Anthropology. — *Cheirometric relations between relatives of the first degree.* By J. HUIZINGA. (Communicated by Prof. M. W. WOERDEMAN.)

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Contents:

I. *Introduction and Problem.*

Until today anthropological research of the normal hand has not been done very often. Surely when one surveys for instance the numerous investigations of the skull, the publications on the hand can be neglected. It is difficult to trace which factors have arrested the progress of cheirometric research, perhaps the little scientific sphere spun round the investigation of the hand by the chiromancy plays a part.

Already in 1766 although, measurements of the hand were done by the Parisian anthropologist BUFFON (see WECHSLER), however in the following decennaries the subject was left in peace. As one of the first the French officer CASIMIR STANISLAS D'ARPENTIGNY (1791—1866) investigated the different shapes of the hand, whereby he assumed to distinguish 7 forms.

Only through the work of CARUS (1789—1869), among others, the interest in the hand as an object of anthropo-biological research was again awakened. This versatile man (Phycician to the king of Saxony, also known as a comparative animal-psychologist, as a painter and as a writer) continued D'ARPENTIGNY's work. He distinguished four basic forms of the hand. At the same time the attention was engaged for the extremities and especially for the upper extremity in connection with the anthropogeny which had come to the front suddenly through the descension theory.

Investigation into the phylogeny of the hand also forced closer investigation of the normal hand.

Different investigation-technics were suggested (VIRCHOW, TOPINARD) which ultimately led to a rather generally accepted measuring-technic.

Among others, ECKER's problem concerning the prominence of the second finger with regard to the fourth finger led to race-investigation, followed by sex-investigation until our days (RUGGLES, 1930).

Heredity research has practically not been done unless concerning certain formvariations: polydactylism, syndactylism, arachno- and bra-

chydactylia were repeatedly brought into connection with heredity-investigations. Even MENDEL's law was first proved in man for the brachydactylia (FARABEE, 1905).

A modest heredity research of WECHSLER (1939) concerned a material of 28 families which results served more to test the technic that she followed, rather than to give a better understanding into genetic problems.

Far we stand even now from this better understanding.

Man's heredity problems from its very nature are difficult to solve, among others on account of the wellknown arresting factors as family-size and development-time. These are the reasons why family investigation is scarce and if done, surely not elaborate.

The biological object as we can ultimately study it, is the result of many factors working in different directions and with different points of application.

These can always be divided into two groups: the endo- and the exogenous or external factors (environment influences).

There latter factors will surely be able to be analysed, be it in part, by accurate investigation.

The investigation of the Viennese anthropologists BREZINA and LEBZELTER (1922—1924) has acquired recognition. They investigated the influence of the profession on different quantitative properties of the hand.

Especially in the width of the hand, these investigators meant to see a variable strongly influencable by work. Their results in this point are clear and were confirmed among others by WECHSLER's investigation (1939).

Such environment influences complicate the picture one can imagine, had only the potencies anchored in the genes acted.

It is true the disposition defines the limits wherein environment factors can exercise their modifying influences, but for practical heredity investigation, the exogenous factors complicate the whole considerably.

If, however, one finds in a group of individuals, practically homogenous in a social-economic respect, a larger resemblance between for instance father and son, than between the son and any other member of the group, then this points in our opinion in the direction of a determination by heredity of the characteristic for which the resemblance was established and this for the very reason that environmental influences (such as labour) will have a leveling action within such a group.

The results of an investigation, published by us in 1947, into the cephalometric relation between relatives of the first degree, led with the aid of the method used in that investigation, also to set up an investigation into the cheirometric relations.

We investigated the resemblances in metric data of the hand between father and son on one side and mother and daughter on the other.

Thereby we were led by the following

problem:

Do there exist between relatives of the first degree resemblances in

metric and derived data of the hand that may find their base in the genetic connection?

II. *The material.*

As the development of numerous morphological properties of child to adult is inadequately known, we were forced to involve only grown-up children in our investigation.

Also in connection with the difficulties connected with collecting data, we thought we could take 21 years as minimum-age.

Divided over age-groups our material looks as follows:

Age	Parents		Age	Children	
	Mothers	Fathers		Daughters	Sons
45—50 years	16	8	18.9—20.11 years	2	1
51—55 years	17	14	21 —24 years	31	22
56—60 years	19	24	25 —28 years	16	21
61—65 years	11	12	29 —32 years	12	17
66—70 years	1	4	33 —36 years	2	3
71—75 years	1	3	37 —40 years	2	1
	65	65		65	65

From the above survey it appears that in three cases only, we were not able to maintain the posed minimum-age requirement.

It does not seem imprudent to consider the hand of the 21-year-old as fullgrown.

HELLMANN (1928) published an investigation into the ossification: "Ossification of epiphysical cartilages of the hand", whereby he used röntgenograms as a method of investigation.

As one of the for us most important conclusions we find: "The average age of greatest increment in growth of the bones of the hand is at thirteen (12—13) years".

It was traced on the basis of verbal communications if we really had to do with the legitimate, biological parents of the children concerned. In social-economical respect the material is practically homogenous (many labourer families).

III. *Method of investigation.*

A.

With the aid of the sliding compass (Gleitzirkel, compas glissière) the following measurements of the right hand were determined of each of the 260 investigated persons (with fingers closed together).

1. *Hand length.*

This we determined according to MARTIN (measurement 49) as the

linear distance between dactylion III and the middle of the line connecting both processus styloidei (interstylion: SCHLAGINHAUFEN).

With the determination of the correct situation of the articulatio radiocarpea so many difficulties are connected, that we gave this up.

MARTIN himself also says of the length of the hand, obtained with the aid of this measuring point: „Sehr unbestimmtes Masz, da die Artikulation nur selten zu palpieren ist und auszerdem nicht transversal, sondern in einem konvexen Bogen verläuft".

It is recommended to indicate the interstylion with a small mark (see metacarpal length).

2. *Hand width.*

This we determined as the linear distance between the part of the capitulum ossis metacarpalis II protruding most radial and the part of the capitulum ossis metacarpalis V protruding most ulnar.

3. *Metacarpal length.*

This we determined as the linear distance between interstylion and the metacarpophalangeal joint of the third finger (see 4).

The metacarpal length is determined better in this manner than when it is calculated as the difference between the length of the hand and that of the third finger, since the back of the hand shows in most cases a sagittal convexity directed dorsally.

4. *Fingerlengths.*

The difficulty in measuring the fingerlengths is mainly in the determination of the metacarpophalangeal joint cavity (phalangion).

The method we followed we found described clearly by WECHSLER: „Dieser Meszpunkt (Phalangion) wird vorteilhaft so aufgesucht dasz des Untersuchers Daumen- und Zeigefingerspitzen geschlossen rittlings auf der zu suchenden Stelle distal-proximal hin- und hergeschoben werden. Ist man über die ungefähre Lage orientiert, so kann mit Daumen- oder Zeigefingernagel, von der radialen Seite her bis auf den dorsalen Rand der Gelenkspalte tastend, der Meszpunkt noch am besten bestimmt werden. Es soll, da die Hautverschiebung Fehler in sich schlieszt, das Zeichen mit dem Dermatographen nich sofort mit der Nagelspur identifiziert werden".

MAHALANOBIUS (from PEARSON's school) according to BAYER and GRAY (1933) carefully analysed the different handmeasurements described and found only 20 % reliable. This will certainly apply also to the determinations of the fingerlengths of one does not work wit the utmost care.

5. *Fingerwidths.*

The width of each of the fingers at the level of the proximal interphalangeal joint.

Remarks:

a. In connection with possible influences of the profession (BREZINA and LEBZELTER) on the various measurable variables of the hand, it had perhaps deserved preference to use the left hand in the investigation.

Also we did not take into consideration the being left- of righthanded of the persons investigated.

b. The measures were determined, as said, in hands with fingers closed together. WECHSLER cites data from an investigation of BAYER and GRAY, whereby the width of the hand was determined of three persons according to the manner above and with the aid of the handröntgenograms for three positions of the fingers:

1. with fingers closed together,
2. with the longitudinal axis of the fingers in line with the corresponding metacarpalia,
3. with the fingers spread wide.

The results appeared to be as follows:

After BAYER and GRAY (according to WECHSLER).

Person		Position of the fingers:		
		1	2	3
1	Normal width	95	94	95
	Roentgen-width	80	80	81
2	Normal width	83	83	82
	Roentgen-width	70	69	70
3	Normal width	75	76	76
	Roentgen-width	65	65	66

We can absolutely agree with WECHSLER's comment on this investigation: „Es ist überraschend, wie unwesentlich der Einflusz der verschiedenen Fingerstellungen auf die Breite der Hand (Metacarp. rad. bis Metacarp. uln.) bleibt. Anderseits ist die Differenz zwischen der Fleisch- resp. Knochenhand gröszer als man leichthin erwartet. Derartige Untersuchungen sind geeignet, über die Qualität eines Maszes bzw. der das Masz begrenzenden Meszpunkte, wertvollen Aufschlusz zu geben".

B.

With the aid of the measurements mentioned under *A.* we then calculated a number of quotients, that we can divide into indices and proportions.

Hereby one must consider an

index: the quotient of two measurements both having relation to an object as a whole,

and a

proportion: the relation of a measurement of a detail to a measurement belonging to the entire object.

So here the relation handwidth to length of the hand is an index; the relation metacarpal length to the length of the hand a proportion (we then speak of *relative* metacarpal length: the same applies mutatis mutandis to the other proportions); the relation finger width to the finger length an index (for the "total measured object" is here the finger).

In this manner the following quotients were calculated (behind them the abbreviations used):

1.	Hand index	$\frac{100 \times \text{handwidth}}{\text{hand length}}$	(h. i.)
2.	Rel. metacarpal length	$\frac{100 \times \text{metacarpal length}}{\text{hand length}}$	(r. mc. 1.)
3.	Rel. thumb length	$\frac{100 \times \text{thumb length}}{\text{hand length}}$	(r. 1e. I)
4.	Rel. 3rd finger length	$\frac{100 \times \text{3rd finger length}}{\text{hand length}}$	(r. 1e. III)
5.	Thumb index	$\frac{100 \times \text{thumb width}}{\text{thumb length}}$	(th. i.)
6.	3rd finger index	$\frac{100 \times \text{3rd finger width}}{\text{3rd finger length}}$	(3rd f. i.)
7.	5th finger index	$\frac{100 \times \text{5th finger width}}{\text{5th finger length}}$	(5th f. i.)

Together with the absolute measurements of the hand such quotients contribute to the comparative formdescription of the hand.

IV. *Method of calculation.*

As we dispose of a number of data represented in numbers of the hands of relatives, in view of the many publications e.g. from PEARSON's school, it seems but natural to calculate, for a given datum, the correlationcoefficient between for instance Father and Son, and to compare this with other such coefficients in order to obtain a understanding of genetical connections.

This biometric school of PEARSON has established through determining correlationcoefficients, degrees of accordance between all kinds of relatives (parents and children, brothers and sisters, cousins etc.).

The material worked out by them is often very large, the calculated results can, at least statistically, be called reliable.

WIBAUT (1940) in his book devotes a separate chapter to this method. The application requires in the first place a large and preferable unselected material, secondly a satisfactory mathematical schooling.

In view of the large number of correlationcoefficients, determined for the use in genetics, these conditions are fulfilled.

More difficult, however, is the interpretation of the obtained results.

Next to mathematical insight, demands are now made of the biological discernment.

By absolute correlation ($r = 1$), according to WIBAUT, one can no longer speak of correlation, "but of relation of function".

Such remarks are misleading.

It is certainly not so, that a correlationcoefficient smaller than 1 proves the absence of any relation or function.

We then can only ascertain, that there is no linear connection between the series of values concerned.

An other functional connection may exist if a correlationcoefficient smaller than 1 is found.

In genetics an r of $\pm$ 0.5 between parents and children or brothers and sisters is the expression of a high degree of genetical connection.

PEARSON figured, that theoretically an $r = 0.33$ can be expected between father (or mother) and child, if we investigate a characteristic that is hereditary completely dominant.

Such a complete dominance, however, happens but rarely.

In intermediary heredity and polymery, also according to PEARSON, a value of $\pm$ 0.5 can be expected in "direct parental inheritance", that is from father (or mother) to child.

As an example we cite some correlationcoefficients from a publication of PEARSON and LEE (1903).

	Father and		Mother and	
	Son	Daughter	Son	Daughter
1. Stature	0.514 ± 0.015	0.510 ± 0.013	0.494 ± 0.016	0.507 ± 0.014
2. Span width	0.454 ± 0.016	0.454 ± 0.014	0.457 ± 0.016	0.452 ± 0.015
3. Fore-arm length	0.421 ± 0.017	0.422 ± 0.015	0.406 ± 0.017	0.421 ± 0.015

These correlationcoefficients were calculated from a material consisting of more than 1000 families.

Very interesting is now the interpretation:

a. S en D are equally influenced by F and M.

b. As to the influence on the descendants, on the average there is no preponderance of F or M, however that may be in individual cases.

c. The heredity appears not to be the same for all variables.

d. The more complex a variable (stature), the larger the intensity of the heredity.

We will assume that these conclusions are only meant for the three variables investigated.

That the interpretation of r certainly is not easy (and therefore often is not performed with enough care), appears from the elaborate survey of ERNA WEBER (1935), of which we derive partly the following: "If $r = 0$, we may speak of an absence of genetical influences.

The correlation is influenced by

1. The manner of inhereting the investigated quality.

2. The frequency of the recessive disposition. WEINBERG (1908) derived a general formula, in which the relation between the correlation-coefficient and frequency is indicated".

Above we already pointed to a connection between dominance and correlationcoefficient, indicated by PEARSON.

From studying the data furnished by WEINBERG, also in connection with PEARSON's calculations, we get the impression that the difficulties in this field have not yet been wholly solved.

3. Environment influences.

Under influence of certain exogenous factors a correlationcoefficient can receive a value that can delude us into seeing the role of heredity too small or too large.

"Only when the surrounding for parents and children were the same, for instance strongly dependent on the prosperity, a too large value for the correlation wil be found" (WIBAUT, 1940).

Furthermore it is ascertained that inbreeding increases the correlation between parents and children.

According to us, however, it is incorrect to conclude to "environment-influences" if the r is found to be smaller than 0.5.

However much we appreciate the, be it often complicated statistical discussion of genetical problems according to the above manner, we have meant to be able to communicate the results of *another method of calculation.*

If the Father of a family A (F/A) has a handlength of, for instance, 203 mm, the grown-up Son (S/A) a handlength of 199 mm, and any given other adult man (F/B) a handlength of 192 mm, then it is obvious to think the accordance between F/A and S/A larger than that between this S/A and the other man F/B.

For a given variable, for instance this handlength, we can always determine the *absolute* difference existing between F/A and S/A.

Our material allows us to determine such a difference 65 times. From these 65 observations the average absolute difference in handlength between F/A and S/A can be determined. This appears to be 8.7 mm.

In the same manner we can determine from 65 observations the average absolute difference existing between S/A and F/B; this appears to be 10.5 mm.

So the average is such, that the absolute length of the hand of a grown-up son shows more resemblance, in our example, to that of his father than to that of an other given adult man.

It is obvious to interpret this through the hereditary relation between F/A and S/A.

That an average difference S/A . F/A will be larger than that for S/A . F/B cannot be expected on biological bases: less accordance than with F/B (being any other given man) S/A can never show with F/A.

So the average difference for S/A . F/A and S/A . F/B ought to be at least the same.

Does it occur nevertheless, that S/A . F/A shows a larger average difference, then, in our opinion, this can only be owing to the extent of the material from which the various factors were determined.

We will see that this larger deviation really occurs as an exception, which shows our material certainly to be sufficiently useful.

A lesser genetical relation makes approximate the values of the average differences; with a stronger genetic relation the value of the average difference of S/A and F/A will differ more from that of S/A and F/B.

Therefore it is obvious to determine the proportion of the average difference for S/A . F/B on the one side to that for S/A . F/A on the other side.

On the mentioned bases we expect that this proportion will be *equal to or larger than 1.*

We introduce for this proportion the expression *ratio.*

In order to obtain easily manageable results, we will determine this ratio as:

$$\text{ratio} = \frac{100 \times \text{average difference S/A . F/B}}{\text{average difference S/A . F/A}}$$

To indicate the relation we consider the ratio a suitable expedient. We determined the ratios for every one of the absolute measurements given above under "method of investigation", and the relative measurements calculated from them,

a. for the relations between men, as was explained in our example (S/A, F/A, F/B),

b. for the relations between women, whereby we consequently compared data of grown-up daughter of family A (D/A) with those of her mother (M/A) and with those of any other given adult woman (M/B).

As arbitrary adult woman (or man) we chose the mother (or father) of the family investigated next.

Since the investigation of the families happened in an arbitrary sequence, in our opinion there is no objection aginst this method.

That we did not look into the relations between F/A and D/A or M/A and S/A in this manner, finds its account in the fact that absolute values of qualities of man and woman are inequivalent.

Between these values there exists a certain sex-ratio (WEBER, 1935), which must be determined separately for each variable of a material.

This complete investigation we hope to be able to do with the aid of a more extensive material.

V. *The investigation.*

A. *The comparison with the aid of measurable variables.*

In the manner indicated above, we determined the ratios of the 13 absolute measurements mentioned.

Ratios determined for the relations between:			
No.	Variables	Men	Women
1	le	121	120
2	wi	144	113
3	mc. l.	129	112
4	le I	98	103
5	le II	121	140
6	le III	122	126
7	le IV	126	129
8	le V	122	108
9	wi I	133	101
10	wi II	132	96
11	wi III	144	99
12	wi IV	169	96
13	wi V	116	91

We notice among others:

1. That the ratios smaller than 100 are not so numerous (5), so that our expectation mentioned above (ratio equal or larger than 100) is confirmed for the greater part.

It is likely that the number of ratios smaller than 100 will drop when the material is expanded.

2. That the ratios determined after mutual comparison of men are considerably larger than those determined by mutual comparison of women.

3. That the masculine ratio is not larger than the feminine ratio for every variable.

As a value of a ratio larger than 100 points to the fact that the value of the concerning variable of parent and grown-up child of the same sex lie closer together than that of this child and any other given adult of the same sex, points 2. to the fact that for the determination of a cheirometric relation with the aid of absolute measurements the relation between father and grown-up son is indicated more clearly on the average than that between a mother and her grown-up daughter.

According to 3. this does not apply to every variable to the same extent.

This may be evident after the grouping of the variables in 1e and wi measures.

The *width-measurements* indicate without exception that the average accordance in absolute value of the concerning variables is considerably

Width-measures of the hand.
(Measured perpendicular to the sagittal plane.)

Ratios determined for the relations between:			
No.	Variable	Men	Women
1	wi	144	119
2	wi I	133	101
3	wi II	132	96
4	wi III	144	99
5	wi IV	169	96
6	wi V	116	91

larger between father and grown-up son than between mother and grown-up daughter. For the *length-measure* this is only the case for mc.le and 5th f.le, be it, however, that the differences in ratios of the width-measures are more considerable.

Length-measures of the hand.
(Measured perpendicular to the transversal plane.)

Ratios determined for the relations between:			
No.	Variable	Men	Women
1	le	121	120
2	mc. le	129	112
3	le I	98	103
4	le II	121	140
5	le III	122	126
6	le IV	126	129
7	le V	122	108

Imagine a man, standing upright, facing us, with the arms extended along the body, and with supinated hands, then the following applies:

the absolute values of variables of the hand, measured perpendicular to the sagittal plane (therefore our width-measures) for the representation of the genetical relation between father and son are of more importance than for those between mother and daughter; while the absolute values of the variables measured perpendicular to the transversal plane (length-measures in the hand) are of more significance for the representation of the genetical relation between mother and adult daughter.

In a previous investigation (1947) we determined among others the ratios of variables of the head.

The above formulation of the importance of the situation of the variable with regard to the sagittal and transversal plane appears also to be undiminished in force for the variables of the *face*.

For the face the variables perpendicular to the sagittal plane are called witdh-measures just as in the hand, the measures perpendicular to the transversal plane, however, are here height-measures.

The ratios are assembled in the following table:

Width-measures of the face.
(Measured perpendicular to the sagittal plane.)

Ratios determined for the relations between:			
No.	Variables	Men	Women
1	Width of the face	108	99
2	Width of the mand. angle	130	124
3	Width of the nose	119	110
4	Width of the mouth	129	103
5	Interorbital width	117	101
6	Width of the orbita	91	99

(So the width of the orbita does not follow the rule; we point to the fact that the corresponding ratios are both smaller than 100 and therefore do not show the connection any way, therefore also cannot be considered to show a difference in meaning for the genetic relations of both sexes.)

Height-measures of the face.
(Measured perpendicular to the transversal plane.)

Ratios determined for the relations between:			
No.	Variables	Men	Women
1	Physiogn. height of the face	127	106
2	Morphol. height of the face	120	99
3	Height of the front	101	113
4	Height of the nose	114	119
5	Height of the upperlip	115	124
6	Height of the chin	106	114
7	Height of the orbita	109	114

(Measures of the fact more or less concerning the totality: the physiognomical and morphological height of the face, do not follow our rule. These are of primary importance for the connection between father and son.)

Should be closer investigation the *meaning of the direction of growth* for the *sexdimorphism* that has appeared so clearly in our investigation, will be found again, then we are of the opinion that in this direction a deepening of our understanding can be expected.

B. *The comparison with the aid of indices and proportions.*

The values of the ratios determined from the 7 quotients mentioned, are assembled in the following table:

Ratios determined for the relations between:			
No.	Variables	Men	Women
1	h. i.	132	126
2	r. mc. le	133	108
3	r. le I	122	112
4	r. le III	147	124
5	th. i.	125	120
6	3rd. f. i.	123	119
7	5th. f. i.	109	99

It is clear that the relative measures of the hand for the investigation into the genetic relation are of more importance generally for the relation between father and son than between mother and daughter: all ratios determined after mutual comparison of the men are larger than those determined after mutual comparison of the women.

This dominance of the ratios belonging to the men over those of the women we did not find so clearly in our investigation into the cepalometric relations (1947).

As far the cheirometric relations between relatives of the first degree we can remark summarily, that the qualities of the hand as far as we investigated them, show more prominently the genetic relation between father and grown-up son than between mother and grown-up daughter.

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