A101 Macromorphoscopic Trait Analysis in Forensic Anthropological Casework

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Learning Overview: After attending this presentation, attendees will be familiar with the implementation of macromorphoscopic trait data in casework associated with human identification. Attendees will learn about the development of a new analytical program for classification of ancestry and the research/analytical potential of data housed in the Macromorphoscopic Databank.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by addressing a significant gap in best practices in the forensic anthropological approaches to macromorphoscopic trait data analysis, particularly as those data relate to the estimation of ancestry and their application in forensic anthropological casework.

Macromorphoscopic traits are primarily binary and ordinal variables of the midface and vault, generally considered skeletal framings for soft tissue variations. Large and appropriate reference samples containing Macromorphoscopic (MMS) trait data collected from individuals with modern birth years are needed for the classification models used in the estimation of ancestry from MMS traits. The Macromorphoscopic Databank (MaMD; $N \sim 7{,}400$) serves that function, making publicly available trait scores for a large sample ($n = 2{,}363$) of modern American populations and worldwide groups of various geographic origins ($n = 1{,}790$). In addition, the MaMD also stores reference data for a large ($n = 3{,}244$) sample of pre-, proto-, and historic Amerindian data, useful for biodistance studies and finer levels of analysis during Native American Graves Protection and Repatriation Act (NAGPRA) -related investigations and repatriations. In developing the MaMD, the goal was always the development of an analytical tool useful to forensic anthropology practitioners for the classification of an unknown individual into a reference population.

This presentation is intended to address the current gap in best practice concerning the implementation of MMS trait data in forensic anthropological analysis, particularly how MMS data can be successfully incorporated into the estimation of ancestry in a manner approximating craniometric analysis using the computer program FORDISC® 3.1. To highlight the utility of this software, this study began with known individuals (age, sex, ancestry) representing Amerindian (*n*=81), Asian (*n*=74), American Black (*n*=82), Hispanic (*n*=82), Thai (*n*=82), and American White (*n*=83) samples drawn randomly from the MaMD. These data were used to build and tune a number of artificial Neural Networks (aNN) using softmax modelling (decay <0.001) and more than 2,000 iterations. Neural networks are a form of machine learning particularly well suited for MMS data. In fact, the final model correctly classified 68% of the sample using six MMS traits. Repeated simulations (*n*=20) indicate a stable classification model (CI=65.6 – 69.7; $\bar{x}$=66.8; sd=1.16). To measure any inherent bias in the model and to cross-validate the results, a second completely independent random sample was drawn from the MaMD (*n*=516) and classified according to ancestry using the original model. Overall, 60% of the sample was correctly classified, ranging from 75% correct for the Asian sample to a lower percent correct for Hispanic sample (35%).

Of course, forensic anthropologists very rarely deal with samples. Instead, they are interested in an individual classification and, perhaps more importantly, measures of classification strength. Hefner and Ousley proposed Optimized Summed Score Attributes (OSSA) as a heuristic classifier using MMS traits.[1] OSSA has been well received but is only suitable for two groups (American Blacks and Whites) and does not provide suitable measures of classification strength. The new classification software uses several machine learning methods to best classify human remains using morphoscopic traits *drawing from the reference data contained within the MaMD*. This software permits user-selected classification algorithms and provides output similar to the results provided by FD3, including posterior and typicality probabilities, sensitivity, specificity, and other measures of model and classification success.

Generally, every forensic anthropological analysis includes an estimation of ancestry. Craniometric analysis traditionally relied on FD3, which provides statistical results to qualify conclusions and validate results through typicality and posterior probabilities. With the introduction of this software and the exploration of additional machine learning methods, MMS trait analysis can enjoy that same level of scientific rigor and method validation.

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Reference(s):

1. Hefner J.T., Ousley S.D. Statistical Classification Methods for Estimating Ancestry Using Morphoscopic Traits. *J Forensic Sci.* 2014:59(4): 883-890.

Macromorphoscopic Trait Analysis, Machine Learning, Optimized Summed Score Attributes