6. Neural network analysis by using the Self-Organizing Maps (SOMs) applied to human fossil dental morphology: A new methodology

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Abstract

Recent studies focusing on dental morphology of extinct and extant human populations have shown, on a global scale, the considerable potential of dental traits as a tool to understand the phenetic relations existing between populations. The aim of this paper is to analyze the dental morphologic relationships between archaic *Homo* and anatomically modern *Homo sapiens* by means of a new methodology derived from artificial neural networks called Self Organizing Maps (SOMs). The graph obtained by SOMs to some extent recalls a classical Multidimensional Scaling (MDS) or a Principal Component Analysis (PCA) plot. The most important advantages of SOMs is that they can handle vectors with missing components without interpolating missing data. The analyzed database consisted of 1055 Lower-Middle and (Early) Late Pleistocene specimens, which were scored by using dental morphological traits of the Arizona State University Dental Anthropology System (ASUDAS). The principal result indicates a close relationship between the *Homo erectus s.l.* and Middle Pleistocene specimens and the

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later Neandertal groups. Furthermore, the dental models of anatomically modern *Homo sapiens* are particularly different compared to the more archaic populations. Thus, SOMs can be considered a valuable tool in the field of dental morphological studies since they enable the analysis of samples at an individual level without any need *i)* to interpolate missing data or *ii)* place individuals in predetermined groups.

Introduction

Studies focusing on dental morphology of anatomically modern human populations have shown, on a global scale, the considerable potential of dental traits as a tool to understand the phenetic relationships between populations (e.g., Coppa et al., 1997, 1999a; Scott and Turner, 1997). Based on these encouraging results some researchers, as a second step, have addressed the question regarding the emergence of anatomically modern humans using the same approach (e.g., Stringer et al., 1997; Irish 1997, 1998, 2000; Bailey and Turner, 1999; Bailey 2002a, 2002b, 2004; Irish and Guattelli-Steinberg, 2002; Bailey and Lynch, 2005).

An extension of this research has been to focus on the frequencies of specific dental traits and how they change over time in a specific area of interest. In this context, the study of Upper Palaeolithic Italian populations has led to the identification of a specific "Italian Upper Palaeolithic dental complex" that enables a clear discrimination between such Palaeolithic populations and more recent Italian groups (Coppa et al., 1999c, 2000a). The identification of this dental complex also makes it possible to distinguish between the different populations that inhabited the Italian peninsula over time. Furthermore, the "Italian Upper Palaeolithic dental complex" has been shown to be a common trait of all the other Upper Palaeolithic European populations in what can now be defined a "European Upper Palaeolithic dental complex" (Coppa et al., 2000b).

Similarly, the comparison of a large number of European, Asian and North-African Upper Pleistocene remains has shown that Neandertals have their own distinct pattern of trait frequencies or "Neandertal dental complex" (Bailey, 2002b; Coppa et al., 1999b, c, 2004). A more refined analysis suggested there is a clear subdivision of the "Neandertal dental complex" into three well-defined groups: "European pre-Würmian" and "European Würmian and Middle Eastern Würmian" subgroups that are distinct from the dental morphologies of anatomically modern *Homo sapiens* remains (AMHS) (Coppa et al., 2001).

While some researchers have pointed out that the Arizona State University Dental Anthropology System (ASUDAS) does not account for all fossil hominid dental morphology (Bailey, 2002a, b), others have applied it to Pliocene specimens (Irish and Guattelli-Steinberg, 2002). While relying only on ASUDAS traits may introduce some bias to this study, our main objective here is to explore a new method for assessing phenetic relationships among groups and not to make broad conclusions about the mode or pattern of human evolution. Because many, if not most, of the ASUDAS traits can be found in fossil hominins, we believe it is, at least a good starting point for investigating relationships among members of the genus *Homo*. For this reason we decided to extend our investigations to more ancient specimens including *Homo erectus s.l.*, non-Neandertal Middle Pleistocene *Homo*, Neandertals, anatomically modern *Homo sapiens* of the Middle Paleolithic from Israel and later Upper Paleolithic AMHS