STRUCTURAL ANALYSIS OF THE RIDGE COUNT DATA OF AUSTRALIAN EUROPEANS USING MULTIVARIATE ANALYSIS

S. SINGH (1), M. A. AITKIN (2), N. H. WESTWOOD (3)

(1) Medical Research Department, Kanematsu Memorial Institute, Sydney Hospital, Sydney, NSW, Australia.
(2) School of Behavioural Sciences, Macquarie University, North Ryde, NSW, Australia.
(3) Division of Animal Production, Commonwealth Scientific and Industrial Research Organisation, North Ryde, NSW, Australia.

Multivariate analyses are used to study the structural patterns of ridge counts of fingers. There is a significant difference between the ridge counts of two hands, chiefly due to the first and fourth fingers. There is asymmetry in the covariance matrix of the ridge counts. The correlations between fingers are significant and the decrease in correlation with increasing distance between fingers is not significant.

INTRODUCTION

Quantitative analyses of total ridge counts and individual ridge counts on fingers of a number of populations of different ethnic origin have been made by da Cunha and Abreu (1954), Lamy et al. (1956), Böök (1957), Holt (1958), Mavalwala (1963), and Parsons (1964). Ridge count is a quantitative measure made on the patterns, e.g., whorls, loops, and arches, found on finger tips. These counts have been shown to be inherited through a complex of polygenes (Holt 1961). Penrose (1969) suggested that there were 6 to 7 additive and equally effective genetic loci involved in the inheritance of total ridge counts.

The structural pattern of fingers in a British population was studied by Holt (1959) by the method of correlation analysis of the ridge counts on different pairs of fingers. She found all correlation coefficients were positive; the highest correlations were between homologous fingers; most of the correlations decreased as the distance between the two fingers increased. Luu-Mau-Thanh (1965) used canonical correlation and factor analysis of the various finger patterns (whorls, loops, and arches) of a group of French males to study the relationship between fingers. He found that the fingers of a hand could be classified into three groups, i.e., 1st finger, 2nd and 3rd fingers, and 4th and 5th fingers.

In the present paper multivariate analyses are used to study the structure of ridge count. The features under study are the ridge counts on the right vs. the left hand, symmetry of covariance matrix of fingers of two hands and the correlation matrix of fingers of two hands. The conventional quantitative data of the dermatoglyphics of Australian Europeans used in this analysis have been described by Singh (1967). A test for equality of ridge counts on homologous fingers of the two hands was carried out by a variation of the Hotelling's T^2 test

CODEN: AGMGAK 26 167 (1977) — ISSN: 0001-5660
Acta Genet. Med. Gemellol. (Roma), 26: 167-171

RESULTS

1. Equality of Ridge Counts

The mean ridge counts for males and females are shown in Table 1. A test for equality of ridge counts on homologous fingers of the two hands may be carried out by a slight variation of Hotelling's T^2 test. The differences' between mean ridge counts on right and left hands are highly significant at the 0.1% level in both cases by Hotelling's T^2 test, the differences being due to 1st and 4th fingers in each case. On all fingers, the right hand had a higher mean ridge count than the left hand, though the difference was significant only for the 1st and 4th fingers.

Table 1. *Mean ridge counts of individual fingers*

Finger	Males (500)		Females (500)	
	Right	Left	Right	Left
1	19.206	16.092	17.362	14.094
2	11.856	11.060	10.442	9.850
3	11.952	11.630	10.898	10.466
4	16.634	15.846	15.078	14.304
5	14.072	13.842	12.542	12.048

The variances and covariances of the ridge counts are not reproduced but can be obtained from the author.

2. Symmetry of the Covariance Matrix

If we denote the covariance matrix of the ridge counts on the left and right hand by

$$\Sigma = \begin{bmatrix} \Sigma_{11} & \Sigma_{12} \\ \Sigma_{21} & \Sigma_{22} \end{bmatrix}$$

the symmetry of this matrix may be expressed in terms of the two conditions $\Sigma_{11} = \Sigma_{22}$ (i.e., the variances and covariances of the ridge counts on the fingers of the left hand are equal to those of the homologous fingers on the right hand) and $\Sigma_{12} = \Sigma_{21}$. The test for this structure is given by Anderson (1958). We find that the hypothesis of symmetry is rejected for both males and females beyond the 1% level. The asymmetry is due to the last three fingers for males and the 2nd and 3rd for females.

3. *Structure of the Correlation Matrix*

The correlation matrices for males and females are shown in Tables 2 and 3. A high degree of symmetry is clearly present. In particular it appears that:

(1) homologous fingers correlate more highly with each other than with other fingers, and this correlation is constant over all fingers;

(2) the correlation between any two nonhomologous fingers are equal whether the fingers are on the same hand or not;

(3) the correlations between the 1st finger and any other finger are all equal. This suggests testing the hypothesis that the population correlation matrix is of the form

https://doi.org/10.1017/S000156600000996X Published online by Cambridge University Press

$$\varrho_0 = \begin{pmatrix}
1 & & & & & & & & & \\
 & 1 & & & & & & & & \\
\varrho_1 & & 1 & & & & & & & \\
\varrho_1 & \varrho_3 & & 1 & & & & & & \\
\varrho_1 & \varrho_3 & \varrho_3 & & 1 & & & & & \\
\varrho_1 & \varrho_3 & \varrho_3 & \varrho_3 & & 1 & & & & \\
\varrho_2 & \varrho_1 & \varrho_1 & \varrho_1 & \varrho_1 & & 1 & & & \\
\varrho_1 & \varrho_2 & \varrho_3 & \varrho_3 & \varrho_3 & \varrho_1 & & 1 & & \\
\varrho_1 & \varrho_3 & \varrho_2 & \varrho_3 & \varrho_3 & \varrho_1 & \varrho_3 & & 1 & \\
\varrho_1 & \varrho_3 & \varrho_3 & \varrho_2 & \varrho_3 & \varrho_1 & \varrho_3 & \varrho_3 & & 1 \\
\varrho_1 & \varrho_3 & \varrho_3 & \varrho_3 & \varrho_2 & \varrho_1 & \varrho_3 & \varrho_3 & \varrho_3 &
\end{pmatrix}$$

with ϱ_1, ϱ_2, and ϱ_3 unspecified. The structure ϱ_0 suggested for the correlation matrix was tested for consistency with the male and female correlation matrices above. The values of ϱ_1, ϱ_2, and ϱ_0 were estimated in each case by the average of the appropriate sample correlations and the test due to Aitkin (1969) was applied. The resulting approximate χ^2 values were quite small and nowhere near the upper 10% point of the appropriate χ^2 distribution. Thus, the hypothetical structure was consistent with the data in each case.

Table 2. *Correlation matrix of ridge counts between fingers in males* (N = 500)

$$\mathbf{R} = \begin{pmatrix}
1.0 & & & & & & & & \\
0.453 & 1.0 & & & & & & & \\
0.520 & 0.649 & 1.0 & & & & & & \\
0.529 & 0.564 & 0.638 & 1.0 & & & & & \\
0.471 & 0.583 & 0.587 & 0.687 & 1.0 & & & & \\
0.749 & 0.457 & 0.477 & 0.482 & 0.437 & & & & \\
0.408 & 0.703 & 0.650 & 0.559 & 0.548 & 0.463 & 1.0 & & \\
0.492 & 0.537 & 0.802 & 0.634 & 0.579 & 0.471 & 0.661 & 1.0 & \\
0.513 & 0.606 & 0.680 & 0.826 & 0.691 & 0.469 & 0.604 & 0.692 & 1.0 \\
0.533 & 0.552 & 0.548 & 0.694 & 0.805 & 0.527 & 0.510 & 0.558 & 0.696
\end{pmatrix}$$

Table 3. *Correlation matrix of ridge counts between fingers in females* (N = 500)

$$\mathbf{R} = \begin{pmatrix}
1.0 & & & & & & & & \\
0.438 & 1.0 & & & & & & & \\
0.508 & 0.628 & 1.0 & & & & & & \\
0.417 & 0.536 & 0.615 & 1.0 & & & & & \\
0.493 & 0.488 & 0.521 & 0.650 & 1.0 & & & & \\
0.770 & 0.433 & 0.478 & 0.411 & 0.431 & 1.0 & & & \\
0.425 & 0.740 & 0.576 & 0.538 & 0.518 & 0.408 & 1.0 & & \\
0.458 & 0.614 & 0.755 & 0.648 & 0.528 & 0.424 & 0.598 & 1.0 & \\
0.493 & 0.538 & 0.622 & 0.814 & 0.626 & 0.462 & 0.542 & 0.688 & 1.0 \\
0.473 & 0.499 & 0.514 & 0.637 & 0.776 & 0.450 & 0.509 & 0.585 & 0.678
\end{pmatrix}$$

https://doi.org/10.1017/S000156600000996X Published online by Cambridge University Press

DISCUSSION

The results of the test for equality of ridge counts on homologous fingers show that the right hand has significantly more ridges than the left hand. The major component of difference is due to the first and fourth fingers. Holt (1954), Parsons (1964) and Singh (1968) have discussed asymmetry of ridge counts of right and left hands.

Holt (1959) reported the covariance matrix of her ridge count data of a British sample, but no reference to symmetry of the covariance matrix was made. The present results of test of symmetry of the covariance matrix reveal that there is asymmetry in the covariance matrix. In males it is due to the third, fourth, and fifth fingers, and in females it is due to the second and third.

Most of the results of the correlation matrix agree with those of Holt (1959). All correlations between fingers are significant, while those between homologous fingers have the highest values. Correlations decrease as the distances between fingers increase, but this change is statistically not significant. The first finger is exceptional in having lower correlation values with other fingers, perhaps mainly due to its anatomical position; a fact which was first pointed out by Holt (1951).

REFERENCES

Aitkin M.A. 1969. Some tests for correlation matrices. Biometrika, 56: 443-446.

Anderson T.W. 1958. Introduction to Multivariate Statistical Analysis. New York: Wiley.

Böök J.A. 1957. Frequency distributions of total ridge counts in the Swedish population. Hereditas, 43: 381-9.

Da Cunha A., Abreu A. 1954. Impressoes digitais de portugueses. Perceulagens de figuras, valores quantitatives e frequencia empericus des genes, V, R e W. Contrib. Estudo Antropol. Port., 5: 315.

Holt S.B. 1951. The correlations between ridge counts on different fingers. Ann. Eugen., 16: 287-297.

Holt S.B. 1954. Genetics of dermal ridges: Bilateral asymmetry in finger ridge counts. Ann. Eugen., 18: 211-231.

Holt S.B. 1958. Genetics of dermal ridges: Relation between total ridge count and variability of counts from finger to finger. Ann. Hum. Genet., 22: 323-339.

Holt S.B. 1959. The correlations between ridge counts of different fingers estimated from a population sample. Ann. Hum. Genet., 23: 459-460.

Holt S.B. 1961. Inheritance of dermal ridge patterns. In L.S. Penrose (ed.): Recent Advances in Human Genetics. London: Churchill.

Lamy M., Frézal J., De Gruchy J., Kelly J. 1956. Le nombre de dermatoglyphes dans un échantillon de jumeaux. Adv. Hum. Genet., 21: 374-385.

Luu-Mau-Thanh 1965. Etude des structures digitales de 6000 inculpés français par les empreintes digitales. Bull. Mem. Soc. Arith. Paris, 11: 23-38.

Mavalwala J. 1968. Quantitative analysis of finger ridge counts of the Parsi community in India. Ann. Hum. Genet., 26: 305-313.

Parsons P.A. 1964. Finger print pattern variability. Acta Genet. (Basel), 14: 201-211.

Penrose L.S. 1969. Effects of additive genes at many loci compared with those of a set of alleles at one locus in parent-child and sib-sib correlations. Ann. Hum. Genet., 33: 15-22.

Singh S. 1967. Quantitative analysis of finger ridge counts in Australian of European ancestry. Hum. Biol., 39: 368-373.

Singh S. 1968. A measure of asymmetry in finger ridge counts. Acta Genet. (Basel), 18: 599-605.

RIASSUNTO

Analisi Strutturale dei Conteggi dei Dermatoglifi Digitali di Europei Australiani Mediante Analisi Multivariata

Viene usata un'analisi multivariata per lo studio delle caratteristiche strutturali dei conteggi dermatoglifici digitali. Vi è una differenza significativa fra i conteggi delle due mani, prevalentemente a causa del primo e del quarto dito. Vi è asimmetria nella matrice di covarianza dei conteggi. Le correlazioni fra dita sono significative e la riduzione di correlazione con l'aumento della distanza fra dita non è significativa.

RÉSUMÉ

Analyse Structurelle des Comptes des Crêtes Digitales d'Australiens Européens Moyennant Analyse Multivariée

Une analyse multivariée est utilisée dans l'étude des caractéristiques structurelles des comptes des crêtes digitales. Une différence significative existe entre les comptes des deux mains, surtout à cause du premier et du quatrième doigt. Il y a asymétrie dans la matrice de covariance des comptes. Les corrélations entre doigts sont significatives et la réduction des corrélations avec l'augmentation de la distance entre les doigts n'est pas significative.

ZUSAMMENFASSUNG

Strukturanalyse mittels multivariierter Analyse der Zählungen der Fingerlinien bei europäischen Australiern

Zur Untersuchung der Strukturmerkmale bei den Zählungen der Fingerlinien wird eine multivariierte Analyse angewandt. Die Zählungen der beiden Hände sind, hauptsächlich aufgrund des ersten und des vierten Fingers, wesentlich verschieden. Es besteht eine Asymmetrie in der Kovarianz-Matrize der Zählungen. Die Korrelationen zwischen den einzelnen Fingern sind wesentlich, während die Verminderung der Korrelation bei zunehmender Distanz zwischen den Fingern nicht bedeutsam ist.

Dr. Sardool Singh, Medical Research Department, Kanematsu Memorial Institute, Sydney Hospital, Sydney, Australia.