and Asuku AY

[1,2]Department of Anatomy, Faculty of Basic Medical Sciences, College of Health Sciences, Bayero University Kano, Nigeria.

Corresponding Author: ANAS Ibrahim Yahaya.
E-mail: suhhis7@0gmail.com; +2349098104401

ABSTRACT

A substantial body of literature have reported findings on facial symmetry and asymmetry and their role in human mate choice. However, major gaps persist, with nearly all data originating from the WEIRD (Western, Educated, Industrialized, Rich and Developed) populations, and results remaining largely equivocal when compared across studies. The present study aimed at quantifying facial asymmetry from the 3D faces of the Hausa ethnic group of northern Nigeria and aimed at determining their perceptions and judgements of standardized facial images with different levels of asymmetry through rating. Ethical approval to scan the faces of the subjects was given by the University College London and Federal Ministry of Health, Nigeria. Data were analyzed using R-studio software and results indicated that males were 12% (0.35mm) & 15% (0.23mm) more asymmetric in the face and eye respectively than females (Face: 0.3mm & Eye: 0.20mm). Additionally, individual 3D facial scans with lower levels of facial asymmetry (near facial symmetry) were perceived as more attractive, more suitable as spouses and more caring, whereas those with higher levels of facial asymmetry were perceived as more aggressive. The study conclusively asserted that all faces are asymmetric and the preference for less asymmetric faces was not just dependent on single facial trait, but rather on multiple facial traits; thus the study suggests that physical attractiveness is not just an arbitrary social construct, but at least, in part, a clue to overall health and a possible pointer to environmental influence.

Keywords—Sub-Saharan African's facial asymmetry, Quantification of facial asymmetry, Preference of asymmetry of 3D face models

INTRODUCTION

The methods for the quantification of facial asymmetry are numerous, emanating from both direct and indirect anthropometric measurements. These are stereophotogrammetry[1,2], surface imaging[3], landmark-based[4], 3D photogrammetry[1], 2D photogrammetry[5], 2D radiometry[6] and many more. However, 3D facial laser scanometry has gained much attention for most of quantifiers of facial asymmetry in the recent time[7,8,9] with high accuracy.

From the previous and the current facial studies, all human faces are asymmetric[10,11,12,9] but artificial symmetric faces were previously and currently created using computers. Some specific human body parts are preferred by the opposite sex, and face is one of the most important portions preferred especially when making choice for a partner. Certain facial features are attractive, for example, facial averageness[13,14], facial adiposity[15], eye color[16], facial hair in men[17], and facial symmetry[18,19]. Although all human faces are asymmetric[11,20], faces with lower facial asymmetry were previously rated as more attractive[21,22,23], and were mostly preferred in selecting mate[24,25,26], possibly because less asymmetric faces cue both genetic and phenotypic qualities[27], as in the "good genes" theory of human mate choice[28]. Studies on facial asymmetry are largely limited to developed and urbanized western participants[4,3,2] the so-called WEIRD population (western, educated, industrialized, rich and democratic)[29], with barely none in Sub-Saharan Africa. The present study aimed to determine among the selected Sub-Saharan African populace: 1) the extent of facial asymmetry 2) the effect of facial asymmetry on attractiveness and choice of mates for a long-term relationship.

MATERIALS AND METHODS

The study was conducted on Hausa subjects which are mostly found in the northern states of Nigeria with a population of about 75 million[30], and speak Hausa language (of mixed origin), a Chadic group of Hamitic (or Afro-Asiatic) family of languages and the language is spoken by millions of people in the North and West Africa[31].

Four hundred and twenty-six Hausa subjects (215 males, 211 females) were recruited randomly and scanned with an Exascan surface laser scanner (Plate 1). Their age ranged but restricted to from 18-25 years to minimize the effects of both ongoing ontogenetic development and aging on facial asymmetry.

Subjects were scanned with their consents and ethical approval from the Federal Ministry of Health Nigeria. The scanner was calibrated to correct any optical or electronic distortions and the sensor configured for dark skin. Prior to scanning, positioning targets were placed on the face of each participant, from the hair line down to the chin, and along each side of the face including the ears. Scanning was done with participant seated in an upright position, sitting still on a chair with the head faced up (neck extended) at a slight angle of about 45 degree relative to the floor (most convenient and comfortable position). Participants were instructed to keep neutral faces and their eyes closed to avoid discomfort from the laser beams. During the scanning process, the 3D digital scan was generated on the computer screen in real time, allowing the researcher to continue scanning until a satisfactory scan has been created. The scans were exported as .stl files into Geomagic Studio 2012 software, cleaned and trimmed, then saved as a .wrap file which served as the original scan for further analysis. Each of the original scans were mirrored and aligned to make a 3D facial model ready for asymmetry analyses.

From the pool of the 426 facial models, 36 models (of 18 males, 18 females), each with a wider range of whole face asymmetry values but with similar facial masculinity-femininity scores were selected after being analyzed, then enhanced, refined, smoothened, and relaxed, to make uniform and smooth asymmetric models (Plates 5 & 6) using the Geomagic 12 software. Similarly, 6 facial models (3 males, 3 females) with highest facial asymmetry were selected, and symmetric 3D facial models' version of each of the 6 was made to a pair (i.e., 3 pairs of asymmetric/symmetric of males and 3 pairs for females) all acquired by modification of previous methods[32,33,34] [(Plates 3 & 4)]. These facial models were rated by 179 Hausa subjects (98 males & 81 females) as which of them was most attractive, most likely as long-term partner, most caring, or as most aggressive, and males rated females and vice-versa with 6—most attractive and 1—least attractive. The raters' (Plate 2) [18-25 years] filled a brief demographic questionnaire.

Plate 1: ExaScanner

Plate 2: Cross-section of Female raters

A1 A2

Plate 3: First pair of the females' 3D facial models: A1 (original), & A2 (symmetricised) models (2nd & 3rd pairs not shown).

A1 A2

Plate 4: First pair of the females' 3D facial models: A1 (original), & A2 (symmetricised) models (2nd & 3rd pairs not shown).

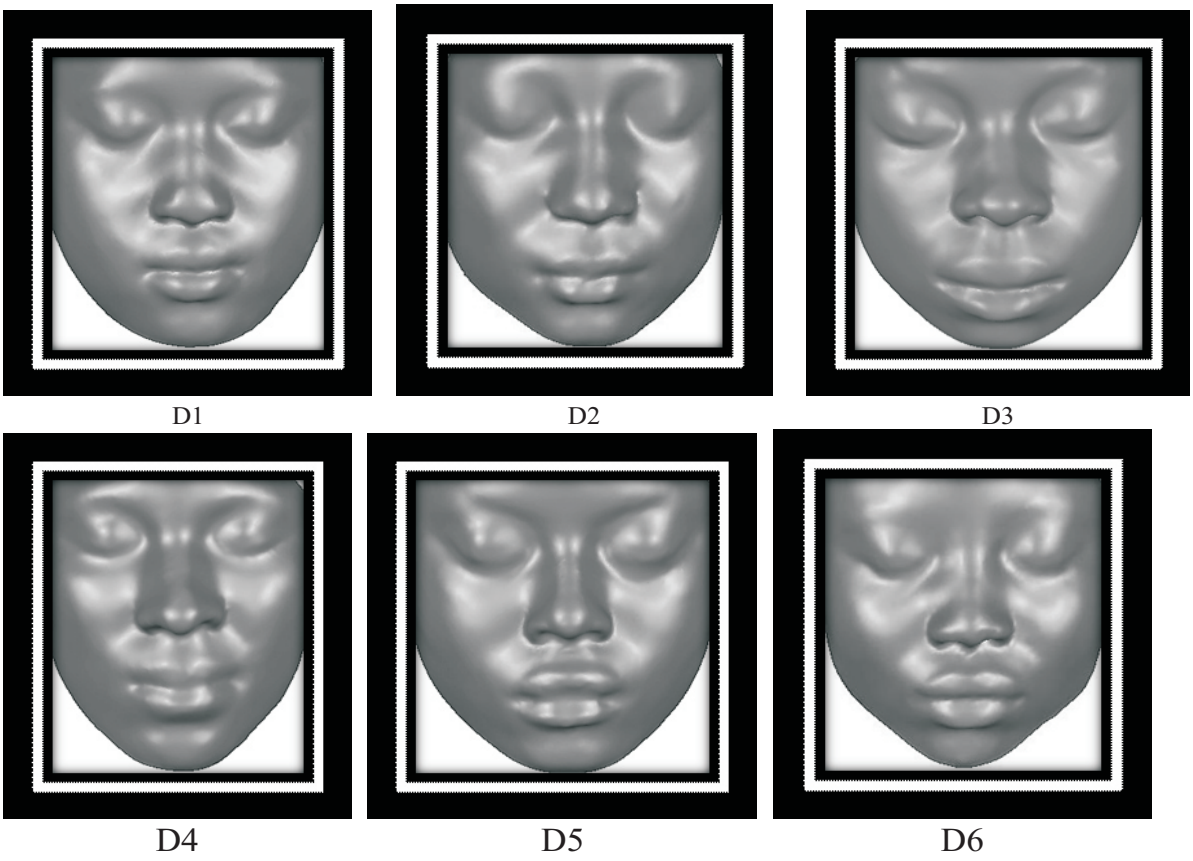


Plate 5: 1st of the 3 sets of females' 3D asymmetric facial models (2nd & 3rd pairs not shown).

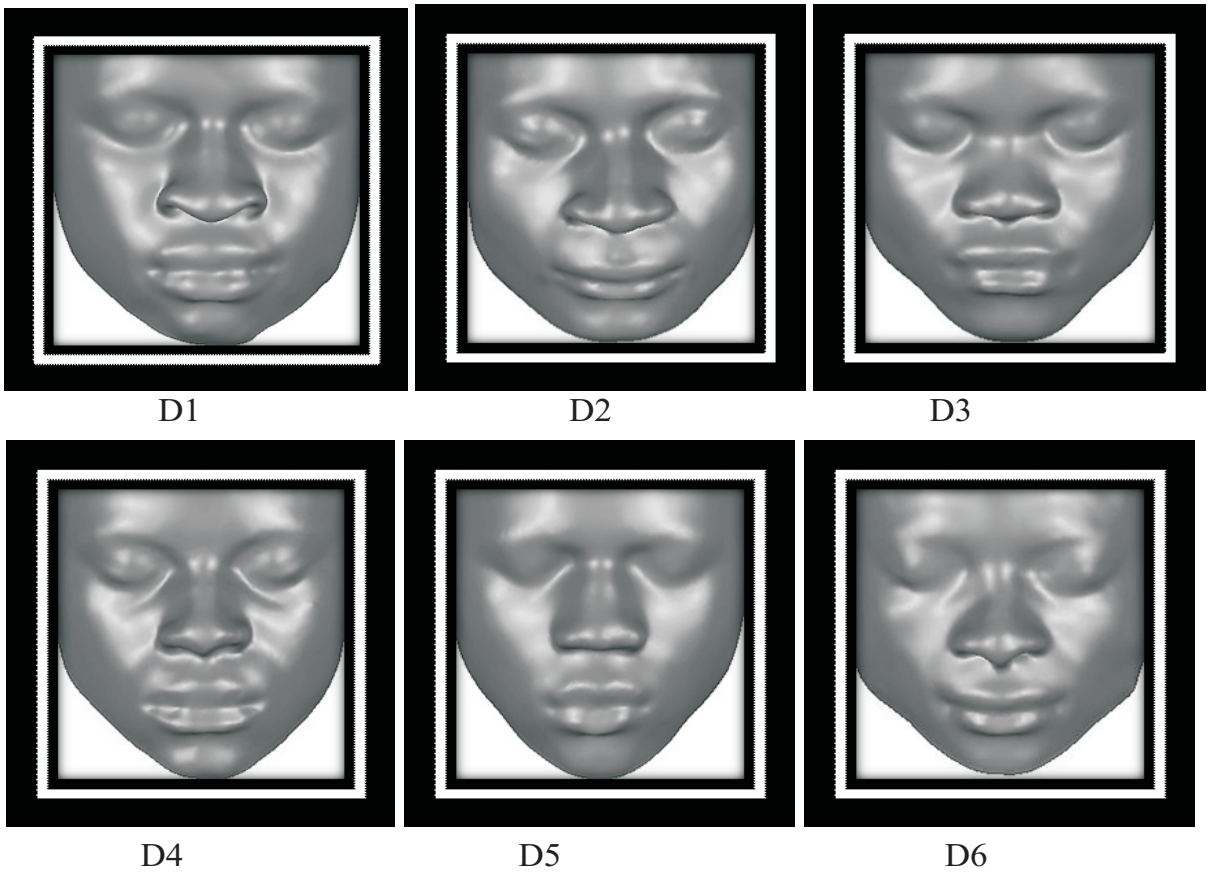


Plate 6: 1st of the 3 sets of males' 3D asymmetric facial models (2nd & 3rd pairs not shown).

RESULTS

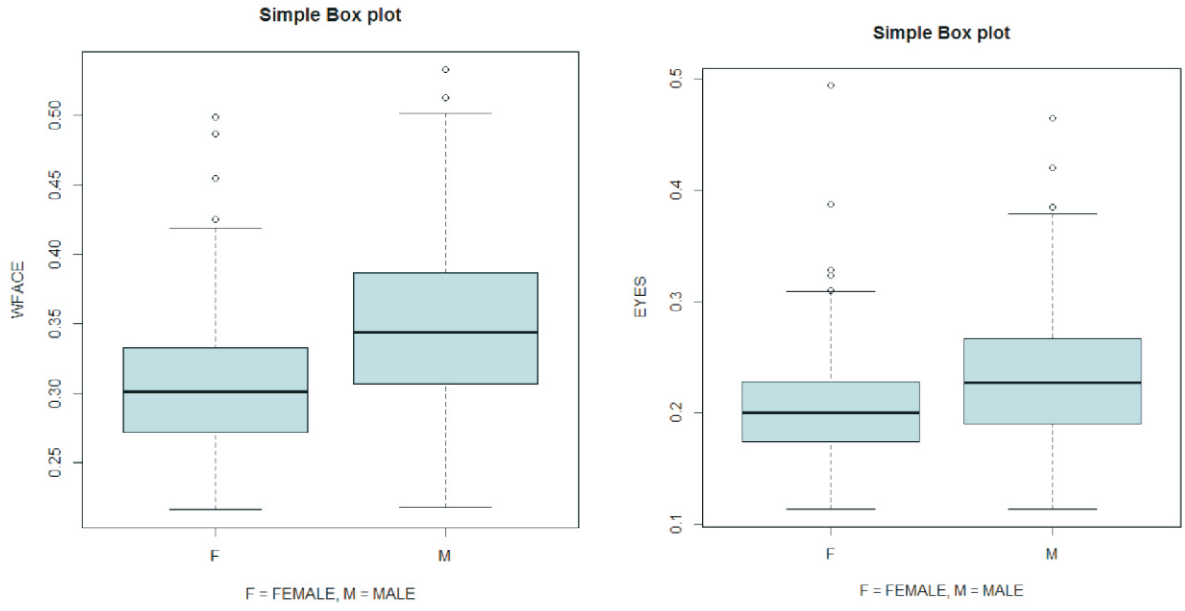
From Table 1 the analyses show that the mean whole face asymmetry for the females was 0.31mm (range, 0.22mm-0.50mm) and for the males, it was 0.35mm (range, 0.22mm-0.53mm); while the mean asymmetry around the eye in females was 0.2 mm (range, 0.11mm-0.49mm), and 0.23mm (range, 0.11mm-0.47mm) for the males. There was also a statistically significant sexual difference in the whole face asymmetry and asymmetry around the eyes (Table 2). No correlation was observed between facial asymmetry & masculinity-femininity (F-statistics, 0.0572; P, 0.8110). On average, significant percentage of both male and female raters preferred symmetric models as most attractive, most likely as a marriage partner, or most caring, and considered asymmetric models as most aggressive (Figures 1 & 2).

Table 1: Descriptive statistics for Age, whole face asymmetry (WFACE) and asymmetry around the eyes (EYES).

Variable	Sex	N	Minimum	Maximum	Mean	STD	S.E Mean
AGE (years)	F	211	18.0	25.0	20.6	2.40	0.20
	M	215	18.0	25.0	21.8	2.10	0.10
WFACE (mm)	F	211	0.22	0.50	0.31	0.10	0.00
	M	215	0.22	0.05	0.35	0.10	0.00
EYES (mm)	F	211	0.11	0.49	0.20	0.00	0.00
	M	215	0.11	0.47	0.23	0.10	0.00

Table 2: Mann-Whitney U tests: between Whole face asymmetry values (WFACE), and asymmetry around the eyes and SEX

Variables	W	P-value
Whole face asymmetry (WFACE) &Sex	13134.5	5.697e-14
Asymmetry around the eyes (EYES) & Sex	16024.5	1.604e-07



(A) (B)

Figure 1: Boxplots of whole face asymmetry (WFACE), asymmetry around the eyes (EYES) & sex

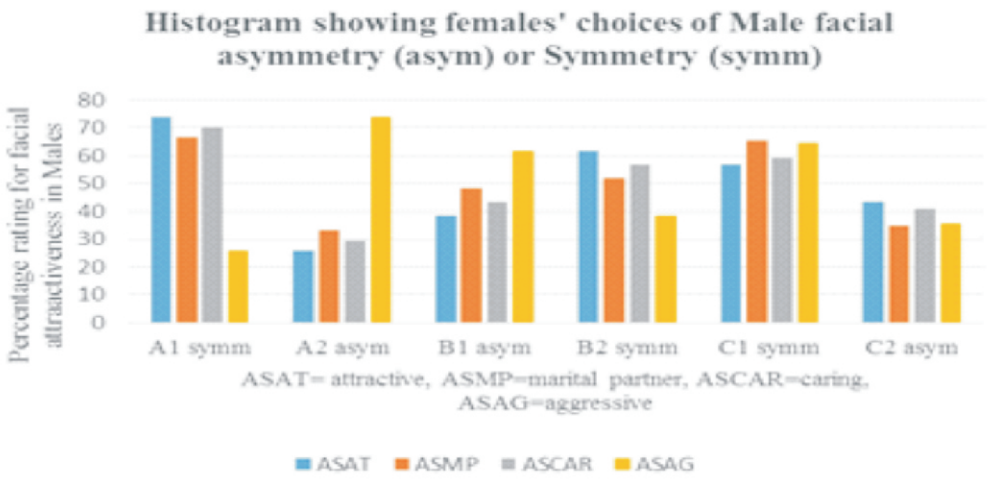


Figure 2: Females' choices of males' facial asymmetry

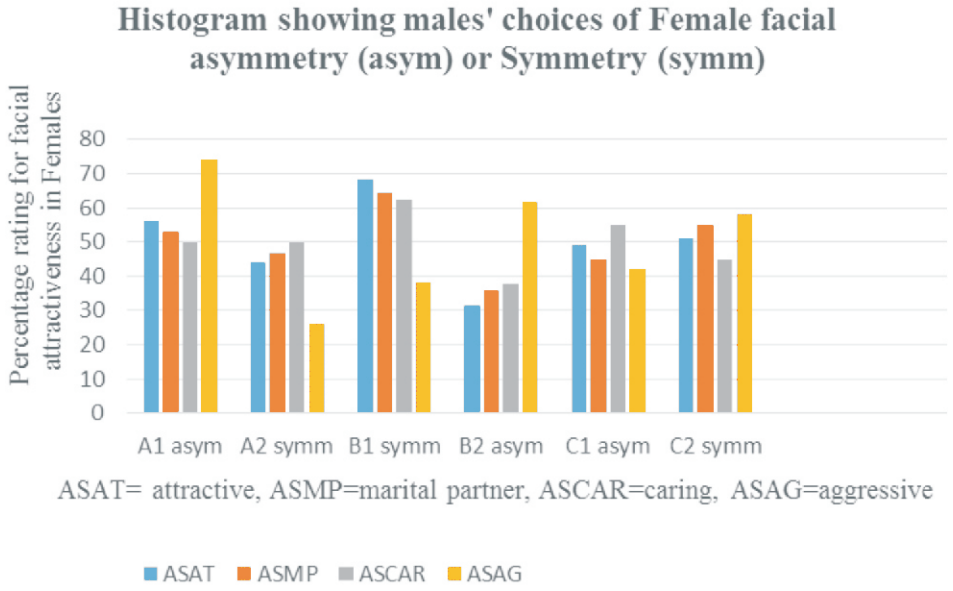


Figure 3: Males' choices of females' facial asymmetry

DISCUSSION

Individuals are mostly choosy particularly in friends or in a long-term sexual relationship by making, specifically an aesthetic facial judgment. It is widely believed that men consider physical attractiveness cues more valuable than do women in romance and mating, primarily because of its value as cue to age[35,36,37]. However, variations exists in the rating of facial attractiveness where women's ratings of men's facial attractiveness appear to vary more than men's ratings of women[38], probably because women's ratings reflect personal circumstances more than men's for example menstrual-cycle point, pursuit of short-versus long-term relationships, variable willingness to trade-off between physical attractiveness and material benefits in mate choice.

In rating facial attractiveness, facial masculinity-femininity trait was tested for correlation with facial symmetry-asymmetry trait, so that the rating of facial symmetry-asymmetry attractiveness could not be due to covariation with masculinity-femininity.

Previous studies showed that unmanipulated faces were typically preferred by raters over the manipulated (computerized) ones (made symmetrical) and vise-versa in some studies. However, more recent studies suggest that the preference may likely be due to the nature of the manipulation used to generate the symmetrical faces making them less natural, which has now led the recent researchers to improve their methodology by using 3D rather than 2D images, including this study. Similarly, the preference of manipulated asymmetric facial photos in some studies, were possibly due to the introduction of the abnormal

facial features as demonstrated [33], and a problem of presenting images with different skin textures as seen in the study of Swaddle and Cuthill[39] Moreover, some studies on facial attractiveness & facial asymmetry of some aspect of facial traits [e.g., asymmetry of nose and jaw[40,41] may miss certain important facial traits which may show significant asymmetry.

In general, several studies on facial attractiveness with regards to the symmetry-asymmetry traits, indicated that symmetry is attractive[42,33], which are in keeping with the findings of the current study. Symmetrical faces were more attractive for both sexes that rated pairs of 3D symmetrical versus 3D asymmetrical facial models in the 1st rating method in this study, although the result was mixed. Similarly, in the 2nd rating method where 6 individuals (males or females with wider range of facial asymmetry values) were presented to the raters, both sexes preferred faces with lower facial asymmetry values as more attractive, most likely as marital partners or as most caring faces than those with higher values although results were also mixed. In both sexes, attractiveness covaried with the degree of symmetry, because the association between the average facial attractiveness scores and the facial asymmetry values was negative and significant in females but insignificant in males, which means the more facial asymmetry value decreases; the more the face is rated as more attractive. The negative but significant level of association between facial asymmetry values and the facial attractiveness rating may possibly be due to the more attractive feminine features seen in the females than in males.

The aggressiveness rating findings in this study on average, showed that both sexes had chosen individuals with higher whole face asymmetry values as looking more aggressive although results were also mixed in both sexes.

CONCLUSION

It was concluded from the present study that Sub-Saharan Africans exhibit facial asymmetry and the extent of this phenomenon is similar to the Caucasians' [11]. The significance of such similarity is however subject to further investigation. Also, facial preference in the studied population was mixed (asymmetry-symmetric) since facial asymmetry was linked to aggression and symmetry to attractiveness.

ACKNOWLEDGEMENT

The Author acknowledged the contribution of Staff from Anatomy Department, Faculty of Basic Medical Sciences, College of Health Sciences, Bayero University Kano in assisting during the data collection and the students from the same Faculty who participated as subjects. Similarly, Bayero University Kano, is also acknowledged in providing an enabling environment for the study to take place.

CONFLICT OF INTEREST

Authors indicate No conflict of interest

REFERENCES

1. Linden OE, He JK, Morrison CS, Sullivan SR, Taylor HOB. The Relationship between Age and Facial Asymmetry. Plast Reconstr Surg. 2018;142(5):1145–52.
2. Cassi D, Battistoni G, Magnifico M, Di Blasio C, Pedrazzi G, Di Blasio A. Three-dimensional evaluation of facial asymmetry in patients with hemifacial microsomia using stereophotogrammetry. J cranio-maxillo-facial Surg Off Publ Eur Assoc Cranio-Maxillo-Facial Surg. 2019; 47(1):179–84.
3. Kornreich D, Mitchell AA, Webb BD, Cristian I, Jabs EW. Quantitative Assessment of Facial Asymmetry Using Three-Dimensional Surface Imaging in Adults: Validating the Precision and Repeatability of a Global Approach. Cleft palate-craniofacial J Off Publ Am Cleft Palate-Craniofacial Assoc. 2016; 53(1):126–31.
4. Verhoeven T, Xi T, Schreurs R, Bergé S, Maal T. Quantification of facial asymmetry: A comparative study of landmark-based and surface-based registrations. J cranio-maxillo-facial Surg Off Publ Eur Assoc Cranio-Maxillo-Facial Surg. 2016; 44(9):1131–6.
5. Berlin NF, Berssenbrugge P, Runte C, Wermker K, Jung S, Kleinheinz J. Quantification of facial asymmetry by 2D analysis-DA comparison of recent approaches. Craniomaxillofac Surg. 2014; 42(3):265–71.
6. Choi KY. Analysis of Facial Asymmetry. Arch craniofacial Surg. 2015; 16(1):1–10.
7. Zhao Y, Xiong Y, Wang Y. Three-Dimensional Accuracy of Facial Scan for Facial Deformities in Clinics: A New Evaluation Method for Facial Scanner Accuracy. PLoS One [Internet]. 2017; 12(1):e0169402. Available from: https://doi.org/10.1371/journal.pone.0169402
8. Amornvit P, Sanohkan S. The Accuracy of Digital Face Scans Obtained from 3D Scanners: An In Vitro Study. Int J Environ Res Public Health. 2019;16(24).
9. Anas IY, Bamgbose BO, Nuhu S. A comparison between 2D and 3D methods of quantifying facial morphology. Heliyon [Internet]. 2019;5(6):e01880. Available from: http://www.sciencedirect.com/science/article/pii/S2405844018337472
10. Bugaighis I, Mattick C, Tiddeman B, Hobson R. Three-dimensional gender differences in facial form of children in the North East of England. Eur J Orthod [Internet]. 2011; Available from: http://ejo.oxfordjournals.org/content/early/2011/04/29/ejo.cjr033.abstract
11. Primozic J, Perinetti G, Zhurov A, Richmond S, Ovsenik M. Assessment of facial asymmetry in growing subjects with a three-dimensional laser

scanning system. Orthod Craniofac Res [Internet]. 2012;15(4):237–44. Available from: http://dx.doi.org/10.1111/j.1601-6343.2012.01550.x
12. Djordjevic J, Toma AM, Zhurov AI, Richmond S. Three-dimensional quantification of facial symmetry in adolescents using laser surface scanning. Eur J Orthod [Internet]. 2011;36(2):125–32. Available from: http://ejo.oxfordjournals.org/content/36/2/125.abstract
13. Rhodes G, Yoshikawa S, Clark A, Lee K, McKay R, Akamatsu S. Attractiveness of facial averageness and symmetry in non-Western populations: in search of biologically based standards of beauty. Perception. 2001;30:611–25.
14. Apicella CL, Little AC, Marlowe FW. Facial averageness and attractiveness in an isolated population of hunter-gatherers. Perception. 2007;36:1813–20.
15. Coetzee V, Perrett DI, STEPHEN ID. Facial adiposity: a cue to health? Perception. 2009;38:1700–11.
16. Penton-Voak IS, Little AC, Jones BC, Burt DM, Tiddeman BP, Perrett DI. Female condition influences preferences for sexual dimorphism in faces of male humans (Homo sapiens). J Comp Psychol http//dx.doi.org/101037/0735-70361173264 Medlin. 2003;117(3):264–71.
17. Neave N, Shields K. The effects of facial hair manipulation on female perceptions of attractiveness, masculinity, and dominance in male faces. Pers Indiv Differ. 2008;45:373–7.
18. Puts DA. Beauty and the beast: mechanisms of sexual selection in humans. Evol Hum Behav [Internet]. 2010;31(3):157–75. Available from: http://www.sciencedirect.com/science/article/pii/S1090513810000279
19. Zaidel DW, Hessamian M. Asymmetry and Symmetry in the Beauty of Human Faces. Symmetry (Basel) [Internet]. 2010;2(1):136–49. Available from: http://www.mdpi.com/2073-8994/2/1/136
20. Pound N, Lawson D, Toma A, Richmond S, Zhurov A, Penton-Voak IS. Facial fluctuating asymmetry is not associated with childhood ill-health in a large British cohort study. Proc - R Soc Biol Sci [Internet]. 2014;281(1792):20141639. Available from: http://sfx.ucl.ac.uk/sfx_local?url_ver=Z39.88-2004&url_ctx_fmt=info%3Aofi%2Ffmt%3Akev%3Amtx%3Actx&rft_val_fmt=info%3Aofi%2Ffmt%3Akev%3Amtx%3Ajournal&rft.artnum=ARTN 20141639&rft.atitle=Facial fluctuating asymmetry is not associated with childhood ill-heal
21. Tamsin KS, Lisa MD, Benedict CJ, Anthony CL, Craig R c. A longitudinal study of of adolescents' judgement of facial symmetry, averageness, and sexual dimorphism. J Evol Psychol DOI 101556/JEP92011221. 2011;1–13.
22. Pisanski K, Feinberg DR. Cross-Cultural Variation in Mate Preferences for Averageness, Symmetry, Body Size, and Masculinity. Cross-cultural Res [Internet]. 2013;47(2):162–97. Available from: http://sfx.ucl.ac.uk/sfx_local?sid=Elsevier%3AScopus&_service_type=getFullTxt&issn=10693971&isbn=&volume=47&issue=2&spage=162&epage=197&pages=162-197&artnum=&date=2013&id=doi%3A10.1177%2F1069397112471806&title=Cross-Cultural Research&atitle=Cross-Cultural
23. Little AC, Jones BC, DeBruine LM. Facial attractiveness: evolutionary based research. Philos Trans R Soc B Biol Sci [Internet]. 2014;366(1571):1638–59. Available from: http://rstb.royalsocietypublishing.org/content/366/1571/1638.abstract
24. Conwell RE, Law Smith MJ, Boothroyd LG, Moore FR, Davis HP, Stirrat M, et al. Reproductive strategy, sexual development and attraction to facial characteristics. Philos Trans R Soc L B Biol Sci. 2006;361:2143–54.
25. Rhodes G, Simmons LW. Symmetry, attractiveness and sexual selection. Oxford Handb Evol Psychol (eds R Dunbar, L Barrett) Oxford, UK Oxford Univ Press. 2007;333–64.
26. Thompson AE, O'Sullivan LF. The relationship between men's facial masculinity and women's judgments of value as a potential romantic partner. Can J Hum Sex [Internet]. 2013;22(1):5–12. Available from: http://dx.doi.org/10.3138/cjhs.929
27. Thornhill R, Gangestad SW. Facial attractiveness. Trends Cogn Sci [Internet]. 1999;3(12):452–60. Available from: http://www.sciencedirect.com/science/article/pii/S1364661399014035
28. Hamilton W, Zuk M. Heritable true fitness and bright birds: a role for parasites? Science (80-). 1982;218:384–7.
29. Henrich J, Heine SJ, Norenzayan A. The weirdest people in the world? Behav Brain Sci. 2010;33(2–3):61–83, discussion 83-135.
30. Christian A. Pure foy "“Cencus stirs old Rivalries Between Nigeria's Tribes”". . Indep accessed online http//news.independent.co.uk. 2006;
31. Gwandu Aliu A. Abdullahi b. fodio as a Muslim jurist. Durham theses, Durham Univ Available Durham E-Theses Online http//etheses.dur.ac.uk/8030/. 1977;
32. Rhodes G. Facial symmetry and the perception of beauty. Psychon Bull Rev [Internet]. 1998;5(4):659–69. Available from: http://sfx.ucl.ac.uk/sfx_local?ctx_ver=Z39.88-2004&rft_val_fmt=info%3Aofi%2Ffmt%3Akev%3Amtx%3Aarticle&rft.atitle=Facial symmetry and the perception of beauty.&rft.aufirst=Gillian&rft.auinit=G&rft.auinit1=G&rft.aulast=Rhodes&rft.au=Rhodes%2CGillian&rft.do
33. Perrett DI, Burt DM, Penton-Voak IS, Lee KJ, Rowland DA, Edwards R. Symmetry and Human

Facial Attractiveness. Evol Hum Behav [Internet]. 1999; 20(5):295–307. Available from: http://www.sciencedirect.com/science/article/pii/S1090513899000148

34. Honekopp J, Bartholome T, Hönekopp J, Bartholomé T, Jansen G. Facial attractiveness, symmetry, and physical fitness in young women. Hum Nat [Internet]. 2004;15(2):147–67. Available from: http://sfx.ucl.ac.uk/sfx_local?url_ver=Z39.88-2004&url_ctx_fmt=info%3Aofi%2Ffmt%3Akev%3Amtx%3Actx&rft_val_fmt=info%3Aofi%2Ffmt%3Akev%3Amtx%3Ajournal&rft.atitle=Facial attractiveness%2C symmetry%2C and physical fitness in young women&rft.aufirst=J&rft.aula
35. Buss DM. Sex differences in human mate preferences: Evolutionary hypotheses tested in 37 cultures. Behav Brain Sci. 1989;12(01):1–14.
36. Feingold A. Gender differences in effects of physical attractiveness on romantic attraction: a comparison across five research paradigms. J Pers Soc Psychol. 1990;59:981–93.
37. Symons D. Beauty is in the adaptations of the beholder: the evolutionary psychology of human female sexual attractiveness, in Sexual Nature/Sexual Culture (Abramson, P.R. and Pinkerton, S. D., eds) . Univ Chicago Press. 1995;80–118.
38. Wiederman MW, Dubois SL. Evolution and sex differences in preferences for short-term mates: results from a policy capturing study . Evol Hum Behav. 1998;19:153–70.
39. Swaddle JP, Cuthill IC. Asymmetry and Human Facial Attractiveness: Symmetry May not Always be Beautiful. Proc Biol Sci [Internet]. 1995; 261(1360):111–6. Available from: http://www.jstor.org/stable/50054
40. Grammer K, Thornhill R. Human (Homo Sapiens) facial attractiveness and sexual selection: the role of symmetry and averageness. J Comp Psychol. 1994;108:233–42.
41. Shackelford TK, Larsen RJ. Facial Attractiveness and Physical Health. Evol Hum Behav [Internet]. 1999;20(1):71–6. Available from: http://www.sciencedirect.com/science/article/pii/S1090513898000361
42. Mealey L, Bridgstock R, Townsend GC. Symmetry and percieved facial attractiveness: a monozygotic co-twin comparison. J Pers Soc Psychol. 1999;76:157–65.