THE FINGER PRINTS OF TWINS.

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(With Plates XVII, XVIII.)

CONTENTS.

I. Introduction.

The material dealt with in this paper consists of the finger prints of 100 pairs of same-sexed twins, 50 pairs diagnosed as identicals and 50 pairs as fraternals. The methods of diagnosis are described in an earlier paper (Newman, 1928). The data presented in this paper constitute an important item in diagnosis and will serve to show how, in many cases, finger patterns serve as evidence of monozygosity.

The foundations of our modern study of finger prints were laid by Galton in 1892 with the publication of his classic volume on finger prints.

As the result of this pioneer study, increased interest has been manifested in finger prints, and a great deal of detailed technical work has been done, chiefly by criminologists. For the most part these studies have dealt with the classification and cataloguing of finger prints for identification of criminals. Consequently very little has been done towards solving the biological problems involved.

One of the most important biological studies of finger prints since that of Galton was published in this *Journal* by Kristine Bonnevie (1924). Her study was based upon the finger prints of 24,518 Norwegian criminals. She discusses and gives examples of the main pattern-types and the various combinations of these. The three main pattern-types in Galton's classification, which is employed by Bonnevie, are whorls, loops and arches. The whorls have two triradii, the loops one triradius, and the arches none. Evidently the whorl is the most complete expression of digital pattern, and is usually considered to be phylogenetically the most primitive; the loop is a partially reduced whorl; while the arch is the most reduced of all, and may be considered as a vestigial pattern, though phylogenetically the most advanced.

Statistical studies of the relative frequency of the three main pattern-types were made by Bonnevie, first for the total of all fingers, and secondly according to their distribution among the five fingers. In her material 25·65 per cent. of all fingers show whorls, 66·95 per cent. loops, and 7·4 per cent. arches. The distribution of the various types of pattern on the five fingers of the two hands revealed many striking peculiarities, and these run somewhat the same for all races, although significant minor racial differences exist. Inasmuch as the present paper concerns itself largely with these matters, we shall not review all of Bonnevie's data here, but shall reserve most of them for later discussion.

Bonnevie also finds that the phenotypical character of finger patterns depends upon the interaction of three independently varying genetic factors: (1) the tendency to twist; (2) the general shape of pattern (circular or elliptical); and (3) the quantitative value as determined by the number of ridges involved in the pattern.

Thirty-one pairs of twins, all same-sexed, were studied by Bonnevie with reference to the quantitative values of the finger patterns. Fifteen of these pairs were classed as monozygotic, though the criteria for such classification were rather indefinite. These 15 pairs showed a coefficient of correlation of $+ 0{\cdot}924 \pm 0{\cdot}037$, a figure which, in the light of our results, suggests that a few fraternal pairs might have been included among the identicals.

Without further preliminary review of Bonnevie's monograph, we may now proceed with the presentation of our own data.

II. THE DISTRIBUTION OF FINGER PRINT PATTERN-TYPES IN OUR TWINS.

In our 100 pairs of twins taken as a whole the three main pattern-types occurred in the following percentages: whorls 34 per cent., loops 61·25 per cent., arches 4·75 per cent. Our Chicago material is seen to show a considerably higher percentage of loops and a considerably lower percentage of arches than that of Norwegian criminals as studied by Bonnevie.

In another part of her paper Bonnevie gives a table showing the statistical occurrence of pattern-types (whorls, loops and arches) in nine different races. In this table it is noteworthy that the Norwegian criminal data run the lowest of all in percentage of whorls, the highest in percentage of arches and second to highest in percentage of loops. It is not surprising then that our group of twins, taken from the environs of Chicago and derived from many races, should differ in percentages of pattern-types from the pure Norwegian group, and we might expect them to approximate very closely the average for the nine races listed in Bonnevie's table (p. 19). This expectation is actually realised. Our figures also agree closely with those of Cummins and Midlo (1927) for 100 European-Americans, which show 32·1 per cent. whorls, 62·7 per cent. loops, and 5·2 per cent. arches.

In Tables I and II (p. 418), showing the distribution of pattern-types upon the various digits of 100 identical twins and 100 fraternal twins, three types of whorls and two types of loops are listed separately, and the explanation of this will be given in the next section of the present paper. It will be noted further that the identical twins average much higher in whorls, much lower in arches, and slightly lower in loops than the fraternal twins. These differences may or may not be significant. The number of individuals, only 200 altogether, is probably not large enough to lend much statistical importance to differences of this sort. Two or three less pairs of identical twins with whorls on all fingers would very materially have lowered the percentage of whorls in the whole group, while two or three more pairs showing a preponderance of arches would have brought up the percentage of arches to that of the fraternal twins. Hence it seems fair to consider these differences between identical and fraternal twins as without statistical significance, and to lump together

TABLE I.

Distribution of pattern-types on the digits of 50 pairs of identical twins.

Type of pattern	Digits of right hand I	II	III	IV	V	Total of right	Digits of left hand I	II	III	IV	V	Total of left	Total of both
Ulnar whorls	34	19	17	29	17	116	26	18	15	31	16	106	222
Radial whorls	1	21	2	2	0	26	0	25	0	0	0	25	51
Symmetrical whorls	11	8	4	25	8	56	9	7	6	18	5	45	101
Ulnar loops	50	32	72	42	75	271	60	26	72	48	79	285	556
Radial loops	0	17	1	0	0	18	0	22	1	0	0	23	41
Arches	4	3	4	2	0	13	5	2	6	3	0	16	29
All	100	100	100	100	100	500	100	100	100	100	100	500	1000

TABLE II.

Distribution of pattern-types on the digits of 50 pairs of fraternal twins.

Type of pattern	Digits of right hand I	II	III	IV	V	Total of right	Digits of left hand I	II	III	IV	V	Total of left	Total of both
Ulnar whorls	23	15	9	26	13	86	16	14	10	28	14	82	168
Radial whorls	1	11	1	2	1	16	1	8	1	0	0	10	26
Symmetrical whorls	15	9	12	23	4	63	16	7	10	14	2	49	112
Ulnar loops	56	28	68	46	82	280	58	31	62	57	84	292	572
Radial loops	0	23	0	2	0	25	0	28	3	0	0	31	56
Arches	5	14	10	1	0	30	9	12	14	1	0	36	66
All	100	100	100	100	100	500	100	100	100	100	100	500	1000

the data from the two tables in dealing with the problem of reversed asymmetry in patterns, a problem taken up in the subsequent section.

One other item in the distribution of pattern-types deserves some attention, namely, the unequal distribution of whorls, loops and arches in the two hands, rights and lefts. In Bonnevie's data there was a distinct preponderance of whorls on the right hands (57·27 per cent. on rights, and 42·73 per cent. on lefts); a distinct preponderance of both loops and arches on left hands (52·43 per cent. of loops on lefts, and 47·57 per cent. on rights; 53·26 per cent. of arches on lefts, and 46·74 per cent. on rights). In such large numbers of individuals these differences are undoubtedly significant, and this significance is enhanced by the fact that in our own collection of twins this same relative distribution of pattern-types holds for each group, identicals and fraternals. In the 100 identical twins 53·21 per cent. of whorls occur on right and 46·79 per cent. on left hands; 51·59 per cent. of loops on left and 48·41 per cent. on right hands; 55·17 per cent. of arches on left and 44·83 per cent. on right hands. In the 100 fraternal twins 53·93 per cent. of whorls occur on right and 46·07 per cent. on left hands; 51·43 per cent. of loops on left and 48·57 per cent. on right hands; 54·54 per cent. of arches on left and 45·46 per cent. on right hands.

The difference in distribution of pattern-types in the two hands is not very great, but it is strikingly consistent and doubtless furnishes us with another example of the workings of the asymmetry mechanism. In general the right side of the body of vertebrates, as well as other groups, is the inferior side and it may be significant that there is a consistent preponderance of the most primitive patterns (whorls) on the inferior side and an equal preponderance of the most advanced patterns, especially arches, on the superior side. Here again we see another factor other than heredity or environment, an intrinsic epigenetic factor causing differences in the expression of genetically determined characters. This factor, the asymmetry mechanism, must be held responsible for part of the relatively slight differences in digital patterns between the individuals of pairs of monozygotic twins.

The conclusions reached here are further strengthened by the fact that in identical twins the total of quantitative values of ridges in patterns is definitely greater in the right hands than in the left hands. The same is equally true for the fraternal twins. Reduction in numbers of ridges in patterns means a more advanced condition phylogenetically and, once more, it is the left side that shows the more advanced condition. The figures that lead to this conclusion are given later in the section dealing with quantitative values of finger patterns (see Tables V and VI).

This asymmetry situation is in striking contrast to that found in palm patterns, in which the left hand shows the more primitive, or fully expressed condition, and the right hand the more advanced, or poorly expressed condition. A discussion of this situation appears in a very recent paper by the present writer (Newman, 1930).

(*a*) *The distribution of radial loops on the various fingers.*

Loops constitute the commonest pattern in human fingers and the great majority of these loops, in our twin material 92·08 per cent., open upon the ulnar, or little finger, side of the digit. These are called "ulnar loops" and are designated *U* in Tables III and IV. There is thus a pronounced ulnar asymmetry of the whole hand, most of the patterns turning towards the ulnar side of the hand. The remaining loops, in our material 7·92 per cent. of all loops, involving 97 finger patterns all told, are reversed loops opening on the radial side of the digit. These are called "radial loops" and are designated *R* in Tables III and IV.

Radial loops, a relatively rare finger pattern, found in less than 5 per cent. of all fingers, have a most extraordinary distribution, being almost entirely confined to digit II, the index finger, 80 out of 97 (82·47 per cent.) of such patterns being on that digit.

Bonnevie also noted and discussed the fact that, in Norwegian criminals, loops as a rule open on the ulnar side of the finger. In her collection 5·91 per cent. of all loops open on the radial side, showing a reversal of the usual asymmetry. Of the radial loops 82·57 per cent. occurred on the index finger. A reason for this is suggested by Bonnevie and discussed later.

(*b*) *The incidence of radial whorls on the various fingers.*

We also noticed an interesting phenomenon, largely overlooked by Bonnevie, namely, that whorls also show ulnar and radial asymmetry. Very frequently the whorls are twisted as a whole in a clockwise or counter-clockwise direction; or else the ridges, instead of being arranged in concentric circles, form a more or less complete spiral that, beginning on the outside and moving centralwards, turns in a clockwise or counter clockwise direction. In prints of finger patterns of the right hand the direction of twist or spiral, as shown in prints, is typically clockwise; in those of the left hand, counter-clockwise. Thus counter-clockwise whorls on right hands and clockwise whorls on left hands are called "radial whorls," and constitute instances of reversed asymmetry belonging to the same category as "radial loops." Hence either counter-clockwise whorls in right-hand finger prints or clockwise whorls in left-hand finger prints will be represented by the symbol *Wr*; while clockwise whorls in right-hand finger prints and counter-clockwise whorls in left-hand finger prints will be denoted by *Wu*, since they twist in an ulnar direction.

Sometimes we find a small whorl enclosed within a larger loop, the loop opening in either an ulnar or a radial direction (Plate XVII, fig. 5). Such a pattern is called a whorl, but the asymmetry of the enclosing loop must also be recorded. Thus a whorl in an ulnar loop is designated *Wlu*; one in a radial loop *Wlr*. Classified also as whorls, since they have two triradii, are double loops that are more or less spirally twisted about each other in either a clockwise or a counter-clockwise direction (Fig. 9). Such patterns are designated *Wdu* or *Wdr*, according to whether the twist is in an ulnar or a radial direction.

Of the total number of whorls 57·35 per cent. are ulnar, 11·32 per cent. are radial, and 31·32 per cent. are without definite twist or spiral, and are classified as symmetrical and designated *W*. Of the 77 radial whorls in the 100 pairs of twins, 65 (84·41 per cent.) occur on digit II. For some unknown reason radial whorls are considerably more frequent in our identical twins, while radial loops are somewhat more frequent in our fraternal twins.

The total incidence of radial loops and of radial whorls is remarkable in that 155 out of 174, or over 89·09 per cent., occur on the index finger, digit II, and the rest are scattered among the other four fingers: 3 in digit I, 9 in digit III, 6 in digit IV, and only 1 in digit V. It may also be significant that in only 1 out of 100 sets of twins does a radial loop or whorl occur on any of the other digits, except when radial loops or whorls occur on one or both the index fingers of at least one of the twins. Also there are only 3 of the 200 hands in which a radial loop or whorl occurs on digits I, III, IV or V without also occurring on digit II of the same hand. When radial patterns occur on more than one digit, the usual arrangement is that such patterns occur on digits II and III, or II and IV. In one instance (pair 43) radial whorls appear on digit II in all four hands of the twin pair, and in the right hand of twin B radial whorls occur on three digits, II, III and IV, making six radial whorls in one pair of identical twins.

The tendency towards radial patterns seems to be strongly hereditary, as it occurs on both individuals of 21 out of 50 pairs of identical twins. Even more remarkable is the fact that radial patterns occur in all four index fingers in seven pairs of identical twins.

The distribution of radial patterns in the two hands is not significantly different, 85 occurring on the right hand and 89 on the left, although in

Bonnevie's material attention is called to the fact that radial loops are commoner on the right hands.

(c) *Earlier interpretations of the mysterious distribution of radial patterns.*

The peculiar distribution of radial loops has been noted by writers previous to Bonnevie, and has been variously interpreted. Wilder (1904) seems to have been the first to call special attention to their mysterious incidence. In his monograph, "Duplicate Twins and Double Monsters," he noted "the mysterious reversal of index patterns in one hand or the other" of duplicate twins, and was inclined to consider it a consequence of twinning, a sort of vestige of asymmetry reversal belonging to the same category as *situs inversus viscerum*. "But why the transposition should affect one finger alone, or why that finger should always be the index, these are at present questions beyond solution." In his 1916 paper, "Palm and Sole Studies," he stated that in true duplicate twins one finds as a condition "not absolutely constant, but frequently noted, a reversal of the pattern of the index fingers in the two individuals, affecting either the two right hands or the two left hands, or occasionally both sets."

In *The Biology of Twins* (1917) the present writer followed Wilder in interpreting radial patterns of index fingers as evidence of mirror-imaging, or asymmetry reversal, resulting from monozygotic twinning, an interpretation that must be entirely abandoned in view of the following facts:

One need only to refer to Table II, in which the distribution of pattern-types of 50 pairs of fraternal twins is shown, to realise *that radial patterns have nothing whatever to do with monozygotic twinning.* In fact, radial patterns occur nearly as frequently in dizygotic as they do in monozygotic twins. Thus in 50 pairs of monozygotic twins 92 radial patterns occur, and in 50 pairs of dizygotic twins 82 such patterns are found.

Bonnevie also found that, in her experience, radial patterns did not occur any more frequently in twins than in other persons. It seems clear then that the occurrence of radial patterns and their concentration on index fingers cannot be explained as a result of monozygotic twinning.

Bonnevie realised this and cast about for a more satisfactory explanation. Following Wilder, Whipple, and others, she is inclined to look upon the direction of papillary ridges as playing an adaptive rôle as friction ridges. These ridges are believed to be placed "at right angles to the direction of pressure against the object to be touched." "Looking at the human hand," she says, "we should expect to find a functional adaptation above all upon digit II, this finger being of a use more varied and extensive than any other finger.... Remembering the position of the second finger when working alone in opposition to the first one (the thumb), it seems evident that the radial side of digit II and its papillary pattern should be of great importance whether the function of those lines be of a mechanical or sensory nature. Among the different pattern-types, therefore, the ulnar loop will be the one *least* useful, its ridges running away from the radial side of the finger.... But no other pattern would, for the special use of the second finger, serve better than radial loops, the ridges on the radial side of the finger here being combined into pairs as arms of one and the same loop."

Apart from the fact that this type of explanation carries an unfortunate and unsupported Lamarckian implication, namely, that the direction of papillary ridges has been determined by the direction of pressures against objects and that such induced somatic modifications have become hereditary, there are other, more cogent, reasons for objecting to it.

While the argument that radial *loops* offer a better friction surface between index finger and thumb might seem to have some reasonable basis, what functional explanation can be offered for the equal prevalance of radial *whorls* on this finger? Surely no advantage could be gained by having a pattern twisted or spirally coiled counter-clockwise rather than clockwise, unless the position of the whole pattern were moved towards the radial side of the finger: and this is not usually the case.

Another crucial argument against Bonnevie's explanation of radial patterns inheres in the fact that, while radial loops are almost confined to digit II and are highly characteristic of that digit, ulnar loops, spoken of as the "least useful" pattern for that particular finger, are always more numerous than the supposedly highly advantageous radial loops. Thus there occur on the index fingers of our 100 pairs of twins 117 ulnar loops as compared with only 90 radial loops. If the advantage of radial loops be real and the effects of use inherited, why do we find more ulnar than radial loops? The direction of radial loops therefore could hardly be explained as the result of the inheritance of the effects of use unless a similar explanation be offered for that of the more numerous ulnar loops on the same digit.

(*d*) *A new interpretation of radial patterns.*

As the result of the study of a series of human hands with supernumerary fingers, and especially of double or nearly double hands, the writer (Newman, 1923) in his book *The Physiology of Twinning* came to the conclusion that the hand is a modified symmetrical structure in which the major plane of symmetry falls between the thumb and the index finger. The hand is looked upon as a structure that has undergone asymmetrical doubling, or twinning, the first step in twinning giving rise to the thumb, on the radial side, and the primordium of the remaining digits on the ulnar side. More powerful than the mirror-image symmetry between the thumb and the rest of the hand is the deep-seated ulnar asymmetry of the whole appendage that has been shown by Harrison and others, for Amphibia, to be established prior to the visible formation of limb buds. This overpowering ulnar asymmetry nearly always determines the asymmetry of the thumb patterns. In our twin material there were no radial loops in 400 thumbs and only 3 radial whorls, indicating that the thumb is dominated by the ulnar asymmetry of the whole hand. Nearly all of the radial loops and whorls are found on the index finger, which in its origin is the twin of the thumb. Occasionally digits III and IV, along with digit II, of the same hand, assume a radial asymmetry, suggesting that at one time the primordium of the four fingers (II, III, IV, V) stood over against the thumb as its twin partner.

More commonly than not, however, the overpowering ulnar asymmetry of the whole appendage wipes out the reversed (radial) asymmetry of the fingers, acquired as the result of the first step in twinning, and imposes upon it the ulnar asymmetry of the whole hand. Evidently there is a conflict between the tendency to retain the mirror-image symmetry, resulting from the first dichotomous division of the distal portion of the limb bud, and the powerful ulnar asymmetry of the whole appendage. Sometimes, the original asymmetry prevails over most of the hand, as when two or even three fingers show reversed (radial) asymmetry of pattern; frequently, however, the reversed, or radial, asymmetry is retained only on the index finger which lies closest to the thumb; but even more commonly still, the original mirror-image asymmetry is completely obliterated by the ulnar asymmetry of the whole hand.

(*e*) *An interpretation of arches and symmetrical whorls.*

Arches do not seem at first to fit into such a scheme as that just discussed. Bonnevie, however, found arches most numerous on digit II, 44·5 per cent. of all arches occurring on this digit. Arches are also common on digit III, 29·81 per cent. of all arches appearing on that digit. In my somewhat limited collection of finger patterns the incidence of arches on digits II and III slightly favours the latter, and I find that there are only a few less arches on digit I than on digit II. Doubtless Bonnevie's figures, since they deal with much larger numbers of cases, are more representative of the average situation than mine, and therefore may be accepted as a basis of discussion. The arch may be looked upon as either a rudimentary pattern (a pattern reduced to its lowest terms) or as a pattern produced by partial asymmetry reversal. Many arches occur in which a high, medium, or low perpendicular ridge proceeds up the centre of the pattern, resembling the centre pole of a tent. The other ridges arch over this central upright ridge as a tent roof arches over its centre pole. Such arches are appropriately called "tented arches." In my experience the arches occurring on digit II are mostly of this tented form, except in the cases of those hands in which flat arches prevail on most of the digits. As a rule, an arch occurring on a hand in which high loops or whorls prevail will be a tented arch. The prevalence of high-tented arches on digit II seems to me to signify partial reversal of asymmetry. Such a pattern may be looked upon as the resultant of a drawn battle between opposed forces; that of mirror-imaging between twin components (thumb and index finger) and that of the ulnar asymmetry of the whole appendage. Thus a tented arch may be a compromise between a radial and an ulnar loop. It seems probable also that symmetrical whorls may be a compromise between radial and ulnar asymmetrical whorls. A good many of the whorls designated *W* in my tables are slightly asymmetrical, but not very distinctly so.

The hypothesis here offered in explanation of radial patterns and their concentration on the index finger seems to the writer to approach more nearly a rationalisation of the situation than those previously presented. It agrees with, and helps to explain, the normal process of limb development, as well as the production of double or reduplicated limbs. Ordinarily, when the hand grows in its normal organic environment, its twinning tendency is more or less checked and overruled by the dominance of the body as a whole, and incipient twinning is modified by the overpowering asymmetry of position of the appendage with reference to the bodily axes. When, however, a limb bud is transplanted to a foreign position, it grows more or less independently, for a time at least, and frequently goes ahead with its twinning to the extent of producing twin limbs, each with normal digits arranged in mirror-image relation to one another. Thus a twinned, or reduplicated, limb may be thought of as a result of the physiological isolation of a limb rudiment from its organic environment, resulting in a freedom of the rudiment to complete its natural tendency to undergo twinning. In the normally developing limb rudiment, however, the twinning process is almost completely overruled, and a hand develops as a single organ with a pronounced ulnar asymmetry, the result of its relation to the side of the body on which it grows. Only in the frequent radial patterns on the index finger do we find evidence that originally the thumb and the four fingers once held the relation to each other of twin components.

III. Comparison of finger print patterns of identical and fraternal twins.

Two different modes of comparison may be made between the two sets of twins (identical and fraternal). They may be compared with respect to the qualitative characters of their patterns, and with respect to the quantitative values of the patterns as based on a count of the number of papillary ridges involved in the pattern. For purposes of studying the qualitative resemblances and differences in the two sets of twins I have prepared the rather extensive Tables III and IV in which the type of pattern is indicated for every finger of the 200 individuals.

Key to Tables III and IV.

The following key will be necessary in the interpretation of the symbols used in the tables:

A and B (1st column)	= the two individuals of a twin pair.
M. and F. (2nd column)	= male and female respectively.
R., L., A. (3rd column)	= right-handed (R), left-handed (L. fully; l. partially), ambidextrous (A.).
+ and − (4th column)	= clockwise and counter-clockwise hair whorl, respectively.
(+ −) (4th column)	= double hair whorl, half of which is clockwise, other half counter-clockwise.
R and *U*	= single radial and ulnar loops.
W	= symmetrical whorls (Plate XVII, fig. 1).
Wu and *Wr*	= whorls with ulnar or radial twist or spiral (Plate XVII, figs. 2, 3, 4, 7, 8).
Wlu and *Wlr*	= whorls enclosed within ulnar or radial loops (Plate XVII, figs. 5, 6).
Wdu and *Wdr*	= double loops (sometimes called twin loops or lateral pocket loops) with two triradii, twisted in ulnar or radial direction (Plate XVII, fig. 9).
Ua and *Ra*	= ulnar or radial loops that are vestigial, or almost arches.
A	= arches.

In Table III the twin pairs are arranged in the order of their degrees of resemblance, the most nearly identical in all respects being first, and the least similar being last. This order is explained in an earlier paper (Newman, 1928).

An analysis of these tables leads to a number of significant conclusions. Wilder (1904) on the basis of 9 pairs of duplicate twins came to the conclusion that the palm patterns show a much higher degree of symmetry between right and left hands of such twins than is the case in ordinary individuals. Bonnevie studied the degree of symmetry in finger prints in connection with 15 pairs of twins adjudged by her to be monozygotic, and came to the conclusion that "the symmetry of pattern values between right and left hands of (identical) twins is not essentially different from that of single individuals."

Assuming that our 50 pairs of fraternal twins (Table IV) represent 100 single individuals, let us compare the degree of correspondence of their right and left hands (finger for finger) with that shown in identical twins (Table III).

In both sets we may consider symmetry perfect if homologous digits of the two hands of an individual correspond in type of pattern, and are therefore represented by the same symbol. In identical twins there are 17 cases with all five digits in both hands of an individual alike, 32 cases with four digits alike, 35 with three alike, 13 with two alike, and 3 alike in one digit only. In fraternal twins there are 15 individuals with all five digits alike in both hands, 34 with four alike, 38 with three alike, 8 with two alike, and 5 alike in one digit only. Thus there is no significant difference to be noted between identical and fraternal twins in the distribution of these various grades of symmetry between the hands of the same individual. If we add up the total of fingers alike in right and left hands of the same individuals, we find that there are 347 fingers alike in the two hands in identical twins as compared with 326 in fraternal twins. The difference is certainly not great, though it favours slightly the identical twins. Thus it appears that our data are rather more in accord with Wilder's statement than with Bonnevie's, though the difference is perhaps not significant.

Using the same method of comparison, we may determine whether in identical twins the resemblance between the hands of two individuals of any pair is greater or less than that between right and left sides of the same individual.

(a) Comparison between hands of same individual and those of two individuals of a pair in identical twins.

If we compare the correspondences of right hands with rights, and left hands with lefts, we find that in *identical twins* there are 27 cases in which all five fingers of the two right hands or of the two left hands are alike, 37 cases with four fingers alike, 27 with three fingers alike, 8 with two fingers alike, and 1 with only one finger alike in two left hands. This shows a same-sided (homolateral) correspondence of 351 fingers indicating a somewhat higher correspondence, in the case of identical twins,

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TABLE III.

Finger print formulae of 50 pairs of identical twins arranged in the order of their closeness of resemblance.

				Finger print formulae									
				Digit (right hand)					Digit (left hand)				
No.	Sex	Handed-ness	Hair whorl	I	II	III	IV	V	I	II	III	IV	V
62 A	M.	R.	+	*Wu*	*Wr*	*U*	*Wu*	*Wu*	*Wu*	*R*	*Wlu*	*Wu*	*Wu*
B		R.	+	*Wu*	*Wu*	*U*	*Wu*	*Wu*	*Wu*	*Wr*	*Wu*	*Wu*	*Wu*
98 A	F.	R.	+	*U*	*U*	*U*	*U*	*U*	*U*	*R*	*U*	*U*	*U*
B		R.	+	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*
63 A	M.	R.	+	*W*	*Wr*	*Wr*	*W*	*W*	*W*	*Wr*	*Wu*	*W*	*W*
B		R.	–	*W*	*Wu*	*Wu*	*W*	*W*	*W*	*W*	*Wu*	*W*	*W*
40 A	M.	R.	(+ –)	*Wu*	*U*	*Wu*	*W*	*Wu*	*U*	*Wr*	*W*	*W*	*W*
B		R.	+	*Wu*	*U*	*U*	*W*	*Wu*	*U*	*Wr*	*U*	*W*	*Wlu*
3 A	M.	R.	?	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*
B		R.	?	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*
9 A	F.	R.	–	*U*	*U*	*U*	*U*	*U*	*Ua*	*Ua*	*U*	*U*	*U*
B		R.	+	*Ua*	*Ua*	*U*	*U*	*U*	*A*	*Ra*	*U*	*U*	*U*
80 A	F.	R.	+	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*A*	*U*	*U*
B		R.	+	*U*	*U*	*U*	*U*	*U*	*U*	*R*	*U*	*A*	*U*
67 A	M.	R.	+	*Wr*	*R*	*U*	*U*	*U*	*W*	*R*	*U*	*U*	*U*
B		l.	+	*Wu*	*Wr*	*U*	*U*	*U*	*W*	*R*	*U*	*U*	*U*
55 A	M.	R.	+	*U*	*Ua*	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*
B		R.	+	*U*	*Ua*	*U*	*U*	*U*	*U*	*Ua*	*U*	*U*	*U*
35 A	M.	R.	–	*Wu*	*Wr*	*U*	*W*	*U*	*Wu*	*Wu*	*U*	*W*	*U*
B		R.	+	*Wu*	*Wr*	*W*	*W*	*U*	*Wu*	*Wu*	*U*	*U*	*U*
96 A	M.	R.	–	*Wu*	*Ra*	*U*	*U*	*U*	*Wu*	*Ua*	*Ua*	*U*	*U*
B		R.	+	*Wu*	*Ra*	*U*	*U*	*U*	*W*	*U*	*U*	*U*	*U*
73 A	F.	l.	–	*U*	*Ua*	*Ua*	*Ua*	*U*	*U*	*R*	*A*	*A*	*U*
B		A.	–	*U*	*Ua*	*A*	*A*	*U*	*U*	*R*	*A*	*A*	*U*
102 A	F.	R.	–	*W*	*W*	*U*	*W*	*W*	*U*	*W*	*U*	*W*	*Wu*
B		R.	+	*Wu*	*W*	*U*	*W*	*W*	*U*	*Wu*	*U*	*W*	*Wu*
25 A	M.	R.	–	*W*	*W*	*W*	*W*	*U*	*Wu*	*W*	*W*	*W*	*U*
B		R.	–	*W*	*W*	*W*	*W*	*U*	*W*	*W*	*W*	*W*	*U*
30 A	F.	R.	+	*U*	*A*	*U*	*U*	*U*	*U*	*R*	*W*	*Wlu*	*U*
B		R.	+	*U*	*R*	*U*	*Wlu*	*U*	*U*	*Wr*	*Wu*	*Wlu*	*U*
23 A	F.	A.	+	*U*	*Wdu*	*U*	*Wu*	*Wu*	*U*	*Wdu*	*U*	*Wu*	*U*
B		A.	+	*U*	*Wdu*	*Wu*	*U*	*Wu*	*U*	*Wdu*	*U*	*U*	*U*
94 A	F.	R.	+	*Wu*	*W*	*U*	*Wu*	*U*	*U*	*Wu*	*U*	*Wu*	*U*
B		L.	+	*U*	*Wlr*	*U*	*Wu*	*U*	*Wu*	*Wu*	*U*	*Wu*	*U*
68 A	F.	R.	–	*Wu*	*Wr*	*Wu*	*Wu*	*Wu*	*Wu*	*Wlr*	*U*	*Wu*	*U*
B		R.	+	*Wu*	*Wu*	*Wu*	*Wu*	*U*	*Wu*	*Wu*	*U*	*Wu*	*U*
49 A	F.	l.	–	*Wu*	*Wr*	*Wu*	*Wu*	*U*	*Wu*	*Wlr*	*U*	*Wu*	*U*
B		R.	+	*Wu*	*Wu*	*U*	*Wu*	*U*	*Wu*	*Wlr*	*U*	*W*	*U*
13 A	F.	R.	–	*U*	*Ua*	*U*	*U*	*U*	*U*	*R*	*U*	*U*	*U*
B		L.	+	*U*	*U*	*U*	*U*	*U*	*U*	*R*	*R*	*U*	*U*
78 A	M.	L.	+	*U*	*R*	*U*	*U*	*U*	*U*	*R*	*U*	*U*	*U*
B		R.	+	*U*	*R*	*U*	*U*	*U*	*U*	*R*	*U*	*U*	*U*
87 A	M.	A.	–	*U*	*U*	*U*	*U*	*U*	*U*	*R*	*U*	*Wu*	*Wu*
B		A.	+	*U*	*U*	*U*	*W*	*U*	*U*	*U*	*U*	*W*	*Wu*
43 A	M.	l.	–	*U*	*Wr*	*U*	*W*	*Wu*	*U*	*Wr*	*U*	*W*	*U*
B		l.	+	*U*	*Wr*	*Wr*	*Wr*	*W*	*U*	*Wr*	*U*	*W*	*U*
38 A	F.	l.	–	*U*	*U*	*U*	*Wlu*	*U*	*U*	*Wlr*	*U*	*Wlu*	*U*
B		l.	–	*U*	*U*	*U*	*Wlu*	*U*	*U*	*U*	*U*	*Wlu*	*U*

TABLE III *continued.*

No.	Sex	Handed-ness	Hair whorl	Finger print formulae: Digit (right hand) I	II	III	IV	V	Digit (left hand) I	II	III	IV	V
79 A	M.	R.	+	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*
B		L.	+	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*
72 A	M.	L.	+	*Wu*	*Wr*	*U*	*W*	*U*	*U*	*Wu*	*U*	*U*	*U*
B		R.	−	*Wu*	*R*	*U*	*W*	*U*	*U*	*Wu*	*U*	*U*	*U*
99 A	M.	R.	+	*Wu*	*R*	*U*	*U*	*U*	*U*	*U*	*U*	*Wlu*	*U*
B		R.	+	*Wu*	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*
33 A	M.	L.	+	*Wu*	*Wr*	*U*	*U*	*U*	*Wu*	*Wu*	*U*	*Wu*	*U*
B		R.	+	*U*	*R*	*U*	*U*	*U*	*U*	*Wr*	*U*	*U*	*U*
53 A	M.	R.	+	*Wu*	*Wu*	*U*	*Wu*	*U*	*Wu*	*U*	*U*	*Wu*	*U*
B		L.	+	*U*	*R*	*U*	*U*	*U*	*Wu*	*Wr*	*U*	*U*	*U*
44 A	M.	L.	+	*U*	*Wlr*	*U*	*Wu*	*Wu*	*U*	*Wlr*	*U*	*U*	*U*
B		R.	+	*U*	*Wlr*	*R*	*Wu*	*U*	*U*	*Wlr*	*U*	*U*	*U*
2 A	F.	L.	?	*W*	*Wu*	*Wu*	*Wu*	*Wu*	*Wu*	*Wu*	*Wu*	*Wu*	*Wu*
B		R.	?	*W*	*Wu*	*Wu*	*Wu*	*Wu*	*Wu*	*Wu*	*Wu*	*Wu*	*Wu*
91 A	F.	R.	+	*U*	*Wu*	*U*	*U*	*U*	*U*	*U*	*U*	*Wlu*	*U*
B		R.	+	*Wu*	*U*	*U*	*U*	*U*	*U*	*Wu*	*U*	*Wlu*	*U*
100 A	M.	R.	+	*U*	*U*	*U*	*U*	*U*	*U*	*R*	*U*	*U*	*U*
B		R.	+	*U*	*R*	*U*	*Wlu*	*U*	*U*	*U*	*U*	*U*	*U*
101 A	M.	R.	+	*Wu*	*Wu*	*Wu*	*Wu*	*Wu*	*Wu*	*W*	*Wu*	*Wu*	*Wu*
B		L.	+	*Wu*	*Wr*	*Wu*	*W*	*W*	*Wu*	*Wr*	*Wu*	*Wu*	*Wu*
70 A	M.	R.	+	*Wu*	*R*	*U*	*U*	*U*	*Wu*	*R*	*U*	*U*	*U*
B		L.	+	*Wu*	*R*	*U*	*U*	*U*	*Wu*	*R*	*U*	*U*	*U*
37 A	M.	R.	+	*U*	*U*	*U*	*U*	*U*	*A*	*Wlr*	*U*	*U*	*U*
B		l.	+	*U*	*Wlr*	*U*	*Wlr*	*U*	*A*	*Wlr*	*U*	*U*	*U*
34 A	M.	R.	+	*A*	*A*	*A*	*U*	*U*	*A*	*A*	*A*	*U*	*U*
B		l.	+	*A*	*Ua*	*Ua*	*U*	*U*	*A*	*A*	*A*	*U*	*U*
28 A	F.	R.	−	*W*	*Wlr*	*U*	*Wu*	*U*	*W*	*Wlr*	*U*	*U*	*U*
B		R.	+	*W*	*Wlr*	*U*	*Wu*	*U*	*W*	*Wlr*	*U*	*Wu*	*U*
7 A	M.	l.	−	*U*	*R*	*U*	*W*	*U*	*U*	*U*	*U*	*W*	*U*
B		l.	+	*U*	*R*	*U*	*W*	*U*	*U*	*R*	*U*	*W*	*U*
6 A	F.	R.	+	*Wu*	*U*	*U*	*W*	*U*	*Wu*	*R*	*U*	*U*	*U*
B		R.	+	*Wu*	*Wu*	*U*	*U*	*U*	*Wu*	*Wlr*	*U*	*U*	*U*
97 A	F.	R.	+	*Wu*	*Wu*	*Wu*	*Wu*	*Wu*	*U*	*U*	*Wu*	*Wu*	*Wu*
B		R.	+	*W*	*Wu*	*Wu*	*Wu*	*Wu*	*W*	*Wr*	*Wu*	*Wu*	*U*
17 A	F.	R.	+	*Wu*	*Wu*	*Wu*	*W*	*U*	*Wu*	*Wu*	*Wu*	*Wu*	*U*
B		R.	+	*Wu*	*Wu*	*Wu*	*W*	*U*	*U*	*W*	*Wu*	*Wu*	*U*
14 A	F.	R.	−	*A*	*Wlr*	*Wu*	*W*	*U*	*U*	*Wlr*	*W*	*W*	*U*
B		R.	+	*A*	*Wlr*	*Wu*	*Wu*	*U*	*U*	*Wlr*	*Wu*	*Wu*	*U*
15 A	M.	R.	+	*W*	*W*	*W*	*Wu*	*W*	*Wu*	*Wu*	*Wu*	*W*	*W*
B		R.	−	*Wu*	*Wu*	*Wu*	*W*	*W*	*Wu*	*W*	*W*	*W*	*W*
69 A	M.	R.	+	*Wu*	*Wlr*	*U*	*Wu*	*U*	*U*	*U*	*U*	*U*	*U*
B		R.	+	*Wu*	*U*	*U*	*W*	*U*	*Wu*	*U*	*U*	*U*	*U*
24 A	M.	R.	+	*U*	*Wu*	*U*	*W*	*Wu*	*U*	*Wr*	*U*	*Wu*	*Wu*
B		l.	+	*U*	*Wu*	*U*	*W*	*Wu*	*U*	*Wu*	*U*	*Wu*	*Wu*
18 A	M.	R.	+	*U*	*R*	*U*	*U*	*U*	*U*	*Wu*	*U*	*U*	*U*
B		R.	+	*U*	*W*	*U*	*Wlu*	*U*	*U*	*U*	*U*	*U*	*U*
27 A	M.	R.	−	*U*	*U*	*U*	*Wu*	*U*	*U*	*U*	*U*	*U*	*Wu*
B		l.	−	*U*	*U*	*U*	*Wu*	*Wu*	*U*	*U*	*U*	*Wu*	*Wu*
41 A	F.	L.	?	*U*	*W*	*U*	*U*	*U*	*U*	*R*	*U*	*U*	*U*
B		R.	?	*U*	*U*	*U*	*U*	*U*	*U*	*R*	*U*	*U*	*U*
60 A	F.	R.	+	*U*	*A*	*A*	*A*	*U*	*U*	*Ra*	*A*	*U*	*U*
B		l.	+	*U*	*R*	*A*	*U*	*U*	*U*	*U*	*U*	*U*	*U*

TABLE IV.

Finger print formulae of 50 pairs of fraternal twins.

				Finger print formulae									
				Digit (right hand)					Digit (left hand)				
No.	Sex	Handed-ness	Hair whorl	I	II	III	IV	V	I	II	III	IV	V
61 A	F.	R.	+	*U*	*U*	*U*	*U*	*U*	*U*	*R*	*A*	*W*	*Wlu*
B		R.	+	*W*	*R*	*U*	*U*	*U*	*Wu*	*U*	*Ra*	*U*	*U*
65 A	F.	R.	+	*Wu*	*Wu*	*W*	*W*	*U*	*Wu*	*R*	*W*	*W*	*W*
B		R.	+	*W*	*Wr*	*W*	*W*	*U*	*W*	*Wr*	*U*	*W*	*U*
74 A	F.	R.	+	*Wu*	*Ra*	*U*	*U*	*U*	*Wu*	*Ra*	*Ra*	*U*	*U*
B		R.	+	*U*	*A*	*A*	*U*	*U*	*U*	*R*	*U*	*U*	*U*
57 A	F.	R.	+	*W*	*W*	*W*	*W*	*W*	*W*	*Wr*	*W*	*W*	*U*
B		R.	−	*Wu*	*Wu*	*W*	*W*	*W*	*Wu*	*Wr*	*W*	*W*	*Wu*
39 A	M.	R.	+	*W*	*U*	*U*	*U*	*U*	*Wu*	*U*	*U*	*U*	*U*
B		R.	+	*W*	*R*	*U*	*R*	*U*	*U*	*Ra*	*U*	*U*	*U*
22 A	M.	R.	+	*Wu*	*W*	*U*	*Wlu*	*U*	*Wu*	*Wlu*	*W*	*Wlu*	*U*
B		R.	+	*Wu*	*R*	*Wlu*	*Wlu*	*U*	*W*	*Wlu*	*U*	*Wlu*	*U*
26 A	M.	R.	+	*U*	*Wr*	*Wu*	*Wu*	*U*	*U*	*A*	*Wu*	*Wu*	*U*
B		R.	+	*U*	*Ra*	*U*	*Wlu*	*U*	*U*	*U*	*U*	*U*	*U*
71 A	M.	R.	+	*U*	*U*	*U*	*Wr*	*U*	*U*	*U*	*U*	*U*	*U*
B		R.	+	*U*	*R*	*U*	*U*	*U*	*U*	*R*	*R*	*U*	*U*
86 A	M.	R.	+	*W*	*A*	*A*	*U*	*U*	*U*	*Ra*	*A*	*U*	*U*
B		R.	+	*A*	*A*	*A*	*U*	*U*	*A*	*A*	*A*	*U*	*U*
95 A	M.	R.	+	*U*	*A*	*A*	*A*	*U*	*A*	*A*	*A*	*A*	*U*
B		R.	+	*U*	*U*	*U*	*Wu*	*U*	*U*	*Wu*	*U*	*Wu*	*U*
16 A	M.	R.	+	*Wu*	*Wlu*	*U*	*W*	*Wu*	*U*	*U*	*U*	*Wlu*	*Wlu*
B		R.	+	*Wu*	*Ua*	*U*	*Wlu*	*U*	*Wu*	*U*	*Ua*	*U*	*U*
75 A	F.	R.	+	*U*	*W*	*U*	*W*	*U*	*W*	*W*	*U*	*W*	*W*
B		R.	(+ −)	*U*	*W*	*U*	*U*	*U*	*U*	*Wu*	*U*	*U*	*U*
31 A	M.	R.	+	*U*	*Ra*	*U*	*U*	*U*	*U*	*R*	*U*	*U*	*U*
B		L.	+	*Wu*	*U*	*Wu*	*W*	*Wu*	*Wu*	*U*	*W*	*W*	*Wu*
89 A	F.	R.	+	*U*	*R*	*U*	*Wu*	*U*	*U*	*U*	*U*	*Wu*	*U*
B		R.	−	*U*	*U*	*U*	*U*	*U*	*U*	*Ra*	*Ua*	*U*	*U*
45 A	F.	R.	+	*U*	*Ua*	*A*	*U*	*U*	*U*	*A*	*A*	*U*	*Ua*
B		A.	+	*Ua*	*A*	*A*	*Ua*	*U*	*A*	*Ua*	*A*	*U*	*Ua*
84 A	M.	R.	+	*A*	*A*	*U*	*Wlu*	*U*	*A*	*A*	*U*	*U*	*U*
B		R.	+	*U*	*R*	*U*	*U*	*U*	*U*	*R*	*U*	*U*	*U*
66 A	M.	R.	+	*Wu*	*A*	*U*	*U*	*U*	*Wu*	*R*	*A*	*U*	*U*
B		R.	+	*U*	*Ua*	*U*	*U*	*U*	*U*	*R*	*U*	*U*	*U*
5 A	F.	R.	+	*W*	*W*	*W*	*W*	*U*	*W*	*W*	*W*	*Wu*	*U*
B		R.	+	*U*	*Wr*	*Wr*	*U*	*U*	*U*	*W*	*U*	*U*	*U*
10 A	M.	R.	+	*U*	*R*	*U*	*W*	*U*	*U*	*R*	*U*	*Wu*	*U*
B		R.	+	*Wu*	*Wu*	*Wu*	*Wu*	*Wu*	*W*	*Wu*	*Wu*	*Wu*	*U*
50 A	F.	R.	+	*U*	*Wlr*	*U*	*U*	*Wlu*	*U*	*U*	*U*	*U*	*W*
B		R.	+	*U*	*Wu*	*U*	*Wlu*	*U*	*U*	*R*	*U*	*U*	*U*
52 A	M.	R.	+	*Wu*	*Wr*	*U*	*W*	*Wu*	*Wu*	*U*	*U*	*Wu*	*Wu*
B		R.	+	*Wu*	*Wu*	*U*	*Wu*	*Wu*	*Wu*	*Wu*	*U*	*Wu*	*Wu*
12 A	M.	L.	+	*Wu*	*Wu*	*Wu*	*Wu*	*U*	*W*	*U*	*Wu*	*Wu*	*U*
B		R.	+	*Wu*	*Wr*	*Wu*	*Wu*	*Wu*	*W*	*Wr*	*Wu*	*Wu*	*Wu*
8 A	F.	R.	+	*Wu*	*U*	*U*	*W*	*Wlu*	*Wu*	*U*	*U*	*Wu*	*Wu*
B		R.	+	*U*	*Wu*	*U*	*Wlu*	*U*	*U*	*Wlr*	*U*	*U*	*U*
85 A	F.	R.	+	*U*	*A*	*U*	*U*	*U*	*U*	*R*	*U*	*U*	*U*
B		l.	+	*Wu*	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*
90 A	F.	R.	+	*U*	*U*	*U*	*W*	*U*	*U*	*U*	*U*	*W*	*Wlu*
B		R.	+	*U*	*R*	*U*	*W*	*U*	*U*	*A*	*U*	*Wlu*	*U*

TABLE IV *continued.*

				Finger print formulae									
				Digit (right hand)					Digit (left hand)				
No.	Sex	Handed-ness	Hair whorl	I	II	III	IV	V	I	II	III	IV	V
82 A	M.	R.	+	U	Ua	U	U	U	U	U	U	U	U
B		R.	+	U	A	A	U	U	U	A	A	U	U
83 A	F.	R.	+	U	U	U	U	U	U	R	A	U	U
B		l.	+	Ua	A	U	U	U	Ua	A	U	U	U
88 A	F.	R.	+	Wu	U	U	U	U	Wu	U	U	U	U
B		l.	+	Wu	W	Wlu	Wlu	U	Wu	W	W	Wu	U
81 A	M.	R.	+	U	R	U	U	U	U	R	U	U	U
B		R.	+	U	R	U	U	U	U	U	U	U	U
59 A	F.	R.	–	U	W	U	Wlu	U	U	Wu	Wlu	Wlu	U
B		R.	+	U	Wu	W	Wlu	U	U	Wu	U	Wlu	U
58 A	F.	R.	+	A	A	A	U	U	A	A	A	U	U
B		R.	+	W	W	U	U	U	W	W	A	U	U
47 A	M.	R.	+	U	U	U	W	U	U	U	U	U	U
B		R.	+	U	U	U	U	U	U	R	A	U	U
77 A	M.	R.	+	Wu	Wu	W	W	U	W	Wu	Wu	W	U
B		R.	+	U	R	U	Wlu	U	U	W	U	U	U
29 A	F.	R.	+	U	U	U	U	U	A	U	U	Ua	U
B		R.	+	U	Ua	U	R	U	U	R	U	U	U
21 A	M.	R.	+	U	Ua	U	U	U	U	R	U	U	U
B		R.	+	U	Wu	U	Wu	U	U	U	U	U	U
42 A	F.	R.	+	U	R	U	U	U	U	U	U	U	U
B		R.	+	A	A	Ua	U	Ua	A	A	Ua	U	Ua
19 A	F.	R.	+	W	W	W	W	U	W	Wr	W	W	U
B		R.	+	Wu	Wlr	U	W	Wlu	Wu	W	W	W	Wlu
93 A	F.	l.	+	W	U	U	U	U	Wu	U	U	U	U
B		R.	+	U	U	U	U	U	U	R	U	U	U
11 A	F.	R.	?	W	Wr	W	W	Wu	W	Wu	W	Wu	Wu
B		R.	?	U	U	U	W	W	U	Wu	U	W	U
36 A	F.	R.	+	W	A	U	U	U	W	R	U	U	U
B		L.	+	Wu	U	U	U	U	W	R	U	U	U
4 A	M.	L.	+	U	U	U	Wlu	U	U	Ua	U	U	Wu
B		R.	+	U	U	U	Wr	Wr	U	U	U	Wu	Wu
56 A	F.	R.	–	U	Wu	U	W	U	U	Wlr	Wlu	Wlu	U
B		R.	+	U	R	U	U	U	U	Wu	U	Wlu	U
92 A	M.	R.	+	U	R	U	Wu	Wu	U	U	U	U	U
B		L.	+	W	R	U	U	U	W	R	U	U	U
76 A	F.	R.	+	U	R	U	U	U	U	R	U	U	U
B		R.	+	U	U	U	U	U	U	U	U	U	U
32 A	M.	R.	+	U	R	U	Wlu	U	U	U	U	Wlu	U
B		R.	+	U	Wu	U	W	U	U	Wu	U	W	U
20 A	M.	R.	+	W	R	U	W	W	U	U	U	W	U
B		R.	?	Wu	Wlu	W	W	U	U	A	U	Wu	U
46 A	F.	R.	+	A	A	Wu	Wu	U	A	A	Wu	Wu	U
B		L.	+	Wu	Wu	Wu	Wu	U	U	Wu	Wu	Wu	Wu
54 A	F.	R.	+	W	Wr	U	U	U	A	R	U	U	U
B		R.	+	U	Ra	A	U	U	W	R	A	U	U
48 A	F.	R.	+	U	R	U	U	U	U	R	A	U	U
B		R.	+	U	U	A	U	U	U	U	U	U	U
64 A	F.	R.	+	Wlr	Wlr	W	Wu	Wu	Wlr	Wr	Wu	Wu	U
B		R.	+	U	Wlr	W	Wu	Wu	U	U	Wr	Wlu	U

between same (homolateral) hands of different twins than between opposite (heterolateral) hands of same twins, which was shown to involve 347 fingers.

(b) Comparison between hands of same individual and those of two individuals of a pair in fraternal twins.

In the case of *fraternal twins* there are only 2 cases of correspondence between right and right or left and left in all five fingers, 13 cases in four fingers, 42 cases in three fingers, 22 cases in two fingers, 16 cases in only one finger, and 5 cases in which all five patterns are different in the two hands. This makes a total of 248 corresponding patterns between homolateral hands of fraternal twins, over 100 less than for identical twins. This difference would be much more impressive if we were to omit from consideration in both sets of twins the patterns of digit V, which for over 80 per cent. of all human hands are ulnar loops and therefore alone account for a correspondence in over 160 fingers. If we omit digit V, we find in the other four digits 288 digits alike in homolateral hands of identical twins and 168 alike in homolateral hands of fraternal twins, a very considerable difference.

To summarise, in fraternal twins the correspondence in finger patterns between right and left hands of same individual is very much greater than between the homolateral hands of the two individuals of a pair; while in identical twins the resemblance between homolateral hands of twins is greater than that between heterolateral hands of the same individual.

A much more striking inter-individual resemblance is revealed when we compare the same hands of those twins in which homolateral resemblance is obvious, and combine with this the comparison between the right hand of one twin and the left hand of the other twin in those cases where heterolateral cross resemblance is clear, as in pairs where one twin is partially or completely left-handed or has a counter-clockwise hair whorl. The result of such a comparison gives the following figures: in 33 cases all five fingers are alike, in 38 cases four fingers are alike, in 20 cases three fingers are alike, in 9 cases two fingers are alike. There are no cases in which there are fewer than two fingers alike. The total of fingers alike is 395, as compared with 351 when homolateral hands of two individuals are rigorously compared, and with 347 when heterolateral hands of same individuals are compared. This difference would be considerably more impressive, for the reason above noted, were we to compare only the first four fingers.

These statistical results tend to support the conclusion stated in a previous paper (Newman, 1928) "that in monozygotic twins there is stronger cross resemblance between the hands of one twin and those of the other than between the two hands of the same individual." The existence of resemblances of this sort, when finger prints and palm patterns are considered together, is of the greatest value as an aid in diagnosing twins as to their monozygotic origin. The rule holds in all cases that seem in other respects unequivocally monozygotic. Consequently, when in a few slightly doubtful cases, the rule is found to hold, this goes far towards settling the diagnosis in favour of monozygotic origin.

(c) *Resemblances in finer details of pattern.*

While the codified formulae of finger print patterns shown in Tables III and IV indicate in a rough way the various degrees of resemblance between the finger prints of twins, far more convincing evidence of resemblance is afforded by a comparative study of the finer details of pattern peculiarities in homologous finger prints. The ideal way of presenting these data would be to publish half-tone enlarged reproductions of the 2000 finger prints involved, but unless this study were of extreme importance such extravagance of illustration would be unwarranted. It seems well, however, to illustrate the character of resemblance by means of a few instances that may be considered as typical (see Plate XVIII, figs. 10–16).

(d) *Never complete identity between finger prints of twins.*

In this connection the writer would like to take the opportunity of putting himself right with a number of police officials, as to the possibility that the finger prints of identical twins might cause difficulty for the finger print experts. On one occasion in a public lecture on twins we stated that frequently the individual finger prints were "extraordinarily alike." A newspaper reporter in a summary of the lecture quoted us as saying that the finger prints of twins are "often alike." The reporter, no doubt with conservative intent, omitted the word "extraordinarily." This omission, however, radically changed the meaning. "Alike" means identical or indistinguishable, while "extraordinarily alike" implies only a high degree of similarity.

The result of this publicity was that for two weeks we were besieged with communications from detective bureaus all over the country requesting that we offer proof of the statement that the finger prints of identical twins are "alike." Apparently we had appeared to challenge the infallibility of finger print science as a mode of personal identification.

Needless to say, our reply was soothing to the outraged feelings of the experts, for we had to admit that, even in identical twins, *no two finger prints of different individuals are ever exactly alike.*

There are, however, numerous instances in which the prints of two or more homologous fingers are so nearly identical as to be indistinguishable to the naked eye. When, for example, the patterns in both individuals are simple loops, having the same shape and involving the same number of ridges, it is possible only by using considerable magnification to discover differences in the branching of ridges and breaks in ridge continuity. Differences of this sort, however, are certain to be found, and afford an easy means of identification. Hence there is no likelihood that, in cases of criminal procedures, one member of a twin pair might be confused with the other because of identity of finger prints.

While resemblances are sometimes closer in those cases where the finger prints consist of simple patterns, such as loops, symmetrical whorls, or flat arches, it is of greater interest and significance to find very high degrees of resemblance between the prints of homologous fingers of two individuals when the pattern in both is complex and unusual. There are in our collection a good many cases of this sort and, because such cases have frequently been allowed to weigh heavily in our diagnoses of monozygosity, it seems worth while to illustrate this condition by means of several examples.

Plate XVIII, figs. 10–16, represent typical instances where the prints of homologous fingers of two individuals, particularly at the core of the pattern, possess more or less unique peculiarities. In all of these cases it would be no exaggeration to say that the finger print of one twin is more like that of the other twin than like that of any other finger in the entire collection of 2000 fingers. Such a finding, even with no corroborating evidence, would seem to justify the diagnosis of such a pair of twins as monozygotic. In a few instances where some slight doubt as to the monozygosity of a given pair of twins has existed prior to an examination of palm and finger patterns, the discovery of such extraordinary correspondences as those figured has clinched the diagnosis. In this connection it must be said with emphasis that no cases of resemblances so close as those shown in the illustrations were ever found in the twins diagnosed as dizygotic.

From what has just been said the reader will understand that it may readily be determined whether, for example, the pattern of the third finger of the right hand of twin A is more like that of the homologous finger of twin B than like that of his own left hand. Similarly all of the fingers may be compared, and a judgment reached as to whether in identical twins the finger prints of homolateral hands of two individual twins are more or less similar as a whole than are those of the two hands of the same individual. Such a detailed comparison has been made for the 50 pairs of identical twins in our collection.

A summary of the results of these comparisons is given below, the numbers used being those found in Tables III and IV. When the resemblance is greatest between the right hand of one twin and the right hand of the other twin of the same pair it may be designated R. like R.; when two lefts are most alike, L. like L.; when right of one is most like left of the other, R. like L.

R. like R. and L. like L.: 62, 102, 23, 13, 72, 99, 100, 14	8 sets.
R. like R.: 80, 96, 68, 87, 38, 28, 97, 17, 24	9 sets.
L. like L.: 40, 67, 73, 49, 43, 44, 91, 37, 34, 6, 69, 41	12 sets.
R. like L.: 9, 30, 94, 53, 15, 60, 33	7 sets.
All four hands equally alike: 98, 63, 3, 35, 78, 79, 2, 101, 70	9 sets.
Three hands equally alike and one different: 55, 25, 7	3 sets.
R. and L. of same individual more alike than either hand of other twin: 27	1 set.
No decision possible: 18	1 set.

In 36 out of 50 pairs there is very positively stronger cross-resemblance between hands of twins A and B than there is resemblance between two hands of the same individual. In 9 out of the remaining 14 pairs all four hands were so nearly identical that differences were too slight to permit of judgment as to the degree of resemblance between particular hands. Such pairs must, of course, be adjudged identical twins. Where three hands are equally similar there is also very strong evidence of monozygosity, but it is not possible to decide whether inter-individual resemblances are greater or less than intra-individual resemblances. In pair 18 there was no very close resemblance of any one of the four hands with any other, making a decision very difficult.

Out of 16 pairs in which R. is like L. or in which all four hands are practically alike (a condition interpreted as partial asymmetry reversal) nine pairs of twins are characterised by having one of the individuals left-handed and four pairs by having one of the individuals counter-clockwise (reversed) in hair whorl. The majority of these show also distinct reversals in palm patterns. There is thus a high degree of correlation between reversed asymmetry (mirror imaging) in finger patterns and that in the rest of the body and in the palms. Hence the fingers as well as the palms serve as indicators of bodily asymmetry reversal.

In only one case, pair 27, was there stronger intra-individual resemblance than inter-individual resemblance. The facts that in this pair the palm prints show much stronger inter-individual resemblance, that both twins have counter-clockwise hair whorl, and that the quantitative values of the finger prints are closely similar, outweigh the divergent evidence of the qualitative resemblances in finger patterns in diagnosing this particular pair as monozygotic twins.

It may be said in concluding this phase of the study that *not one of the 50 pairs of fraternal twins showed stronger or even as strong inter-individual resemblance as intra-individual resemblance in details and peculiarities of finger patterns*. This furnishes a valuable criterion in diagnosing them as dizygotic in origin.

IV. Comparison of quantitative values of finger print patterns in identical and fraternal twins.

Bonnevie has devised an improved method for comparing finger prints quantitatively. Her method consists of counting the number of papillary ridges involved in each pattern. The count includes all ridges between the triradius bounding the pattern and the core, or centre, of the pattern, not counting either of the bounding ridges. Such a study is comparable with that of counting the number of scutes in the armour bands of the armadillo, and may be used to arrive at coefficients of correlation between the two hands of each twin and between the hands of the two members of the twin pair. The ridges do not run with complete regularity, some of them being interrupted or branched. Also some patterns are so broad that the prints, even when made by rolling the fingers, do not include quite the whole pattern. In such cases one has to estimate the number of ridges not printed. With regard to ridge counting Bonnevie says: "In order to diminish the effects of such irregularities the results reached by counting the ridges are not directly used for expressing the distance between triradius and centre; but they are grouped to classes marked 0–10 and distinguished as follows":

		No. of ridges	Class
Triradii	None (arches)	—	0
,,	1–2	0	1
,,	,,	1–2	2
,,	,,	3–4	3
,,	,,	5–6	4
,,	,,	7–8	5
,,	,,	9–10	6
,,	,,	11–13	7
,,	,,	14–16	8
,,	,,	17–20	9
,,	,,	>20	10

This classification is, of course, somewhat arbitrary, but will give at least as accurate results as would direct use of all ridges counted. Two weaknesses in Bonnevie's method have developed in the course of my own work. The first of these has to do with her method of handling whorls. In order to prevent over-valuing whorls as compared with loops, she gives a value to each side of the whorl and divides it by two. When the whorls are symmetrical this procedure is quite fair, but when there are many ridges between one triradius and the centre, and few between the other triradius and centre, the total divided by two gives a relatively small pattern value that does not do justice to the pattern as a whole. It seems to me that the difference between a whorl and a loop is a qualitative one, and that a quantitative comparison would be much closer if one counted only the ridges on the longer side of all whorls. Were there some way of counting both sides of *loops* and dividing by two, we could fairly compare this with the counts of both sides of whorls, but this is impossible because of the absence of a triradius on one side of the loops. It is logical then to count only one side of a whorl, the side having the more ridges, and this has been done in the present study. It also seems to me that Bonnevie's classification is unfair to the largest patterns, in that she gives the same value, 10, to all patterns with more than 20 ridges. In my collection there are some patterns with over 30 ridges, and these should not be valued the same as those with only 21 ridges. Hence I have used the following scale of values, in which only one triradius is used for each pattern:

No. of ridges	Value	No. of ridges	Value
0	1	17–18	10
1–2	2	19–20	11
3–4	3	21–22	12
5–6	4	23–24	13
7–8	5	25–26	14
9–10	6	27–28	15
11–12	7	29–30	16
13–14	8	31–32	17
15–16	9		

This seems to give a fairer distribution of quantitative values throughout the whole series, and is less arbitrary.

No attempt was made by Bonnevie to compare finger with finger as to their quantitative values, but the totals of values of the five fingers of each hand were taken. This compares with the method used in the armadillo (Newman, 1913), where the totals of scutes in the nine bands of armour were used for comparing the degrees of resemblance among the quadruplets. The following tables (Tables V and VI) give the values obtained for both identical and fraternal twins, right hand and left hand being given separately as well as the totals of both. The figures represented in these tables fall short of complete accuracy, especially in one respect—in the first few cases studied the fingers were not sufficiently rolled to produce the entire pattern, as in Plate XVIII, figs, 13, 14 and 16. In most cases, however, where a strong impression of close resemblance is present in the part of the pattern recorded, they were given the same numerical value. The same treatment was accorded the dizygotic twins.

TABLE V.

Quantitative values of finger patterns of 50 pairs of identical twins.

No.	Right hand	Left hand	Total	No.	Right hand	Left hand	Total	No.	Right hand	Left hand	Total
62 A	44	45	89	68 A	47	36	83	70 A	47	50	97
B	46	44	90	B	47	42	89	B	41	41	82
98 A	27	32	59	49 A	47	46	93	37 A	27	26	53
B	29	27	56	B	47	46	93	B	28	24	52
63 A	52	48	100	13 A	34	37	71	34 A	12	12	24
B	52	47	99	B	37	34	71	B	19	11	30
40 A	50	52	102	78 A	37	41	78	28 A	47	49	96
B	52	50	102	B	39	39	78	B	48	49	97
3 A	37	37	74	87 A	30	36	66	7 A	42	38	80
B	40	37	77	B	37	37	74	B	40	38	78
9 A	35	28	63	43 A	60	57	117	6 A	56	53	109
B	29	35	64	B	60	56	116	B	55	57	112
80 A	28	16	44	38 A	50	44	94	97 A	48	45	93
B	25	16	41	B	48	46	94	B	48	49	97
67 A	48	44	92	79 A	19	29	48	17 A	46	47	93
B	47	45	92	B	27	21	48	B	45	52	97
55 A	21	25	46	72 A	55	56	111	14 A	34	38	72
B	21	20	41	B	57	55	112	B	38	36	74
35 A	53	56	109	99 A	30	34	64	15 A	50	54	104
B	58	55	113	B	36	34	70	B	51	52	103
96 A	41	33	74	33 A	57	60	117	69 A	41	44	85
B	37	37	74	B	58	59	117	B	37	42	79
73 A	15	12	27	53 A	44	48	92	24 A	44	46	90
B	13	12	25	B	48	48	96	B	45	43	88
102 A	53	44	97	44 A	43	43	86	18 A	57	55	112
B	55	42	97	B	40	43	83	B	56	54	110
25 A	57	53	110	2 A	56	48	104	27 A	43	45	88
B	56	58	114	B	56	50	106	B	40	34	74
30 A	31	45	76	91 A	46	39	85	41 A	38	35	73
B	41	38	79	B	36	39	75	B	39	42	81
23 A	57	53	110	100 A	23	20	43	60 A	12	11	23
B	55	51	106	B	21	22	43	B	30	26	56
94 A	48	45	93	101 A	52	57	109				
B	47	49	96	B	53	56	109				

TABLE VI.

Quantitative values of finger patterns of 50 *pairs of fraternal twins.*

No.	Right hand	Left hand	Total	No.	Right hand	Left hand	Total	No.	Right hand	Left hand	Total
61 A	24	28	52	5 A	48	51	99	21 A	40	45	85
B	38	25	63	B	34	36	70	B	53	47	100
65 A	53	54	107	10 A	44	41	85	42 A	42	39	81
B	52	60	112	B	47	52	99	B	10	6	16
74 A	44	30	74	50 A	42	40	82	19 A	50	52	102
B	27	26	53	B	49	50	99	B	57	54	111
57 A	54	56	110	52 A	56	53	109	93A	54	53	107
B	49	53	102	B	48	48	96	B	30	31	61
39 A	28	27	55	12 A	47	48	95	11 A	49	49	98
B	31	27	58	B	53	53	106	B	37	33	70
22 A	50	52	102	8 A	49	48	97	36 A	39	43	82
B	54	56	110	B	36	40	76	B	42	48	90
26 A	52	42	94	85 A	19	19	38	4 A	32	31	63
B	38	47	85	B	43	37	80	B	45	43	88
71 A	37	44	81	90 A	40	41	81	56 A	41	36	77
B	52	41	93	B	36	31	67	B	33	35	68
86 A	28	25	53	82 A	27	28	53	92 A	51	51	102
B	13	7	20	B	23	18	41	B	38	32	70
95 A	10	2	12	83 A	34	21	65	76 A	28	23	51
B	41	38	79	B	12	11	23	B	29	24	53
16 A	47	41	88	88 A	36	33	69	32 A	31	34	65
B	41	38	79	B	50	50	100	B	47	51	98
75 A	46	51	97	81 A	27	29	56	20 A	48	39	87
B	42	37	79	B	34	33	67	B	44	37	81
31 A	32	26	58	59 A	48	41	89	46 A	28	29	57
B	40	44	84	B	54	51	105	B	56	56	112
89 A	34	28	62	58 A	7	9	16	54 A	35	26	61
B	16	10	26	B	41	33	74	B	11	9	20
45 A	18	13	31	47 A	40	40	80	48 A	45	38	83
B	5	3	8	B	39	20	59	B	35	30	65
84 A	10	13	23	77 A	54	54	108	64 A	47	46	93
B	31	23	54	B	57	53	110	B	38	36	74
66 A	39	35	74	29 A	19	12	31				
B	30	31	61	B	30	32	62				

Though it requires a considerable amount of careful work on the part of an experienced statistician to arrive at the various correlations capable of being determined from the figures in the above tables, it will not take long to set them down. They are shown in Table VII.

It will be noted that the correlation between identical twins as determined by Bonnevie (+ 0·924 ± 0·037) is somewhat lower than our own correlation for 50 pairs of carefully diagnosed identical twins (+ 0·95 ± 0·01). It is, however, not in great disagreement, for the probable errors calculated for her material and mine are large enough to cover the discrepancy. It is possible, as stated before, that a few of Bonnevie's "identical twins" are fraternals. Her figure for fraternal twins (+ 0·535 ± 0·082) is somewhat higher than ours (+ 0·46 ± 0·08), but the probable errors of both are fairly large, sufficient to cover the discrepancies. The correlation between right and left hands as determined by Bonnevie is less both for identical twins and for single individuals than ours for either identical or fraternal twins. In this case the discrepancy is so great that it is not covered by the probable error. Our figures deal with larger numbers of individuals, and we find exactly the same degree of correlation (+ 0·93 ± 0·01) between right and left hands of identical twins as between right and left of fraternal twins. This finding lends no support

TABLE VII.

Coefficients of correlation between total ridge counts of five fingers of each hand based upon figures supplied in Tables V and VI.

	Identical twins	Fraternal twins
Correlation between right and left hands of each individual	$r = 0·93 \pm 0·01$	$0·93 \pm 0·01$
Correlation between right hand of A and right hand of B	$r = 0·92 \pm 0·01$	$0·34 \pm 0·08$
Correlation between left hand of A and left hand of B	$r = 0·93 \pm 0·01$	$0·50 \pm 0·07$
Correlation between right hand of A and left hand of B	$r = 0·91 \pm 0·02$	$0·47 \pm 0·07$
Correlation between left hand of A and right hand of B	$r = 0·93 \pm 0·01$	$0·40 \pm 0·08$
Correlation between totals of both hands of A and both hands of B	$r = 0·95 \pm 0·01$	$0·46 \pm 0·08$

Bonnevie worked out several correlations for total finger prints of the two hands of individuals of various grades of relationship which are as follows:

Correlation between 30 pairs of unrelated individuals	$r = 0·270 \pm 0·128$
Correlation between brothers and sisters (30 pairs)	$r = 0·595 \pm 0·118$
Correlation between fraternal twins (16 pairs)	$r = 0·535 \pm 0·082$
Correlation between identical twins (15 pairs)	$r = 0·924 \pm 0·037$
Correlation between right and left hands of individual identical twins (30 individuals)	$r = 0·860 \pm 0·027$
Correlation between right and left hands of single persons (30 individuals)	$r = 0·886 \pm 0·039$

to the statement sometimes made (Wilder), that right and left sides of identical twins are more alike than are right and left sides of single individuals, for we may consider fraternal twins are no more than sibs born together.

It may also be noted that in identical twins the total for both hands of A and B (+ 0·95 ± 0·01) is higher than any other correlation, in fact, the highest inter-individual correlation ever determined. The highest correlation previously reported was that between twin pairs of armadillo quadruplets (pairs I and II and pairs III and IV), which are true twins formed by the fission of a single embryonic primordium. This correlation, determined for the total numbers of scutes in the nine armour bands, was + 0·9294 ± 0·0057 for 112 pairs (56 sets) of males; and + 0·9129 ± 0·0059 for 118 pairs (59 sets) of females. This averages a little more than + 0·92, which falls several points short of being as high as that in human twins (+ 0·95 ± 0·01).

In spite of the fact that there are several cases in which there is closer resemblance between right hand of one twin and left hand of the other, the general correlation between right and right and between left and left is very high; in one case (left and left) the same as for right and left of same individuals, in the other (right and right) a little less. If we were to correlate right with right in all sets where these are closer, and right with left in the cases where these are closer, and were to combine the two into one correlation, we should get a coefficient of correlation as high as + 0·95, which would bear out our contention that there is closer inter-individual resemblance than intra-individual resemblance among identical twins.

The most impressive feature of these correlations consists in the striking differences in the figures obtained for identical and for fraternal twins. Fraternal twins have correlations for the most part below + 0·5, the usual correlation between sibs. Why most of these correlations run somewhat below + 0·5 is not clear, but if the probable error is taken into account, there is no discrepancy with sib correlations in general. The very high correlation found for the 50 pairs of twins diagnosed as monozygotic and the very low correlation found in 50 pairs of dizygotic twins both tend strongly to corroborate our diagnoses of the two classes of twins. Were there any cases of fraternals diagnosed as identicals or identicals diagnosed as fraternals, one would hardly expect the correlation for identicals to be so high or that for fraternals so low as they actually are.

(a) *Study of individual pairs of identical twins as to quantitative resemblances.*

A closer study of Table V reveals some remarkable facts about individual sets of twins with respect to the quantitative values of their finger patterns. Twelve of the 50 pairs of identical twins have exactly the same total quantitative values of the two hands. Of these 12 pairs, 9 fall among the first 25 in the list, those most alike in features and other physical characters; while none fall in the lowest 15 in the list, those least alike physically. Eight sets show a difference of only 1 in total value between the two individuals, and 13 more show a difference of 2 or 3.

On the other hand, several pairs differ as greatly as do the average of fraternal twins. Pair 60, for example, the last in the list from the standpoint of general resemblance, has a difference of 33 in total friction ridge values; pair 70 (fifteenth from the end of the list) shows a difference of 15 in ridge values; pair 91 (eighteenth from the bottom of the list) shows a difference of 10 in ridge values; and pair 27 (third from the bottom of the list) shows a difference of 13 in ridge values. When these cases are scrutinised the following facts come to light: in pair 60 the difference is found to be due to the presence of arches, with a value of 0, in digits II and IV of twin A, as against fairly high-valued loops in these fingers of twin B. The other digits are strikingly similar in the two twins. It seems probable that the difference here is a qualitative one, involving the presence of a primitive pattern in these two fingers in one twin and its suppression in the other twin. The same sort of thing is common in palm patterns in the case of identical twins, as when a thenar pattern is present in both palms of one twin and absent in one or both palms of the other. In this case the suppression of a pattern in two fingers of each hand in one pair of twins produces ten times as great a difference in total quantitative values as the average of all the other pairs of identical twins combined.

In pair 70 nearly the whole lack of correspondence is the result of a marked difference in one finger on each hand, the index finger, the radial loops of A being large, with values of 9 and 10, while those of B are small, with values of 3 each. All other fingers are strikingly similar both qualitatively and quantitatively.

In pair 91, the two left hands have exactly the same values, 39, but there is a difference of 10 in total values in the two right hands. Here again most of the difference occurs in one digit, V, in which the pattern is highly developed in A and reduced to a vestige in B.

In pair 27 there is a most striking resemblance in the details of patterns between the right hand of A and the left hand of B, the only marked difference being in digit III, A having an extensive loop with twelve ridges and B a vestigial loop with but one ridge.

The total difference between A's and B's of 50 pairs of identical twins is 182, of which about one-third (61) is contributed by the four pairs just discussed. In each of these cases the difference seems to be due to a suppression of a pattern in one or two fingers, rather than to purely quantitative differences in pattern values.

(b) Resemblances in total quantitative values of the right and left hands in identical twins.

As was done in the case of pattern-types, it is possible to list the 50 pairs of identical twins according to the closeness of resemblance of right and left hands in their total ridge values. The following list gives the data:

R. like R. and L. like L.: 63, 80, 67, 102, 23, 49, 43, 38, 33, 2, 100, 101, 18	13 sets.
R. like R.: 55, 94, 68, 6, 97, 24, 41	7 sets.
L. like L.: 73, 99, 91, 28, 7	5 sets.
R. like L.: 62, 98, 40, 9, 35, 25, 13, 79, 72, 14, 69, 30	12 sets.
Three hands alike and one different: 3, 44, 53	3 sets.
R. and L. of same twin more alike than like either hand of opposite twin: 96, 78, 87, 70, 34, 27, 60	7 sets.
No decision possible: 37, 17, 15	3 sets.

Only 7 pairs of twins depart from the rule that inter-individual resemblance is stronger than intra-individual resemblance in one or both twins. In four of these cases, as has been explained, the discrepancy is due to the suppression of one or two patterns rather than differences in quantitative values. It should be noted that 25 pairs show homolateral resemblance and 12 pairs heterolateral resemblance between twins.

V. Comparison between armadillo quadruplets and human twins with respect to integumentary structures.

In comparing armadillo quadruplets with human twins it will be well to consider quadruplets as double twin pairs and to compare twin pairs of armadillo to twin pairs of man. Our comparison will concern itself with the question whether in the case of asymmetrical peculiarities, such as double bands and scutes, the right side is more often like the right (or left like left) than right is like left; and whether homolateral resemblance is greater or less than heterolateral.

With respect to band anomalies we may list the following cases (Newman, 1913):

Set K 87	In foetuses	I and II	R. like R. and L. like L.
		III and IV	R. like L.
Set K 30	,,	I and II	L. like L.
Set K 4	,,	I and II	L. like L.
Set C 1	,,	I and II	R. like R.
		III and IV	R. like L.
Set C 29	,,	III and IV	L. like L.
Set C 40	,,	I and II	R. like L.
Set C 101	,,	III and IV	R. like R., also R. like L.
Set K 2	,,	I and II III and IV	3 alike and 1 different.
Set A 64	,,	III and IV	R. like R. and L. like L.
Set A 96	,,	I and II	R. like R.
		III and IV	R. like R.
Set K 80	,,	I and II	L. like L.
		III and IV	R. like L.

Here there are twelve cases of homolateral resemblance and five cases of heterolateral resemblance, or mirror-imaging. In fact, homolateral resemblance is about twice as frequent as heterolateral in both armadillo quadruplets and human twins.

In the case of asymmetrical scute anomalies it is almost impossible to be sure whether the individual anomalies are equivalent units, for they occur singly at highly variable parts of the carapace in twin pairs. Yet even in scute anomalies homolateral resemblance is far commoner than heterolateral resemblance, there being eight cases of the former to three cases of the latter which are unequivocal. It appears then that in the armadillo as well as in man there is a preponderance of homolateral resemblance in asymmetry as compared with heterolateral, a fact which reinforces our conviction that twinning in man must be essentially the same sort of process as that known for the armadillo, and that twinning in man takes place at about the same time and is related to the symmetry and asymmetry mechanism in the same ways as in the armadillo.

VI. Summary.

1. The finger prints of 50 pairs of twins diagnosed as identical (monozygotic) and of 50 pairs diagnosed as fraternal (dizygotic) were studied and classified as to pattern-types. In general, the distribution of whorls, loops and arches is about the same in the two groups of twins and agrees with that of the general population of single individuals.
2. In both groups of twins radial (reverse) loops are largely confined to the index finger (digit II), only about 8 per cent. being distributed among the other four fingers.
3. Whorls also commonly show ulnar and radial twists and spirals. Those with radial asymmetry, as was the case in radial loops, are largely confined to the index finger. Only about 15 per cent. of the total of radial loops occur on the other four fingers.
4. This remarkable incidence of radial patterns is interpreted as being the result of an early twinning, or dichotomy, of the limb bud, giving rise to the primordia of the thumb and the remainder of the digits. Since the thumb practically always has ulnar asymmetry, the frequency of radial patterns on digit II is believed to be a vestige of a mirror-image relationship once present in the bilateral halves of a twinning appendage. As development proceeds, the position of the limb with respect to the bodily axes affects the symmetrical relations of the twin components in such a way that the whole appendage develops a strong ulnar asymmetry, and this is expressed in the patterns of most of the fingers. Only in the index

finger, the original twin part of the thumb, is the original twinning relation retained in the form of numerous radial (reversed) patterns.

5. Tented arches, so common on index fingers, are interpreted as instances of partial asymmetry reversal, such an arch being a compromise between an ulnar and a radial loop.

6. A detailed comparison of the pattern-types of identical and fraternal twins is made with respect to whether there is greater resemblance between hands of opposite twins or between opposite hands of same twins. In identical twins the rule is that one or both hands resemble the hands of the other twin more strongly than do opposite hands of same individual. Quite the reverse is true for fraternal twins. This may be used as a criterion for the diagnosis of doubtful twin pairs.

7. As the result of counting the friction ridges in the finger prints, using a method somewhat different from that of Bonnevie, it was found that in quantitative pattern values the coefficient of correlation between right and left hands of the same individual is the same for both identical and fraternal twins ($+ 0{\cdot}93 \pm 0{\cdot}01$); that for identical twins the correlation between total values of right plus left hands of A and B is $+ 0{\cdot}95 \pm 0{\cdot}01$, and only $+ 0{\cdot}46 \pm 0{\cdot}08$ for fraternal twins. The correlation between one or both hands of opposite twins is greater for identical twins than that between opposite hands of same individuals; while exactly the reverse is the case for fraternal twins.

8. Studies of individual pairs of twins are presented to show parallel resemblance, mirror-image resemblance, and lack of resemblance. These data cannot be summarised.

9. A comparison is made between the finger patterns of human twins and the band and scute patterns in armadillo quadruplets with respect to the relative frequency of parallel-imaging and mirror-imaging of asymmetrical peculiarities. In both man and the armadillo parallel-imaging is about twice as frequent as mirror-imaging. This emphasises the probability that twinning in man is closely similar in time and in method to that in the armadillo, and that there exists in both the same intimate relation between twinning and the symmetry and asymmetry mechanism.

REFERENCES.

BONNEVIE, KRISTINE (1924). "Studies on the papillary patterns of human fingers." *Journ. Gen.* XV.

CUMMINS, H. and MIDLO, C. (1927). "Dermatoglyphics in Jews." *Journ. Phys. Anthrop.* X.

GALTON, FR. (1892). *Finger Prints.* London.

NEWMAN, H. H. (1913). "The modes of inheritance of aggregates of meristic (integral) variates in the polyembryonic offspring of the nine-banded armadillo." *Journ. Exp. Zool.* XV.

—— (1916). "Heredity and organic symmetry in armadillo quadruplets. I. Modes of inheritance of band anomalies. II. Modes of inheritance of double scutes and a discussion of organic symmetry." *Biol. Bull.* XXX.

—— (1917). *The Biology of Twins.* Chicago.

—— (1923). *The Physiology of Twinning.* Chicago.

—— (1928). "Studies of human twins. I. Methods of diagnosing monozygotic and dizygotic twins. II. Asymmetry reversal, or mirror-imaging in identical twins." *Ibid.* LV.

WILDER, H. H. (1904). "Duplicate twins and double monsters." *Amer. Journ. Anat.* III.

—— (1916). "Palm and sole studies." *Biol. Bull.* XXX.

DESCRIPTION OF PLATES XVII, XVIII.

PLATE XVII.

Figs. 1–9. Sample finger prints from right hands, showing various types of symmetrical and asymmetrical whorls. 1, a symmetrical whorl. 2, 4, 7 and 8, whorls showing the normal asymmetry, called ulnar whorls (*Wu*), and with a clockwise twist or spiral. 3 and 6, whorls showing reversed asymmetry, called radial whorls (*Wr*), and with a counter-clockwise twist or spiral. 5, a whorl within an ulnar loop (*Wlu*). 9, a double loop with a reversed or counter-clockwise twist (*Wdr*), classed as a whorl because it has two triradii. (Slightly enlarged.)

PLATE XVIII.

Figs. 10–16. Examples of the closest approach to identity between the patterns of homologous fingers in three pairs of identical twins. 10 *a* and 10 *b*, for example, represent homologous patterns in two individuals of the same pair of identical twins. These examples are chosen, in spite of the fact that some of them are incomplete, because they represent the ways in which the centres or cores of patterns show close resemblances even when the pattern is unusual or unique in character. (Slightly enlarged.)


1
2
3
4
5
6
7
8
9


10a
11a
12a
10b
11b
12b
13a
13b
14 a
14 b
15 a
15 b
16 a
16 b