A28 Spatial Analysis on a Global Scale: Cranial Non-Metric Trait Variability

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After attending this presentation, attendees will understand some principles of cranial non-metric trait analysis with geospatial tools, the necessary elements for the application of geospatial analysis in biodistance studies, and an example of the practical application of geospatial analysis.

This presentation will impact the forensic science community by quantifying global variation in cranial non-metric traits through novel geospatial tools that permit the visualization of qualitative variables.

Cranial non-metric trait (*sensu stricto*) variation in ancestry estimation has been documented by multiple researchers, but the global distribution of that variation using geospatial analyses and large samples has not been explored. Using a dataset of nearly 8,000 individuals, this study explored global spatial variation and the underlying patterns of trait distributions in an effort to fine-tune the analysis of cranial non-metric traits in the estimation of ancestry. Prior to analysis, a selection of Ossenberg's database (n=4,579) was appended to include centroid data (decimal degrees) for each individual from each World Region, each Major Region (by country), and each Country Region (by specific region). To explore how cranial non-metric traits vary around the world and to determine which traits are more useful for population estimations, Ossenberg's dataset was subjected to Principal Components Analysis (PCA) and Principal Coordinates Analysis (PCO) using the generalized inverse of each variable. These data were analyzed within a geospatial framework modified for biodistance analysis.

Experimental variograms explore the relationship between a biological distance measure and the physical (spatial) distance between individuals while providing empirical information regarding the magnitude, extent, and pattern of spatial correlation. The pattern of the variogram suggests the level of spatial autocorrelation. For example, an undulating variogram indicates a correlation between physical distance and biological distance. Following variogram analysis, this study used the calculated spatial correlation to interpolate values between individuals and the empty space between them to construct a smooth plot from contour data using a kriging method. Kriging is a regression method used to estimate unsampled values using a weighted average of known values from nearby individuals. Unlike ad hoc methods, kriging is weighted using the specific underlying pattern of spatial correlation and variation derived from the variogram analysis. The result is a map highlighting the relationship between the individuals or populations. Levels of global spatial autocorrelation were measured using Moran's I, which tests the probability that the amount of spatial clustering present is not due to random chance. Moran's I ranges from 1 to -1, where I >1 indicates a statistically significant positive autocorrelation and I <1 a negative autocorrelation. Additionally, a minimally variable z-score is computed following random permutation calculations (N_p=199 for this analysis). This score also indicates statistical significance for positive autocorrelation when z >1.96.

Following PCA, the factor loadings were examined to determine trait clustering. The first PC explained nearly 40% of the sample variation. The highest loadings for this PC all centered on the highly canalized structures of the basicranium, particularly in the basiocciptal region (e.g., the highest loadings for the first PC were transverse fissue of basiocciput, odonto-occipital articulation, precondylar tubercles). In direct contrast, the second PC, which accounted for an additional 12% of the variation, predominately loaded cranial non-metric traits of the mandible, demonstrating a shift in importance to the lower face. The results of this spatial analysis may explain this shift. These results indicate positive spatial autocorrelation for each of the first four PCs. The Moran's I for the four principal components were, respectively, I=0.07163 (z=~45), I=0.122443 (z=~81), I=0.294553 (z=~190), and I=0.06075 (z=~40). These values indicate that although the second PC explained less of the variation in the sample, it has more spatial dependence (clustering) than the first, while the third PC has the highest level of clustering of these four. Visualization of these clusters sheds light on their patterns of variation and how they shift across space.

This research supports the applicability of cranial non-metric traits in the estimation of ancestry, beyond merely supplemental notes collected during more "trusted" metric or macromorphoscopic analyses. Geographic spatial clustering of grouped cranial traits is evident and, therefore, these traits should be investigated when attempting to assess the ancestry of unknown human remains.

Forensic Sciences, Forensic Anthropology, Geostatistics