

ARM-FOLDING IN FAMILIES: A REVIEW OF LITERATURE AND SOME NEW DATA

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1. I am good at sports.
2. I like school subjects.
- *3. I tend to get mad when I do not get my way.
4. I often play and study with other kids.
5. I like the way I look.

6. I do not want to play with other kids.
- (7). My teacher thinks that I am good at sports.
8. I get good marks in school subjects.
9. I get along with other kids easily.
- **10. I do not want to join in group activities.
- (11). My teacher thinks that I am good-looking.
12. I like to run and play hard.
- (13). My teacher thinks that most other kids like me.
- **14. I am too shy.
15. Work in school subjects is easy for me.
16. I try to keep myself clean and tidy.
- *17. I often start fights and arguments with others.
18. My body is strong and powerful.
19. I have lots of friends.
- *20. I often make fun of others.
21. I am interested in school subjects.
22. I have a good looking body.
23. I am a good athlete.
- **24. I have very few friends.
- (25). My teacher thinks that I am good at school subjects.
26. I have a pleasant looking face.
- *27. I often keep some kids from being in my group during activity or play time.
28. Other kids want me to be their friend.

Note: Items with * were used to evaluate children's self-evaluation of aggression, while items with ** were for self-perception of withdrawal. Items 1, 12, 18, 23 were used to assess children's self-evaluation on physical ability; items 2, 8, 15, 21 were for self-evaluation on academic ability; items 5, 16, 22, 26 were for self-evaluation on appearance; and items 4, 9, 19, 28 were for self-evaluation on peer-relations. Items with () were used to assess children's self-perception of teacher evaluation on the four domains. Originally, Questionnaire I was written in Chinese.

Key words: laterality, arm-folding, genetics, determination

Numerous authors have noted ethnic differences in this laterality pattern in man, pointing out the importance in the study of peoples (see McManus & Mascie-Taylor, 1979; Oeser, 1970; Reiß, 1998 for a review). Reiß (1998) has identified in the literature 72 studies of arm-folding; the distribution, sex ratio and generational differences have been well described. There is a clearly dominance of the populations with more right arm-folding (RAF) individuals than LAF individuals.

This paper will summarize the literature on the familial data and will describe the results of a new survey. There are 12 studies in the literature which give family data on arm-folding. 11 of them are shown in Table 1, the study by Ferronato, Thomas & Sadava (1974) have been excluded, because they presented only the direct

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Table 1. The Results of 12 Studies of Frequency of Left and Right-Arm-Folding in Progeny from R × R, R × L and L × L Matings. Relative Values in Parenthesis

Study	p(L) progeny	p(L) parents	MATINGS						χ^2 df=2
			R × R		R × L		L × L		
			R	L	R	L	R	L	
Falk & Ayala (1971)	.56	*	136 (.57)	102 (.43)	280 (.45)	347 (.55)	111 (.34)	220 (.66)	$p < .001$
Legube & Martinez-Fuentes (1971)	.56	.56	104 (.50)	106 (.50)	167 (.41)	239 (.59)	113 (.43)	151 (.57)	NS
McManus & Mascie-Taylor (1979)	.58	.54	21 (.33)	42 (.67)	71 (.46)	84 (.54)	33 (.40)	50 (.60)	NS
Pons (1963)	.62	.38	3 (.25)	9 (.75)	27 (.36)	47 (.64)	9 (.56)	7 (.44)	NS
Quele-Salgado, Freire-Maia & Freire-Maia (1961)	.56	.53	61 (.56)	48 (.44)	96 (.46)	111 (.54)	52 (.34)	103 (.66)	$p < .001$
Mahapatra (1970)	.51	.52	185 (.57)	139 (.43)	230 (.48)	248 (.52)	78 (.38)	127 (.62)	$p < .001$
Rhoads & Damon (1973)	.59	.63	26 (.50)	26 (.50)	35 (.38)	56 (.62)	46 (.39)	71 (.61)	NS
Shami (1979)	.55	.53	15 (.43)	20 (.57)	43 (.43)	57 (.57)	23 (.50)	23 (.50)	NS
Veeraju & Satyanarayana (1972)-Kapus	.53	.39	11 (.46)	13 (.54)	24 (.48)	26 (.52)	12 (.44)	15 (.56)	NS
Veeraju & Satyanarayana (1972)-Salis	.55	.59	13 (.52)	12 (.48)	21 (.50)	21 (.50)	17 (.36)	30 (.64)	NS
Veeraju & Satyanarayana (1972)-Jalaries	.49	.60	10 (.50)	10 (.50)	21 (.66)	11 (.34)	8 (.33)	16 (.67)	NS
Veeraju & Satyanarayana (1972)-total	.52	.53	34 (.49)	35 (.51)	66 (.53)	58 (.47)	37 (.38)	61 (.62)	NS
Wiener (1932)	.56	.54	31 (.38)	50 (.62)	81 (.45)	99 (.55)	58 (.45)	70 (.55)	NS
Arrieta, Martinez & Lostao (1988)	.52	.48	73 (.54)	61 (.46)	77 (.51)	74 (.49)	49 (.38)	80 (.62)	$p < .005$
Raiß (this study)	.61	.53	42 (.55)	34 (.45)	57 (.43)	77 (.57)	20 (.21)	75 (.79)	$p < .0005$
Mathematical sum (12 studies)	.56	.52	731 [.52]	672 [.48]	1230 [.45]	1497 [.55]	629 [.38]	1038 [.62]	$p < .0005$

L=LAF; R=RAF

L=LAF; R=RAF

R × L = R(F) × L(M) + L(F) × R(M); F=father; M=mother

* p(L) not available

combination between parents and children.

Table 1 gives also the frequency of the LAF in parents and children (10 studies). In 6 studies there is a greater frequency of LAF in children than in parents, in 3 populations there are reverse distributions and one population shows similar frequency in the two generational groups.

Table 1 shows also the proportion of LAF individuals in relation to the parental arm-folding type (11 studies). Four populations show significant increase of LAF offspring as the number of LAF parents increases from none to two parents. The study by Pons (1963) demonstrates no change of the LAF offspring. In the remaining 6 populations there are non-significant "irregular" relationships.

The data by Ferronato, Thomas and Sadava (1974) show a significant relationship between fathers and children, but not between mothers and children or between fathers and mothers. The other studies analyzing sex differences—parental or children influence (Arrieta, Martinez, & Lostao, 1988; Falk & Ayala, 1971; Leguebe & Martinez-Fuentes, 1971; Wiener, 1932) did not found any relationship. Concerning assortative mating there are 12 studies available. Comparison of observed with expected values on the basis of random mating reveals no significant differences, showing that mating is random and hence non-assortative.

Only two studies have provided data on arm-folding in monozygotic and dizygotic twins. In neither study are there data from family studies. Data from the studies are shown in Table 2. Monozygotic and dizygotic twins show a binomial proportion of R-R, R-L and L-L pairs. The concordance of the monozygotic and dizygotic twins is nearly the same (see Reiß, 1996 for further details). Therefore the work described here was undertaken in order to assess the role of familial or genetic components in arm-folding.

METHOD

Subjects were 270 students of medicine at the University of Halle, Germany. The principal data consisted of information on 292 families of mother, father and offspring, and in addition in those families with more than one offspring, 35 siblings pairs were studied. Two separate generations were therefore studied, the age of the parental generation ranging from 38 to 65 years (mean age=40.2) and of the offspring generation ranging from 19 to 32 (mean age=22.8). In the offspring generation there were altogether 144 male and 161 female subjects.

Arm-folding was assessed by means of a self-report inventory. The question was, "When you fold your arms, which fore-arm is on the top? Right, left or either?".

According to the family data, we would like to see if there is an increase in the number of children exhibiting LAF with a corresponding increase in the number of such parents. The distribution of the

Table 2. The Observed Numbers of R-R, R-L and L-L Pairs of Monozygotic and Dizygotic Twins from 2 Studies

Study	p(L)	MZ-twins			p(L)	DZ-twins		
		RR	RL	LL		RR	RL	LL
Forrai & Bankövi (1983)	.59	20 (.21)	38 (.40)	38 (.39)	.56	12 (.18)	36 (.53)	20 (.29)
Verschuer (1932)	.55	28 (.20)	71 (.50)	42 (.30)	.52	25 (.26)	42 (.44)	29 (.30)

children should compare with the several matching pairs based upon the χ^2 -test.

RESULTS

The majority of subjects (54%) prefer to fold the left fore-arm over the right [LAF; $p(L)$ =incidence of individuals with LAF], with only a small proportion, of about 4%, reporting no preference.

The results concerning the family data are shown in Table 3, ignoring those subjects who reported no preference for the right or the left arm, resulting in 270 parent-child pairings. Table 3 shows also the relationship to the parental arm-folding type, considering $R \times L$ and $L \times R$ families separately [where $R(F) \times L(M)$ indicates that mother shows LAF, and $L(F) \times R(M)$ indicates that the father shows LAF]. Data are also reported separately for male and female offspring.

Statistical analysis shows that the proportion of LAF offspring increases as the number of LAF parents from none (44% LAF) to one (57% LAF) to two (79% LAF) parents with LAF ($\chi^2=22.01$, $df=2$, $p<.0005$). χ^2 -analysis also shows significant differences between male children and parents (for further details see Table 4). The analysis of the family-size gives no further aspects.

Table 3 shows also the distribution of the various parental mating patterns ($R \times R$, $R \times L$ and $L \times L$). Comparison of observed with expected values on the basis of random mating shows no significant differences ($\chi^2=2.0$, $df=1$, NS), showing that

Table 3. Distribution of Arm-Folding in Offspring as a Function of Parental Arm-Folding Type

Parents	N (pairs)	offspring					
		males and females		males		female	
		R	L	R	L	R	L
$R \times R$	68	42 (.55)	34 (.45)	22 (.56)	17 (.44)	20 (.54)	17 (.45)
$R \times L$ in total	117	57 (.43)	77 (.57)	25 (.43)	33 (.57)	32 (.42)	44 (.58)
$L \times L$	85	20 (.21)	75 (.79)	4 (.09)	43 (.91)	16 (.33)	32 (.67)
$R(F) \times L(M)$	[62]	35 (.49)	37 (.51)	18 (.51)	17 (.49)	17 (.46)	20 (.54)
$L(F) \times R(M)$	[55]	22 (.35)	40 (.65)	7 (.30)	16 (.70)	15 (.38)	24 (.62)

Note: Parents and offspring without a preference have been omitted from the analysis.

Table 4. Statistical Analysis of the Results of Table 3 with the χ^2 -Test

Combinations	df	males and females	males	females
$R \times R/R \times L/L \times L$	2	22.01	$p<.0005$	23.89 $p<.0005$
$R \times R/R \times L$	1	3.15		3.68
$R \times R/L \times L$	1	21.38	$p<.0005$	1.65
$R \times L/L \times L$	1	11.50	$p<.0005$	1.43
$R(F) \times L(M)/L(F) \times R(M)$	1	2.35	$p<.001$	23.18 $p<.0005$
			15.54 $p<.0005$	3.67
			2.49	.95
				.44

mating is random and hence non-assortative.

The direct comparison of the parents and children, similar to the results by Ferronato, Thomas and Sadava (1974), shows several significant relationships (χ^2 -test): Between fathers and children, fathers and sons, mothers and sons ($p<.01$, $df=1$) further between mothers and children ($p<.05$, $df=1$). The combination between fathers and daughters shows nearly a significant value.

It is also possible to estimate the heritability (Falconer, 1965). The analysis shows a value of 63.2 ($p<.05$) suggesting a relative strong genetic component. According to handedness there is a value of 76.8 ($p<.05$) (see Reiß, 1997).

DISCUSSION

The present data confirm that in Europe more individuals show LAF, and the number of individuals with RAF is smaller (McManus & Mascie-Taylor, 1979; Oeser, 1970; Reiß, 1998).

The present data on family studies emphasize the heritable component of asymmetry of arm-folding: The frequency of individuals with LAF increases continuously with the number of parents with LAF.

According to the twin data (Forrai & Bankövi, 1983; Verschuer, 1932) as well as a great number of family studies (7 from 12) have found little or no evidence for a genetic component in arm-folding (but see the arithmetical sum of all data in Table 1). It is true that no simple genetic mechanism could explain the family data. We have shown recently, that twin data show a so-called laterality-specific effect and that distribution and concordance is in all examined lateralized signs, i.e. hemispheric specialization, handedness, footedness, eyedness, earedness, hand-clasping and arm-folding. So it seems impossible to prove a genetic control with twin method (Reiß, 1996).

Nevertheless at least the ethnic differences may have influence on the manifestation of the trait (Reiß, 1998). But there is no strong relationship to handedness and hand-clasping suggesting the independence of arm-folding (Reiß, 1998) and a weak concept of "latent handedness" proposed by Luria (1970) and Sakano (1982). What is the origin of the asymmetrical distribution of non-functional, postural asymmetries such as arm-folding, hand-clasping or leg-crossing? Certainly it is conceivable that morphological differences between the arms may play a role in determining the direction of arm-folding. So Freire-Maia (1976) and Geschwind and Galaburda (1985) have suggested that arm-folding and hand-clasping have a morphological substrate. Freire-Maia (1976) assumed that hand-clasping may be an idiosyncrasy due to or influenced by "physical" bilateral differences in the hands. In most people, particularly right-handers, the right arm is longer, thicker and heavier than the left arm (Hasse & Dehner, 1893; Reichel, Runge & Bruchhaus, 1990), and it might be therefore be marginally easier to fold one fore-arm over the other. As shown by Garn and Rohmann (1962; 1966) there is evidence that genetic factors control to some extent most aspect of bone growth and genetic factors play a large role in

determining postnatal bone growth. Whether such a small difference could bias such a proportion of the populations with some ethnic differences is not obvious.

An adequate model of arm-folding must also explain why there are only slight differences between the number of RAF and LAF. Especially my own data reported here as well as some data in literature suggest a biological basis. It is possible to summarize in all available data including mine and others (see Table 1) there is the following distribution of LAF in the families in relation to the $R \times R$, $R \times L$ and $L \times L$ parents: 48%, 55% and 62% ($\chi^2=64.03$, $df=2$, $p<.0005$). This documents a continuously statistically significant increase of LAF. Of course the increase is only small. The use of a mathematical summary is possible, because—contrary to left-handedness—there are concerning arm-folding no classification problems assessing LAF or RAF. The data are not compatible with any simple, conventional Mendelian model, in which one allele produces RAF and the other produces LAF, but they are similar to models based on the concept of fluctuating asymmetry, which proposed for handedness (Annett, 1985; McManus, 1985) and for hand-clasping (McManus & Mascie-Taylor, 1979).

The family, populational and twin data presently available in the literature do not permit a conclusion against some kind of genetic factors on arm-folding. Of course, the majority of the data—better naming it the arithmetical sum—are suggestive of a genetic basis of some kind, although environmental influences are also evident. Like hand-clasping, LAF runs in families, also not strongly (e.g. McManus & Mascie-Taylor, 1979).

At our present stage of knowledge arm-folding is a very complex sign to study the relationship between genetic and environmental factors.

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