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Bilateral Variation in Man: Handedness, Handclasping, Armfolding and Mid-Phalangeal Hair

Carol J. Loveland
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To the Graduate Council:

I am submitting herewith a thesis written by Carol J. Loveland entitled "Bilateral Variation in Man: Handedness, Handclasping, Armfolding and Mid-Phalangeal Hair." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.

Richard L. Jantz, Major Professor

We have read this thesis and recommend its acceptance:

Cheryl B. Travis, Wialliam M. Bass

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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We have read this thesis
and recommend its acceptance:

Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

BILATERAL VARIATION IN MAN:

HANDEDNESS, HANDCLASPING, ARMFOLDING

AND MID-PHALANGEAL HAIR

A Thesis

Presented for the

Master of Arts

Degree

The University of Tennessee

Carol J. Loveland

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ABSTRACT

A study of bilateral variation among individuals from three populations was conducted. One sample consisted of 174 Cashinahua Indians who reside along the Curanja River in the Peruvian rain forest. A second group was composed of 286 students from anthropology classes at the University of Tennessee, Knoxville. Eighty-six families, including 372 individuals, constituted the third sample.

Four laterality traits - handedness, armfolding, handclasping, and mid-phalangeal hair - were analyzed by population and by individual family.

The most interesting variation occurred in the frequency of right and left handclasping and in the presence or absence of mid-phalangeal hair. The percentage of left and right armfolders among the populations was fairly stable. Handclasping and armfolding do not seem to be related to handedness, however, conflicting data on the relationship between armfolding and handclasping showed that further study is needed.

The Cashinahua differed more from the two Tennessee populations than the latter two did from each other. In particular, the frequency of mid-digital hair among the Cashinahua was very low, which is consistent with data from other American Indian groups. The two Tennessee populations, on the other hand, compared with other Caucasoid samples in hair frequency.

Analysis of the family data provided some evidence for the

heritable character of the handclasping trait and strong evidence for the heritability of the mid-phalangeal hair trait. Armfolding and handedness, on the other hand, did not seem to reflect a strong genetic character.

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CHAPTER I

INTRODUCTION

This study is concerned with bilateral variation among individuals from three groups located in two different geographical areas of the Americas. One sample consisted of 174 Cashinahua Indians who reside along the Curanja River in the Peruvian rain forest near the headwaters of the Amazon River. A second group was composed of 286 students from anthropology classes at the University of Tennessee, Knoxville. Eighty-six families from the Knoxville, Tennessee, area comprised the third group. There were 372 individuals in the 86 families.

Four laterality traits - handedness, armfolding, handclasping, and mid-phalangeal hair - were considered. These were analyzed in two ways: (1) population data and (2) family data.

The criteria employed to classify an individual as either "right" or "left" handed in studies of laterality is subject to controversy. The most common criteria is classification according to the "writing hand" of the individual - this method was used in this study.

When the hands of an individual are clasped with the fingers entwined, as illustrated in Figure 1, a majority of individuals have a natural tendency to consistently place one thumb above the other. A person is thus classified as a "right handclasper" if his right thumb falls naturally into the uppermost position. A person having only a casual acquaintance with this trait may be inclined to assume that it is merely a manifestation of "handedness". Actually these

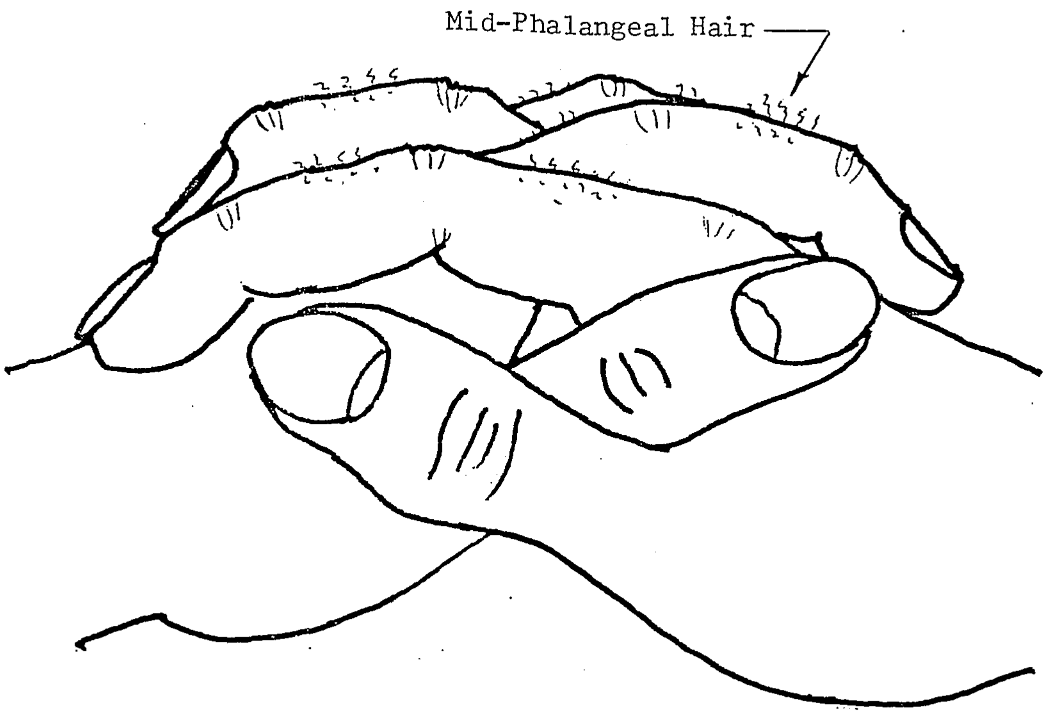

Figure 1. A Right Handclasper

two traits seem to be independent, as the data from this study suggest.

With few exceptions an individual also exhibits a clear preference for the uppermost arm when the arms are folded across the chest in the natural way. A sketch of an individual classed as a right armfolder is given in Figure 2. Again the data here fails to show a definite relationship between the armfolding phenotype and either handedness or handclasping.

Most people have hair on the first segment of each of their fingers; however, the development of hair on the middle segments (see Figure 1) varies considerably among individuals and populations. There is no middle phalanx in the thumb; therefore, hair patterns on it are of no concern in this study. The existence of this mid-phalangeal hair on some fingers does not carry with it the implication that all digits will be affected; generally speaking this mid-digital hair trait will be exhibited symmetrically. The fourth digit (the ring finger) of each hand seems to be the most commonly affected. These hair patterns shall be further investigated in the populations studied here.

The laterality traits considered in this study varied in frequency from group to group; however, the percentage of left and right armfolders among the various populations was fairly stable. There were no clear-cut associations among the traits, but analysis of the family data provided some evidence for the hereditary nature of both handclasping and mid-phalangeal hair traits.

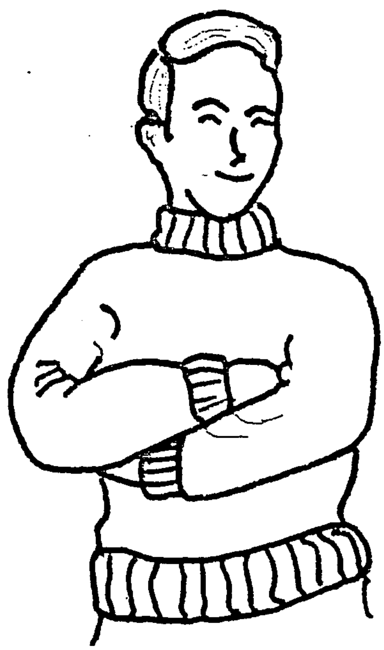

Figure 2. A Right Armfolder

CHAPTER II

REVIEW OF THE LITERATURE

The concept of lateral dominance has been recognized for many years; however, relatively little is known of the effect of heredity and environment upon its development. It is developed to a much greater degree in man than in any other animal perhaps because of man's greater reliance upon manipulatory skills. It probably had greater survival value than bilaterality for early man because of the increased skill which could be attained in performing various tasks.

Evidence presented by Raymond Dart (1949) showed that the Australopithecines exhibited a strong preference for use of their right hands. In his analysis of baboon skulls Dart found that cranial injury, presumably inflicted by the Australopithecines, was so localized that he was able to determine from which direction the death blow had been directed. Twenty-seven out of 42 skulls were fractured by blows delivered directly from the front. Seven skulls were fractured by strokes delivered on the left side and also presumably from the front. Only 2 skulls appeared to have received blows from the right side. He concluded, "The Australopithecines seem therefore to have had a preference for the right hand" (Dart 1949:9).

Hulse (1968:203) stated that tools found with Sinanthropus were suitable for holding in the right hand rather than in the left. Anatomical evidence of handedness was presented by Coon (1963:544) who stated that the right humerus of La Chapelle aux Saints was more highly developed than the left, thus suggesting that the individual was right handed.

Although it may be surmised that lateral preference has been a strong hominid characteristic for a long time, the actual cause of the variation among people has not been determined, and it is not known what factors account for the strong shift toward right lateral dominance in man. Annett (1972) suggested that variations may arise from three sources: (1) they may be transmitted genetically, (2) they may depend on factors operating accidentally in the course of development, and (3) they may be transmitted culturally. She felt that lateral differences among animals should be attributed to the effect of random accidental variations probably operating during embryonic growth. However, the systematic shift to the right of a whole species could not be due to chance in her opinion. She believed that both genetic and cultural influences held strong claim to a role in the inducement of human beings toward dextrality.

Annett stressed that an important factor in considering the greater proportion of right lateral dominance among hominids was the higher occurence of right handedness among females than males. She believed that unless the assumption is made that females are more subject to cultural factors than males, laterality would have to be affected by factors which are sex linked in the genetic sense. Annett stated, "Another well-established difference between the sexes which applies particularly during early stages of development concerns the rate of growth and efficiency of certain language functions such as vocabulary size and reading skill. . . . The advantage of girls in early development of these skills together with their greater dextrality suggests that the shift to the right and language development may both depend on a common factor and that this factor may be related to whatever induces the left cerebral hemisphere to serve speech in the majority of human species" (Annett, 1972:356).

Rife (1950) suggested that handedness was determined by a single pair of genes with three genotypes: RR which manifests right handedness, rr which manifests left handedness, and Rr which is ambidextrous. The R allele is usually dominant and r usually recessive, but there is partial penetrance of R in heterozygotes. Thus he felt that heterozygotes Rr could be right, left, or ambidextrous.

Collins (1961) stressed that handedness, which she defined as limb dominance for any manipulation performed by the upper extremities, might best be considered in terms of the active or dominant positioning of the entire limb for manipulation of objects. She felt that such positioning involved a medial rotation and circumduction of the entire limb at four separate levels simultaneously, the shoulder, elbow, wrist, and thumb. Such an analysis would allow for the large number of possibilities for mixed dominance of the limbs in a given population and the small possibility of absolute dominance in such a heterogeneous group.

Dahlberg (1926) addressed himself to the problem of right and left handedness in his study of twins. He stated that functional asymmetry was based on hereditary dispositions which occasioned an asymmetric development of the soma. He believed that handedness involved genotypical asymmetries rather than inheritance of a single character.

Chamberlain attempted to find families in which both parents were lefthanded for his study. However, he determined that there were so many degrees of left handedness that it was necessary to establish certain boundaries as to what constituted right and left handedness. He settled on "writing hand" since "the reflex pathways necessary to writing are extremely complicated and are much more likely to be an inherited structure than the reflexes necessary to handling other simpler implements with the left hand" (Chamberlain, 1928:557).

Annett (1973) found a significant maternal influence in the determination of handedness and an association of borderline significance between sisters. Paternal influence was felt to be present particularly for sons. She suggested that the most straight forward polygenic model of the determination of handedness would entail the action of several genes, each of small and equal effect over the entire laterality distribution.

Lutz (1908) was the first to point out that a definite pattern is followed when an individual clasps his hands with his fingers interlocking. He determined that the position assumed had no relation to handedness even though a small majority of people put the right thumb uppermost. He felt that the mode of clasping the hands is inherited since it is such an inconsequential action that it could scarcely be acquired by imitation. However he found that the trait did not seem to follow the simple Mendelian law since neither position bred completely true.

Dahlberg (1926), on the other hand, upon investigating twins, found no evidence that the pattern of handclasping was genetically determined. His study of monozygotic and dizygotic twins showed that the frequency of the trait was the same as that expected by a chance distribution.

In a study of handclasping by Lai and Walsh (1965) it was suggested that the pattern of handclasping was established at an early age and by habit rather than by inherited factors. They felt that the varying frequency of right handclasping individuals in various populations constituted the only support of the hypothesis that the pattern of handclasping is genetically determined. Family studies conducted by Lai and Walsh did not suggest a significant association of the pattern in the offspring with that of the parents.

A relationship between handclasping and handedness was indicated by Downey (1926). She observed a connection between right handed and right handclasping males that was not significant for females. She felt that the failure to establish a link between the traits among the females was due to a small sample size.

A higher incidence of right handclaspers among females than among males was noted by Downey (1926), Freire-Maia et al. (1958), Pons (1961), and Beckman and Elston (1962). The study by Freire-Maia, Quelce-Salgado, and Freire-Maia (1958) involved Caucasians, Mulattoes, and Negroes. They felt that the consistency of the excess of right handclasping females over males in their data pointed to a definite sexual difference in the frequency of the trait. Pons (1961) noted that the frequency of right handclaspers rises with age. Kawabe (1949) noted that among the Japanese group he studied the frequency of right handclaspers rose from 57.4% for those under 20 years of age to 62.3%

for those over 20.

The postulated genetic base for the handclasping trait has rested largely on differences in the frequency of the trait in the various populations. Freire-Maia and De Almeida stated, "Apparently, at least some results seem to indicate the possibility that selective forces are acting differently in different ethnic groups and/or different environments. Therefore, the differences in some results obtained in different populations should not be viewed as 'contradictory' in the sense that one or both of them are wrong. The possibility must be considered that such results may represent different situations regarding the action or interaction between genetic and/or environmental factors" (Freire-Maia et al., 1966:178).

Family data was first considered relative to handclasping by Lutz (1908) and later by Wiener (1932). Wiener's observations led him to conclude that the manner of clasping the hands and folding the arms are habits formed early in life and that the particular manner selected by each individual was due to chance alone. Lai and Walsh (1965) and Rhoads and Damon (1973) reported that even though there were more right handclasping offspring than left from the R x R matings, the difference was not significant.

Freire-Maia, Quelce-Salgado, and Freire-Maia (1958), in their study of family data, showed some parental influence on the type of handclasping encountered among their children. They hypothesized that a prenatal factor (probably genetic in nature) was responsible for the correlation. Other evidence supporting this view was given by Yamaura (1940), Kawabe (1949), and Pons (1961).

Wiener (1932) instigated the study of the trait of armfolding. He believed that, like handclasping, the trait was formed by habit early in life and had no genetic basis. A partial genetic control for the armfolding trait was suspected by Freire-Maia et al. (1960); however, Rhoads and Damon (1973) took a different view. They stated that since the variance of armfolding among different populations was not as great as was that for handclasping and since family patterns of inheritance have not been clearly demonstrated, a genetic component in armfolding could not be assumed.

A higher frequency of right armfolding among females was found by Beckman and Elston (1962) even though right armfolding was less frequent than left in the total population they studied. They speculated that bilateral asymmetries in the shape and length of the fingers and arms might play a role in the determination of right and left handclasping and armfolding.

Rhoads and Damon (1973) found that handclasping and handedness were significantly associated in their study. Two-thirds of right or left handed persons in their group clasped their hands with the corresponding thumb uppermost. However, they found no association between handclasping and armfolding.

Beckman and Elston (1962) and Jantz (1964) found no association between handedness, armfolding, and handclasping.

Danforth (1921) was the first to systematically study mid-phalangeal hair. He concluded that the presence of hair on the middle phalanges was dominant over its absence. He noted that if hair was present at all on the middle phalanges that it would appear on the fourth finger in 92% of the cases. The third finger was next most likely to have hair followed by the fifth finger. Danforth also noted that with few exceptions a child will have mid-phalangeal hair on no more fingers than its most hairy parent.

Bernstein envisioned a hypothetical series of alleles A_1, A_2, A_3, and A_4 (in order of increasing dominance) with subscripts corresponding to the number of digits affected with hair. An allele A_0, in the homozygous condition, would correspond to the absence of mid-digital hair (Bernstein and Burks, 1942).

Hindley and Damon (1973) determined that mid-phalangeal hair varied with sex, age, and population, in a rough correspondence with the total amount of body hair. Furthermore, they felt that beyond the genetic basis of population differences in the amount of body hair the existence of any separate genetic control for mid-phalangeal hair was uncertain. Among the Lau and Baegu of the Solomon Islands, whom they studied, the absence of mid-phalangeal hair was not a strict recessive trait.

Several authors have observed sex differences in the incidence of mid-phalangeal hair (Boyd, 1950; Garn, 1951; Giles et al., 1968; Hindley and Damon, 1973). Mid-phalangeal hair occurred more frequently in males than in females. Asymmetrical cases of mid-phalangeal hair were noted by Bernstein and Burks (1942) and by Setty (1966). Giles et al. (1968) determined that a nonsymmetric pattern was twice as common in males than in females. Jantz (1964) found that hair was more likely to occur on the digits of the left hand than on the right.

It has also been noted that mid-phalangeal hair is affected by age with a greater occurrence of hair after puberty than before (Garn, 1951; Hindley and Damon, 1973; Saldanha et al., 1961). Garn (1951) showed that the frequency of individuals with middle phalangeal hair among castrated males is lower than among controls from the general population. He suggested that since the incidence of the trait varied with age and sex it was not unreasonable to suspect that the trait was hormone mediated as well as being genetically determined.

Saldanha et al. (1961) found that the incidence of mid-digital hair in individuals of both sexes increased after the onset of puberty (considered 15 years for males and 13 years for females). The percentage of males rose from 50.8% before puberty to 68.2% after. Of the females 47.3% showed the hair trait before puberty as compared with 54.8% after.

Washburn decided that because the trait was under "special genetic control" it might reflect a partial adaptation to knuckle-walking by our ancestors. He stated, "It is far from clear why this particular hair should be subject to special genetic control, unless it is remembered that this is precisely the weight-bearing surface of the knuckle-walker. . . . The development of a weight-bearing surface is correlated both with the thickening of the epidermis and with the loss of hair and it may be that the condition of mid-digital hair in man is at least a partial adaptation to knuckle-walking by our remote ancestors" (Washburn, 1968:26).

Interestingly, Tuttle (1967) noted that even though chimpanzees had knuckle pads over the middle phalanges of all four fingers only the middle and ring fingers (the fingers most likely to have mid-digital hair in man) appeared to be essential for supporting the animal during quadrupedal locomotion. However, he did not believe that the ancestors of the hominidae went through a knuckle-walking or fist-walking stage before assuming a bipedal gait.

CHAPTER III

METHOD AND PROCEDURE

This study was based on data from individuals in three different populations. One of these population groups was composed of 174 Cashinahua who form a small isolate of American Indians residing in the Peruvian rain forest. The three villages in which they live are located along the Curanja River in the province of Coronel Portillo in southeastern Peru. Data was obtained on 107 individuals from the village of Balta, the largest village of the three. Thirty-eight individuals from the village of Samuel and 29 persons from the village of Sika made up the rest of the sample. The Cashinahua were studied in the spring of 1966; cultural and biological data was obtained by means of interview, examination, and observation. Included with the data gathered was information concerning handclasping and mid-phalangeal hair (Jantz et al., 1970). Unfortunately data was not collected on either handedness or armfolding. Infants who were too small to clasp their hands were recorded but have not been included in this study. The Cashinahua villages were first analyzed separately in order to make village-by-village comparisons. Then the total Cashinahua population was considered in order to make a large enough group to compare statistically with the Tennessee populations.

A second population was composed of 268 University of Tennessee students who were enrolled in introductory physical anthropology classes in 1972. This sample was limited to Caucasians and to those who were born in the southeastern United States. Collected as part of a "human variation" survey, this data contained information on handedness, armfolding, handclasping, and mid-phalangeal hair along with the usual information on age, sex, height, weight, etc. Of those responding 133 were male and 135 were female.

During Winter Quarter, 1974, another questionaire, this time designed to solicit family information, was circulated with response from 86 families. In most cases a student at the University of Tennessee was asked to solicit the needed information from his family. In addition many faculty families from both the mathematics and anthropology departments participated. Thus the third population was made up of 86 families, consisting of 180 male and 192 female members, each in some way connected with activities in and around Knoxville, Tennessee, in the winter of 1974. Handclasping, armfolding, handedness (the writing hand), mid-phalangeal hair (including the specific fingers affected), age, and sex information was solicited.

Since the data involving the University of Tennessee students and the University of Tennessee families was collected largely by means of a self-administered questionaire, it is possible that some of the information provided was inaccurate. However, it seems unlikely that enough inaccuracies would have occurred to significantly affect the results presented here.

Most of the the tables and statistical analyses found in Chapter V were extracted and adapted from computer output obtained through the use of the Statistical Analysis System, which was designed and implemented by Barr and Goodnight, Department of Statistics, North Carolina State University. The IBM 360 computer at the Computer

Center, The University of Tennessee, Knoxville, was utilized in processing much of the data. All of the statistical analysis on the family data from the Tennessee population was done with a hand calculator. In particular the Chi-square (X^2) test for statistical significance was used throughout Chapter V; frequent use was made of the "Chart of X^2" given by Crow (1966:205). Statistical formulas, originating from Fisher (1918) and Mather (1949) as adjusted by Penrose (1971) for population studies, were used in the family data to estimate hereditary variance. Fisher (1958), Edwards (1965), and Rohlf and Sokal (1969) contain the standard statistical techniques used in this paper.

CHAPTER IV

GOALS OF THE STUDY

The goals of this study are the following:

(1) To determine the incidence and variation of handclasping and mid-phalangeal hair among the three populations.

(2) To compare the occurrence of right and left handedness and armfolding in the two Tennessee populations.

(3) To analyze the frequency of the four laterality traits in the families included in the samples, with particular emphasis on the Tennessee families, in an effort to determine the heritability of the traits.

(4) To attempt to expose any existing relationships among the laterality traits and their relation to both sex and age.

(5) To compare the results of this study with those of other similar studies.

CHAPTER V

RESULTS

The sample consisting of the students from the University of Tennessee anthropology classes will be referred to as "Tennessee I" throughout the remainder of this thesis. Information pertaining to the other Tennessee group, the family sample, will be labeled "Tennessee II". Handedness and armfolding in these two populations will be considered following an analysis of handclasping and mid-phalangeal hair. After the presentation of the results on the four traits there will be a section showing the results of bivariate analyses carried out to determine the degree of association among the laterality traits.

The last section of this chapter will consist of the presentation of data from the Cashinahua and Tennessee II family groups which was collected in an attempt to isolate the possible hereditary nature of each of the four traits. As mentioned previously, there was no data on either handedness or armfolding from the Cashinahua sample.

I. POPULATION DATA

Handclasping

The frequency of right handclasping varied among the three Cashinahua villages as shown in Table 1. The largest village of the three, Balta, differed somewhat from the other villages; however, the difference is clearly not significant. These results are interesting since they differ from those obtained in other studies of the same Cashinahua group. Jantz et al. (1970) found that the village of

Samuel was the most aberrent in their study of palmar dermatoglyphics. Samuel also differed from the other villages in serum protein distribution (Johnston et al., 1969). The slight variation in handclasping frequency is attributable to sample size.

Table 1

Incidence of Right and Left Handclasping

Among the Cashinahua

Village	Sex	R	%R	L	%L	Percent R in Total Village
Balta	M	40	78.4	11	21.6	74.8
	F	40	71.4	16	28.6	
Samuel	M	14	70	6	30	68.4
	F	12	66.7	6	33.3	
Sika	M	10	71.4	4	28.6	69.0
	F	10	66.7	5	33.3	
Combined Villages	M	64	75.3	21	24.7	72.4
	F	62	69.7	27	30.3	

The percentage of right handclaspers among the Cashinahua exceeds that reported for Brazilian Indians by Freire-Maia et al. (1958). In that study 54.7% of 192 individuals were found to be right handclaspers. The percentage of right handclaspers among the Cashinahua was higher than in most other groups (see Table 2). Lourie (1972) found 78% right handclaspers among Yemenite males; Freire-Maia et al. (1958) found 68.7% among Brazilian negroes; and Rhoads and Damon (1973) found 66.4% among Solomon Islanders.

Handclasping patterns among the Cashinahua showed no age ($X^2 = 3.85$, d.f. = 4, $p > 0.43$) or sex ($X^2 = 0.69$, d.f. = 1, $p > 0.41$) effects.

Nine individuals out of the total sample of 174 were observed as having mid-digital hair. Six of these were from Balta, two were from Samuel, and one was from Sika. Five were females and four were males. Six of those observed with hair were 15 years of age or younger. Hair was recorded only on the fourth digit with the exception of one individual who had hair on the third, fourth, and fifth digits on the right hand and on the third and fourth digit of the left hand.

The general lack of mid-digital hair among the Cashinahua is in agreement with data collected on other American Indian groups. Danforth (1921) described a small Indian population from the north-eastern part of the United States with a frequency of hairlessness of 60% while Sewell (1939) found 98.7% of Eskimos of unspecified sex were without mid-digital hair. Giles et al. (1968), in their study at Ticul of 780 males and 651 females, found that 75.9% of the males and 87.1% of the females were without hair. They concluded that the frequency they found in Yucatan provided independent evidence for the fact that a relatively small amount of European admixture existed in the Ticul sample.

The Cashinahua data is not consistent with other studies

Table 2

Handclasping in Cashinahua and Other Populations

Population	Author	Date	Number Tested	Percent Right
United States (Kansas Males)	Jantz	1964	249	41.8
Hungarian	Gyorgy and Gyorgy	1968	415	45.8
United States (Tennessee II)	This Study	1974	372	46.5
Chinese	Lai and Walsh	1965	70	48.6
Australians (White)	Lai and Walsh	1965	207	49.3
Kurdish Jews	Lourie	1972	112	50.0
United States (Tennessee I)	This Study	1974	268	50.4
Spaniards	Pons	1961	486	52.1
Swedes	Beckman and Elston	1962	981	52.1
Brazilians (Indians)	Freire-Maia et al.	1958	192	54.7
Brazilians (White)	Freire-Maia et al.	1958	1566	55.2
Japanese	Yamaura	1940	1411	55.5
Japanese	Lai and Walsh	1965	111	55.9
Brazilians (Russian Immigrants)	Freire-Maia et al.	1960	58	57.0
India (Maharastrian females)	Shastree and Malhotra	1971	616	59.2
Brazilians (Japanese)	Freire-Maia et al.	1958	1012	60.6
Bantu (Angola)	Freire-Maia et al.	1966	1431	62.0
New Guineans	Lai and Walsh	1965	781	62.7
Filipinos	Lai and Walsh	1965	80	63.3
Australians (Aboriginal)	Lai and Walsh	1965	66	65.0
Solomon Islanders	Rhoads and Damon	1973	1438	66.4
Yemenite Jews	Lourie	1972	74	68.0
Brazilians (Negro)	Freire-Maia et al.	1958	489	68.7
Cashinahua (Peru)	This Study	1974	174	72.4
India (Manipuri Brahmins)	Singh and Malhotra	1971	330	75.2

which found a higher frequency of hair among males than among females (Garn, 1951; Giles et al., 1968; Hindley and Damon, 1973).

Table 3 summarizes the data collected on handclasping from the two Tennessee populations. Tennessee I had 50.4% right handclaspers among the total population whereas 46.5% of those in Tennessee II were right handclaspers. These percentages are in general

Table 3

Frequency of Right and Left Handclasping

in Two Tennessee Populations

Population	Sex	R	L	A*	Percent R
	M	59	68	6	44.4
Tennessee I	F	76	54	5	56.3
	Total	135	122	11	50.4
	M	87	93	0	48.3
Tennessee II	F	86	106	0	44.8
	Total	173	199	0	46.5

*This column is for those reporting no preference in the handclasping trait. In Tennessee II there were two individuals not responding, and these were not included in the sample.

agreement with those obtained by other researchers (see Table 2) reporting on Caucasian populations in the United States, Australia, Brazil, Hungary, Spain, and Sweden. However, as can be seen from

Table 2, most investigators report a higher frequency of right handclaspers than left, with such frequencies ranging as high as 75.2% (Singh and Malhotra, 1971) and as low as 41.8% (Jantz, 1964).

It is worth noting that the frequency of right handclasping males (48.3%) exceeds the frequency of right handclasping females (44.8%) in Tennessee II. The opposite situation exists in the Tennessee I group. Yamaura (1940) noted a similar difference in two Japanese populations. He attributed the discrepancy to sampling error. Most investigators have found a higher frequency of right handclaspers among females than among males (Freire-Maia et al., 1958; Downey, 1936; Beckman and Elston, 1962; Saldanha et al., 1961). However among Angola Negroes (Freire-Maia et al., 1966), Bengals (Chattopadhyay, 1968), and Yemenites in Israel (Lourie, 1972) the right handclasping frequency was higher among males.

There was no significant relationship between handclasping and sex in either Tennessee I or Tennessee II ($X^2 = 3.82$, d.f. = 2, $p > 0.145$ and $X^2 = 0.468$, d.f. = 1, $p > 0.501$, respectively). Since the students comprising the sample of Tennessee I were of a fairly uniform age, no analysis of the age-handclasping relationship was possible. However, in Tennessee II there was no significant relationship between handclasping and age ($X^2 = 4.818$, d.f. = 6, $p > 0.569$).

Mid-phalangeal Hair

The frequency of hair on the mid-phalangeal surfaces of the individuals in Tennessee I and II is shown in Table 4. The incidence of individuals without mid-phalangeal hair in Tennessee I is lower than that found by other researchers; however, it is close to the 21.6% of hairlessness found by Bernstein and Burks (1942) in their sample of whites in the United States. The number of individuals without hair in Tennessee II compares with the frequency found among most Caucasoid populations. Fewer females than males in both groups had hair.

Table 4

Frequency of Hair in Two Tennessee Populations

Population	Sex	No Hair	Hair	Percent No Hair
	M	25	103	19.5
Tennessee I	F	31	104	23.0
	Total	56	212	20.9
	M	56	124	31.1
Tennessee II	F	74	118	38.5
	Total	130	242	34.9

Table 5 shows the distribution of hair on each finger. The pattern distribution conforms to that originally noted by Danforth (1921) and since noted by other workers. Digit 4 exhibits the highest incidence of hair followed by digit 3. The second digit has the least amount of hair.

The frequency of hair in Tennessee II is lower than that found in Tennessee I. This is undoubtedly a reflection of the range of ages present in the Tennessee II sample whereas the individuals in

Table 5

Distribution of Mid-Phalangeal Hair on Right and Left Digits

Population	Sex		Digits: Left Hand II	III	IV	V	Right Hand II	III	IV	V
Tennessee I	M	N	32	82	107	44	32	83	107	44
		%	24.1	61.7	80.5	33.1	24.1	62.4	80.5	33.1
	F	N	41	85	104	43	40	85	103	43
		%	30.4	63.0	77.0	31.9	29.6	63.0	76.3	31.9
	Total	N	73	167	211	87	72	168	210	87
		%	27.2	62.3	78.7	32.5	26.9	62.7	78.4	32.5
Tennessee II	M	N	28	89	119	66	30	92	117	65
		%	15.5	49.4	66.1	36.7	16.7	51.1	65.0	36.1
	F	N	20	87	114	60	18	90	114	58
		%	10.4	45.3	59.4	31.3	9.4	46.9	59.4	30.2
	Total	N	48	176	233	126	48	182	231	123
		%	12.9	47.3	62.6	33.9	12.9	48.9	62.1	33.1

Tennessee I comprised a more homogeneous group. The individuals in Tennessee II were divided into ten year age intervals to test the relation of hair to age. The X^2 test proved highly significant ($X^2 = 19.36$, d.f. = 6, $p < 0.004$); however close scrutiny of the data revealed that most of the significance was in the 0-10 age interval where there were many more actual hairless individuals than was expected by chance. The next most divergent group was made up of individuals in the oldest age range (60-70 years). The individuals in the intermediate ranges did not differ as significantly from the expected values. Hindley and Damon (1973) and Saldanha et al. (1961) noted a significant increase in the frequency of hair after puberty.

The pattern of mid-phalangeal hair in Tennessee I is shown in Table 6. The most frequent hair pattern in this population involved digits 3 and 4; however, this is not the most frequent pattern generally found. Even though the third finger is the one most likely to have hair after the fourth one, the most common pattern found by other workers is 3,4,5 (Danforth, 1921; Bernstein and Burks, 1942; Garn, 1951). The hair frequency pattern found in Tennessee II, on the other hand, followed that found by other workers (see Table 7).

Observation of the pattern frequencies on digit 4 and digits 2,3,4,5 between males and females in Table 7 suggested a difference in hair patterns between sexes in Tennessee II. A calculation of the significance of this observation proved interesting ($X^2 = 13.25$, d.f. = 6, $p < 0.035$). When the calculation is made with the "other" category included the significance is even greater. The main contributors to this value of X^2 were, in order of their contribution, patterns 2,3,4,5;

Table 6

Pattern Frequency of Mid-Phalangeal Hair in Tennessee I

	Left Hand						Right Hand					
	Male		Female		Total		Male		Female		Total	
Pattern	N	%	N	%	N	%	N	%	N	%	N	%
0	25	18.8	31	23.0	56	20.9	25	18.8	31	23.0	56	20.9
3,4	25	18.8	30	22.2	55	20.5	24	18.1	30	22.2	54	20.1
4	26	19.5	18	13.3	44	16.4	26	19.5	18	13.3	44	16.4
2,3,4,5	17	12.8	27	20.0	44	16.4	17	12.8	25	18.5	42	15.7
3,4,5	24	18.1	14	10.4	38	14.2	25	18.8	15	11.1	40	14.9
2,3,4	14	10.5	14	10.4	28	10.5	14	10.5	15	11.1	39	14.6
4,5	1	0.8	1	0.7	2	0.8	1	0.8	1	0.7	2	0.7
Other	1	0.8	0	0	1	0.4	1	0.8	0	0	1	0.4
Totals	133		135		268		133		135		268	

Table 7

Pattern Frequency of Mid-Phalangeal Hair in Tennessee II

	Left Hand						Right Hand					
	Male		Female		Total		Male		Female		Total	
Pattern	N	%	N	%	N	%	N	%	N	%	N	%
0	60	33.3	75	39.1	135	36.3	63	35	76	39.6	139	37.4
3,4,5	39	21.7	44	22.9	83	22.3	37	20.5	44	22.9	81	21.7
3,4	24	13.3	26	13.5	50	13.4	30	16.7	29	15.1	59	15.9
4	28	15.5	20	10.4	48	12.9	20	11.1	21	10.9	41	11
2,3,4,5	26	14.4	13	6.8	39	10.5	27	15	12	6.3	39	10.5
2,3,4	0	0	5	2.6	5	1.3	0	0	5	2.6	5	1.3
4,5	2	1.1	4	2.1	6	1.6	2	1.1	3	1.6	5	1.3
Other	1	0.6	5	2.6	6	1.6	1	0.6	2	1.0	3	0.8
Totals	180		192		372		180		192		372	

2,3,4; and 4, with the males having a greater frequency of hair in each pattern. It is interesting that no significant difference was found in the mid-digital hair patterns between sexes in Tennessee I ($X^2 = 7.49$, d.f. = 7, $p > 0.30$). This suggests that perhaps age has a bearing on the different patterning of the hair between the sexes.

There were some differences between the distribution of hair on the right and left hands; however, the differences observed in Tennessee I and II were not as great as those observed by other researchers (Saldanha, 1961; Giles et al., 1968; Bernstein and Burks, 1942). Only 6 asymmetries (2.2%) were recorded in Tennessee I whereas 32 (8.6%) were observed in the Tennessee II data. Since Tennessee I was composed of students around 20 years of age, it is possible that very little change had occurred in their hair patterns whereas the individuals of varying ages in Tennessee II would have been more susceptible to the wearing off of hair. It is also possible that some individuals failed to note asymmetrical hair patterns as they completed the questionaires. In the asymmetric cases slightly more hair was found on the left digits than on the right. This agrees with the results of Jantz (1964).

Handedness

Table 8 shows the variation in hand preference between the two Tennessee populations. There is a higher incidence of left handed males than females in both samples. Similar results were found by other investigators (Annett, 1972, 1973; Chamberlain, 1928; Rife, 1940). However the difference in frequency between the two sexes was not statistically significant in either sample (Tennessee I: $X^2 = 1.38$, d.f. = 2, $p > 0.51$; Tennessee II: $X^2 = 1.07$, d.f. = 1, $p > 0.30$).

Table 8

Frequency of Right and Left Handedness

in Two Tennessee Populations

Population	Sex	R	L	A*	Percent R
	M	116	13	4	87.2
Tennessee I	F	123	8	4	91.0
	Total	239	21	8	89.2
	M	156	24	0	86.7
Tennessee II	F	173	19	0	90.1
	Total	329	43	0	88.4

*This column is for ambidextrous individuals.

The average percentage of left handedness in this study is comparable with that found by Jantz (1964) in his Kansas student population; however, it was higher than that found by Collins (1961), Chamberlain (1928), Rhoads and Damon (1973), Beckman and Elston (1962), and Pelecanos (1969). In the Rhoads and Damon paper an association between the percentage of left handedness and the state of Western acculturation was claimed, with the frequency of left handedness increasing as the culture becomes more Westernized. A recent article concerning left handed individuals in the Japanese culture appeared in Time Magazine (1974) where it was reported that many Japanese people consider left handedness a defect and force their children to suppress the left handed tendacies. Left handed individuals are discriminated against in many cultures, and this undoubtedly tends to lower the incidence reported for this character in many populations.

Armfolding

The frequency of right and left armfolding in the two Tennessee populations is shown in Table 9. In both groups the frequency of right armfolders is less than the frequency of left armfolders. Furthermore, there are more right armfolders among females than among

Table 9

Frequency of Right and Left Armfolding in Two Tennessee Populations

Population	Sex	R	L	A*	Percent R
	M	47	85	1	35.3
Tennessee I	F	62	66	7	45.9
	Total	109	151	8	40.7
	M	60	119	1	33.3
Tennessee II	F	71	121	0	37.0
	Total	131	240	1	35.3

*No preference.

males in both groups. Similar results have been found in other studies (Rhoads and Damon, 1973; Freire-Maia et al., 1960; Wiener, 1932;

Beckman and Elston, 1962) with the majority of populations containing 35-50% right armfolding individuals.

The Chi-square test for sex versus armfolding was not significant in Tennessee II ($X^2 = 1.55$, d.f. = 2, $p > 0.46$); however, a similar test in Tennessee I showed significance at the 5% level ($X^2 = 8.94$, d.f. = 2, $p < 0.015$). Other studies (Lourie, 1972; Pelecanos, 1969; Saldanha et al., 1961) found no significant sex difference. Since Tennessee I was composed of students of similar age, it was not possible to consider a relationship between age and armfolding in that group. However a Chi-square test for age versus armfolding in Tennessee II was not significant ($X^2 = 6.83$, d.f. = 12, $p > 0.869$).

Pairwise Laterality Relationships

No correlation was found in this study between handedness and armfolding ($X^2 = 6.32$, d.f. = 4, $p > 0.175$ for Tennessee I; $X^2 = 1.3$, d.f. = 2, $p > 0.465$ for Tennessee II) or between handedness and handclasping ($X^2 = 3.59$, d.f. = 4, $p > 0.47$ for Tennessee I; $X^2 = 0.422$, d.f. = 1, $p > 0.53$ for Tennessee II). Wiener (1932) and Beckman and Elston (1962) also found no association between handedness and either armfolding or handclasping.

There was a significant relationship between handclasping and armfolding in Tennessee I ($X^2 = 11.22$, d.f. = 4, $p < 0.03$). No such relationship was found between these traits in Tennessee II ($X^2 = 1.40$, d.f. = 2, $p > 0.50$).

II. FAMILY DATA

Family data was analyzed in an effort to isolate the possible hereditary nature of each of the four laterality traits. The data for each such trait is first tested against chance expectation; then those traits showing significant variation are analyzed further. Penrose (1971) states that by considering the values of the parent-child and sib-sib correlation coeficients the following questions can be answered:

(1) How much of the variation of a given character is attributable to hereditary influence?

(2) How far are dominant or recessive characters involved in a given measurement?

His methods will be followed in this section when it is appropriate.

Handclasping

The data from the three combined Cashinahua villages represents 42 marriages resulting in 102 offspring. The handclasping type of 27 of the 102 offspring was not recorded because the individuals were too young to attempt the activity. Table 10 is adapted from one prepared by Johnston (1969), who was involved in the original survey of the Cashinahua. Johnston reported a lack of genetic basis for handclasping among this population based on a X^2 of 4.596 ($0.30 < p < 0.50$, d.f. = 5); however, one of his expected values was slightly miscalculated. The corrected Chi-square, however, shows that the variance is still not significantly different from that expected by chance ($X^2 = 2.472$, d.f. = 2, $0.30 < p < 0.40$). Of course it should be noted that the sample size is rather small; in particular, the data on the offspring

Table 10

Distribution of Handclasping Among the Offspring of 42 Marriages in the Peruvian Cashinahua Grouped According to Mating Type

Parental Mating Type	N	L	R	Total
R x R	30	18	35	53
R x L	10	7	11	18
L x L	2	3	1	4
Total	42	28	47	75

of the R x L and L x L couples combined involved only 22 children.

In some respects the Cashinahua data supports results reported by other observers. For instance, 66% of the offspring of the R x R matings were right handclaspers. Others reporting on the percentage of right handclaspers from R x R matings were: Lai and Walsh (1965)- 61% and 55%; Lutz (1908) - 72%; Yamaura (1940) - 70%; Pons (1961) - 61%; Freire-Maia et al. (1958) - 70%; and Rhoads and Damon (1973) - 71%.

Family data was also collected on handclasping among 84 families having children in the Knoxville, Tennessee, area. The percentage of right handclaspers among the offspring of the R x R matings in this group is 69.5%, again consistent with most of the data in the literature. The distribution of the offspring with respect to parental mating type is given in Table 11. A statistical analysis of the data in Table 11, using the X^2 test, shows almost no possibility that this variance is due to chance alone ($X^2 = 28.84$, d.f. = 3, $p < 0.001$). Similar findings, though not as significant, have been reported by Lutz (1908), Yamaura (1940), Kawabe (1949), Freire-Maia et al. (1958), and Pons (1961); while Wiener (1932), Lai and Walsh (1965), and Rhoads and Damon (1973) found no reason to reject the chance hypothesis.

Table 11

Distribution of Handclasping Among the Offspring of 84 Families Grouped by Parental Mating Type

Parental Mating Type	N	L	R	Total
R x R	17	14	32	46
R x L	21	27	27	54
L x R	21	27	33	60
L x L	25	52	14	66
Total	84	120	106	226

The percentage of left handclasping children resulting from L x L matings is 79%; this percentage is higher than that found in any other study (see Table 12). Furthermore, the frequency of L x L matings in the Tennessee sample is much larger than other reported frequencies. One might suspect assortative mating against the L x L coupling in the other studies but the authors of those investigations reported statistical insignificance in this regard. A Chi-square test for assorative mating in the Tennessee sample showed it likely to be absent ($X^2 = 0.0006$, d.f. = 3, $p > 0.95$).

Table 12

Frequency of L Handclasping in Offspring of L x L Matings and Frequency of L x L Matings in Various Studies

Author	Percent of L Children in L x L Matings	Percent of L x L Matings
Present Study (Cashinahua)	75*	4.8
Present Study (Tennessee)	79	30.0
Lutz (1908)	58	16.9
Wiener (1932)	55	19.2
Yamaura (1940)	68	14.5
Kawabe (1955)	30	15.8
Freire-Maia et al. (1958)	52	16.3
Pons (1961)	71	16.3
Lai and Walsh (1965)	58	21.0
Rhoads and Damon (1973)	42	8.5

At least part of the divergence of the present sample from the others, as given in Table 12, can be accounted for by the fact that in the Tennessee parent population there were only 45.2% right handclaspers. The groups represented in Table 12 vary from 57% to 73% right handclasping parents (mean = 63.3%). However it should be noted that 69.5% of the offspring of the R x R matings in the Tennessee family data were right handclaspers despite the fact that the total population has more left handclaspers. (This 69.5% frequency compares favorably with that from other investigations.)

Since the data in Table 11 on handclasping in the Tennessee population suggest significant familial patterning, it should be analyzed further. The traditional measure of the hereditary influence is given by the heritability index h^2 which measures the fraction of the total variance which can be attributed to hereditary factors. This is what determines the degree of resemblance between relatives; thus, heritability is defined as the ratio of additive genetic variance to phenotypic variance (Falconer, 1960:165). Penrose (1971) estimates h^2 using the formula $h^2 = 4r_{ss} - 2r_{pc}$. The coefficients r_{ss} and r_{pc} are the sib-sib and parent-child coefficients first studied by Fisher (1918).

The formula given by Edwards (1965:159) can be used to calculate $r_{pc} = 0.046$ for the Tennessee handclasping data. For the computation of r_{pc} all possible ordered parent-child pairs (using the parent over in as many pairs as he/she has children) are recorded as R,R; R,L; L,R; or L,L trait values. The coefficient $r_{pc} = 0.046$ proved to be insignificant ($X^2 = 0.973$, d.f. = 1, $p > 0.35$), indicating no demonstrable genetic effect for handclasping.

The computation of the sib-sib coefficient r_{ss} using the formula from Edwards (1965:159) gave unreliable results, and it was found that this formula depends upon the order of the children within each family. The computation of the Intraclass Correlation Coefficient r_I given by Rohlf and Sokal (1969:211) does not have this defect and yields $r_{ss} = 0.14$ ($X^2 = 4.998$, d.f. = 1, $p < 0.03$).

The heritability index h^2 is found to be 0.468 using the above values for r_{pc} and r_{ss}. This index suggests that over 50% of the variance in the handclasping data is determined by factors other than heredity. Loesch (1971:286) states that when h^2 is below 0.5 further genetic analysis will not be informative; however, this minimal figure for h^2 appears to be an arbitrary one. Therefore, the data has been further analyzed for dominance and recessivity using the dominance-recessivity index $(dr)^2$ given by the formula $(dr)^2 = (4(r_{ss} - r_{pc}))/h^2$ as set forth by Penrose (1971). This index, which is independent of environmental effects, turns out to be 0.895 and indicates dominance. The frequency q of the recessive allele and the index $(dr)^2$ are related by $(dr)^2 = (1 - q)/(1 + q)$. From this q is calculated to be 0.055, and the frequency q^2 of the recessive character is 0.003. However, actual measurements show character frequencies of 0.535 for left handclaspers and 0.465 for the right handclaspers, and neither frequency is close to the formally calculated value of 0.003. This would seem to rule out the possibility that there is a major gene effect in the handclasping pattern.

<u>Mid-phalangeal Hair</u>

The lack of mid-phalangeal hair among the Cashinahua makes it impossible to use that population to statistically determine how the characteristic is transmitted from generation to generation. In fact only 9 individuals had the hair trait, and these individuals belonged to 8 families. Thus only the 86 families from the Tennessee area were considered in the analysis of family data.

Complete absence of hair on the mid-phalanges has been labeled "0" in this discussion; a person is said to have phenotype "1" if there is hair on some digit of either hand. Table 13 shows the distribution of these hair phenotypes of the offspring from the various mating possibilities. An analysis of the data shows it to be significantly different from chance ($X^2 = 37.99$, d.f. = 3, $p < 0.0001$), and the chance hypothesis must be rejected. It thus appears that the presence or absence of hair on the mid-phalanges has some hereditary basis. A study of Solomon Islanders by Hindley and Damon (1973) failed to show any reason for suspecting such a hereditary basis ($X^2 = 0.42$, d.f. = 3, $p > 0.95$). Danforth (1921) was first to suggest that the absence of mid-phalangeal hair was due to a reccessive gene or genes, and family data collected by Bernstein and Burks (1942) and by Bernstein (1949) supported this hypothesis.

Table 13

Distribution of Mid-phalangeal Hair Among the Offspring of 86 Families by Parental Mating Type

Parental Mating Type	N	0	1	Total
0 x 0	10	18	7	25
0 x 1	11	16	15	31
1 x 0	24	25	40	65
1 x 1	41	24	88	112
Total	86	83	150	233

Since this study and the Hindley-Damon study point toward opposite conclusions it might be well to consider them further. Hindley and Damon feel that considering children that have not yet reached puberty in the family data on hair can produce erroneous results. They cite this factor as being responsible for a contrary conclusion made by Beckman and Böök (1959) in a Swedish family study (Hindley and Damon, 1973:193). Apparently the range of age among children in the Swedish study was from 1.5 to 4.5 years. This seems to be a legitimate criticism for the Swedish data, but it doesn't seem to be as serious in the present study. Of the 233 children studied, only 48 (21%) were under the age of 10 years, and of those 48 children there were 20 reported as having mid-phalangeal hair. (Among the Cashinahua population there were only 9 individuals with hair and 6 of those were under the age of 15.) Since most of this population came from families with college-age children, the majority of families had at least one child around 20 years of age. About 72% of the children in this study were between 10 and 30 years old.

The data collected for this study comes entirely from subject testimony as to the presence or absence of hair. It was found by Bernstein and Burks (1942) that observation using magnifying equipment reveal different results from a casual observation. In many cases where lack of hair is recorded by a casual observation, a finer study with a magnifying glass will reveal either hair or hair follicles. Thus the method of data collection in this study may have caused "affected" individuals to be classed as hairless. The frequency of hairless children in this study is 36% while it is 56% for the Hindley-

Damon data. Although the individuals studied by Hindley and Damon (1973) were examined individually, there was no effort made to magnify the fingers.

Both this and the Hindley-Damon samples involved the same number of families (86 for the present study and 88 for the other); however, there were 233 children studied here and only 78 in the Hindley-Damon research. Perhaps the differences in the results are due to sample size.

The variation in the mid-phalangeal hair trait that is attributable to hereditary influence was determined using the method proposed by Penrose (1971). The Pearson Product Moment Correlation provided $r_{pc} = 0.398$, where the presence of hair was recorded as being 0,1,2,3, or 4 according to the number of affected fingers. The sib-sib intraclass correlation was calculated as suggested by Rohlf and Sokal (1969:211); $r_{ss} = 0.4825$. The heritability index, h^2, is found to be 1.13. It should be remembered that this figure is only an estimate. As Penrose (1971:291) states, the true value of h^2 "varies between 0 and 1 but, in consequence of small sample irregularities, it may, in an estimation, lie outside these limits." Additionally, observational error, due to the method by which the data was collected, may have entered in and contributed to the excessively high h^2 value.

The dominance-recessivity coefficient $(dr)^2$ is found from the equation $(dr)^2 = (4(r_{ss} - r_{pc}))/h^2$ (Penrose, 1971:291). This index shows the measurement of the effect of heterozygotes as compared with the mean effect of the homozygotes; in the case of the involvement of multiple genes it gives the average effect (Loesch, 1971:286). For the data on mid-phalangeal hair $(dr)^2 = 0.373$, indicating recessivity. The frequency q of the recessive allele is computed to be 0.457 from the equation $(dr)^2 = (1 - q)/(1 + q)$. Thus the frequency q^2 of the recessive character is found to be 0.209. The actual frequency of individuals with no mid-phalangeal hair in the Tennessee population is 0.349, not too far from the calculated value.

The mode of transmission of this mid-digital hair characteristic is unclear. Perhaps, as first suggested by Danforth (1921), there is some sort of a "field" dominance involved; that is, perhaps the size of the field (the number of digits having hair) may be associated with the degree of dominance. Table 14 displays this "strength of field" effect for the Tennessee population. In this table the number "8" in the third row and the second column means that there were

Table 14

Parent-Child Relationship Involving the Number of Digits on which Hair is Present

		The Number of Affected Digits of Child					
		0	1	2	3	4	Total
Number of	0	83	19	21	21	10	154
Affected	1	34	20	13	9	2	78
Digits	2	12	8	20	22	8	70
of	3	23	10	13	39	7	92
Parent	4	7	5	17	20	19	68
	Total	159	62	84	111	46	462

8 parent-child situations where the parent had two affected digits and the child had exactly one. In tabulating this data when the two hands were not symmetrical with respect to hair, the hand with the most affected fingers was used. A computation of the correlation coefficient, as is described by Fisher (1958), yields r = 0.336. This correlation is highly significant ($X^2 = 52$, d.f. = 16, $p < 0.0001$).

Danforth (1921) found that with very few exceptions a child will have mid-digital hair on no more fingers than its most hairy parent. The data here confirms this "rule of thumb" since there were only 25 children with more digits affected than their most affected parent out of 462 possibilities. Bernstein and Burks (1942) also confirmed Danforth's observation. However it can be seen from Table 14 that there are many cases where a child will be more affected than at least one parent.

Handedness

No handedness data was collected from the Cashinahua villages; thus this section is concerned only with the families from the Tennessee area. The handedness data is presented in Table 15. Statistical tests show the data to be insignificant as far as demonstrating any deviation from chance occurrence ($X^2 = 2.368$, d.f. = 3, $p > 0.45$). Of course it would be futile to try to draw any conclusions from this particular family study since the sample size is much too small. There were only 14 left handed parents and 28 left handed children in comparison with 158 right handed parents and 210 right handed children. There was only one L x L mating in the sample. This problem seems to turn up in most samples except where information is solicited by advertisement as in the studies by Chamberlain (1928) and Annett (1973). Chamberlain's hypothesis of left handedness being recessive in the Mendelian sense, which was rejected by his own data, is also found invalid by the data in this study.

Table 15

Distribution of Handedness Among the Offspring of 86 Families Grouped by Parental Mating Type

Parental Mating Type	N	L	R	Total
R x R	73	25	179	204
R x R	5	2	10	12
L x R	7	1	20	21
L x L	1	0	1	1
Total	86	28	210	238

Armfolding

The armfolding data, compiled in Table 16, comes from 85 families in the Tennessee area as there was no armfolding data collected from the Cashinahua. The variance indicated in the table is not significantly different from chance expectation ($X^2 = 7.01$, d.f. = 3, $p > 0.50$). Rhoads and Damon (1973) also found no significant association of armfolding with the parental mode of folding the arms in their study of Solomon Islanders. Wiener (1932) gathered data from 103 families relative to the armfolding trait and concluded that the trait was not inherited.

One pattern does emerge consistently through the three studies. In no study was the frequency of left armfolding offspring from R x R matings larger than the frequency of the right phenotype. It also appears that when at least one parent is a left armfolder, as in the other three mating categories, the frequency of left armfolding children dominates the right.

Rhoads and Damon (1973) reported no assortative mating with respect to armfolding. There appeared to be no assortative mating in Wiener's (1932) study, and an analysis of the present data also shows a lack of assortative mating ($X^2 = 3.39$, d.f. = 3, $p > 0.35$).

Table 16

Distribution of Armfolding Among the Offspring of 85 Families Grouped by Parental Mating Type

Parental Mating Type	N	L	R	Total
R x R	15	24	26	50
R x L	16	30	17	47
L x R	15	23	16	39
L x L	39	66	28	94
Total	85	143	87	230

CHAPTER VI

DISCUSSION

The results presented here provide several insights into bilateral variation in man. It is likely that genetic, accidental, and cultural factors all play a role in the various manifestations of laterality that are observable. The interplay of the above influences is suggested in the variability observed in different populations. However, it is difficult to determine which factor is most responsible for determining the various patterns of lateral dominance observed among various groups.

The data in this study shows that there is no correlation between handedness and armfolding or between handedness and handclasping. Furthermore, the evidence of a relationship between handclasping and armfolding is conflicting; thus there exists a possibility that different factors are influencing these traits.

The variation in right handclasping frequency among different populations and the results of family data analysis, which shows some parental influence on the type of handclasping encountered among their children, indicate that the manner of handclasping is probably controlled by genetic factors. However, it is possible that other factors such as prenatal environment, anatomical differences, or cultural factors may be responsible.

The data suggests, though, that a genetic component is more evident in handclasping than in armfolding since in armfolding there is no tendency for frequencies to cluster according to geographical or ethnic groupings. Certainly the trait is less useful than handclasping as an anthropological marker.

The presence of hair on the middle phalanges is another trait which shows wide variability in different populations. Analysis of family data provides evidence that hair patterns are similar in families. However, it is uncertain whether mid-phalangeal hair patterns are the result of a separate genetic control or whether they are part of overall "hair" pattern on the body.

Some Additional Problems

Several problems have come to mind during the preparation of this thesis. Studies of lateral dominance have proved difficult to conduct since there are so many degrees of right and left "handedness". Classifying individuals as right or left handed does not have a great deal of validity unless only certain specific traits are considered. Further analysis of laterality is needed with specific attention being devoted to the range of lateral performance exhibited in carrying out a variety of tasks. Also, a study of lateral dominance should perhaps be analyzed with regard to the dominant positioning of various parts of the body as certain tasks are performed. This in turn should be compared with anatomical variations in man.

A further problem suggested for study concerns the factor or factors acting specifically upon man which inclines the distribution of lateral dominance as a whole toward greater skill on the right. It is possible that the factor inclining most individuals toward the more intense use of the right side of the body is linked to the tendency of most human beings to develop speech in the left hemisphere.

The presence of mid-phalangeal hair among members of some populations and not of others suggests other problems. Specifically it has not been determined whether the presence or absence of hair on the middle phalanges is under separate genetic control or whether it is related to the total amount of body hair. The clustering of hair around the third and fourth digits needs more study, perhaps in connection with the use of those digits by apes and man.

Fewer studies of various laterality traits have been conducted among American Indian groups than among other populations. This is an area needing further study.

Summary

A study of laterality traits was conducted on 174 Cashinahua Indians, 268 students from The University of Tennessee, and 86 families composed of 372 individuals from the Tennessee area. The most interesting variation occurred in the frequency of right and left handclasping and in the presence or absence of mid-phalangeal hair. The frequency of right armfolding and right handedness (writing hand) was also calculated for the two Tennessee populations. Analysis of these four laterality traits in family groupings was considered.

The Cashinahua differed more from the two Tennessee populations than the latter two did from each other. In particular, the frequency of mid-digital hair among the Cashinahua was very low, which is consistent with data from other American Indian groups. The two Tennessee populations, on the other hand, compared with other Caucasoid populations in hair frequency.

It was found that the frequency of left and right handclasping, armfolding, and handedness varied from group to group. Handclasping and armfolding do not seem to be related to handedness; however, conflicting data on the relationship between armfolding and handclasping showed that further study is needed.

Analysis of the family data provided some evidence for the heritability of the handclasping and mid-phalangeal hair traits. However, armfolding and handedness did not seem to reflect a strong genetic basis.

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She entered the Graduate School at the University of Tennessee in September, 1973, and received a Master of Arts degree with a major in anthropology in August 1974.

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