Genetic and Environmental Factors Influencing Certain Anthropometric Traits

WOLFRAM OSTERTAG, Indiana University

I

A major part of bioanthropology is concerned with group differences. These group differences have to have a genetical basis. They need not to be absolute in the sense, that one group has in all its individuals a distinct set of genes, which would make every individual of this group differ in all these traits from an inlividual of another human group. All group differences inside the species Homo sapiens are relative, that is, that the groups merely differ in gene frequencies.

To evaluate such differences it is also necessary to know the variability of the observed traits in different environmental situations.

In the following part of the paper, I will try to summarize the most important data obtainable from genetics, regarding the environmental variability of traits that may be used to differentiate between human groups.

II

The majority of all traits depend not on single but on multiple gene action and their exact modus of inheritance is unknown. In most cases our knowledge is restricted to the fact that a genetical basis of a particular trait is established, that we are sure the trait is influenced by several genes, and that the genes concerned may have varying penetrance.

III

The evaluation of environmental consistency of different traits is based in Homo sapiens on a few limited sources: (1) family data, (2) population analysis, (3) the comparison of twins. This paper is limited to the last of these three sources.

Galton (5) was the first to concern himself with the possibility of a separation of environmental from genetic influences on the basis of twin comparison. The subject was taken up by a large number of investigators, notably Lenz (9), von Verschuer (13), Newman and Holzinger. Galton still assumed that genotype + environment = phenotype, or applied to twin comparison, phenotype — genotype = environmental factors.

The main objectives of the twin method are the following seven points summarized by Hug (7):

1. Concordance and disconcordance in twins depend on the frequency of the tested trait in the population. Comparison of the data will give us no estimate to what extent environment and genotype play a role. We have also to take into consideration the fact that the intensity of environmental influences on identical twins is more

or less unidirectional in the same environment, while in fraternal twins the unidirectional influences fall off, because of gene differences. It is also important whether a trait is largely based on recessive or dominant genes.

2. The possibility that interpair genotype differences may also account for variations in the degree of intrapair similarity is frequently overlooked. The extent to which a trait may be conditioned by environment is dependent on the genotype (11).

3. Selection of measurement or observation.

4. Errors in observation.

5. Plasmatic factors.

6. Age and sex.

7. Modificability of a trait. The separation of autonomous and peristatic variability is impossible to calculate (4).

The main difficulty is that genotype and environmental factors can not be separated. Both condition each other. The interrelation is not one of $a + b = c$, but rather $a\ C\ b = c$, where C changes with b from situation to situation. The twin method might only tell us something about the stability of a certain trait in relation to environment. We might be able to distinguish between traits that are 1) relatively stable in regard to environment, 2) traits, that are unstable and change to a large degree with changing environment, an 3) traits that are intermediate. For anthropological observations only stable traits are useful.

We come now to the estimation of environmental differences. The estimation of heritability by a comparison of identical twins with fraternal twins involves the assumption that the environments of the two members of a set of identical twins are, on the average, neither more nor less different from one another than are the environments of the two members of a pair of dizygous twins of like sex.

The assumption is that differences in fraternal twins include genetic and environmental factors, whereas the differences in identical twins include only environmental factors. This leads to the following formula:

Heritability (h^2) is the intrapair difference of fraternal twins (pD^2) minus intrapair differences of identical twins (pM^2) divided by the total possible intrapair variation (pD^2) or expressed as a formula:

$$h^2 = \frac{pD^2 - pM^2}{pD^2}$$

As already mentioned, h^2 does not express the percentage of heritability, but nevertheless gives us an estimate of the variability of certain traits in respect to environment. Traits with a low value for h^2 are not suitable as anthropometric traits.

The following table 1 comprises values obtained from different sources and by means of different statistical formula. The results obtained by the above formula, which was first applied by Holzinger and again by Clark (2) appear in the first column. The second and third columns comprise data obtained by the Japanese Osato and Awano (10). The statistical formula for the data shown in the second column are obtained by applying the formula used by von Verschuer (1927) and those in the third column by an application of the formula of Lenz (Lenz's Erbkraft). A few results are derived from Hanna (6) and from von Verschuer (13).

TABLE I

	h^2 Values	Genetic Share	Lenz's Erbkraft
Weight	69	45	2,27
Stature*	88*	57*	4,31*
Span*	85*		
Sitting height	72	55*	3,87*
Bi-iliac b.	59		
Total arm l.*	90*	60*	4,99*
Forearm l.*	81*		
Hand length	82*	47	2,50
Middle finger l.*	88*		
Hand breadth	80*	44	2,21
(Bi-acromial br.)	(31)	(40)	(1,77)
Foot Length*	81*	54*	3,70*
Chest circumf.	61		
Waist circumf.	(25)		
Neck circumf.	67	43	2,02
Hip circumf.	63	57*	4,50*
Midarm circumf.	62		
Head length	54	58*	4,66*
Head breadth	72*	47	2,47
Minimum frontal	61		
Bizyg. breadth	60	52*	3,23*
Bigonial br.*	71*	60*	5,03*
Nose breadth	66	49	2,81
Head height	69		
Total facial h.	74*		
Upper facial h.	72*		
Nose height*	76*	50*	2,98*
Ear height	75*	48	2,67
Ear breadth	52	(27)	(0,86)
Head circumf.*	74*	59*	4,91*
Cephalic module	80*		
Cephalo-facial I	54		
Cephalic Index	(38)	52	3,30
Total facial I*	72*		
Nasal Index		50	2,96
Relative shoulder breadth	(33)		
Relative sitting height	67		
Fingerprint pattern int.*	88*		
Palmar main line index	61		

* Indicates relative stable traits.

() Indicates unstable ones.

The results shown on table 1 show remarkable correlations. Independently, if we take calculations 1, 2 or 3, we always get about the same picture.

The most stable traits in relation to environment and therefore suitable for anthropometric observations and comparisons are: stature, span, sitting height, total arm length, forearm length, foot length, bigonial breadth, total and upper facial height, nasal height, and head circumference. Of the indices mentioned in the table only fingerprint pattern intensity shows a high degree of environmental stability.

Traits, that are relatively stable in relation to environment are hip circumference, head length and breadth, bizygomatic breadth and height of ear.

Traits unsuitable for anthropometric purposes are especially the different indices: cephalic index, cephalo-facial index, relative shoulder breadth, and relative sitting height.

From the figures of table 2 we may conclude that, with the exception of the last mentioned constitutional index, all tested constitutional indices show a very high environmental stability and should be applied more extensively in physical anthropology.

TABLE II

(no values for h^2)

	Genetic Share	Lenz's Erbkraft
Index of Pignet—Vervaeck	61*	5,58*
Index of Rohrer	61*	5,41*
Index of Pignet	70*	9,73*
Index of Kamp-Davenport	47	2,57

* Indicates relative stable traits.

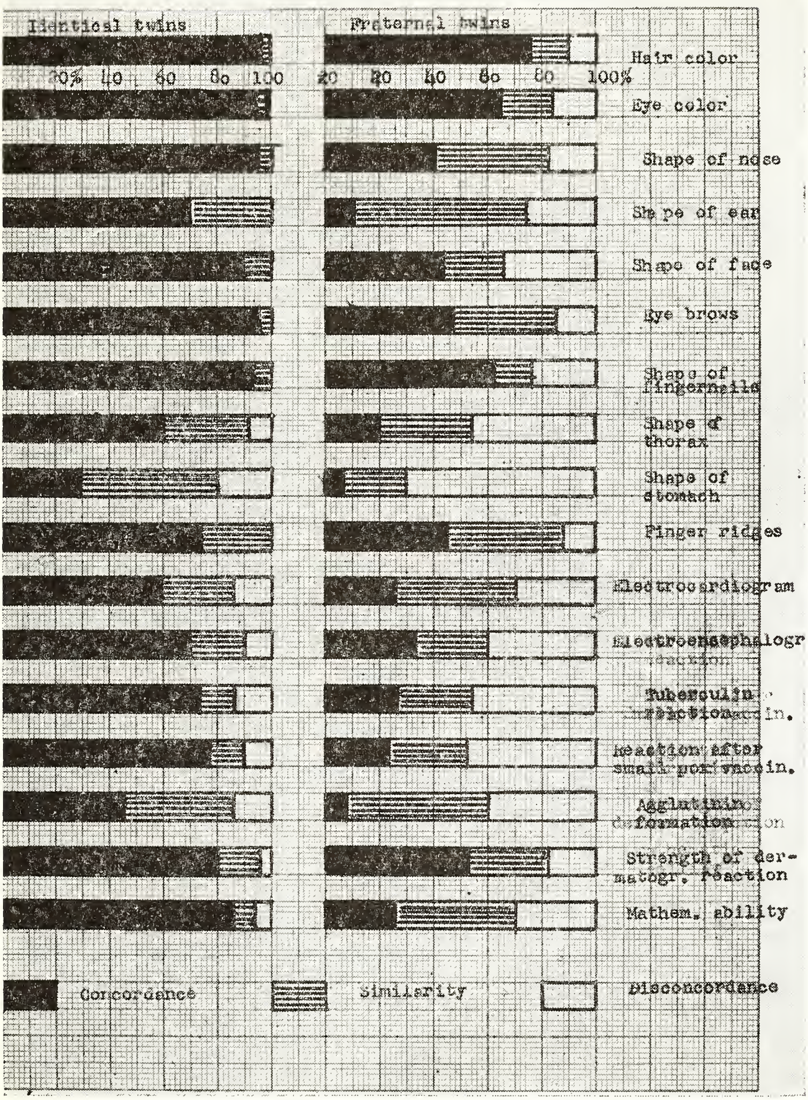
A high degree of environmental stability are shown in hair pigment concentration, as well as hair and eye color (6, 10, 13).

Still more interesting, and showing further possibilities for future anthropological observations seem to be the following traits which are compared according to concordance and disconcordance alone (table 3, according to Osato and Awano).

According to table 3, shape of nose, ear, and face show remarkable concordance in identical twins, while fraternal twins show a high percentage of disconcordance. Together with the following traits: shape of eye brows, of fingernails, and of thorax they might give us a better substitute for the frequently applied indices. Group differences in all these traits are highly probable. A still wider field for future anthropological research is opened in relation to physiology and psychology. The mentioned physiological traits show all a strong genetic penetrance and also to a great extent environmental stability. The only psychological factor tested, that might help physical anthropologists in group comparisons is mathematical ability, which seems to have a very strong genetic background, and almost complete penetrance. Further psychological traits might be added in future.

The biochemical field, in which beginning research was done by R. J. Williams (14) also shows great promise. He found environmental consistent traits that differed from one individual to another more than 100 fold.

Table 3 acc. to Osato - Awano



Summary

Recent work in various fields of genetics and biochemistry has shown that several anthropometric characters, which were and still are frequently used to demonstrate group differences, nevertheless show a high degree of instability in respect to environment and are therefore unsuited for the evaluation of group differences. The same work showed, on the other hand, that a certain number of anthropometric characters can still be used and are suitable for certain purposes. Several genetic

traits, which are stable in regard to environment are added to help us to get a better picture of group differences, traits that are not only physical but also physiological and psychological. Further research in both human genetics and anthropology is urgent. The basis of environmental evaluation, which until now had been based primarily on twin comparison, is rather questionable and unsuited for more accurate evaluations.

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