SOURCES OF INFORMATION FOR DISCRIMINATING MZ AND DZ TWINS BY DERMATOGLYPHIC PATTERNS

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It is shown that the within twin-pair difference is the most important source of information in determination of twin zygosity using dermatoglyphic data. Inclusion of a measure of among-pair variability provides added discrimination beyond that found with the within-pair difference alone.

Dermatoglyphic patterns are believed to be influenced by a number of genetic loci with primarily additive effects (Holt 1968). Although there are generally no differences in the means of dermatoglyphic variables between identical (MZ) and fraternal (DZ) twins, discrimination is possible using the variances of such variables (Bartlett and Please 1963), because the within-pair differences for DZ twins should be greater than the differences within MZ twins. In addition to differences in partitioning of genetic variance between MZ and DZ twins some dermatoglyphic traits have been found to have different total variances for MZ and DZ twins (Reed et al. 1975), which theoretically could provide an added source of discriminating power.

The within-pair difference or |A—B| where A and B refer to two members of a twin set has been the classic method employed when using dermatoglyphics for twin zygosity diagnosis. Most of the zygosity diagnostic methods have dealt with only a single dermatoglyphic trait, usually the total finger ridge count, and have ignored other dermatoglyphic patterning. Allen (1968) compared four methods utilizing within twin-pair differences, and both ridge count and pattern type were judged to be useful. In addition, discriminant function methods were shown to be more efficient than simpler approaches.

We analyzed the dermatoglyphics in 45 pattern areas in 360 sets of like-sexed twins (223 MZ, 137 DZ). The dermatoglyphic variables were both quantitative, such as the finger ridge counts, and qualitative pattern types of the fingers, palms and soles. The qualitative variables were quantitated by a scoring system previously reported (Reed et al. 1975). The results of the discriminant function using the within-pair differences from the 45 variables is shown in the Table, part a. In the Table, the results are displayed in two ways. First is the number of twin pairs correctly classified using a single intermediate cutoff halfway between the means of the two types of twins. The second approach utilizes an area of doubt encompassing the overlap area between the MZ and DZ twins in this sample. Only twin sets falling outside the overlap area are classified; those in the overlap area remain in doubt. Use of the area of doubt approach is more logical when further tests may be utilized in classifying the two groups or if there is substantial overlap in the distributions of the two groups (Habbema and van der Burgt 1974). Furthermore the twins in the overlap area can be classified as MZ or DZ according to probability values that

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Table. *Discriminant function analysis of dermatoglyphic variables in* 223 *MZ and* 137 *DZ twin pairs*

	Source of information	No. of significant variables	D^2	% Correctly classified MZ	DZ	Total	% Outside overlap MZ	DZ	Total
a.	$\lvert A-B \rvert$	14	4.80	92.4	79.6	87.5	10.8	36.5	20.6
b.	$[\lvert A-B \rvert \times (A+B)]$	9	2.73	88.3	71.5	81.9	14.8	13.1	14.2
c.	$\lvert A-B \rvert$, $[\lvert A-B \rvert \times (A+B)]$	18(15+3)	5.39	93.7	80.3	88.6	7.6	57.7	26.7
d.	$\lvert (A+B)/2 - \bar{x} \rvert$	8	0.85	70.0	65.0	68.1	4.0	0.0	2.5
e.	$\lvert A-B \rvert$, $\lvert (A+B)/2 - \bar{x} \rvert$	19(13+6)	5.51	93.3	80.3	88.3	26.9	55.5	37.8
f.	$\lvert A-B \rvert$, $\lvert (A+B)/2 - \bar{x} \rvert$, $[\lvert A-B \rvert \times (A+B)]$	18(11+4+3)	5.55	93.7	81.0	88.9	39.5	51.1	43.9

can be calculated for all scores in the overlap.

Using $|A-B|$ on the present sample only 20.6% of the twin pairs had scores falling outside the overlap values (Table, part a). The variation measured by the among-pair mean squares also has potential for discriminating between MZ and DZ twins. Gaines and Elston (1969) reasoned that $|A-B|$ may have a different meaning depending on the value $(A+B)$. For example, in a trait in which the variance increases with the mean, a small $|A-B|$ from a twin pair with a small $(A+B)$ may have as much or more discriminating power as a larger $|A-B|$ from a pair with a larger $(A+B)$. Morton (1974) stated that a correlation between $|A-B|$ and $(A+B)$ was an indication that the variance for the trait was changing with the mean. Indeed in the present sample $|A-B|$ and $(A+B)$ were significantly correlated in 26 of 45 variables. In an attempt to take this second source of variation into account, an interaction between $|A-B|$ and $(A+B)$, the quantity $[|A-B| \times (A+B)]$ was utilized. This interaction term when used alone proved to have discriminating power (Table, part b). When both the within-pair difference and interaction variables were employed, the resulting function increased the percentage of twins falling outside the overlap boundaries from 20.6% to 26.7% when compared to using $|A-B|$ alone (Table, part c).

A second reason for potential discriminating power of $(A+B)$ is the fact that like the within-pair differences, the deviations of twin pairs from the mean are expected to be different for MZ and DZ twins when genetic variance is present (Christian et al. 1974). For example, a quantitative trait in which all the genetic variation is additive genetic variation, the among-MZ mean square would be expected to contain 2 times the population genetic variance while the among-DZ mean square would be expected to contain 3/2 population genetic variance. To utilize this third source of variation for discriminating MZ and DZ twins, the quantity $\left|\frac{(A+B)}{2} - \bar{x}\right|$ was employed, where $\bar{x}$ equals the mean of the combined sample of MZ and DZ twins. Gaines and Elston (1969) previously showed that for a single variable (total finger ridge count) a similar expression of among-pair variability, $(A+B-2\bar{x})^2$, yielded added discrimination. Part d of the Table shows the results of using $\left|\frac{(A+B)}{2} - \bar{x}\right|$ alone to derive a function, which indicated that the among-pair variability is of some use but certainly not as valuable as the within-pair difference or interaction variables alone. The results using both $\left|\frac{(A+B)}{2} - \bar{x}\right|$ and $|A-B|$ are shown in the Table, part e. Although there was little difference in the percentage of twins correctly classified using $|A-B|$ alone and $\left|\frac{(A+B)}{2} - \bar{x}\right|$ with $|A-B|$, the latter function was a more efficient discriminator when considering the overlap area. Almost twice as many twin sets fell outside the area of doubt using $\left|\frac{(A+B)}{2} - \bar{x}\right|$ and $|A—B|$ in comparison to using $|A—B|$ alone. This effect is also illustrated in the Figure which includes distributions of discriminant scores in the 360 twin sets using both functions a and e. The use of the among-pair variation with the within-pair differences results in a reduction of outlying twin-pairs in both groups, so that the overlap in the distributions between MZ and DZ twins is reduced even though both functions result in similar discrimination at a single intermediate cutoff (dotted line).

A function utilizing the combination of within, among and interaction variables was the most efficient in the number of twin sets falling outside the overlap area (Table, part f). That there was not a strikingly large increase in the discrimination provided by function f over that using function e indicates that perhaps at least part of the effect of the interaction term includes simi-

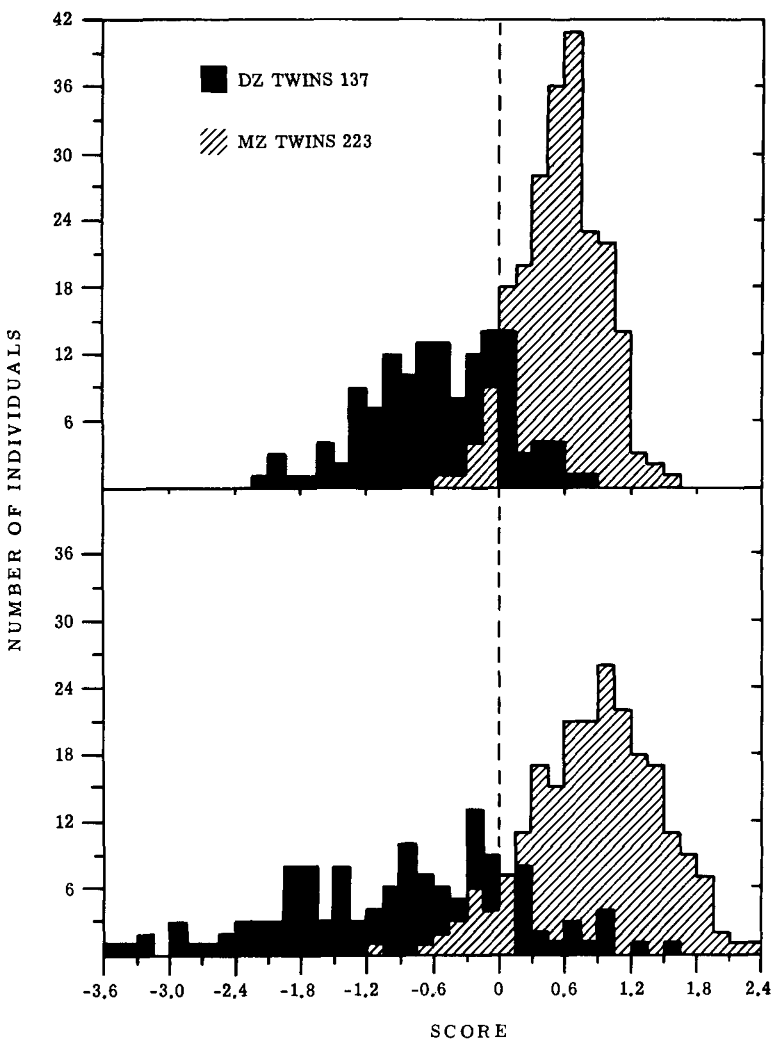

Figure. Distribution of discriminant scores using $|A\text{-}B|$ and $\left|\frac{(A+B)}{2} - \bar{x}\right|$ (top) compared with $|A\text{-}B|$ alone (bottom). The overlap between MZ and DZ twins is less in the top histogram despite similar discrimination at a central cutoff point (dotted line).

lar among-pair variability. Furthermore, to eliminate bias due to the number of significant variables used in each of the functions in the Table, all analyses were repeated using a common set of variables and the function utilizing all three sources of variation (as in f) had fewer cases falling outside the overlap than was found using only among and within-pair variables (as in e). In our sample functions, the use of squared values such as those employed by Gaines and Elston (1969) provided less powerful discrimination, particularly those which included $(A—B)^2$, than those utilizing first order terms.

In summary, we have found that both the within-pair differences, $|A—B|$, and a measure of among-pair variability, $\left|\left|\frac{(A+B)}{2}\right| - \bar{x}\right|$, can be useful sources of information in discriminating MZ from DZ twins with dermatoglyphic variables. The direct adjustment of the within-pair difference to $[|A—B| \times (A+B)]$ is also theoretically useful, but in our sample the interaction variables had appreciable value primarily when the within-pair differences were not used, and also when the within-pair difference but not among-pair variables were employed.

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