A STUDY ON THE VARIATION AND HEREDITY OF FINGER PATTERNS

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The material for the present study consists of finger patterns of 303 sets of twins and 796 non-twin individuals. The twins were selected from among children of primary schools in Osaka, Kyoto, and Tokyo. The material from Kyoto and Tokyo I owe Professor Taku Komai of this University and Professor Torao Obonai of Tokyo Higher School respectively. The twins are classified into 75 male and 50 female pairs of monozygotic (identical) sets and 75 male, 53 mixed, 50 female pairs of dizygotic (fraternal) sets. The non-twin individuals belong to 166 families all resident in Kyoto-Osaka-Kobe district except a few families living in Yokohama or Nara.

For the classification of finger patterns, I have adopted besides the classical scheme, the scheme devised by Bonnevie (1924).

First, the coefficients of correlation were obtained; (1) between the twins of the same pairs in regard to the number of ridges for all fingers, (2) between the right and left hands of the same individual of the twins, and (3) between the corresponding hands of the twins. The results are shown in Table 1.

In this table the corresponding values obtained by Bonnevie (1924) and Newman (1930) are also shown for comparison. Though the results obtained here are not quite the same as those given by these authors, the general tendency is the same. Especially noteworthy is the fact that the coefficients of correlation between the corresponding hands of different individuals of the monozygotic twin pairs are substantially equal to the coefficients of correlation between the right and left hands of the same individual. v. Verschuër (1934) gives essentially the same fact as regards individual fingers of twins.

In the dizygotic twins, on the contrary, it is found that whereas the coefficients of correlation between the right and left hands of the same persons is nearly 0.9, that between the corresponding hands of the twins is only ca. 0.4. This difference found between monozygotic and dizygotic twins testifies

to that in the determination of the number of ridges on fingers heredity plays a part as important as in the case of stature, head length, etc. In this

Table 1. Correlation between twins in number of ridges of finger patterns

	Monozygotic Twins		Dizygotic Twins			Author
	MM	FF	MM	MF	FF	
Correlation between both hands of A and both hands of B.	0.97 ± 0.004	0.96 ± 0.006	0.36 ± 0.067	0.35 ± 0.081	0.35 ± 0.085	Fukuoka
	0.924 ± 0.037		0.535 ± 0.082			Bonnevie
	0.95 ± 0.001		0.46 ± 0.008			Newman
Correlation between right and left hands of the same individual.	0.935 ± 0.007	0.896 ± 0.013	0.881 ± 0.016	0.895 ± 0.013	0.805 ± 0.024	Fukuoka
	0.860 ± 0.027					Bonnevie
	0.93 ± 0.01		0.93 ± 0.01			Newman
Correlation between left hand of A and left hand of B.	0.953 ± 0.007	0.944 ± 0.011	0.336 ± 0.087	0.216 ± 0.092	0.243 ± 0.091	Fukuoka
	0.93 ± 0.01		0.50 ± 0.07			Newman
Correlation between right hand of A and right hand of B.	0.938 ± 0.094	0.924 ± 0.014	0.411 ± 0.118	0.225 ± 0.146	0.355 ± 0.128	Fukuoka
	0.92 ± 0.01		0.34 ± 0.08			Newman

table it is also shown that the value of the coefficient of correlation is higher in male pairs than in female pairs, especially as regards dizygotic twins. Whether this is due to mere chance or has some deeper significance, the available material is too meager to decide.

Next, the coefficients of correlation in the number of ridges between parent and children of the same families are shown in Table 2.

Table 2. Correlation between parent and children in the number of ridges of finger patterns

	Coefficient of correlation
Father and son	0.30 ± 0.094
Father and daughter	0.47 ± 0.081
Mother and son	0.54 ± 0.074
Mother and daughter	0.35 ± 0.091

As shown in this table there is always a possitive pretty high correlation

between parent and child. This fact gives further support to the view set forth above. Further it may be noticed that the correlation value is higher between father and daughter than between father and son, and between mother and son than between mother and daughter. Thus, it is likely that a sex-linked gene plays a part in the transmission of the type of finger pattern. Incidentally, according to Suda (1935), there is a rather marked sexual difference in the frequency of different patterns.

In the accompanying figure a polygon (See Fig. 1.) is plotted on the basis of my material to denote the degree of variation in the number of ridges of the fingers in the whole families. The number of ridges is represented on the abscissa, while the number of individuals is recorded on the ordinate. The dotted line shows the actual polygon, while the heavy line represents the result of smoothing of the same by means of moving averages. The latter is approximately a binominal polygon. This seems to show that the number of ridges is determined by multiple factors which show neither complete dominance nor complete recessiveness.

I have also worked on the mode of inheritance of the different types of pattern. For this purpose I have examined how the different kinds of patterns are distributed among the members of the family. Table 3 represents the result of this study.

It is shown in this table that as a general tendency the majority of the children have the same pattern as the parent, yet there are many cases where they have entirely different patterns. For instance, loop may appear in the children of the parents both of whom have arch pattern; the children of the couple of loop may have arch or whorl beside loop; all arch, loop and whorl may be expected among the children of the mating whorl $\times$ whorl. On the whole, however, there is unmistakable tendency that arch behaves as a recessive to loop or whorl. But it is hard to tell which of loop or whorl is dominant or epistatic, because both the types may appear from either loop $\times$ loop or whorl $\times$ whorl.

In short, the heredity is much less marked as to the type of pattern than as to the number of ridges. Elderton (1920) also admits that no clear result has been secured from her study on the heredity of the type of finger pattern.

Fig. 1. Polygon of individual pattern-values

Table 3. The relation between parent and child in the type of finger-pattern of each finger (A-arch, L-loop, W-whorl)

[illegible]

Next Table 4 shows the frequency of the radial loop in the children whose parents, both or one, have this pattern, as compared with the frequency of the same pattern in the children of parents both without the radial loop. There is practically no difference in the value of this frequency between those two groups of children.

Table 4. The frequency of the radial loop in the children whose parents, both or one, are with this pattern, or both without this pattern

P \ F ₁	Sex of F ₁	Left Hand				
		II	III	IV	V	I
Both or one with radial loop	M	26.8±7.5%	16.7±15.2%			
	F	50.0±7.2%	11.1±10.4%			
Both without radial loop	M	28.9±6.8%	2.9±2.0%		1.6±1.1%	2.5±2.5%
	F	44.2±7.6%	4.6±2.2%			

P \ F ₁	Sex of F ₁	Right Hand				
		II	III	IV	V	I
Both or one with radial loop	M	4.38±8.8%	11.1±10.4%	20.0±17.9%		
	F	25.0±5.8%	11.1±10.4%			
Both without radial loop	M	25.9±8.4%	2.5±1.8%	2.7±2.7%		
	F	20.9±6.2%	3.8±1.8%	1.7±1.7%	1.0±1.0%	

In Table 5 is shown the frequency of the sets of twins both or one of whom have the radial loop pattern on the index finger; the twin-sets are classified according to their zygoty and sex, and compared with one another. There is substantially no difference between monozygotic and dizygotic groups.

In short, as regards the radial loop pattern there is no evidence for its inheritance.

Table 5. The frequency of the sets of twins both or one of whom have the radial loop pattern on the index finger

	Left Hand				
	Monozygotic		Dizygotic		
	M M	F F	M M	M F	F F
Both with radial loop	8.0±3.2 [%]	4.0±2.8 [%]	8.0±4.0 [%]	10.0±4.0 [%]	8.0±3.9 [%]
One with radial loop	17.9±3.18 [%]	13.0±1.06 [%]	10.0±4.24 [%]	21.1±9.36 [%]	12.5±5.23 [%]

	Right Hand				
	Monozygotic		Dizygotic		
	M M	F F	M M	M F	F F
Both with radial loop	7.0±3.2 [%]	2.0±2.0 [%]	5.0±2.5 [%]	5.0±3.0 [%]	3.0±2.4 [%]
One with radial loop	14.4±2.91 [%]	5.1±2.21 [%]	1.6±1.64 [%]	26.3±10.10 [%]	27.5±7.06 [%]

Next, as to the twisting tendency, the tendency to form complex patterns (Bonnievie, 1924), the relation between parent and child is shown in Table 6.

Table 6. Relation between parent and children as to the presence (T) or absence (R) of the tendency to twist

P \ F _I	T T		T R		R R	
	T	R	T	R	T	R
M	60	19	47	25	3	11
F	75	23	39	53	6	16

Here one can recognize the indication that the twisting tendency is inherited, though the precise mode is uncertain.

Lastly, regarding the shape of the pattern which is denoted by the ratio between the height and width, the patterns are divided into C (circular) and E (elongated) according as the ratio is smaller than $2/3$ or not; the relationship between parent and child is given in Table 7.

Table 7. Relation between parent and child as to pattern shape (circular or elongate)

P F ₁	E . E		E . C		C . C	
	E	C	E	C	E	C
M	56	107	39	40	2	11
F	67	20	57	39	3	13

Here also, we can recognize that the tendency to form elongate or circular pattern is inherited, but the mode is difficult to determine. Bonnevie (1924) arrived at the same conclusion as regards the twisting tendency and in the shape of the pattern.

Summary

(1) The material consists of finger patterns of 303 sets of twins and 796 non-twin individuals.

(2) For the classification of patterns, two different schemes have been adopted: the one according to the type of pattern, and other invented by Bonnevie which is based upon ridge-counting.

(3) The result of ridge-counting shows that the coefficient of correlation between right and left hands of the same individual is substantially the same either in monozygotic or in dizygotic twins (nearly 0.9); the correlation between different individuals of the same set of monozygotic twins is nearly 0.9, while it is only 0.4 in dizygotic twins.

(4) The number of ridges seems to be determined by multiple factors which show neither complete dominance nor complete recessiveness. Also a sex-linked factor seems to take part.

(5) The heredity is less marked as to the type of pattern.

(6) There is no evidence for the inheritance of the tendency to form a radial loop.

(7) The tendency to twist (to form composite pattern) and the tendency

to form elongate or circular pattern seem to be inherited, but the mode is difficult to determine in either case.

In concluding, I wish to tender my best thanks to Professor T. Komai for the valuable criticism and to all my friends to whom I owe the materials for the present study.

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摘 要

I. 材料として東京、京都、大阪市の小児児童中の双生児 303 組及び京阪神居住の一般家族 796 人を用ゐた。

II. 指紋の分類方法としては指毎に型の上より弓状紋、甲種蹄状紋、乙種蹄状紋、渦状紋、混合紋の五種に分つ方法と Bonnevies の脈数並びに紋の形に據る方法を採用した。

III. 一卵性の双生児間の全指又は左右手別に取つた脈数の相関値は同一児の左右手間の相関値にほぼ等しく 0.9 内外である。之に反して二卵性双胎児に於ては同一人の左右手間の相関値は 0.9 に近きも、同組兩児の同側の兩手間又は全指に就ての相関値は 0.4 に過ぎない。

IV. 指紋の脈数の決定には優劣の關係にあらざる同義因子が關與してゐる事を示すと共に、伴性因子が關與して居る様に思はれる。

V. 指紋の型は遺傳される傾向があるが、其様式は明瞭でない。

VI. 甲種蹄状紋を作る傾向は遺傳的と見るべき證據はない。

VII. 指紋の旋廻の傾向及び高さに就ては遺傳の傾向ある事は見られるが、其様式は明かでない。