

Fluctuating Dermatoglyphic Asymmetry in Psychotic Twins

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Abstract. Fluctuating asymmetry of bilateral morphological traits is the result of prenatal developmental instability and has been shown to be greater in organisms having more homozygous genotypes (aabb vs. AaBb, for example). This expected increase in fluctuating asymmetry has been found among individuals having a high degree of liability for schizophrenia, as this disorder appears to have a polygenic basis. We tested the additional prediction that the greater genetic liability for schizophrenia necessary for concordance between twins should be associated with greater fluctuating asymmetry in twin pairs in which both twins are mentally ill compared to twin pairs in which one individual is normal. Our analysis of asymmetry for finger ridge counts from fingerprints of concordant and discordant pairs of twins supports this prediction and provides additional indirect support for the roles of polygenic transmission and prenatal epigenetic vulnerability in schizophrenia.

Key Words. Fluctuating asymmetry, genetics, schizophrenia, concordance, twins.

In bilaterally symmetrical organisms, including man, paired structures develop as mirror images of each other. Several exceptions to this general principle are known in which organisms display asymmetry. When the asymmetry in all members of a population favors the same side of the body, it is termed "directional asymmetry" and results from the organism's developmental program. Examples of directional asymmetries include the differences in the number of lobes of the lungs on the right and left sides and the consistent positioning of organs such as the heart or liver to one side of the midline. On the other hand, random deviations from bilateral symmetry are designated "fluctuating asymmetry" and may be induced by factors within the uterine environment. Fluctuating asymmetry reflects the organism's inability to buffer or ward off these environmental influences during development (Waddington, 1957). Examples of fluctuating asymmetry include any right-left differences in such traits as molar cusp number or heights of the ears.

Buffering ability has been shown to depend upon levels of heterozygosity across the entire genotype, with a greater number of heterozygous loci being associated with increased developmental stability and bilateral symmetry in invertebrates as well as

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vertebrates (Lerner, 1954; Tebb and Thoday, 1954; Van Valen, 1962; Bader, 1965). Allelic substitutions which increase homozygosity should therefore be associated with increased fluctuating asymmetry. Thus, for a polygenic trait controlled by three loci, an aabbcc genotype would have greater asymmetry than AaBbCc. This relationship has been tested for traits in man which fit a polygenic threshold model—cleft lip with and without cleft palate, CL(P) (Fraser, 1980), and schizophrenia (Gottesman and Shields, 1967, 1972, 1982; McGue et al., 1983). As the number of putative disease-specific alleles necessary for the expression of these traits increases, so do homozygosity and fluctuating asymmetry (Adams and Niswander, 1967; Woolf and Gianas, 1976, 1977; Markow and Wandler, 1986).

These findings predict additional relationships between phenotypic expression and fluctuating asymmetry. One prediction is that the presence of a higher number of alleles for a threshold trait should increase the probability of concordance for that trait in twins as well as produce a concomitant increase in fluctuating asymmetry in concordant individuals. This prediction is explored in a pilot fashion and tested in the present study for twins with schizophrenia. Slater (1953) reported upon dermatoglyphic traits in a series of twins who were seen as inpatients for mental illness at psychiatric hospitals in the greater London area. We have reanalyzed the dermatoglyphic data from that study to compare fluctuating asymmetry in twins that were discordant for schizophrenia (normal cotwin), twins that were concordant for schizophrenia, and twins in which one member was schizophrenic and the cotwin had another mental disorder, but not schizophrenia.

Methods

Subjects. All subjects used in the present analysis are reported upon by Slater (1953), where case histories and bases for zygosity assignments are presented. The processes by which he made clinical diagnoses for psychiatric genetic research are given in exquisite detail by Shields (1979). Slater (cf. Shields and Gottesman, 1971) described himself as a neo-Krapelinian and noted that no one in the 1930s (his twins were collected and interviewed by him in 1935-39 and followed up after World War II by Shields in 1947-49) thought of double-blind diagnoses with respect to zygosity: "... the only way to scientific integrity was to set the standard of evidence for a firm diagnosis, and for a 'probable' diagnosis, and try to abide by them consistently, even when one saw the evidence going against the working hypothesis" (p. 18). When he later diagnosed the Gottesman and Shields (1972) twins, first blindfolded and then unblindfolded to resolve discrepancies with other judges, he matched the consensus monozygotic (MZ) concordance rate for all six judges; his probandwise rate for the Gottesman and Shields MZ twins was only 7% lower than for his own study (61% vs. 68%) and recent work applying *DSM-III* criteria to the former twins yields a probandwise rate of 48% (Farmer et al., 1987). Although the majority of Slater's (1953) twins were schizophrenic, they came from a comprehensive study of 297 pairs, all of whom were used only once in one of the four categories: schizophrenic, affectively ill, epileptic or organic, and psychopathic or neurotic; the integrity of his nonblind diagnoses is confirmed by the appreciable number of crossover diagnoses in the cotwins, siblings, and parents of his four groups of twin probands.

We restricted our sample to those patients diagnosed as schizophrenic for whom complete finger prints and diagnoses were also available for their cotwins. Subjects were assigned, according to the diagnoses of the cotwins, into the following three groups:

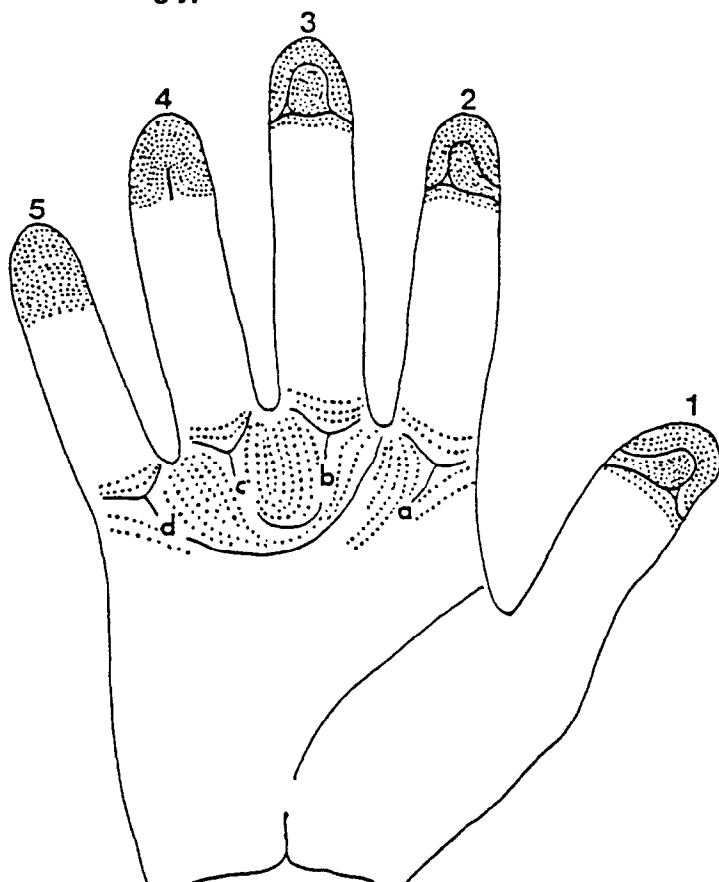
1. Concordant (CONC)—cotwin with a diagnosis of schizophrenia ($n = 44$ twin individuals).
2. Discordant (DISC)—cotwin normal ($n = 38$ twin individuals).
3. Both mentally ill (BOTH)—cotwin with a mental disorder other than schizophrenia; these

consisted primarily of affective disorder, psychopathic personality, and neuroses ($n = 18$ twin individuals).

Of the 22 twin pairs in the concordant group, 16 were reported to be MZ twins. Three of the 19 discordant pairs were MZ twins, and in the group designated as BOTH, two of the nine pairs were MZ twins. The proportion of females in each group was about 60%. Subjects from different zygosity and sex groups were pooled because Markow and Gottesman (in press) found that zygosity has no influence on either ridge counts or fluctuating asymmetry for the dermatoglyphic traits being studied, and that while the number of ridges is slightly higher in males, the sexes do not differ for fluctuating asymmetry.

Dermatoglyphics. Finger tip patterns were reported on in the original study in such a way as to allow analysis of absolute finger ridge count (AFRC) as well as the digital patterns by themselves (Slater, 1953). The different finger patterns are shown in Fig. 1. The range of values for the AFRC is greater than for total finger ridge count, which makes AFRC preferable for comparative purposes (Holt, 1968). Finger ridge counts, as well as other ridge counts such as the a-b ridge count (also shown in Fig. 1) reported on by Markow and Wandler

Fig. 1. Basic dermatoglyphic characters



Finger 1, ulnar loop. Finger 2, radial loop. Finger 3, whorl. Finger 4, tented arch. Finger 5, plain arch. Palmar triradii a through d are located at the bases of fingers 2 through 5.

(1986), are under the polygenic control of a large number of genes acting additively (Holt, 1968).

The AFRC was obtained by counting all ridges between the center of a pattern and the triradii. With a whorl or a double loop, two triradii are present. Radial and ulnar loops have only one triradius, and arches have none (Cummins and Midlo, 1943). No data are available for a-b ridge count in these twins.

Fluctuating Asymmetry. For AFRC the difference between the number of ridges on a person's right and left hand was determined for each pair of fingers separately as well as for all fingers pooled. In the determination of fluctuating asymmetry for pattern type, the pattern for each finger was first recorded as either a whorl (two triradii), a loop (one triradius, ulnar or radial), or an arch (no triradii). Differences between hands were scored as the number of dissimilar patterns on paired digits. If all paired digits had the same pattern, the individual received a score of zero. If one pair of digits had dissimilar patterns, the individual received a score of one. A score of five would reflect a situation in which different patterns occurred on all five paired digits.

The statistical methodology for analysis of fluctuating asymmetry has been critically evaluated by Palmer and Strobeck (1986), who suggest that directional asymmetry (right or left) is most appropriately distinguished from fluctuating asymmetry by a mixed-model analysis of variance (ANOVA) rather than a paired *t* test. Because an earlier report (Jantz, 1970) suggested the possibility of directional asymmetry for ridge count in the thumb, we analyzed ridge count asymmetry of each digit pair separately as well as for all five fingers pooled. Diagnostic groups were further compared by the Student-Neuman-Keuls (SNK) multiple range test for unequal samples. Mean dissimilarities for pattern type were also compared between groups by the same statistical analyses.

Results

AFRC Asymmetry. Ridge counts were evaluated for each finger separately in the three groups. Mean ridge counts are shown in Table 1. Ridge counts tended to be higher in the group in which both twins were mentally ill, and in some cases these differences were significant. The mixed-model ANOVA showed no significant "side" effects for any of the digits, ruling out the existence of directional asymmetry as a confounding factor. Absence of platykurtosis for any of the right-left distributions indicates that antisymmetry (the consistent but random enlargement of one side) is also absent. Significant fluctuating asymmetry was found in two analyses, finger 5 and the pooled values for fingers 1 through 5. In these analyses, the SNK multiple range test revealed that twin pairs in which both were ill, but only one had schizophrenia, exhibited significantly greater fluctuating asymmetry.

Pattern Asymmetry. Mean fluctuating asymmetry for pattern type is presented in Table 2. As with AFRC, discordant twins were placed in the multiple range subset showing the least fluctuating asymmetry. However, the concordant group, in which both twins manifested schizophrenia, exhibited the greatest degree of asymmetry in accord with our hypothesis.

Discussion

Dermatoglyphic traits such as finger ridge counts, a-b ridge counts, and digital and palmar pattern frequencies have been analyzed in sample populations of patients having every imaginable disorder (reviewed by Loesch, 1983). Most disorders, in-

Table 1. Absolute ridge counts and their right-left differences in Slater's twins

Finger	Group	Right		Left		Asymmetry (right-left)	
		Mean	SD	Mean	SD	Mean	SD
1	BOTH	22.01	9.84	19.50	11.12	8.28	5.47
	CONC	17.42	11.87	15.45	9.02	5.95	5.70
	DISC	22.91	13.13	19.55	13.31	6.79	6.72
2	BOTH	19.66	11.16	15.83	10.94	6.89	5.47
	CONC	12.06	9.09	12.41	10.68	4.40	4.18
	DISC	16.24	17.14	15.26	16.77	4.07	4.99
3	BOTH	17.67	11.41 ^a	17.06	9.72 ^a	4.50	3.39
	CONC	9.93	6.23 ^b	9.66	9.02 ^b	4.86	4.64
	DISC	12.79	8.01 ^b	14.27	11.71 ^{ab}	4.24	5.30
4	BOTH	22.56	12.51	22.50	11.53	4.16	3.05
	CONC	17.47	10.81	16.14	11.01	4.29	4.04
	DISC	19.76	13.56	18.52	14.55	5.10	5.79
5	BOTH	17.50	10.69 ^a	17.44	8.44 ^a	5.05	3.39 ^a
	CONC	10.91	5.5 ^b	11.66	6.83 ^b	3.52	3.25 ^{ab}
	DISC	12.93	7.58 ^b	12.21	7.83 ^b	2.59	2.59 ^b
Total	BOTH	99.33	46.45 ^a	92.38	45.27 ^a	18.06	9.72 ^a
	CONC	67.82	32.24 ^b	56.04	33.17 ^b	12.29	11.46 ^b
	DISC	84.97	48.8 ^{ab}	78.05	49.60 ^{ab}	11.29	15.19 ^b

Note. Designations a, b indicate subset memberships from the Student-Neuman-Keuls multiple range test at $\alpha = 0.05$. CONC = concordant, cotwin with a diagnosis of schizophrenia. DISC = discordant, cotwin normal. BOTH = both mentally ill, cotwin with a mental disorder other than schizophrenia.

cluding schizophrenia (Singh, 1967), have been reported to show deviant frequencies in some ridge count or other trait, when compared to an unaffected population. These deviations, while interesting, are of unknown causation, with no known mechanism to account for the association between the aberrant patterns and the particular diagnosis, and are not the focus of the present study. However, in an earlier study, Markow and Wandler (1986) examined dermatoglyphics to test the specific hypothesis that genetic liability to schizophrenia is associated with increased developmental instability as reflected by elevated fluctuating asymmetry, i.e., as an indicator of a biological principle correlated with polygenic inheritance in many species. Using a different dermatoglyphic trait, a-b ridge count (the number of ridges crossing a line between the a and b palmar triradii depicted in Fig. 1), they found that schizophrenic patients showed greater fluctuating asymmetry than either normal controls or affective disorder patients. Furthermore, patients with earlier onset of schizophrenia showed greater asymmetry than later onset patients, providing additional support for increased polygenic liability in early onset patients and therefore, by inference, greater homozygosity for the putative schizophrenia-related genes.

The present study asks whether twins who are concordant for schizophrenia show a greater genetic liability for developing the disorder than discordant twins as in-

Table 2. Mean intrapair variances for digit patterns

	Mean (SD)
CONC	1.3636 (0.42) a
BOTH	0.8889 (0.46) b
DISC	0.8158 (0.37) b

Note. a, b: The Student-Neuman-Keuls multiple range test gave 2 different subsets at $\alpha = 0.05$. CONC = concordant, cotwin with a diagnosis of schizophrenia. DISC = discordant, cotwin normal. BOTH = both mentally ill, cotwin with a mental disorder other than schizophrenia.

ferred from greater fluctuating asymmetry, with the latter implying greater homozygosity. While the assumptions underlying the use of fluctuating asymmetry in dermatoglyphic traits to test the genetic model are identical to the assumptions in Markow and Wandler (1986), a different dermatoglyphic trait had been measured in Slater's twins. The other difference between the Markow and Wandler study and the present one is that the patients in the Markow and Wandler study were singletons. While the possible influence of zygosity on fluctuating asymmetry was raised by Rose et al. (1987), an earlier study by Markow and Gottesman (1989) demonstrated that zygosity categories examined in the present study do not represent a deviant sample with respect to either absolute ridge count or fluctuating asymmetry for ridge counts. We therefore conclude that the differences we observe are a function of the diagnostic groupings. The tendency for discordant pairs to show the least fluctuating asymmetry for both dermatoglyphic measures is expected, based on the hypotheses that discordant twin pairs should have a lower "gene dosage" for the genetic predisposition or liability toward schizophrenia than concordant twins (Gottesman and Shields, 1972). That is, we can infer greater heterozygosity for the underlying polygenic system with consequently fewer of the "plus" alleles in toto and hence greater buffering against developmental stressors. In twins where the nonschizophrenic cotwin was diagnosed with some other form of psychopathology, an increase in fluctuating asymmetry was also observed. These findings suggest that the genetic predisposition for schizophrenia may, in the presence of various environmental stressors, lead to the development of other disorders, some of which may also predispose the individual to develop schizophrenia.

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