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The Influence of Measures of Socioeconomic Status on Human Facial Asymmetry

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ABSTRACT
Minor variations between the left and right sides of all human faces exist and are considered normal. These are called asymmetries and result from the effects of genes or environment on the developing face. The environmental factors include but not limited to socioeconomic status and its influence on the facial asymmetry was only studied in the Caucasians. The aim of the present study is to test the effects of socioeconomic status on the facial asymmetry in the less privileged population. Four hundred and twenty-six subjects were randomly recruited, and their faces scanned, using ExaSurface Laser Scanner, after getting an informed consent and ethical approval from the appropriate authority. Scans were prepared and mirrored images merged with the original to estimate the asymmetry between sides. Sociodemographic characteristics of the subjects were acquired using a questionnaire, where socioeconomic status of the individuals was categorized into 3 based on the economic, occupation and education condition of the participants. The overall facial asymmetry and asymmetry around the eye region were recorded using a Geomagic software version 12 USA. The socioeconomic status (SES) and asymmetry data were analyzed using IBM SPSS statistics software version 20. Wilcoxon's, Analyses of variance (ANOVA) and Kruskall Wallis' tests were conducted to test the effects of the SES on the face asymmetry. However, results indicated no significant differences in the mean values of facial asymmetry between the three SES groups but there was a significant mean difference of asymmetry around the eye region between the 3 groups of SES in both sexes. Conclusively, facial asymmetry may not be a good measure of developmental instability since mean difference of the facial asymmetry between the three classes of SES is not significant.

KEY WORDS: Face, Asymmetry, Influence, Sub-Saharan African, Socioeconomic status

INTRODUCTION
Although the anatomical structures of most animals indicate an overall bilateral symmetry, minor variations in terms of size or position of internal organs between the two sides of the mid-sagittal plane are present. These variations are called asymmetries[1] and can occur everywhere in the body, including the face. From our knowledge of evolutionary biology, our genotypes generate our phenotypes, and identical set of genes control the growth of either of our two sides to achieve perfect symmetry . However, perfect symmetry is unfortunately not achieved, because the effect of those genes, environment or both on the left and right sides of the body is not identical, resulting to the variations[3], which are generally mild[4,5].

In the animal taxa, three categories of asymmetry are identified: Fluctuating asymmetry (FA), Directional asymmetry (DA) and Antisymmetry (AS). Fluctuating asymmetry (FA), is primarily due to exposure to various environmental stresses [6,3,7]during ontogeny, and is considered to be an index of developmental stability[8,9,10,11]. An individual is developmentally stable only if he/she can buffer or resist developmental stressors[12,13,14]. Directional asymmetry (DA) IS when a character is consistently larger on one side in a population [e.g., [2,15]with some genetic component[16], although it might result from handedness [17,18,19] or differential biomechanical loading during bone growth[20,21]. While some DAs are subtle[22,20], as found in the face[23], others are conspicuous[24,25]. Antisymmetry (AS) on the other hand, is when half of the individuals in a population have greater development of a character on the dextral side and the other half on the sinistral side [2,26,25], without any prediction for which side will dominate the other in the population[27,28,29].

So far, asymmetry (FA, DA or both) exists in all human faces [29,30,31,32] resulting from a wide range of environmental factors, for example: FA was suggested to be due to poor health [33,34,35]from parasites and other microbial infections[36,37], symptoms of diseases[38,39,34,40], maternal health[41], health risks[42,43], pollutants and other adverse physical conditions[6,3], extreme temperatures[44], poor living conditions[21], lack of shelter[3,13], and poor/inadequate nutrition[45]. For the non-heritable DA is suggested to be due to prolonged repetitive strenuous exercise[23] for example, prolong chewing with one side.

From the theoretical framework, an association between socioeconomic status (SES) and facial asymmetry is expected since higher levels of fluctuating asymmetry in any part of the body are considered to be a sign that a population is under stress[46]. The influence of adverse socioeconomic levels on asymmetry in general, has only been studied by a few authors[34,47,48,21] mainly on Caucasians.

This study tested whether lower socioeconomic status signals developmental instability as measured by overall facial asymmetry and whether intra or intersexual competition for resources as measured by the number of siblings and birth order, is reflected in the form of facial asymmetry (as a consequence of increasing competition for the resources: a marker of lower SES). The study analyzed three measures of SES (educational levels, occupation, and income) and facial asymmetry separately for males and for females to determine the effects of intra or intersexual competition for the resources on facial asymmetry.

MATERIALS AND METHODS

In the study, four hundred and twenty-seven participants (215 males, 212 females), were randomly selected, with an informed consent received from each of them. The participants' age range was restricted to between 18-25 years to minimize the effects of both ongoing ontogenetic development and aging on facial asymmetry. The study was approved by the Federal Ministry of Health in Nigeria. The demographic and basic somato-metric data of the participants were collected by well-trained community research assistants from Ahmadu Bello University Zaria, Nigeria and their 3D morphological data were collected using a self-positioning EXAScan laser surface scanner from Creaform (www.handyscan3d.com).

The scanning was done with each participant seated in an upright position, sitting still on a chair with the head facing up at a slight angle of about 45 degree relative to the floor (natural head position) as this has been shown to be reproducible[49] and was found to be the most comfortable position to scan in. Participants were instructed to keep their eyes closed to avoid discomfort from the laser beams. During the scanning process, the 3D digital model is generated on the computer screen in real time, allowing the researcher to continue scanning until a satisfactory model has been created (Figure 1). Good quality 3D facial scans were obtained with the subject maintaining a natural pose with neutral facial expression.

Figure 1: Uncleansed facial scan

Figure 2: Original and Mirrored facial scans before alignment

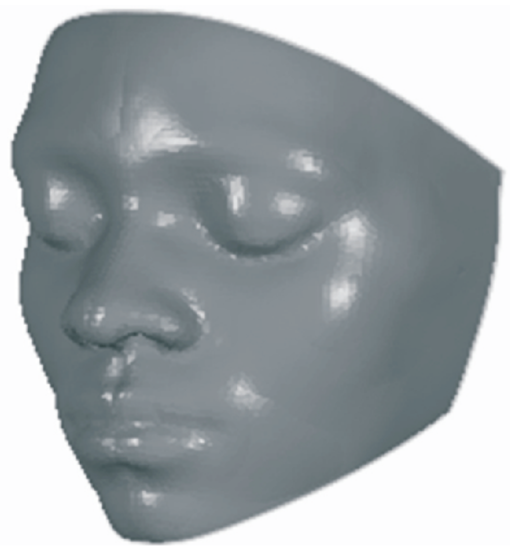

Figure 3: Combined (original and mirrored) facial scans (after alignment)

Repeatability: To quantify repeatability, 10 repeat scans of 2 participants were produced, cleaned, trimmed, mirrored, and aligned. The standard deviations of the aligned original and mirrored images were determined, and the mean standard deviations were calculated. Average deviation from the mean for each participant's ten scans was then calculated. Repeatability error was calculated as the proportion of the average deviation of repeats from the mean relative to the average asymmetry value. The resulting error values were 0.070 and 0.028 (or 7.0% and 2.8%) respectively for the two participants indicating high repeatability of the scanning procedure.

Measures of Socioeconomic status: Three key indicators of socioeconomic status are: economic status, measured by income; social status, measured by education; and work status, measured by occupation"[50]. Since not all the participants were in the working class, those category of participants were asked to report their parental economic status (the income) or work status, but the educational levels of participants and their parents (mother & father) were used as the social status. Other indicators for example, marital status, birth order, number of siblings in a family and the social class to which each participant belongs were also included.

Participants and their parents (mother and father) were categorized as having received a western education or not and coded as follows: no western education = 0, western education = 1. Influence on asymmetry values was tested separately according to the participant's level of education (ELP), the mother's level of education (ELM) and the father's level of education (ELF). To determine differences in mean WFACE and mean EYES values between education categories, a Wilcoxon Two-Sample test was applied if one of the counts (educated and non-educated) was small compared to the other. A

Welch Two-Sample test was carried out where counts in the two groups were more comparable. In addition, the participants were assigned to one of four groups according to a combination of their own and their parents' levels of education: group 4 = participant and both parents had received a western education (1, 1, 1); group 3 = participant and one parent had received a western education (0, 1, 1); group 2 = participant but none of the parents had received a western education (0, 0, 1); group 1 = neither participant nor the parents had received a western education (0, 0, 0). Because of uneven sample sizes in the 4 groups, a Kruskal-Wallis test, rather than ANOVA was performed to test for differences in the mean WFACE and mean EYES values between education level groups.

The Marital Status (MS) of the participants was considered as part of the socioeconomic context because, in the Hausa community, being able to get married is a sign of good socio-economic standing. Initial categories included: married, widowed, separated, divorced, and single, but for easy analysis, these were combined into two groups: married = 1 and not married = 0. A Welch Two Sample t-test or a Wilcoxon test was performed following the criteria set out above to test for differences in mean WFACE values and mean EYES values between the married and unmarried participants.

Birth order (BO) of each participant was recorded as the paternal birth order, because it is one of the aims of the present study to explore the influence of resource distribution within families (mostly polygynous). The potential influence of Birth order was tested by regression model fitted to WFACE or EYES values and BO.

The Number of siblings (NOS) in each of the participant's family was also recorded and its potential influence on asymmetry was tested by regression model fitted to WFACE or EYES values.

The Income (INCOM) of each participant was recorded as total earnings per month whether as earnings from business or from any other source and was recorded in Nigerian currency (Naira). Simple linear regression was used to test for relationships between monthly income and WFACE or EYES.

Overall Socio-Economic Status (SES) was assessed for each participant based on the following criteria:

1. Educational levels (primary, secondary, or post-secondary education) of the participant and his or her parent (mother and father).
2. Occupation of the participant (if independent) or parent (if dependent).
3. Assets ownership by participant or parents such as: lands, houses, livestock, or vehicles such as bikes and cars (see Questionnaire in the appendices).

In each community, there must be common attributes of poor or the rich, so is the case in Hausa community. These attributes are very much like what is obtained in other African countries such as Tanzania, Ghana, and Uganda (see www. profor. info/ Documents/ pdf/liveli hoods/field_ manual and appendix 4). Participants' indicators of wealth were enquired using questionnaires and were socially stratified into three categories based on three key indicators of wealth that include education, income, and assets (land ownership, houses, and valuables). Based on the information obtained from the questionnaires, each participant was placed into SES 1 = rich, SES 2 = average, SES 3 = poor. Following Bartlett tests of homogeneity of variance, ANOVAs were used to test for differences in mean WFACE values and mean EYES values between the three socio-economic categories.

RESULTS

Table 1 indicates the socioeconomic characteristics of the Hausa ethnic groups and the classification of the participants based on the standard characteristics.

Table 2 shows the mean values of WFACE and EYES for both male and female subjects based on the MS (marital status: married/unmarried), OCCUP (occupation: student/non-student), ELP (educational level of participant: educated/uneducated), ELM (educational level of the participant's mother: educated/uneducated), and ELF (educational level of the participant's father: educated/uneducated).

Table 3 shows the Wilcoxon rank sum tests between whole face asymmetry, asymmetry around the eyes, and socioeconomic measures of the participants with a statistically significant difference in the mean values of WFACE between married and un-married male subjects ($P<0.05$). Similarly, there was statistically significant difference in the mean values of EYES between educated and un-educated female subjects ($P<0.05$).

Table 4 Shows the frequency distribution of the SES and the mean WFACE & EYES of the three groups. The Kruskal-Wallis test conducted on the mean WFACE and the mean EYES values for the different SES categories did not show any statistically significant differences ($P>0.05$). Again, simple linear regression analyses did not show statistically significant relationship between either WFACE or EYES and INCOME, BO, NOS, MS, OCCUP, ELM, ELF, or ELP ($P>0.05$). The same result was found when multiple regression analyses was conducted in order to determine relations between the combined measures of the socioeconomic status (INCOME, BO, NOS, MS, OCCUP, ELM, ELF, or ELP) and the WFACE (F, 1.007; P-value, 0.4705) or with EYES (F-stat, 0.7674; P-value 0.9316).

Table 1: Socioeconomic characteristic of the Hausa ethnic group

Variable	Poor N = 226	Average N = 178	Rich N = 23	Total N = 427
Number of siblings				
0-5	57	23	1	81
6-10	133	74	10	217
11-15	27	47	8	82
16-20	4	10	1	15
>21	5	24	3	32
				427
Educational level (Mother)				
No formal education	202	20	0	222
Formal education	24	158	23	205
				427
Educational level (Father)				
No formal education	193	14	0	207
Formal education	33	164	23	220
				427
Educational level (Participant)				
No formal education	111	0	0	111
Formal education	115	178	23	316
				427
Occupational status (Participant)				
Student	21	177	23	221
Non-student	205	1	0	206
				427
Residential status				
Muddy	223	5	0	228
Non-muddy	3	173	23	199
				427
Number of rooms per house				
<3	87	50	1	138
4	124	100	3	227
>5	15	28	19	62
				427

Table 2: Mean whole (total) face asymmetry (WFACE) by measures of socioeconomic status and asymmetry around the eyes (EYES) of the participants in both sexes

Variables	Sex	Mean WFACE		Mean EYES	
		Married	Un-married	Married	Un-married
MS	F	0.3078	0.3008	0.2039	0.2065
	M	0.3674	0.3434	0.2468	0.2287
		Student	Non-student	Student	Non-student
OCCUP	F	0.3010	0.3081	0.2072	0.2033
	M	0.3450	0.3534	0.2297	0.2367
		Educated	Un-educated	Educated	Un-educated
ELP	F	0.2982	0.3140	0.2038	0.2060
	M	0.3473	0.3579	0.2320	0.2341
ELM	F	0.3003	0.3087	0.2064	0.2038
	M	0.3485	0.3474	0.2307	0.2340
ELF	F	0.3014	0.3083	0.2055	0.2043
	M	0.3469	0.3497	0.2321	0.2323

Marital status (MS), occupation (OCCUP), educational levels of the participant (ELP), educational levels of the participant' mother (ELM), and educational levels of the participant' father (ELF).

Table 3: Wilcoxon rank sum tests between whole face asymmetry, asymmetry around the eyes, and socioeconomic measures of the participants.

Variables	Sex	W-statistic		P-value	
		WFACE	EYES	WFACE	EYES
MS	F	4840.5	5118	0.5900	0.9088
	M	2721.5	3028	0.0184*	0.1329
OCCUP	F	5633.5	5057	0.4261	0.5923
	M	5861	5476.5	0.2106	0.7093
ELP	F	6422	5595	0.0412*	0.8660
	M	1655.5	1397	0.5047	0.6591
ELM	F	5757	5218.5	0.3304	0.7911
	M	5767.5	5739	0.8824	0.9323
ELF	F	5730.5	5420.5	0.5158	0.9564
	M	5792	5333	0.5843	0.6328

MS (marital status: married/unmarried), OCCUP (occupation: student/non-student), ELP (educational level of participant: educated/uneducated), ELM (educational level of the participant's mother: educated/uneducated), ELF (educational level of the participant's father: educated/uneducated).
*Significant at $P<0.05$

Table 4: Frequency distribution of the SES and the mean WFACE & EYES of the three groups

Groups	Sex	Frequency	Mean WFACE	Mean EYES
SES1	F	7	0.2926	0.2204
	M	15	0.3419	0.2274
SES2	F	70	0.2989	0.2055
	M	108	0.3443	0.2279
SES3	F	134	0.3094	0.2037
	M	92	0.3534	0.2379

SES1 (Social class 1: rich), SES2 (Social class 2: average), SES3 (Social class 3: poor). WFACE (Whole face asymmetry), EYES (Asymmetry around the eyes).

Table 5: Kruskal-Wallis test, WFACE by SES

Variables	Sex	Kruskal-Wallis	DF	P-value
WFACE	F	2.3121	2	0.3147
	M	2.183	2	0.3357
EYES	F	1.5166	2	0.4685
	M	0.8815	2	0.6435

SES (Social class), WFACE (Whole face asymmetry), EYES (Asymmetry around the eyes).

DISCUSSION

In the current study, three key measures of socioeconomic status, which consist of economic status, measured by income; social status, measured by education; and work status, measured by occupation"[50] were considered., although other supplementary measures such as marital status, birth order, number of siblings in a family, assets ownership (e.g., number of houses and types, and lands) were also included.

The present study did not find any association between measures of SES and facial asymmetry. The finding of this study conforms to others, such as one study that examined asymmetry of 22 traits (facial, bodily and fingerprint) and their relationship with body mass index and health measures. The study found no association between socioeconomic status (SES) with facial asymmetry[51]. However, some studies indicated an increase in asymmetry in individuals with poor socioeconomic status (SES)[34,48] in contrast to the findings of the present study where no relationship exists between all the measures of socioeconomic status [monthly income, educational levels (of participants, father, mother), occupation, birth order, and number of siblings] and whole face asymmetry or asymmetry around the eyes region.

The results of present study did not support the assertion that poor SES could cause developmental instability, which manifests in the form of facial asymmetry. The findings of the present study are also in contrast to the findings of the study of Ozener and Fink[21], which demonstrated significantly higher facial asymmetry amongst high school students from a slum area of Ankara, Turkey, as compared to students from a prosperous urban district. However, the significant association between facial asymmetry and SES in their finding may likely be due to their narrow but adolescent age range, where such association may be confounded by the normal structural facial growth processes as is influenced by secondary sex-hormones particularly in that age range.

While it is particularly and logically true to easily and comfortably manage small family, it is however, a sign of wealth in a family with a larger household, especially where polygyny is allowed and common, specifically amongst Muslims community such as the one where the subjects of this current study were drawn. It is possible that individuals who live in a small family and had more educated mothers had lower levels of facial asymmetry[21] because they had greater emotional, psychological and physiological health than their counterparts[52,53,35]. Although, male may have higher facial asymmetry than their female counterparts in any of the FA studies, this may especially be true because of sexual differences rather than poor living conditions[21].

Given the number of previous studies which have reported no significant associations between human facial fluctuating asymmetry and health risk factor for example, high blood pressure, severity of illness and physical alterations[51], and physical fitness[42,54], it is unlikely that poor living conditions might influence the development of subtle fluctuating asymmetry. This was supported by other studies which did not find any association between: SES and bodily FA of infants[41], or dental asymmetry and children[55].
Moreover, some of the equivocal results concerning the association between asymmetry and health as presented in previous studies[56,57,58], may likely resulted from inadequate sample, or confounding factors (e.g., age, sex and size). Longitudinal study with an unprecedented large sample of British cohort children, involving more than four thousand participants, indicated no association between facial fluctuating asymmetry and health[32] similar to the findings of the current study.

Nutritional status may indeed have an impact on developmental homeostasis, although reports are yet inconsistent. For example, Little et al.[59] compared the asymmetry of six anthropometric traits of chronically mild-to-moderately undernourished school children and a well-nourished control sample in South Mexico. Contrary to expectations, body asymmetry was higher among well-nourished children, leading the authors to conclude that it might be genetic rather than environmental influences that have caused DI[47], on a similar observation in stepchildren in a village in the Dominican Republic].

CONCLUSION

This study found no differences in facial symmetry between individuals of low, middle, and high socioeconomic status. It is true that poverty (low SES) has a significant impact on living conditions, which may lead to the development of many diseases, and ultimately consequences on developmental instability (DI). However, since SES does not relate significantly with facial asymmetry, it means facial asymmetry may not be a good measure of environmental stress or developmental instability.

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CONFLICT OF INTEREST

No conflict of interest

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