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Mirror Imagery and Genetic Variability of Lateral Asymmetries in the Mesiodistal Crown Diameters of Permanent Teeth

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Abstract On the mirror imagery specific to monozygotic twinning and the genetic variability of right-left differences, the mesiodistal tooth crown diameters of the permanent teeth, from the central incisors to the second molars, of both jaws were examined in Japanese monozygotic and dizygotic twins. The results of the chi-square tests showed that the frequency of mirror images in monozygotic twins was not significantly higher than that in dizygotic twins for any of the teeth examined, suggesting no mirror imagery due to the so-called mirror-image mechanism in monozygotic twinning. The comparisons of the mean intrapair variances of the right-left differences in monozygotic and dizygotic twin pairs suggested that there were no or little genetic variances in the right-left differences of the mesiodistal tooth crown diameters of the permanent teeth.

Regarding the genetic determination of asymmetries in bilateral organs, there have been many debates. We may implicitly assume that both the right and left part of a nearly symmetric bilateral trait are determined by a gene or a single set of genes and modified by a lot of random environmental factors which may produce subtle asymmetries for the bilateral trait, especially when we want to estimate the environmental variance for the bilateral trait utilizing the right-left differences. According to MORGAN (1977), some researchers such as G. DAHLBERG and others think that genes may be able to produce asymmetries, but unable to code for the direction of the asymmetries. MORGAN (1977) himself considers the inheritance of asymmetries to be very probably oocytic. LEVY (1977) is of the opinion that there are a variety of asymmetric traits whose directions, on the one hand, can be influenced or even determined entirely by nongenetic factors such as cultural pressures, brain damage, monozygotic twinning, *etc.*, and, on the other hand, are entirely or partially determined by information encoded in the genes.

Although there are many problems, as mentioned above, on the inheritance of asymmetries in the bilateral traits, only two problems were examined in the present study: one is the problem as to whether or not the mirror imagery of mesiodistal tooth crown diameters in twins occurs more frequently than would be anticipated by chance, and the other is as to whether or not lateral asymmetries in such diameters show significant genetic variability. The problems on the mirror imagery of dental traits have been rarely dealt with by previous researchers. As far as the present author knows, NEWMAN *et al.* (1937), BIGGERSTAFF (1973, 1975), STALEY and GREEN (1974), and POTTER and NANCE (1976) have made contributions to this field. Among them, however, only POTTER and NANCE (1976) analyzed the mirror imagery of tooth dimensions, and stated that there was no indication that mirror imagery was a phenomenon more common in monozygotic than dizygotic twins. As regards the genetic variability of the lateral asymmetries in tooth crown dimensions, the results, again, by POTTER and NANCE (1976) suggests that there are no significant genetic variances for the asymmetries in the mesiodistal and buccolingual dimensions of the permanent teeth except the buccolingual dimensions of a few teeth. And SHARMA and CORRUCCINI (1987) recently reported nearly the same results of the analysis of variance, in which all the seemingly significant genetic variances for dental asymmetries were invalidated. To confirm these documents, the present study was carried out.

Materials and Methods

The mesiodistal crown diameters of the right and left permanent teeth except the third molars were measured by the present author on the plaster casts from the Japanese monozygotic (MZ) and dizygotic (DZ) twin pairs who lived in Tokyo or the suburbs. The dental plaster casts were collected during 1950's by the project team for general twin studies supported by the Grant-in-Aid for Scientific Research from the Ministry of Education of Japan, and are now housed in the University Museum, the University of Tokyo. The MZ twin sample used here consists of 137 male and 135 female twin pairs. The DZ twin sample is composed of 42 male and 33 female twin pairs. Measurements were performed after FUJITA (1949) with sliding calipers with an accuracy of 0.05 mm.

The problem of whether there is any particular association between mirror imagery and MZ twinning was examined as follows. First of all, with respect to the mesiodistal crown diameters recorded to an accuracy of 0.1 mm, differences between right and left teeth were obtained by subtracting the diameters of the left teeth from those of the right teeth. If the combination of the positive and negative signs, *i.e.*, $+-$ or $-+$, was obtained for the two right-left differences from the two members of each twin pair, such a combination was considered to indicate mirror imagery in the twins. Then the frequency of the combination of the same signs, $++$ and $--$, as well as the compound frequency of 00 (zero and zero), $0+$, $+0$, $0-$ and -0 were also counted. Although these frequencies may increase or decrease with the scale of measurement accuracy, the ratio between the frequency of the mirror imagery and that of the right-left differences with the same sign in a twin pair is expected to be unity if mirror imagery is caused by chance or by random environmental factors alone. The homogeneity in these frequencies between MZ and DZ twins was tested using the chi-square test with two degrees of freedom.

The significance of the genetic variances of lateral asymmetries, *i.e.*, right-left differences, was examined through the comparison of the mean intrapair variances of the right-left differences in MZ and DZ twin pairs. Unlike a mean intrapair variance within twin pairs for an ordinary trait, a mean intrapair variance within twin pairs for

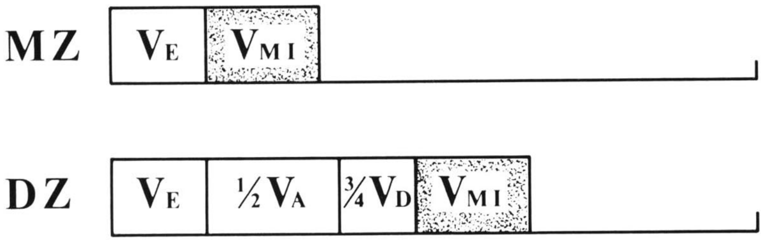

Fig. 1. Schematic diagram for the mean intrapair variances within MZ and DZ twin pairs of the right-left difference of a bilateral metric character. 'V_E' designates the environmental variance; 'V_A', additive genetic variance; 'V_D', dominance variance; and 'V_{MI}', the variance due to mirror imagery.

the right-left difference in a bilateral trait may contain the variance due to mirror imagery (Fig. 1). It is possible, therefore, that the mean intrapair variance for MZ twins is greater than that for DZ twins if the genetic variance is as small as negligible and if there are mirror images produced by the mechanism specific to MZ twins in addition to the mirror images caused by chance. If the variance due to mirror imagery in MZ twins is the same in extent as that in DZ twins, the mean intrapair variance for DZ twins may be found to be greater than that for MZ twins because of some genetic variance for the lateral asymmetry.

In passing, there is no problem even if any directional asymmetry is present, as suggested by MIZOGUCHI (1986), because the effect of the directional asymmetry is automatically eliminated from the mean intrapair variance for lateral asymmetries whenever such a mean intrapair variance is calculated.

The calculations of the above statistical analyses were performed with the HITAC M680H/M682H (VOS3) System of the Computer Centre, the University of Tokyo. Chi-square tests were done using the X2TST program, and mean intrapair variances and intraclass correlation coefficients were obtained by the use of the MIVCRL program. These programs were written in FORTRAN by the present author.

Results

Mirror imagery in mesiodistal tooth crown diameters was found both in the MZ and DZ twin pairs. The frequencies of the twin pairs with the mirror imagery and those of the twin pairs with lateral asymmetries in the same direction are listed in Table 1. The average frequencies of the mirror imagery over the teeth whose sample size is 20 or more are 29.3% for male MZ, 33.4% for female MZ, 36.1% for male DZ, and 33.6% for female DZ twin pairs. In the same way, the average frequencies of the twin pairs with asymmetries in the same direction are 37.2% for male MZ, 33.4% for female MZ, 37.8% for male DZ, and 33.0% for female DZ twin pairs. That is to say, the frequencies not only of mirror imagery but also of asymmetries in the same direction range from about 30% to 40%. And the chi-square test for any of the teeth

Table 1. Frequencies of the twin pairs with mirror imagery and with asymmetries in the same direction in the mesiodistal crown diameters of permanent teeth.

Tooth	Sex	Zygosity	Total No. of pairs	Asymmetries in the same direction (%)	Symmetry in one or two twins (%)	Mirror imagery (%)	χ^2 1)
UI1	M	MZ	116	44 (37.9)	35 (30.2)	37 (31.9)	
		DZ	37	10 (27.0)	13 (35.1)	14 (37.8)	1.46
	F	MZ	113	28 (24.8)	50 (44.2)	35 (31.0)	
		DZ	28	11 (39.3)	9 (32.1)	8 (28.6)	2.54
UI2	M	MZ	111	42 (37.8)	19 (17.1)	50 (45.0)	
		DZ	38	14 (36.8)	12 (31.6)	12 (31.6)	4.09
	F	MZ	117	48 (41.0)	36 (30.8)	33 (28.2)	
		DZ	28	10 (35.7)	3 (10.7)	15 (53.6)	7.93*
UC	M	MZ	66	20 (30.3)	28 (42.4)	18 (27.3)	
		DZ	22	9 (40.9)	4 (18.2)	9 (40.9)	4.23
	F	MZ	86	23 (26.7)	32 (37.2)	31 (36.0)	
		DZ	21	7 (33.3)	8 (38.1)	6 (28.6)	0.54
UP1	M	MZ	82	35 (42.7)	31 (37.8)	16 (19.5)	
		DZ	22	9 (40.9)	5 (22.7)	8 (36.4)	3.29
	F	MZ	99	33 (33.3)	25 (25.3)	41 (41.4)	
		DZ	24	9 (37.5)	7 (29.2)	8 (33.3)	0.53
UP2	M	MZ	52	18 (34.6)	22 (42.3)	12 (23.1)	
		DZ	10	5 (50.0)	3 (30.0)	2 (20.0)	0.89
	F	MZ	71	25 (35.2)	21 (29.6)	25 (35.2)	
		DZ	18	7 (38.9)	6 (33.3)	5 (27.8)	0.36
UM1	M	MZ	95	32 (33.7)	34 (35.8)	29 (30.5)	
		DZ	34	15 (44.1)	5 (14.7)	14 (41.2)	5.28
	F	MZ	102	40 (39.2)	33 (32.4)	29 (28.4)	
		DZ	23	8 (34.8)	6 (26.1)	9 (39.1)	1.04
UM2	M	MZ	7	2 (28.6)	4 (57.1)	1 (14.3)	
		DZ	2	0 (0.0)	0 (0.0)	2 (100.0)	5.14
	F	MZ	17	8 (47.1)	2 (11.8)	7 (41.2)	
		DZ	2	0 (0.0)	1 (50.0)	1 (50.0)	2.63
LI1	M	MZ	87	30 (34.5)	33 (37.9)	24 (27.6)	
		DZ	31	9 (29.0)	13 (41.9)	9 (29.0)	0.32
	F	MZ	93	29 (31.2)	32 (34.4)	32 (34.4)	
		DZ	24	8 (33.3)	11 (45.8)	5 (20.8)	1.82
LI2	M	MZ	99	38 (38.4)	36 (36.4)	25 (25.3)	
		DZ	27	8 (29.6)	10 (37.0)	9 (33.3)	0.96
	F	MZ	103	30 (29.1)	38 (36.9)	35 (34.0)	
		DZ	21	6 (28.6)	11 (52.4)	4 (19.0)	2.30
LC	M	MZ	89	27 (30.3)	29 (32.6)	33 (37.1)	
		DZ	28	11 (39.3)	8 (28.6)	9 (32.1)	0.78
	F	MZ	111	34 (30.6)	41 (36.9)	36 (32.4)	
		DZ	28	8 (28.6)	10 (35.7)	10 (35.7)	0.11
LP1	M	MZ	77	28 (36.4)	21 (27.3)	28 (36.4)	
		DZ	24	11 (45.8)	2 (8.3)	11 (45.8)	3.73

Table 1. (Continued)

Tooth	Sex	Zygosity	Total No. of pairs	Asymmetries in the same direction (%)	Symmetry in one or two twins (%)	Mirror imagery (%)	χ^2 [1)]
	F	MZ	106	31 (29.2)	32 (30.2)	43 (40.6)	
		DZ	23	6 (26.1)	7 (30.4)	10 (43.5)	0.11
LP2	M	MZ	44	22 (50.0)	13 (29.5)	9 (20.5)	
		DZ	9	3 (33.3)	1 (11.1)	5 (55.6)	4.89
	F	MZ	73	31 (42.5)	23 (31.5)	19 (26.0)	
		DZ	10	2 (20.0)	4 (40.0)	4 (40.0)	1.93
LM1	M	MZ	72	29 (40.3)	23 (31.9)	20 (27.8)	
		DZ	27	12 (44.4)	6 (22.2)	9 (33.3)	0.92
	F	MZ	69	26 (37.7)	20 (29.0)	23 (33.3)	
		DZ	15	7 (46.7)	4 (26.7)	4 (26.7)	0.45
LM2	M	MZ	9	3 (33.3)	1 (11.1)	5 (55.6)	
		DZ	2	1 (50.0)	0 (0.0)	1 (50.0)	0.36
	F	MZ	12	2 (16.7)	2 (16.7)	8 (66.7)	
		DZ	4	2 (50.0)	1 (25.0)	1 (25.0)	2.37

1) χ^2-test with two degrees of freedom for the homogeneity in the frequencies of mirror imagery of MZ and DZ twins.
* $P<0.05$; ** $P<0.01$; *** $P<0.001$.

examined except the female upper lateral incisor showed that the distribution of MZ twins did not significantly differ from that of DZ twins (Table 1). Even in the above exception, the frequency of mirror imagery in MZ twins was not higher than that in DZ twins. It is, therefore, most likely that the mirror imagery in the mesiodistal tooth crown diameters of MZ twins is caused by chance or random environmental factors, as in DZ twins.

In Tables 2 and 3, the mean intrapair variances and the intraclass correlation coefficients within twin pairs of right-left differences are shown for males and females separately. The mean intrapair variances for MZ twins were found by one-tailed *F*-tests not to be significantly greater at the 5% level than those for DZ twins except for the case of the female lower canine. This means, if the environmental variance within MZ twin pairs can be assumed to be equal to that for DZ twin pairs, that the variance due to mirror imagery in MZ twin pairs is generally not greater than the compound variance caused by genetic factors and mirror imagery in DZ twin pairs.

On the contrary, several mean intrapair variances for DZ twins were found, also by one-tailed *F*-tests, to be greater than those for MZ twins (Tables 2 and 3). This suggests the existence of significant genetic variances in the lateral asymmetries of the relevant teeth if it is accepted to assume that the variances due to mirror imagery and random environmental factors for MZ twins are equal to those for DZ twins. The tendency for the right-left differences to have significant genetic variances, however, was not necessarily shown as a consistent tendency common to both males and females. This means that there is the possibility of the significant genetic variances

Table 2. Mean intrapair variances and the intraclass correlation coefficients within twin pairs of the right-left differences of mesiodistal tooth crown diameters in males.

	Mean intrapair variance					Intraclass correlation coefficient	
	MZ		DZ				
	d.f.	Var.	d.f.	Var.	F-ratio[1)]	MZ	DZ
UI1	116	.0636	37	.0555	1.15	−0.11	−0.10
UI2	111	.1088	38	.0688	1.58	0.01	0.01
UC	66	.0655	22	.0848	1.30	0.02	0.10
UP1	82	.0307	22	.0445	1.45	0.31**	0.17
UP2	52	.0387	10	.0245	1.58	0.16	0.33
UM1	95	.0730	34	.1150	1.58*	0.14	−0.07
UM2	7	.0343	2	.2925	8.53*	−0.01	−0.81
LI1	87	.0365	31	.0294	1.24	0.03	0.01
LI2	99	.0292	27	.0526	1.80*	0.22*	−0.14
LC	89	.0624	28	.0509	1.23	−0.01	0.06
LP1	77	.0531	24	.0602	1.13	0.06	−0.09
LP2	44	.1863	9	.0722	2.58	0.12	0.35
LM1	72	.0892	27	.0591	1.51	0.15	0.20
LM2	9	.1122	2	.1825	1.63	−0.18	−0.71

1) One-tailed F-test for the comparison of MZ and DZ twin pairs.
* $P<0.05$; ** <0.01; *** $P<0.001$.

Table 3. Mean intrapair variances and the intraclass correlation coefficients within twin pairs of the right-left differences of mesiodistal tooth crown diameters in females.

	Mean intrapair variance					Intraclass correlation coefficient	
	MZ		DZ				
	d.f.	Var.	d.f.	Var.	F-ratio[1)]	MZ	DZ
UI1	113	.0507	28	.0427	1.19	−0.09	−0.00
UI2	117	.0966	28	.1802	1.87*	−0.01	−0.28
UC	86	.0733	21	.0610	1.20	−0.07	0.03
UP1	99	.0536	24	.0710	1.32	0.01	−0.01
UP2	71	.0780	18	.0989	1.27	−0.00	0.25
UM1	102	.0982	23	.0850	1.16	−0.06	−0.09
UM2	17	.1250	2	.1850	1.48	0.16	−0.40
LI1	93	.0327	24	.0679	2.08**	−0.02	−0.03
LI2	103	.0388	21	.0440	1.13	0.01	−0.12
LC	111	.0501	28	.0223	2.25**	−0.15	0.28
LP1	106	.0402	23	.0635	1.58	0.03	−0.05
LP2	73	.0582	10	.1460	2.51*	0.15	−0.39
LM1	69	.0786	15	.0660	1.19	0.08	0.17
LM2	12	.0967	4	.0550	1.76	−0.16	0.71

1) One-tailed F-test for the comparison of MZ and DZ twin pairs.
* $P<0.05$; ** $P<0.01$; *** $P<0.001$.

found here being referred to some sampling errors. For the present, therefore, it would be better to consider that the right-left differences in most of the teeth examined have no or little genetic variability. This is confirmed by the non-significant or extremely low intraclass correlation coefficients within twin pairs for the right-left differences, especially in MZ twins (Tables 2 and 3).

Discussion

According to LEVY (1977), zygotic splitting can produce mirror imagery depending on the developmental stage at which it occurs, though the mechanisms are still unknown. Notwithstanding, the incidence of the mirror images in human MZ twin pairs which are suspected to have been induced by such a mechanism, *i.e*, so-called mirror-image mechanism (NEWMAN *et al.*, 1937; TORGERSEN, 1950) is not so high. For example, it is well known that the frequency of left-handers is significantly higher in twins, regardless of their zygosity, than in singletons (NEWMAN *et al.*, 1937; BOKLAGE, 1980; SPRINGER and SEARLEMAN, 1980). And, SPRINGER and SEARLEMAN (1980) stated on the basis of many previous studies that there was no significant difference between MZ and DZ twins in the frequencies of left-handers. This seems to suggest that in the left-handedness there is no such mirror images as produced by the above mirror-image mechanism in MZ twins. In fact, UETAKE (1956) showed that there were no significant differences between MZ and DZ twin pairs in the frequencies of mirror images of the left-handedness, eye dominance, and so forth, and maintained that mirror imagery in man was not a general phenomenon specific to MZ twins. BULMER (1970) also stated, particularly on the handedness and visceral inversion, that mirror imagery did not occur more often than would be anticipated by chance.

As regards dental characters, NEWMAN *et al.* (1937) said on the basis of the dental casts from 35 MZ twin pairs that there was evidence of more or less extensive mirror-imaging of dental peculiarities in half of the left-handers, and that in several pairs of the MZ twins the mirror images in dentition were correlated with reversals of asymmetry in characters unrelated to teeth. But, needless to say, the problem as to whether the mirror images noted by them were caused by the mirror-image mechanism or by chance can not be solved by the use of only MZ twin data. In recent years, however, BIGGERSTAFF (1973) showed that the mirroring of the CARABELLI's tubercle tended to be minimal both in MZ and in DZ twin pairs, and further stated that mirroring was not prevalent in the shape of the mandibular second deciduous molar, either (BIGGERSTAFF, 1975). On the other hand, STALEY and GREEN (1974) observed mirror imagery in the hypoconulid of the lower first molar and the cusp number of the lower second premolar in some of 90 MZ twin pairs, but, in 90 DZ twin pairs, they did not find any mirror imaging. They stated that while the observed frequency of the above mirror imagery in the hypoconulid was higher than the expected frequency (obtained probably on the basis of chance association), the observed and expected frequencies of the mirror imagery for the cusp number of the second premolar agreed closely with each other.

In sum, among the above functional and morphological characters in man, there seems no or little evidence for the frequency of mirror imagery in MZ twins being higher than the expected frequency by chance.

Now, regarding dental size, the results of the present analyses (Table 1) showed that the distribution of mirror images in the mesiodistal crown diameters of permanent teeth in MZ twin pairs was generally not different from that in DZ twin pairs. This suggests that the frequencies of mirror images are not higher than those expected by chance, and this is consistent not only with the results from the analyses of variance in the present study (Tables 2 and 3) but with the findings by POTTER and NANCE (1976) as well. From all of these, it seems that most of the mirror images of the mesiodistal tooth crown diameters detectable in MZ twin pairs are produced by chance or random environmental factors, not by the mirror-image mechanism which is considered to be specific to MZ twinning. POTTER and NANCE (1976) showed also on the bucco-lingual crown diameters of all the permanent teeth except the third molars that the within-pair variances in MZ twins were not greater than those in DZ twins.

As regards the genetic variance for right-left differences, the F-ratios of the mean intrapair variances for DZ twins to those for MZ twins (Tables 2 and 3) suggested that in most of the teeth examined there were no or little significant genetic variances for the lateral asymmetries of the mesiodistal crown diameters. This is consistent, again, with the results by POTTER and NANCE (1976; Table 3). Furthermore, these results appear to be compatible with the assertion by SHARMA and CORRUCCINI (1987) on the genetic variance of the asymmetries of maximum crown diameters in Punjabi twins, though the detailed data were not shown by them.

To conclude, it is most likely that there are no or little mirror images due to the so-called mirror-image mechanism in the mesiodistal crown diameters of permanent teeth, and that the genetic variances of the right-left differences are hardly present.

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Literature Cited

BIGGERSTAFF, R. H., 1973. Heritability of the Carabelli cusp in twins. *J. Dent. Res.*, **52**: 40–44.

BIGGERSTAFF, R. H., 1975. Cusp size, sexual dimorphism, and heritability of cusp size in twins. *Am. J. Phys. Anthrop.*, **42**: 127–140.

BOKLAGE, C. E., 1980. Hidarikiki no hohai (Left-handed blastula). *In*: Neuropsychology of Left-Handedness, ed. J. HERRON. New York, Academic Press. (Translated by K. KONDO and M. SUGISHITA, 1983, into Japanese and entitled "Hidarikiki-gaku." Niigata, Nishimura Shoten. pp. 111–138.)

BULMER, M. G., 1970. The Biology of Twinning in Man. Oxford, Clarendon Press.

FUJITA, T., 1949. Über das Messungsstandard der Zähne. *J. Anthrop. Soc. Nippon*, **61**: 27–32, 42. (In Japanese with German summary.)

LEVY, J., 1977. The origins of lateral asymmetry. *In*: Lateralization in the Nervous System, ed. S. HARNAD, R. W. DOTY, L. GOLDSTEIN, J. JAYNES and G. KRAUTHAMER. New York, Academic Press. pp. 195–209.

MIZOGUCHI, Y., 1986. Correlated asymmetries detected in the tooth crown diameters of human permanent teeth. *Bull. Natn. Sci. Mus., Tokyo, Ser. D*, **12**: 25–45.

MORGAN, M., 1977. Embryology and inheritance of asymmetry. *In*: Lateralization in the Nervous System, ed. S. HARNAD, R. W. DOTY, L. GOLDSTEIN, J. JAYNES and G. KRAUTHAMER. New York, Academic Press. pp. 173–194.

NEWMAN, H. H., F. N. FREEMAN, and K. J. HOLZINGER, 1937. Twins: A Study of Heredity and Environment. Chicago, the University of Chicago Press.

POTTER, R. H., and W. E. NANCE, 1976. A twin study of dental dimension: I. Discordance, asymmetry, and mirror imagery. *Am. J. Phys. Anthrop.*, **44**: 391–396.

SHARMA, K., and R. S. CORRUCCINI, 1987. Genetic variance of dental asymmetry in Punjabi twins. *Am. J. Phys. Anthrop.*, **72**: 253.

SPRINGER, S. P., and A. SEARLEMAN, 1980. Soseiji no hidarikiki (Left-handedness in twins). *In*: Neuropsychology of Left-Handedness, ed. J. HERRON. New York, Academic Press. (Translated by K. KONDO and M. SUGISHITA, 1983, into Japanese and entitled "Hidarikiki-gaku." Niigata, Nishimura Shoten. pp. 139–157.)

STALEY, R. N., and L. J. GREEN, 1974. Types of tooth cusp occurrence asymmetry in human monozygotic and dizygotic twins. *Am. J. Phys. Anthrop.*, **40**: 187–196.

TORGERSEN, J., 1950. Situs inversus, asymmetry, and twinning. *Am. J. Hum. Genet.*, **2**: 361–370.

UETAKE, S., 1956. Ichiransei soseiji ni okeru kyozo-gensho no kenkyu (A study of the mirror imagery in monozygotic twins). *In*: Soseiji no Kenkyu, Vol. 2, ed. Y. UCHIMURA. Tokyo, Japan Society for the Promotion of Science. pp. 183–189. (In Japanese.)