H61 The More the Better?: Evaluating the Impact of Fixed Semi-Landmark Number in Cranial Shape Variation Analyses

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The goal of this presentation is to refine the applicability of fixed semi-landmark-based techniques in biological profiling.

This presentation will impact the forensic science community by highlighting several important factors which contribute to the effectiveness of fixed semi-landmarks in characterizing morphological variation in cranial curvature.

Geometric morphometrics (GM) often utilizes anatomical landmark coordinates, in either two or three dimensions, to capture biological shape. Anatomical landmark coordinates exhibit biological homology across specimens and are categorized into three groups: Type I - discrete juxtapositions of tissue; Type II - points of maximal curvature; and Type III – extremal points (Bookstein, 1991). However, some anatomical regions, such as boundaries and surface curvature, lack well-defined landmarks. GM addresses this obstacle via the application of semi- landmarks to such regions. The simplest form of semi-landmark data are represented by the placement of equally-spaced points on curves or surfaces. An algorithm resamples raw curve data into a manageable number of evenly-distributed fixed points. The number of fixed semi- landmarks is user-defined and reflects just enough points to maintain the original curve's "shape." However, exactly what constitutes *enough* points is arbitrary and thus entirely at the researcher's discretion.

The present study examines the relationship between the number of fixed semi-landmarks utilized and their effectiveness in detecting sex and population differences in cranial curvature. Three-dimensional fixed semi-landmarks were captured on the orbital rims, zygomatic arches, nasal aperture, and maxillary alveolar ridge of 193 crania embodying a mix of socially-determined race (Black, White) and biologically- determined sex from the Terry, Hamann-Todd, Maxwell Museum, and W.M. Bass skeletal collections of known individuals. Curvature data was gathered as continuous stream data using a portable digitizer. Fixed semi-landmarks were then extracted utilizing a beta program (Slice 2005), which applies an algorithm that re-samples each curve into a user- defined number of evenly-distributed points. Two separate resampling sessions were performed on the original dataset. During the first session of resampling (S1) the following numbers of fixed semi-landmarks were extracted for each region: orbits = 40; zygomatic arches = 64; nasal aperture = 16; maxillary alveolar ridge =16. These amounts were halved during the second resampling session (S2) (orbits = 20; zygomatic arches = 32; nasal aperture = 8; maxillary alveolar ridge =8).

The resultant regional semilandmark data from each session were fit into a common coordinate system via a generalized Procrustes analysis (GPA), which filters out the effects of location, scale, and rotation. A principal component analysis (PCA) was performed on the covariance matrix of the GPA-aligned coordinates in order to reduce dimensionality. The resulting principal component (PC) scores, which accounted for 85% of the total variance in each region, were employed in subsequent multivariate statistical analyses. A multivariate analysis of variance (MANOVA) of the PC scores from both sessions detected significant race and sex effects in all of the regions (Pr>F=<0.05). A discriminant function analysis, which calculates the effectiveness of a set of variables in predicting group membership, was then conducted on the PC scores from both sessions using *crossvalidation* or n-1 method. The error count estimates (proportion of group misclassifications) for race exhibited minimal to no difference between data from Session 1 and 2 in all of the regions (S1 vs. S2 - orbits: Black= 0.3435 vs. 0.3435, White= 0.3387 vs. 0.3226; zygomatic arches: Black= 0.0611 vs. 0.0611, White= 0.2097 vs. 0.27426; nasal aperture: Black= 0.0992 vs. 0.084, White= 0.1613 vs. 0.1935; and, maxillary alveolar ridge: Black= 0.2901 vs. 0.2901, White= 0.2419 vs. 0.3065). The semi-landmark data from Session 1 and 2 produced a similar pattern of error count estimates in terms of sex (S1 vs. S2 - orbits: Female= 0.3284 vs. 0.3433, Male= 0.3095 vs. 0.3095; zygomatic arches: Female = 0.5224 vs. 0.4776, Male= 0.2302 vs. 0.1984; nasal aperture: Female = 0.3582 vs. 0.084, Male= 0.3889 vs. 0.3413; and, maxillary alveolar ridge: Female = 0.4328 vs. 0.5075, Male= 0.3968 vs. 0.3968). Thus, the statistical impact of reducing the number of fixed semi-landmarks in each region was negligible.

These preliminary results indicate that there is little statistical advantage to employing a large number of fixed semi-landmarks to capture shape variation. Moreover, when employing semi-landmark data to discriminate between populations and the sexes, the area from which they are collected, and not their number, is of primary importance. Incorporating such information into standard forensic practice may allow for a more informative assessment of race and sex in unidentified human crania.

Geometric Morphometrics, Semi-Landmarks, Crania