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SEX-DIAGNOSIS OF HUMAN SKULLS

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Key words: Multivariate statistical methods, sex-diagnosis, skulls of *Homo sapiens*.

ABSTRACT

For 41 human skulls from the 19th century in the collection of the Zoological Museum Amsterdam the discriminant function score was calculated using a set of twelve variables in order to arrive at a best-as-possible sex-diagnosis. The function used was developed by Van Vark & Pasveer (1994). This led to a diagnosis of 18 females and 23 males, with an estimated percentage of misclassifications of no more than 13%.

INTRODUCTION

The study of pre- and protohistoric skeletal remains of *Homo sapiens sapiens* is greatly improved by the employment of mathematical multivariate statistical methods that are designed specifically to suit the anthropological problems at issue.

In the present study a relatively simple but efficient procedure is used for simultaneously sex-diagnosing single skulls of different origin or of unknown population designation, employing a discriminant function that was calculated by Van Vark & Pasveer (1994). Moreover, the percentage of correctly diagnosed specimens is increased considerably with this procedure compared with standard methods.

The function was applied to 41 human skulls from the 19th century in the collection of the Zoological Museum Amsterdam (Table I). Most of these skulls lacked data, although on some of the labels indications were given such as 'Batak' (Sumatra, Indonesia), 'krankzinnige' (lunatic; a skull with metopism, the hereditary retention of the mediofrontal suture!), 'Hongaar', (Hungarian), 'Deen' (Dane), 'Brabantse soldaat?' (soldier from Brabant?) or 'oude vrouw' (old woman). No reference was made as to the sex of most of them except for the indications mentioned above.

METHOD

In the case of small samples of mixed and/or unknown origin it is of great help to have a large number of reference specimens at one's disposal. To achieve that goal, scores of skull measurements of k female samples and scores of k male samples, from a series of k populations, can be lumped together and a discriminating linear combination can be calculated

$$Y = \hat{c}_1 X_1 + \hat{c}_2 X_2 + \ldots + \hat{c}_p X_p$$

in which the variable X represents the skull measurements and $\hat{c}$ the estimated accessory coefficients such that the discrimination for these samples is maximum (Van Vark 1995).

An estimate for the mean female and male discriminant function scores $\hat{\mu}_F$ and $\hat{\mu}_M$, respectively, is obtained. A specimen is classified as female if its discriminant function score is smaller than $(\hat{\mu}_F + \hat{\mu}_M)/2$, and as male if its score is larger.

Van Vark & Pasveer (1994) lumped samples from 30 populations which approximately cover the variation of the total recent world population. 1139 female and 1352 male cranial specimens were selected and these lumped samples were used to calculate the discriminant function. All specimens were measured and most were visually sexed by Howells (1973). 70 variables, described and defined by Howells (1973: 161-190), were employed. A discriminatory value D = 2.42 was obtained. However, in order to reduce the enormous work load, Van Vark & Pasveer (1994) then calculated a subsequent discriminant function Y using the complete set of cranial specimens and a set of only 12 variables. The 12 variables were selected according to criteria described in Van Vark & van der Sman (1982). This produced as best estimates for the weighs $c_1, c_2 \ldots c_{12}$:

Y = 0.095(XCB) + 0.332(ZYB) - 0.251(AUB) +
+ 0.231(MDH) + 0.185(MDB) + 0.079(ZMB) - 0.152(EKB)+
+ 0.213(MLS) + 0.658(SOS) + 0.316(GLS) + 0.216(FOL) +
+ 0.090(PAF)

XCB	=	Maximum cranial breadth
ZYB	=	Bizigomatic breadth
AUB	=	Biauricular breadth
MDH	=	Mastoid height
MDB	=	Mastoid width
ZMB	=	Bimaxillary breadth
EKB	=	Biorbital breadth
MLS	=	Malar subtense
SOS	=	Supraorbital projection
GLS	=	Glabella projection
FOL	=	Foramen magnum length
PAF	=	Bregma-subtense fraction

The results of this second function differed only slightly from those of the 70-variable function, the statistics of its function scores being a) estimated sectioning point
$\hat{\mu} = (\hat{\mu}_F + \hat{\mu}_M)/2$ = 47.20, and b) discriminatory value D = 2.25 which corresponds with 13% overlap of the female and male distributions of the discriminant function scores. This implies that the combination of these 12 weighed variables will suffice for the diagnosis of sex in many instances (Van Vark & Pasveer 1994).

The latter 12-variable function was the one that was used in the present study, in part to test the method for applicability and accessibility for the layman as far as advanced statistical methods are concerned. These advanced methods often set up an impregnable stronghold for the non-mathematician.

With the aid of a few measuring instruments, e.g. spreading, sliding and coordinate calipers, and keeping strictly to the definitions of landmarks and measurements of Howells (1973), the 12 measurements were taken for each specimen. The data were stored in a worksheet and the formula was subsequently implemented.

RESULTS

The statistics calculated for the ZMA sample are as follows:
$\hat{\mu} = (\hat{\mu}_F + \hat{\mu}_M)/2$ = 46.43 (s.d. = 3.13)

This figure is close enough to Van Vark & Pasveer's $\hat{\mu}$= 47.20. Therefore it seems reasonable to surmise that the overlap of the female and male distributions of discriminant function scores is more or less equal to their 13%, implying that, according to expectation, no more than 5 of the 41 specimens are possibly incorrectly diagnosed. The result is that 18 of the 41 specimens are diagnosed as female, while 23 specimens are diagnosed as male (See Table I).

DISCUSSION

With the present method specimen ZMA 749, labelled as 'Brabantse soldaat?' is diagnosed as female. This could imply that it concerns a misdiagnosed skull, but in view of the incomplete dentition and the state of the closing of the skull sutures, the discrepancy could also be due to the youthfulness of this soldier.

Three specimens in the collection had been diagnosed before by another method, recommended by the Arbeitsgruppe Europäischer Anthropologen (1979), using 15 weighed morphological characters. ZMA 25.108 was diagnosed as juvenile, ZMA 25.109 as male and ZMA 25.110 as male; a fourth number, ZMA 25.111, a mandibular bone only, was diagnosed as being male following a method described by Loth & Henneberg (1996) (E.M.A. de Looze, unpublished data). These four specimens were excluded from the present study.

Two 19th century ZMA specimens were not included in the test, as their dentition clearly indicated that these were infants, viz. the numbers ZMA 762 (labelled as being 3-4 years old which should be 6-8 years), and ZMA 755 (labelled 7 to 8 years old, which should be 3-4 years old) as diagnosed by their dentition with the method of the Arbeitsgruppe Europäischer Anthropologen (1979).

In the present study the function calculated by Van Vark & Pasveer (1994) could not be tested for reliability but it fulfilled all expectations as to accessibility and simplicity. It is therefore recommended to non-mathematicians in disciplines like archaeology and physical anthropology as well as to the medical scientist.

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Table I. List of 41 human skulls from the 19th century in the collection of the Zoological Museum Amsterdam

ZMA number	Discriminant function score ($\hat{\mu}$ = 46.43)	sex-diagnosis
ZMA 734 'Batak'	47.583	♂
ZMA 749 'Brabantse soldaat?'	45.389	♀ (?)
ZMA 752 'Deen'	50.927	♂
ZMA 753 'Hongaar'	49.569	♂
ZMA 756 'oude vrouw'	44.348	♀
ZMA 757 'krankzinnige'	45.019	♀
ZMA 763	41.933	♀
ZMA 768	48.447	♂
ZMA 771	47.291	♂
ZMA 772	47.826	♂
ZMA 773	47.584	♂
ZMA 774	41.252	♀
ZMA 775	44.171	♀
ZMA 776	45.133	♀
ZMA 777	49.834	♂
ZMA 778	40.822	♀
ZMA 779	49.032	♂
ZMA 780	47.307	♂
ZMA 781	46.545	♂
ZMA 782	49.561	♂
ZMA 783	44.056	♀
ZMA 784[A]	49.259	♂
ZMA 784[B]	45.733	♀
ZMA 785	50.982	♂
ZMA 786	41.97	♀
ZMA 787	48.781	♂
ZMA 790	45.278	♀
ZMA 791	43.13	♀
ZMA 792	49.364	♂
ZMA 793	49.662	♂
ZMA 794	47.484	♂
ZMA 7.529	39.56	♀
ZMA 7.530	49.3	♂
ZMA 7.531	49.22	♂
ZMA 7.532	47.564	♂
ZMA 7.533	45.745	♀
ZMA 8.652	40.941	♀
ZMA 13.472	47.268	♂
ZMA 13.473	52.381	♂
ZMA 22.094	43.228	♀
ZMA 24.129	43.691	♀

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