A79 The Effects of Measurement Properties and Underlying Human Variation on FORDISC® Classification and Tolerance for Craniometric Error

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Learning Overview: After attending this presentation, attendees will better understand how modeling techniques can elucidate the impact of complex variable interactions on skeletal sex and ancestry assessment.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by providing new insight into patterns of misclassification in FORDISC® and new insight for generating appropriate tolerances for craniometric measurement error.

This research uses iterative manipulation to model the effects and interplay of craniometric measurement properties and underlying human variation on FORDISC® classification.[1]

Simulation techniques, such as the approach presented here, can help shed light on the sensitivity and validity of craniometric measurements used in discriminant function analyses, given that underlying variation and overlap in these traits within and among populations can strongly bias results when using small test samples. This study builds on previous work that employed similar methods with casework data by now modeling deviations from simulated "population-mean individuals" in order to parse out the effects of test sample or unknown individual "bias" from intrinsic measurement variables, such as magnitude and reproducibility, on misclassification.[2]

Twelve standard craniometric measurements (Biauricular Breadth [AUB], Basion Bregma Height [BBH], Cranial Base Length [BNL], Basion Prosthion Length [BPL], Maximum Cranial Length [GOL], Frontal Chord [FRC], Maxillo-Alveolar Breadth [MAB], Maxillo-Alveolar Length [MAL], Nasal Breadth [NLB], Nasal Height [NLH], Orbital Breadth [OBB], and Bizygomatic Breadth [ZYB]) were taken from the mean configuration of each of the 13 population groups in the Forensic Anthropology Data Bank (FDB, v1.24). These measurements were selected based on lowest Wilks lambda scores at Step 1 in a Forward Wilks lambda stepwise analysis using all FDB groups and all original DCP 1.0 measurements with the exception of mastoid height (due to issues with its measurement noted in DCP 2.0). For each group's mean individual, an analysis was run using the above measurements and all FDB populations with no transformations. Then one measurement at a time was varied in 1mm increments (±5mm) and reclassified. This process was repeated for all measurements, resulting in 121 runs per FDB group and 1,573 runs total. The classification and posterior probability results were recorded and compared.

Eighty-eight of the 1,560 (5.6%) deviation-based runs resulted in "misclassifications," where error in one measurement changed the classification from that of the original mean individual's group. Misclassification was roughly as likely to result from positive deviations as from negative deviations. Deviations ±1mm resulted in no misclassifications, while ±5 mm affected misclassifications for all measurements except GOL and MAB—iterating these two measurements caused no misclassifications. GOL is the largest measurement included here, (grand mean = 178mm, range of means = 171–188mm), likely influencing its robusticity to perturbations; however, MAB is a "medium-sized" measurement with a smaller range of variation. The variables generating the greatest numbers of misclassifications were OBB and ZYB (N=18 and 15, respectively). Deviations of ±2mm resulted in misclassifications for NLB, NLH, and OBB, which constitute the three smallest measurements in every group and have the smallest ranges. Percentage deviations were also evaluated to standardize comparisons across craniometric measurements.

Parsing the results based on FDB group, WF had 0 misclassifications; WM, BM, AM, and BF groups also had low incidences (<2%). The robusticity against misclassification for WF likely stems from this population's peripheral location in morphospace. Groups that misclassified most frequently were CHM and JM (20% misclassification rate each), followed by HM (10%). These misclassifications were often reciprocal among the three groups (e.g., +4mm deviation on AUB misclassified JM and CHM as HM, and -4mm deviation changed HM to a JM classification). These three groups started with the lowest posterior probabilities for their mean individuals, indicating large amounts of overlap in morphospace. Most misclassifications involved erroneous geographic/racial classification, with fewer instances of sex misclassification. However, all misclassifications of mean individuals from the AF or AM groups involved a switch of sex, and of the eight total instances of misclassified sex, seven involved the AF group.

The results of this study were compared to the results of an earlier study using casework individuals. The contrast in results highlights that the influence of measurement deviation on DFA depends on measurement magnitude, the range of measurement variation expressed by the reference populations, and where an unknown individual lies in morphospace. Together, these two studies suggest that blanket standards for tolerable measurement error are overly simplistic and the need to consider intrinsic measurement properties alongside patterns of human phenotypic variation when establishing guidance for measurement error tolerances.

Reference(s):

1. Jantz R.L., Ousley S.D. *FORDISC® 3: Computerized discriminant functions, version 3.1*. Knoxville (TN): Univ. of Tennessee, 2005.
2. Stock M.K., Rubin K.M., McGhee A. Sensitivity Analysis of Craniometric Measurements and Modeling Techniques to Assess Impact of Measurement Error on FORDISC® Results. *Proceedings of the American Academy of Forensic Sciences*, 70th Annual Scientific Meeting, Seattle, WA. 2018.

Metric Analysis, Modeling, Error Tolerance

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