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## Forensic Misclassification of Ancient Nubian Crania: Implications for Assumptions about Human Variation

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The fundamental pattern of human biological diversity was widely held in premodern anthropology and contemporary folk ideologies to be principally "racial"—that is, largely homogeneous within groups and heterogeneous between them. The groups in question were often presumed to represent entire continents or subcontinents. By the middle of the twentieth century, however, this view had come under considerable scrutiny (Montagu 1941, Livingstone 1962, Washburn 1963, Lewontin 1972). Modern physical anthropology recognizes the major features of human biological diversity as polymorphic (within-group variation being quantitatively predominant), clinal (i.e., structured as gradients), and culturally mediated (as both the largely arbitrary agglomeration of physically diverse peoples into "races" and the response of the body itself to the cultural conditions under which it develops).

Forensic anthropology has been much more reluctant to divorce itself from the premodern partitioning of human biological variation into races (Smay and Armелagos 2000), despite the fact that human biological variation in genetic markers (Lewontin 1972, Stoneking 1993) and cranial morphology (Relethford 1994) is quantitatively greater within than between major geographic regions or

racess. Pressure from local law enforcement officials who insist on "knowing" the social race of unknowns may prompt some forensic anthropologists to designate racial affinity (provided that the sex of the individual can be determined), producing classifications that some have called "bureaucratic races." However, the use of forensic tools to determine ancestry must assume that a given cranium is more similar to those of the ascribed population than to those of any other (e.g., Byers 2002). The fact that populations are variably defined as geographic regions, islands, countries, reproductive isolates, languages, cultures, or race categories may severely limit the reliability of such diagnoses.

Fordisc 2.0 is a computer program designed to standardize the attribution of population affinity for forensic analysis and to provide a user-friendly method for ascribing "social race" to unknowns. Social race is an approximation of biological affinity and is used as the most practical means to identify unknown individuals, regardless of their actual ancestors (Ousley and Jantz 1996). A basic premise of the program is that the unique craniofacial form of a given population remains stable through generational time and is largely resistant to environmental factors. This premise has recently received support from a revisionist historical study claiming to have identified statistical flaws in the initial study of changes in the bodily form of immigrants (Sparks and Jantz 2002; cf. Gravlee, Bernard, and Leonard 2003). This development has strengthened the perceived efficacy of Fordisc 2.0 by suggesting that population and racial traits are constant over time and space.

The popularity of Fordisc 2.0 parallels recent public interest in forensic anthropology, the race concept, and race determination. New forensic anthropology texts present the program uncritically even when it yields determinations opposite to those derived from morphological evaluation. *Hard Evidence*, a forensic anthropology reader (Steadman 2003), features five articles that use Fordisc 2.0 (none of them exclusively to determine race and/or sex), and in two of them it yielded the opposite of standard morphological determinations. *Forensic Osteological Analysis* (Fairgrieve 1999) includes two contributions that utilize Fordisc 2.0 to (1) confirm a morphological evaluation of sex and (2) determine ancestry (this attempt proved unsuccessful). Byers's (2002) *Introduction to Forensic Anthropology* embraces Fordisc 2.0 alongside the nonmetric traits traditionally used by many forensic anthropologists to define social race. The program is "highly recommended" for diagnosing race and sex in the popular *Forensic Anthropology Training Manual* (Burns 1999:40).

Reports of Fordisc 2.0 analyses in the primary literature are scarce, suggesting that practitioners of this program are using a tool that has not been systematically tested for validity. Fordisc 2.0 produced poor results in Ubelaker, Ross, and Graver's (2002) study of sixteenth- and seventeenth-century Spanish crania, with half the crania being attributed to non-European/North African samples using one of its data sets, Howells's (1973, 1995) cranial series, and less than half attributed to the white

category using its other data set, the Forensic Data Bank (Ousley and Jantz 1996). Ubelaker et al. (2002) nevertheless call it "a powerful tool in forensic analysis that is routinely employed in most North American forensic laboratories" and generally support its use provided that care is taken when the samples are not represented in either of its databases (see also Ousley and Jantz 1996). Other researchers are less convinced of Fordisc's practical use. Fukuzawa and Maish (1997) sought to ascribe ancestry to Native Canadians without success, and Leathers, Edwards, and Armelagos (2002) and Belcher, Williams, and Armelagos (2002) found that the program failed to classify populations as expected. We used both of its data sets to identify cranial remains from an ancient Meroitic Nubian population and found that it accurately classified very few of these remains.

#### MATERIALS AND METHODS

Ancient Nubia, located on the upper Nile between the first and fourth cataracts, was ancient Egypt's most powerful rival and important trade partner on the African continent (Williams 1999). From Pre-Dynastic times to the Roman conquest, Nubia and Egypt borrowed heavily from each other's material culture and maintained substantial genetic admixture (Keita 1992, Krings et al. 1999, Williams 1999). While Brace et al. (1993) found Egyptians craniofacially distinct, they also identified a north-south gradient of craniofacial traits from the Nile Delta through Nubia to Somalia. Keita (1992) found that First Dynasty Egyptians from Abydos were similar morphometrically to those from Kerma (south of Nubia). A recent study on mtDNA suggested that modern Nubians and Egyptians are much more similar to one another than either is to southern Sudanese populations and that the divergence between the two northern populations may have occurred during the past few hundred or few thousand years (Krings et al. 1999).

We hypothesized that, using Howells's data in Fordisc 2.0, our Nubian crania (dated 350 BCE–AD 350) would be identified as Late Period Dynastic Egypt (Twenty-sixth to Thirtieth Dynasties, 600–200 BCE), since these data correspond roughly geographically to ancient Nubia. Howells's (1973, 1995) cranial series consists of 28 skeletal samples: Easter Island, Medieval Norse, Zalavar (medieval Hungary), Berg (Austria), Egypt (Twenty-sixth to Thirtieth Dynasties), Teita (Kenya), Dogon (Mali), Zulu and San (South Africa), Andaman Islands, Lake Alexandrina Tribes (Australia), Tasmania, Tolai (New Britain), Mokapu (Hawaii), Buriat (Siberia), Inuit (Greenland), Arikara and Santa Cruz Island (North America), Yauyos (Peru), Ainu, Hokkaido, and Kyushu (Japan), Atayal (Taiwan), Guam, Anyang and Hainan (China), Moriori (Chatham Islands), and the Philippines, roughly equally divided into 50 males and 50 females for each sample. Although Fordisc 2.0 is intended to identify only unknowns represented in its control population sets, it will theoretically classify an individual to its nearest geographical neighboring population when one is available

(Ousley and Jantz 1996).<sup>1</sup> Alternatively, the Nubian material might have been classified as other African continental populations (e.g., the Teita of Kenya or the Dogon of Mali), although these scenarios are less likely because these populations are temporally distinct from ancient Meroitic Nubia and farther from Nubia than Egypt. We expected the Nubian population to cluster as a group and to be attributed to populations geographically near it.

Next, following Ubelaker, Ross, and Graver (2002) we subjected the Nubian crania to Fordisc's Forensic Data Bank series, which includes American blacks (150 males, 125 females), American Indians (50 males, 29 females), American whites (271 males, 195 females), Chinese (79 males), Hispanics (39 males), Japanese (100 males, 100 females), and Vietnamese (51 males) (Jantz and Moore-Jansen 1988, Ousley and Jantz 1996). We expected the program to identify the Nubian sample as black or white. We did not expect any of these crania to be classified as Chinese, Japanese, or Hispanic because of the geographic distance separating these populations from Northeast Africa. Since sex can also be ascribed using Fordisc 2.0, we conducted two tests using the Forensic Data Bank, one with sex known and the other with opposite sex known. We anticipated that the sex attributed to a given cranium would not alter the ascribed biological affinity of that individual. If populations can be readily defined as discrete multivariate clusters, as they are in Fordisc 2.0, we would predict distinct morphological patterns to be exhibited by both males and females of a given population, despite the arguably more obvious patterns of sexual dimorphism observed in human crania.

The craniofacial linear distances we used were obtained by one of us (GJA) from an archeological series of Nubian crania originating from sites opposite modern Wadi Halfa (21°57'28" N and 31°19'10" E) in present-day Sudan. We used 12 cranial measurements for each cranium: glabella to opisthocranium, maximum cranial breadth, bizygomatic breadth (distance between the most lateral points of the zygomatic arches), basion to bregma, nasion to basion, basion to prosthion, prosthion to alveolon, minimum frontal breadth (distance between the two frontotemporale), nasion to nasopinale, nasal breadth (maximum breadth of the nasal aperture), dacryon to ectoconchion, and orbital height (distance between the superior and inferior orbital margins). Of the original 46 adult crania available, 20 crania were male, 20 female, and 6 indeterminate. Of these 46 crania, 4 individuals were excluded because they were missing three measurements, but we included 3 crania that were missing only one of the 12 measurements. Fordisc 2.0 was used to identify each of the remaining 42 crania.

The measurements were chosen on the basis of preservation of the material and the choices given by Fordisc

2.0. These same measurements have been utilized by numerous craniometric studies and have been shown to have diagnostic value (see Howells 1995 and references therein). To ascertain whether the Nubian cranial data were comparable to the control samples in Fordisc 2.0, we compared the Nubian sample with all the African populations from Howells's (1995) data set. Half of the traits compared between the Nubian and the Egyptian populations yielded nonsignificant differences ( $p < 0.05$ ), which is greater than or equal to the number of nonsignificant differences obtained by comparing the Egyptian sample with other African populations (San, Zulu, Teita, Dogon). This suggests that the Egyptians are more similar to the Nubians than they are to any other African population.

In Fordisc 2.0, an unidentified skull is ascribed a population affinity by identifying the closest Mahalanobis distance from the unknown to the mean vector scores for each of Fordisc's skeletal samples. Additionally, Fordisc 2.0 calculates the typicality and posterior statistical probabilities that a single cranium belongs to a specific group. Posterior probabilities (which sum to 1) ascertain the likelihood that a given cranium belongs to more than one sample, whereas typicality probabilities (from 1.0 to 0.000) identify whether a given unknown is statistically significantly different from the population ascribed by the program. Typicality probabilities of 1.0 suggest that a given cranium has values that lie exactly on the mean of one of Fordisc's populations, whereas typicality probabilities less than 0.05 suggest that the cranium is significantly different from the population attributed by Fordisc 2.0 (Ousley and Jantz 1996; Jantz, personal communication).

## RESULTS

*The Howells series.* Fordisc 2.0 could not effectively classify ten of the crania, and of the remainder, eight were identified as Late Period Dynastic Egyptian, six as Zavalav, four as Easter Islander, three as Lake Alexandrina Tribes, and three as Norse (Medieval Norway). Eight were not significantly different from eight separate populations: Teita, Andaman Islands, Zulu, Arikara, Santa Cruz Island, Ainu, Hokkaido, and Atayal. In no case did a nonsignificant typicality statistic exhibit a nonsignificant posterior probability, indicating that each cranium did not belong to a skeletal sample other than the one indicated by the typicality statistic. The typicality statistics were neither uniformly high nor low (table 1).

*The Forensic Data Bank.* Our data were analyzed twice using the Forensic Data Bank in Fordisc 2.0 to examine the degree to which specifying the sex of an individual might alter the results. When the original sex determinations (derived from associated pelvic material) were used, 14 of the crania were significantly different from the population specified by Fordisc 2.0 (typicality  $p < 0.05$ ). Of the remaining crania, 12 were identified as white, 11 as black, 3 as Japanese, 1 as Hispanic, and 1 as Native American. When the sex determination was changed to the opposite of the one identified in the orig-

1. Ousley and Jantz (1996) caution Fordisc 2.0 users to avoid classifying individuals from ethnic groups that are not represented in the database of the program. However, forensic anthropologists may not know a priori whether an isolated cranium derives from one of Fordisc's reference samples.

TABLE 1  
*Fordisc 2.0 Results Using Howells's Cranial Data*

ID	Attributed Sex	Population Ascribed by Fordisc 2.0	Posterior <i>p</i>	Typicality <i>p</i>
1	Indeterminate	Zalavar (Hungary) <sup>a</sup>	0.172	0.003
2	Male	Lake Alexandrina Tribes (Australia)	0.517	0.138
3	Male	Lake Alexandrina Tribes (Australia)	0.520	0.303
4	Male	Late Period Dynastic Egypt <sup>a</sup>	0.907	0.000
5	Female	Norse (Norway)	0.326	0.091
6	Female	Zalavar (Hungary)	0.109	0.864
7	Female	Teita (Kenya)	0.233	0.197
8	Female	Zalavar (Hungary)	0.315	0.589
9	Male	Late Period Dynastic Egypt	0.427	0.312
10	Female	San (South Africa) <sup>a</sup>	0.841	0.000
11	Female	Andaman Island	0.272	0.529
12	Male	Zalavar (Hungary)	0.153	0.996
13	Female	Santa Cruz Island	0.320	0.146
14	Female	Easter Island <sup>a</sup>	0.994	0.000
15	Indeterminate	Easter Island	0.460	0.795
16	Female	Hokkaido (Japan)	0.251	0.351
17	Male	Norse (Norway)	0.188	0.728
18	Male	Santa Cruz Island <sup>a</sup>	0.294	0.040
19	Male	Easter Island	0.307	0.713
20	Male	Lake Alexandrina Tribes (Australia)	0.571	0.533
21	Female	Zulu (South Africa)	0.401	0.780
22	Indeterminate	Late Period Dynastic Egypt	0.427	0.312
23	Male	Easter Island	0.203	0.299
24	Male	Zulu (South Africa) <sup>a</sup>	0.391	0.002
25	Female	Late Period Dynastic Egypt	0.332	0.561
26	Male	Atayal (Taiwan)	0.190	0.915
27	Indeterminate	Easter Island	0.298	0.348
28	Female	Late Period Dynastic Egypt	0.349	0.239
29	Female	Peru <sup>a</sup>	0.826	0.000
30	Female	Late Period Dynastic Egypt	0.281	0.470
31	Male	Zalavar (Hungary)	0.109	0.864
32	Male	Late Period Dynastic Egypt <sup>a</sup>	0.994	0.003
33	Male	Late Period Dynastic Egypt	0.582	0.222
34	Female	Late Period Dynastic Egypt	0.363	0.438
35	Male	Zalavar (Hungary)	0.349	0.518
36	Female	San (South Africa) <sup>a</sup>	0.712	0.002
37	Male	Ainu (Japan)	0.348	0.152
38	Female	Easter Island <sup>a</sup>	0.344	0.043
39	Male	Zalavar (Hungary)	0.406	0.051
40	Male	Late Period Dynastic Egypt	0.356	0.443
41	Indeterminate	Arikara (America)	0.190	0.172
42	Indeterminate	Norse (Norway)	0.313	0.701

<sup>a</sup>A cranium is significantly different from the population ascribed by the program (typicality  $p < 0.05$ ).

inal morphological analysis, the number of crania exhibiting a typicality  $p < 0.05$  increased to 17. Eleven of the crania (excluding those with  $p$  values  $< 0.05$ ) changed population when the sex determination was changed to its opposite (fig. 1), suggesting that Fordisc 2.0 relies heavily on the assigned sex determination in attributing population affinity. The identities assigned to the crania in this test (9 black, 7 white, 7 Hispanic, 1 Chinese, and 1 Japanese) differed most markedly from the previous analysis in that the Hispanic category increased substantially.

#### DISCUSSION

The fact that the Nubian crania were overwhelmingly misclassified and that only eight were grouped with Late Period Dynastic Egypt may have a variety of explana-

tions. Since there is no Meroitic Nubian sample in the program's data sets, there may have been no specific reference sample to compare with these ancient crania. However, Howells's populations were selected to sample the cranial variation found on the continents. If the Late Period Dynastic Egyptian crania differed greatly from the Nubian ones—and our  $t$  tests suggest that they do not—then the Nubian crania might have been classified with other geographically close populations such as the Teita or the Dogon. Alternatively, we might suspect all of the typicality probabilities to be significantly different from the populations ascribed by the program. Instead, Fordisc 2.0 classified the Nubian crania with populations over an enormous geographic range, including North and Central Europe, Easter Island, the Andaman Islands, Japan, Taiwan, South Africa, Australia, and North America. Fordisc's treatment of X-group Nubians corroborates

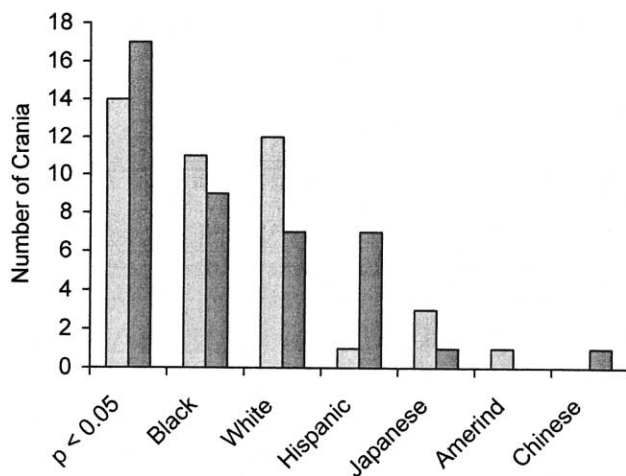


FIG. 1. Population ascribed using Fordisc 2.0's Forensic Data Bank. Left bar of each pair, original sex assignment; right bar, opposite original sex assignment.

these results (Leathers, Edwards, and Armelagos 2002). If Fordisc 2.0 is revealing genetic admixture of Late Period Dynastic Egypt and Meroitic Nubia, then one must also consider these ancient Meroitic Nubians to be part Hungarian, part Easter Islander, part Norse, and part Australian Aborigine, with smaller contributions from the Ainu, Teita, Zulu, Santa Cruz, Andaman Islands, Arikara, Ayatal, and Hokkaido populations. In fact, all human groups are essentially heterogeneous, including the samples within Fordisc 2.0. Using  $F_{ST}$  heritability tests, Relethford (1994) demonstrated that Howells's cranial samples exhibit far more variation within than between skeletal series. There is no reason to assume that the heterogeneity of the Late Period Dynastic Egyptian population exceeds that characterizing our Nubian sample. This heterogeneity may also characterize the populations in the Forensic Data Bank; Fordisc 2.0 classified the Meroitic Nubians not as either all black or all white but as black, white, Hispanic, Chinese, Japanese, and Native American.

The fact that these groupings exist in the Forensic Data Bank of Fordisc 2.0 may stem from a specific understanding of race in America. Folk taxonomies of race are largely nation-specific because they develop from unique historical and demographic factors. For example, the fluidity and multiplicity of racial terms in Brazil corresponds to the lack of hypodescent rules (attributing one's social race to the race of the minority parent) and miscegenation laws; an individual's ascribed whiteness or blackness may change with respect to economic prosperity (money "whitens" [Degler 1970]). In Trinidad, the folk separation of groups uses a much wider range of labels, to the point that full siblings may be of different "races" (Segal 1993). Attribution of race depends heavily on culturally constructed definitions of human difference.

Our results suggest to us that Fordisc 2.0 is fundamentally flawed not only because these types are culturally mediated but because statistically defined populations cannot adequately represent the biological variation that characterizes individuals within each purported group. The idea that human beings represent distinct and divisible biological types is rather recent in human history (Marks 1995), and the lines that are drawn to make distinctions are based on socioeconomic factors and historical circumstances rather than strictly on biological criteria (Armelagos 1995, Goodman 1995, Marks 1995). The type concept relies upon an "idealized" individual that describes only a minute fraction of the variation it is intended to represent. Forensic anthropology has often been called upon to substantiate typological thinking and to reinforce the type concept itself.

The idea that head type is stable through time and thus resistant to environmental factors was very popular among natural scientists from the seventeenth to the nineteenth century. Mid-twentieth-century physical anthropology sought to trace independent human lineages by associating craniofacial remains from past populations with their supposed modern counterparts (Boule and Vallois 1957, Coon 1962). During the same period, several studies demonstrated plasticity of body type through such processes as developmental acclimatization (Baker 1969, Frisancho 1970) and migration to new areas (Shapiro 1939, Bogin 1988). This may help to explain why European Upper Paleolithic populations do not resemble modern Europeans (van Vark 1994), why Kennewick man does not resemble modern Native Americans (van Vark, Kuizenga, and Williams 2003, contra Jantz and Owsley 2003), why American-born children of immigrants resemble their parents less than European-born children of immigrants do (Boas 1912, contra Sparks and Jantz 2002), and why Mesolithic Nubians do not resemble Meroitic Nubians (Van Gerven, Armelagos, and Rohr 1979). This reflects simply what is known about the patterns of variation in the human cranium: it is to some extent an inborn characteristic and also developmentally very sensitive to the conditions of growth. While we acknowledge that many scientists are fully aware of the problems inherent in Fordisc 2.0 and in race determination generally, our experiment provides a point of view that is rarely examined within forensic anthropology, that is, that human cranial populations are suspect as real biological units equivalent to the cultures, languages, geographic regions, and social histories they are intended to represent.

## CONCLUSIONS

We argue that Fordisc 2.0, encapsulating the major skeletal markers and statistical techniques in forensic anthropology, offers little information with regard to the biological affinity of Meroitic Nubians. Given the claims of the program, we predicted that the Nubian population would cluster as a single entity and that the cluster would reflect an affinity to Late Period Dynastic Egyptians or possibly to other African continental popula-

tions. The program failed both tests. We suggest that skeletal specimens or samples cannot be accurately classified by geography or by racial affinity because of (1) the wide variation in crania of the known series that cross-cuts geographic populations (polymorphism), (2) the clinal pattern of human variation, and (3) cultural and environmental factors. Even a presumably homogeneous population such as the Meroitic Nubians shows extensive variation that preclude its classification as a geographic group.

The control population sets within Fordisc 2.0 lack the distinctive morphology necessary to make this forensic application a useful tool for classifying an unknown cranium because the populations used are defined not on the basis of biology but on the basis of the variation in skeletal series or on self-assignment to folk categories that have strong sociohistorical (e.g., black, white), national (Chinese, Japanese), and linguistic (Hispanic) components. Our results suggest that the attempt to classify populations into natural geographic groups or races—as if all of these groupings were biologically equivalent—will continue to fail (Armélagos and Van Gerven 2003).

It is well known that human biological variation is principally clinal (i.e., structured as gradients) and not racial (i.e., structured as a small number of fairly discrete groups). The possibility that skeletal material could be accurately sorted by geographic origin, at any other level than geographic extremes, is quite small. We have shown that for a temporally and geographically homogeneous East African population, the most widely used “racial” program fails to identify the skeletal material accurately.

The assignment of skeletal racial origin is based principally upon stereotypical features found most frequently in the most geographically distant populations. While this is useful in some contexts (for example, sorting skeletal material of largely West African ancestry from skeletal material of largely Western European ancestry), it fails to identify populations that originate elsewhere and misrepresents fundamental patterns of human biological diversity.

Finally, the assumption that cranial form is an immutable “racial” character is very likely to be false, given the diversity of studies of immigrants and the known effects of food preparation and masticatory stress upon cranial form. Cranial form, like other aspects of the body, is a phenotype partly determined by heredity but also strongly influenced by the conditions of life.

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