HAYATI Journal of Biosciences January 2015
Vol. 22 No. 1, p 34-40
EISSN: 2086-4094

Available online at:
http://journal.ipb.ac.id/index.php/hayati
DOI: 10.4308/hjb.22.1.34

Face Shape Variation Among Sundanese People from Western Java, Indonesia

WOLLY CANDRAMILA[1*], SONY HERU SUMARSONO[2],
BAMBANG SURYOBROTO[3], MAELITA RAMDANI MOEIS[2]

[1]*Faculty of Teacher Training and Education, University of Tanjungpura, Jalan Profesor Hadari Nawawi, Pontianak 78124, Indonesia*
[2]*School of Life Sciences and Technology, Bandung Institute of Technology, Jalan Ganeca 10, Bandung 40132, Indonesia*
[3]*Department of Biology, Faculty of Mathematics and Natural Science, Bogor Agricultural University, Darmaga Campus, Bogor 16680, Indonesia*

Received September 4, 2014/Accepted December 29, 2014

The face is an important visual stimulus in daily life and each face identifies a particular person. The bone structure of the skull along with various soft tissues and coloration influence perception of the face. Facial averageness, and bilateral symmetry are the two most commonly used criterion of facial attractiveness, yet, both may be perceived differently based on hormonal status of the person observed. Facial perceptions may also differ according to cultural norms. In this research, we examined variations in face-shape among Sundanese male and female adults aged 18 to 40. We applied geometric-morphometric methods to analyze the landmark-based morphological variations in the frontal and lateral views of subjects' faces. We identified five types of female frontal face views and four of male. We also identified five types each of female and male lateral face views. The trichion, gonion and gnathion were three most variable landmarks among the face views in our study, and highly determined the shape of the individuals' faces. Multiple face type variation may refer to many categories of attractive faces since there is no exactly perfect category in the assessment of facial attractiveness by the viewers. Therefore, we believe that the configuration of facial features cannot constitute the sole visual criterion of facial attractiveness.

Key words: face variation, facial attractiveness, Sundanese adults faces, geometric morphometric

INTRODUCTION

The face is an important visual stimulus in daily life (Goldstein 1983). Inter-individual variation in facial shape is one of the most noticeable phenotypes in humans, and uniquely identifies each individual (Henneberg *et al*. 2003). The bone structure of the skull, complex variations in soft tissue, and skin coloration, all influence the shape of the face and how it is perceived by others (Enlow 1966; Burke & Hughes-Lawson 1988; Jones *et al*. 2002). Moreover, morphological characteristics may be perceived differently in different cultures (Berrios 2003; Noor & Evans 2003; Geldart 2009; Fang *et al*. 2011).

Perceived attractiveness has been studied in relation to evolution, and proposed to signal mate quality with regard to producing healthy offspring. According to this theory, there is a biologically-based preference for three particular perceived facial characteristics, which humans are adapted to seek in order to find good mates. These three characteristics include facial averageness, bilateral symmetry and sexual dimorphism (Johnston & Franklin 1993; Perrett *et al*. 1998; Scheib *et al*. 1999; Rhodes *et al*. 1999; Jones *et al*. 2001; Johnston *et al*. 2001; Rhodes 2006; Weston *et al*. 2007). Face averageness and bilateral symmetry show developmental stability and heterozygosity, and therefore signal aspects of mate quality such as health and heritable resistance to disease (Møller & Swaddle 1997; Thornhill & Møller 1997; Perrett *et al*. 1999). In addition, the morphogenetic aspect of facial sexual dimorphism is controlled by sexual hormones whose effects are activated during puberty (Guerriero 2009). High levels of sex hormones at puberty may correlate to high masculine and/or feminine traits as well as immunological competence (Thornhill & Møller 1997; Penton-Voak & Perrett 2000). On the other hand, facial attractiveness could also be understood as a secondary product of information-processing by the brain of the perceiver, with no correlation to the "good genes" signal (Enquist & Arak 1994; Johnstone 1994; Jansson *et al*. 2002).

In this research, we tried to analyze face shape variation among Sundanese female and male adults, and identify any landmark characteristics that

*Corresponding author. Phone/Fax: +62-561-740144,
E-mail: wcandramila@gmail.com

may constitute facial attractiveness criteria among observers. However, this study made no attempt to assess the mate selection fitness of subjects, or relate this to perceived facial attractiveness.

MATERIALS AND METHODS

Subjects. Sundanese people are a population indigenous to the western part of Java, in Indonesia. They are the second largest ethnic group in Indonesia, besides the Javanese in central and eastern Java, with an estimated population of 36 million people as of 2010. Despite many similarities with Javanese culture, Sundanese people are predominantly Muslims and less rigid in social hierarchy. Based on the dispersal of Austronesian speakers in South East Asia (Shutler & Marck 1975; Blust 1995; Bellwood 1997), both Sundanese and Javanese were originated in Taiwan and reached Java between 1,500 and 1,000 BC. Among Sundanese population, there are some close traditional communities, termed as *kampung adat*, who still practice stronger traditional way of life compared to the outer open communities. These traditional communities still live in relatively remote villages distributed in various regencies in western Java.

In this research, we recruited subjects of fully Sundanese ancestry, sampled from various settlements in West Java Province of Indonesia (Figure 1). Subject's ethnicity was confirmed both by self identification and others' recognition. Subjects were adults of both genders, aged 18-40, drawn from communities ranging from open urban districts to close traditional villages (Table 1). The subjects were not related to each other, as was confirmed by lineage tracking going back 3 generations. Sampling areas were distributed across 14 regencies and 7 Sundanese traditional villages in the western part of Java. Informed consent was obtained from all participants and ethical clearance was obtained from the Health Research Ethics Committee at the Faculty of Medicine in Padjadjaran University-Dr Hasan Sadikin General Hospital, Bandung. Each subject's face was photographed in both frontal- and left and right-portraits. Subjects were photographed with neutral facial expressions at a horizontal lens angle of 6.96°(to minimise distortion), using a digital camera (Panasonic Lumix DMC-FZ35 from Panasonic Corp., Japan).

Facial Analysis. Facial analysis was conducted on 175 female and 150 male photographic portraits using geometric morphometric methods (Bookstein 1989). Geometric morphometrics analyzes shape differences in objects by distinguishing the cartesian location of facial landmarks, as interpolated using the thin plate spline function. Landmark digitization was conducted manually using tps*Dig* program (Rohlf 2005a). There are 36 frontal and 24 lateral standard points or landmarks as shown in Figure 2. Descriptions of each landmark are presented in Table 2. For each facial portrait, the first point was positioned on the maximum ventral curvature and continued downward from left-to-right. Digitization was repeated daily for 5 days, for a total of 5 digitizations to minimize digitizing errors. Average coordinates for each landmark were computed using the tps*Relw* program (Rohlf 2005b). These coordinates represented individual sample data. The average pixel number was calculated and classified as a composite face. The whole calculation was conducted in tps*Super* program (Rohlf 2004a).

All individual data were transformed into individual relative warp values. This calculation was conducted in tps*Relw* program (Rohlf 2005b).

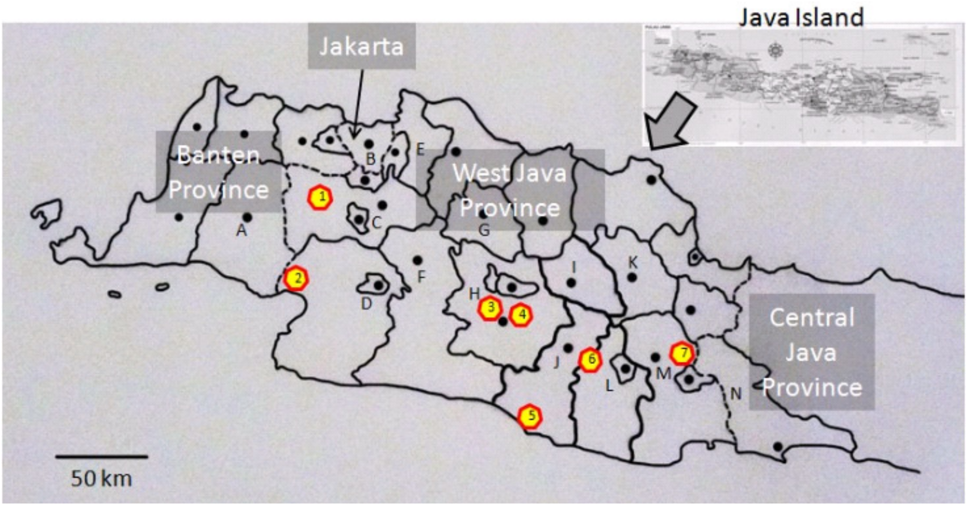

Figure 1. Sampling sites in western Java. Subjects were sampled in open urban communities (A – N) and in close traditional villages (1 – 7). Location names and sample size for each location are presented in Table 1.

Table 1. Sampling sites and number of samples

Location	Number of samples	
	Female	Male
Sundanese Traditional Villages		
1. Kampung Urug, Bogor Regency	25	20
2. Kampung Sinarresmi, Sukabumi Regency	15	10
3. Kampung Mahmud, Bandung Regency	12	14
4. Kampung Cikondang, Bandung Regency	24	26
5. Kampung Dukuh, Garut Regency	15	17
6. Kampung Naga, Tasikmalaya Regency	14	7
7. Kampung Kuta, Ciamis Regency	13	8
Open Communities		
A. Lebak Regency	1	0
B. Jakarta Province	0	2
C. Bogor Regency	2	2
D. Sukabumi Regency	3	3
E. Bekasi Regency	0	2
F. Cianjur Regency	0	1
G. Purwakarta Regency	0	1
H. Bandung (Bandung City, Bandung Regency, Cimahi City, Bandung Barat Regency)	25	17
I. Sumedang Regency	3	2
J. Garut Regency	6	9
K. Majalengka Regency	0	1
L. Tasikmalaya Regency	8	3
M. Ciamis Regency	7	4
N. Cilacap Regency	2	1
Total	175	150

Table 2. Facial anthropometric landmarks for morphometric analysis

Landmarks	Abbreviations	Description
Trichion	tr	The point of intersection of the normal hairline and the centerline of the horizontal/ lateral plane of the forehead
Superciliare*	sc	Highest point of the upper margin of the midline portion of the eyebrow
Glabella	g	Most lateral point of the forehead in either right of left side
Frontozygomaticus*	fz	Most lateral point of the eyebrow
Palperbrale superius*	ps	Highest point of the eyelid when the eye is relaxed open
Exocanthion*	ex	Lateral hinge when the eyelid closes
Endocanthion*	en	The point at which the inner ends of the upper and lower eyelid meet
Palperbrale inferius*	pi	Lowest point of the eyelid when the eye is relaxed open
Maxillofrontale*	mf	The most posterolateral point of the curvature of the base of the nasal alae
Nasale	n	Most inner point on the nose ridge within the eye region or the midline point just superior to the nasal root overlying the naso-frontal suture.
Zygion*	zy	The most lateral point on the zygomatic arch
Pronasale	prn	Nose tip
Alare*	al	Most lateral point of the nose
Columella*	co	Most anterior point of the nostril opening
Subnasale	sn	Most inner point between the nose tip and the upper lip
Subaurale*	sa	The lowest point on the lobe of the ear when the head is positioned in the eye-ear plane
Supercurvature aurale	sca	The highest point of the ear curvature
Subcurvature aurale	sbca	The lowest point of the ear curvature
Tragus	t	The cartilaginous fleshy projection that partially covers the entrance to the external ear
Cheilion*	ch	Most lateral point where the upper and lower lip meet
Stomion	sto	Midline point along the line wherethe upper and lower lip meet
Vermillion**	ve	The most lateral point of the lip when relaxed close
Labiale superius	ls	Highest point of upper lip
Labiale inferius	li	Lowest point of lower lip
Chin fissure	cf	Cleft chin; an indentation in between the lower lip and the chin
Gonion	go	The maximum curvature point at the angle of the mandible
Pogonion	po	Most anterior pointof the chain
Gnathion	gn	Lowest point of the chain

*digitised both at left and right position of the landmark on the face; **digitised both at upper and lower part of the landmark.

Based on each sample's relative warp data, we built a Euclidean distance matrix. Face variation measures were generated based on Saitou and Nei's (1987) neighbor joining method using the Euclidean distance matrix. All computation was done in *ape* package, R program (R Development Core Team 2006). A grid deformation was made for each face variant using the tps*Splin* program (Rohlf 2004b). Differences between facial features were defined based on disimilarities in bending trend for each facial landmark.

RESULTS

We identified four and five frontal face types, in Sundanese male and female adults, respectively (Figures 3 & 4). For lateral portraits, we identified five face types each in Sundanese male and female adults (Figures 5 & 6). Different facial features were described in terms of the bending of the cartesian grid. The characteristics of each frontal and lateral face type is described below.

Females. Types II and IV were the two most common frontal face type among female subjects, with 27 and 25% frequency, respectively. Both types encompass distinct facial features, particularly with the nose and chin. Type II was characterized by posterior movements of the pronasion and gnathion, which results in less projection of the nose and chin. By contrast, Type IV faces had greater projection of the nose and chin. Low projection of the nose and a lower chin were also found in Type I and III, and greater projection of the nose and chin was

Figure 2. Facial landmarks in (a) frontal and (b) lateral view portraits. See Table 2 for descriptions of the landmarks.

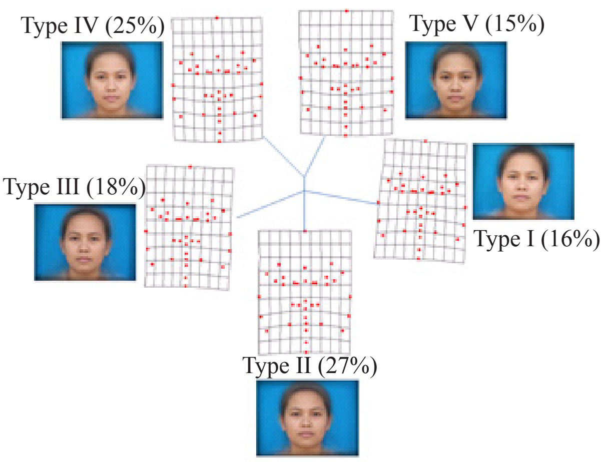

Figure 3. Sundanese females: frontal view face variation, deformation grids, and frequency (n = 175).

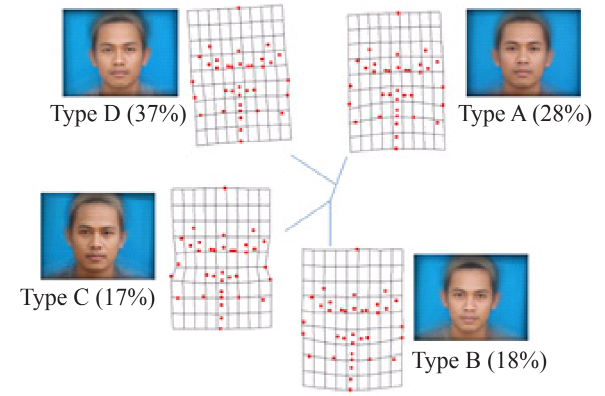

Figure 4. Sundanese males: frontal view face variation, deformation grids, and frequency (n = 150).

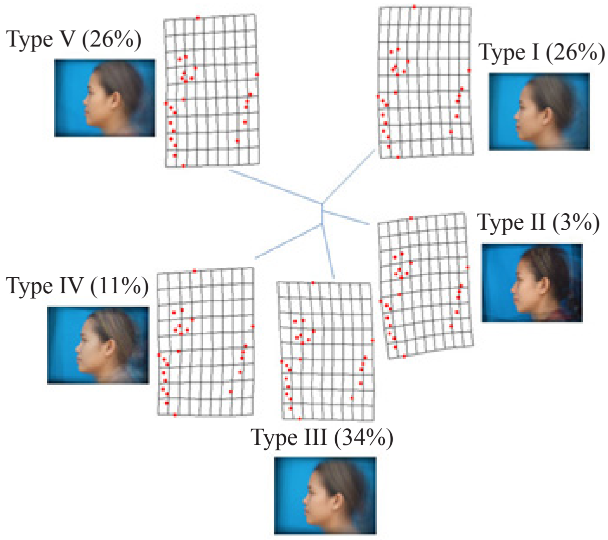

Figure 5. Sundanese females: lateral view face variation, deformation grids, and frequency (n = 175).

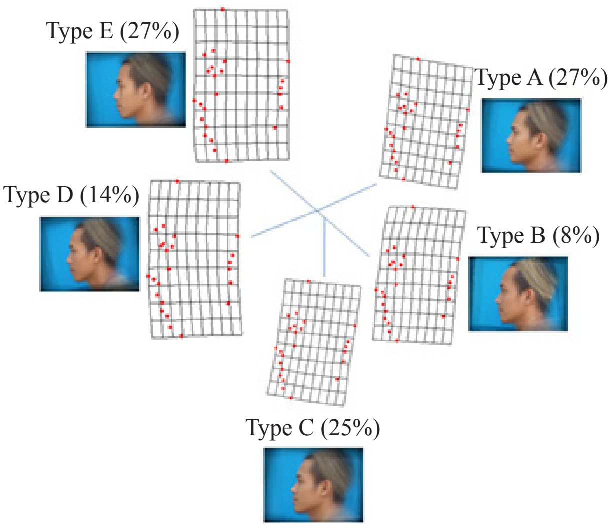

Figure 6. Sundanese males: lateral view face variation, deformation grids, and frequency (n = 150).

also found in Type V. Except for Type I, almost all Sundanese female frontal face portraits showed an outward movement of the forehead. Type I, however, exhibited inward movement of the trichion-glabella area, resulting in a narrower forehead. We were also able to classify female frontal portraits by jaw characteristics. Most of the face types (Type I, II, IV, and V) displayed outward movement of the bigonian, presenting as a wider jaw. Narrower jaws were seen only in Type III, caused by inward movement of the bigonion. Nevertheless, in considering the trichion, gonion and gnathion characteristics, we might decide to classify female faces in frontal view, into round, oval and oblong shapes. Round faces were found in Types I and V, oval in Types II and III, and oblong in Type IV.

Among lateral face portraits, Type III was most common in females, occuring with 34% frequency. Type III is characterised by a flat forehead, less projected nose, cheek bones, and chin, as well as narrow jaw. The flat forehead results from inward orientation of the glabella, meanwhile, less projected nose and cheek bone were shown by inward orientation of the pronasion and zygion, respectively. The narrow jaw is the manifestation of the orientation of the gonion away from the subaurale, while the low chin results from the posterior orientation of the gnathion. A flat forehead was observed in most lateral female portraits of Types II, III, IV, and V. A projected forehead was seen only in Type I, resulting from the outward orientation of the glabella away from the trichion. Forty percent of females (Type I, II, and IV) had a more projected nose and the rest had a less projected nose (Type III + V). Less prominent cheek bones were also seen in Types IV and V; with, more projected cheek bones found in Types I and II.

Males. Frontal portraits of Sundanese male faces could be grouped into four types. Type D was the most common, with a frequency of 37% among the population. This type was characterised by an inferior orientation, yet wide forehead, large bizygomatic distance, and less projected nose and chin. Type A was similar to Type D, except for a narrower forehead and smaller bizygomatic distance. Meanwhile, the nose and chin were more projected in Types B and C. Type C differed from Type B in having a wider jaw and more masculinised face with a square shape. The lateral view of male faces were grouped into five types. Types A and E were the most common types with both of them occurring at a 27% frequency. Type A is characterized by a flat forehead, moderately projected nose and cheek bones, wide jaw, and less projected chin. Type E faces featured a flat forehead and less projected nose, but had flat cheek bones, narrower jaw and greater projection of chin. The Type C lateral facial view was almost as common among Sundanese males, with a frequency of 25%. As seen in Types A and E, Type C had a flat forehead. Meanwhile, Type C had less projected chin, moderately projected cheek bones and wide jaw as seen in Type A, but had less projected nose as seen in Type E. Finally, Types B and D differed from Type C in that both types featured a more projected forehead and nose as a result of the outward orientation of the glabella and pronasion, respectively. Compared to Type B, however, Type D had a narrower jaw and less projected chin.

DISCUSSION

Facial variations among Sundanese female and male adults was found to be relatively high in this study. Each face type showed both similarities and disimilarities to the others. These effects may result from different forces of evolutionary selection resulting in different face phenotypes. Similar face types may be the result not only of descent from a common ancestor, but also due to parallel or convergent evolution.

Differences in face type were observed in the upper and lower facial structures. For example, different forehead shape differentiated Type I from Type II frontal face portraits among females, while, Type III and IV showed differences in the nose and chin. However, among both men and women, and for both front and lateral facial views, the trichion, gonion and gnathion were the three most variable landmarks. Therefore, we believe that these three landmarks are most deterministic of individual face shape and the perception of the face.

Various studies have reported different results regarding perception of facial characteristics. According to Jones and Hill (1993), Jones *et al*. (2001), and Valenzano *et al*. (2006), facial proportions close to the population average were associated with increased attractiveness. In some cases, the exaggeration of shape differences from the sample mean increased perception of attractiveness (Perrett *et al*. 1994), but in other cases exaggeration of features, such as the masculinization of an otherwise average face shape, decreased the perceived attractiveness of both male and female faces (Perrett *et al*. 1998). For example, enhancing masculinity in face shape predisposed certain negative, yet stereotypic, personality attributions, such as perceived dishonesty (Berry & Wero 1993), increased infidelity, violence and divorce (Booth & Dabbs 1993). Preference for average characteristics in female faces could be interpreted as the result of stabilization over time of directional selection for extreme sexual characteristics that indicate enhanced femininity (Perrett *et al*. 1998). On the other hand, Grammer and Thornhill (1994) found that overall averageness of male facial features among individual male faces correlates negatively with attractiveness. Instead, the faces of men perceived as attractive, were correlated to bilateral symmetry and prototypicality which was assumed to infer both health and reproductive success of males (Grammer & Thornhill 1994; Thornhill & Gangestad 1994; Scheib *et al*. 1999; Rhodes *et al*. 2001). Perception and preference of symmetry might also be an adaptation by which females can discriminate between potential mates, allowing them to infer the apparent health of male mates by their facial traits (Jones *et al*. 2001).

Interestingly, female preferences for male face characteristics changed cyclically over the menstrual cycle. Women in the follicular phase of the menstrual cycle were more likely to choose a masculine face than those menstruating, or in luteal phase (Gangestad & Thornhill 1998; Penton-Voak & Perrett 2000). The menstrual cycle also affected mens' perception of female facial attractiveness. Womens' faces were perceived by men as more attractive when the women were fertile, as opposed to when women were menstruating or in the luteal phases of their menstrual cycle (Roberts *et al*. 2004). These findings indicate that facial clues to hormonal status affect perception of attractiveness for both sexes. Women prefer testosterone-related facial characteristics in males, and men prefer female faces that exhibit visible cues to ovulation. Presumably these preferences are adaptive for the success of conception.

To summarize, we may say that there is no facial type that is "perfect" in the assessment of facial attractiveness by viewers of either sex. Despite the above findings of increased perceived attractiveness for some types of male and female faces, we found relatively high facial variation overall among Sundanese adults, and both averageness as well as bilateral symmetrical characteristics can be observed in every face type. For this reason, there will be more than one type of face that is perceived as attractive. As stated by O'Doherty *et al*. (2003), the attractiveness of a face is a highly salient social signal, influencing mate selection and other social judgments. Other, non-structural facial features were also shown to influence perceived facial attractiveness, i.e. fairness of skin tone (Jones *et al*. 2004) and an ideal aesthetic smile (Shaw *et al*. 1985; Ashri 2014; Lecocq & Truong Tan Trung 2014). Although facial features are important to perceived attractiveness, such features should not be disadvantageous for the individuals in terms of heredity; hence, we believe that the facial features must not be the only visual criterion of the attractiveness of a potential mate.

ACKNOWLEDGEMENT

This research was funded by the Doctorate Dissertation Grant from the Ministry of Education of the Republic of Indonesia. We are also thankful to the regional government overseeing each sampling area for their permission to do this study, and for the cooperative participations from all subjects.

REFERENCES

Ashri NY. 2014. The beauty in facial esthetics: Gummy smile and options of treatment. *The Saudi Journal for Dental Research* 5:71-72. http://dx.doi.org/10.1016/j.sjdr.2014.06.001

Bellwood P. 1997. Prehistory of the Indo-Malaysian Archipelago. Honolulu: University of Hawai'i Pr.

Berrios GE. 2003. The face in medicine and psychology: a conceptual history. In:Katsikitis, M (ed). *The human face: measurement and meaning*. New York:Springer Science+Business Media. p 49-62.

Berry DS, Wero JLF. 1993. Accuracy in face perception: a view from ecological psycholgy. *J Per* 61:497-520. http://dx.doi.org/10.1111/j.1467-6494.1993.tb00780.x

Blust RA. 1995. The prehistory of the Austronesian-speaking peoples: the view from language. *J World Prehist* 9:453-510. http://dx.doi.org/10.1007/BF02221119

Bookstein FL. 1989. Principal warps: Thin-plate spline and the decomposition of deformations. *IEEE T Pattern Anal*11:567-585. http://dx.doi.org/10.1109/34.24792

Booth A, Dabbs JM. 1993. Testosterone and men's marriages. *Soc Forces* 72:463-477. http://dx.doi.org/10.2307/2579857

Burke PH, Hughes-Lawson CA. 1988. The growth and development of the soft tissues of the human face. *J Anat* 158:15-120.

Enlow DH. 1966. A morphogenetic analysis of facial growth. *Am J Orthod* 52:283-299. http://dx.doi.org/10.1016/0002-9416(66)90169-2

Enquist M, Arak A. 1994. Symmetry, beauty and evolution. *Nature* 372:169-172. http://dx.doi.org/10.1038/372169a0

Fang F, Clapham PJ, Chung KC. 2011. A systematic review of inter-ethnic variability in facial dimensions. *Plast Reconstr Surg* 127:874-881. http://dx.doi.org/10.1097/PRS.0b013e318200afdb

Gangestad SW, Thornhill R. 1998. Menstrual cycle variation in women's preferences for the scent of symmetrical men. *PRoy Soc Lond B* 265:927-933. http://dx.doi.org/10.1098/rspb.1998.0380

Geldart S. 2009. That woman looks pretty, but is she attractive? Female perceptions of facial beauty and the impact of cultural labels. *Revue européenne de psychologie appliquée* 60:79-87. http://dx.doi.org/10.1016/j.erap.2009.12.003

Goldstein AG. 1983. Behavioral scientist' fascination with faces. *J Nonverbal Behav* 7:223-255. http://dx.doi.org/10.1007/BF00986268

Grammer K, Thornhill R. 1994. Human (*Homo sapiens*) facial attractiveness and sexual selection: the role of symmetry and averageness. *J Comp Psychol* 108:233-242. http://dx.doi.org/10.1037/0735-7036.108.3.233

Guerriero G. 2009. Vertebrate sex steroid receptors: evolution, ligands, and neurodistribution. *Ann N Y Acad Sci* 1163:154-168. http://dx.doi.org/10.1111/j.1749-6632.2009.04460.x

Henneberg M, Simpson E, Stephan C. 2003. Human face in biolgical anthropology: craniometry, evoution and forensic identification. In: Katsikitis M (ed). *The human face: measurement and meaning*. New York: Springer Science+Business Media. p 29-48.

Jansson L, Forkman B, Enquist M. 2002. Experimental evidence of receiver bias for symmetry. *Anim Behav* 63:617-621. http://dx.doi.org/10.1006/anbe.2001.1936

Johnstone RA. 1994. Female preference for symmetrical males as a by-product of selection for mate recognition. *Nature* 372:172-175. http://dx.doi.org/10.1038/372172a0

Johnston VS, Franklin M. 1993. Is beauty in the eye of the beholder? *Ethol Sociobiol* 14:183-189. http://dx.doi.org/10.1016/0162-3095(93)90005-3

Johnston VS, Hagel R, Franklin M, Fink B, Grammer K. 2001. Male facial attractiveness-Evidence for hormone-mediated adaptive design. *Evol Hum Behav* 22:251-267. http://dx.doi.org/10.1016/S1090-5138(01)00066-6

Jones BC, Hill K. 1993. Criteria of facial attractiveness in five populations. *Hum Nature* 4:271-296. http://dx.doi.org/10.1007/BF02692202

Jones BC, Little AC, Burt DM, Perrett DI. 2004. When facial attractiveness is only skin deep. *Perception* 33:569-576. http://dx.doi.org/10.1068/p3463

Jones BC, Little AC, Penton-Voak IS, Tiddeman BP, Burt DM, Perrett DI. 2001. Facial symmetry and judgements of apparent health: Support for a "good genes" explanation of the attractiveness-symmetry relationship. *Evol Hum Behav* 22:417-429. http://dx.doi.org/10.1016/S1090-5138(01)00083-6

Jones BC, Little AC, Burt DM, Perrett DI. 2002. When facial attractiveness is only skin deep. *Perception* 33:569-576. http://dx.doi.org/10.1068/p3463

Lecocq G, Truong Tan Trung L. 2014. Smile esthetics: Calculated beauty. *Int Orthod* 12:149-170. http://dx.doi.org/10.1016/j.ortho.2014.03.016

Møller AP, Swaddle JP. 1997 Asymmetry, Developmental Stability and Evolution. Oxford University Press.

Noor F, Evans DC. 2003. The effect of facial symmetry on perceptions of personality and attractiveness. *J Res Pers* 37:339-347. http://dx.doi.org/10.1016/S0092-6566(03)00022-9

O'Doherty J, Winston J, Critchley H, Perrett D, Burt DM, Dolan RJ. 2003. Beauty in a smile: the role of medial orbitofrontal cortexin facial attractiveness. *Neuropsychologia* 41:147-155. http://dx.doi.org/10.1016/S0028-3932(02)00145-8

Penton-Voak IS, Perrett DI. 2000. Female preference for male faces changes cyclically:Further evidence. *Evol Hum Behav* 21:39-48. http://dx.doi.org/10.1016/S1090-5138(99)00033-1

Perrett DI, Burt DM, Penton-Voak IS, Lee KJ, Rowland DA, Edwards R. 1999. Symmetry and human facial attractiveness. *Evol Hum Behav* 20:295-307. http://dx.doi.org/10.1016/S1090-5138(99)00014-8

Perrett DI, Lee KJ, Penton-Voak IS, Rowland DA, Yoshikawa S, Burt DM, Henzik SP, Castles DL, Akamatsu S. 1998. Effects of sexual dimorphism on facial attractiveness. *Nature* 394:884-887. http://dx.doi.org/10.1038/29772

Perrett DI, May KA, Yoshikawa S. 1994. Facial shape and judgements of female attractiveness. *Nature* 368:239-242. http://dx.doi.org/10.1038/368239a0

Rhodes G, Sumich A, Byatt G. 1999. Are average facial configurations attractive only because of their symmetry? *Psychol Sci* 10:52-58. http://dx.doi.org/10.1111/1467-9280.00106

Rhodes G, Zebrowitz LA, Clark A, Kalick SM, Hightower A, McKay R. 2001. Do facial averageness and symmetry signal health? *Evol Hum Behav* 22:31-46. http://dx.doi.org/10.1016/S1090-5138(00)00060-X

Rhodes G. 2006. The evolutionary psychology of facial beauty. *Annu Rev Psychol* 57:199-266. http://dx.doi.org/10.1146/annurev.psych.57.102904.190208

Roberts SC, Havlicek J, Flegr J, Hruskova M, Little AC, Jones BC, Perret DI, Petrie M. 2004. Female facial attractiveness increases during the fertile phase of the menstrual cycle. *Proc R Soc Lond B* 271:S270-S272. http://dx.doi.org/10.1098/rsbl.2004.0174

Rohlf FJ. 2004a. tpsSuper version 1.13. New York: Department of Ecology and Evolution, State University of New York, Stony Brook.

Rohlf FJ. 2004b. tps*Splin* version 1.20. New York:Department of Ecology and Evolution, State University of New York, Stony Brook.

Rohlf FJ. 2005a. tps*Dig* version 2.04. New York: Department of Ecology and Evolution, State University of New York, Stony Brook.

Rohlf FJ. 2005b. tps*Relw* version 1.42. New York: Department of Ecology and Evolution, State University of New York, Stony Brook.

Saitou N, Nei M. 1987. The Neighbor-joining Method: A New Method for Reconstructing Phylogenetic Trees. *Mol Biol Evol* 4:406-425.

Scheib JE, Gangestad SW, Thornhill R. 1999. Facial attractiveness, symmetry and cues of good genes. *P Roy Soc Lond B*266:1913-1917. http://dx.doi.org/10.1098/rspb.1999.0866

Shaw WC, Rees G, Dawe M, Charles CR. 1985. The influence of dentofacial appearance on the social attractiveness of young adults. *Am J Orthod* 87:21-26. http://dx.doi.org/10.1016/0002-9416(85)90170-8

Shutler R, Marck JC. 1975. On the dispersal of the Austronesian horticulturalists. *Archaeology and Physical Anthropoogy in Oceania* 10:81-113.

Thornhill R, Gangestad SW. 1994. Human fluctuating asymmetry and sexual behavior. *Psychol Sci* 5:297-302. http://dx.doi.org/10.1111/j.1467-9280.1994.tb00629.x

Thornhill R, Møller AP. 1997. Developmental stability, disease and medicine. *Biol Rev* 72:497-548. http://dx.doi.org/10.1111/j.1469-185X.1997.tb00022.x

Valenzano DR, Mennucci A, Tartarelli G, Cellerino A. 2006. Shape analysis of female facial attractiveness. *Vision Res* 46:1282-1291. http://dx.doi.org/10.1016/j.visres.2005.10.024

Weston EM, Friday AE, Lio P. 2007. Biometric evidence that sexual selection has shaped theHominin face. *PLoS ONE* 2:e710. http://dx.doi.org/10.1371/journal.pone.0000710