Measuring Cultural Relatedness Using Multiple Seriation Ordering Algorithms

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Abstract Seriation is a long-standing archaeological method for relative dating that has proven effective in probing regional-scale patterns of inheritance, social networks, and cultural contact in their full spatiotemporal context. The orderings produced by seriation are produced by the continuity of class distributions and unimodality of class frequencies, properties that are related to social learning and transmission models studied by evolutionary archaeologists. Linking seriation to social learning and transmission enables one to consider ordering principles beyond the classic unimodal curve. Unimodality is a highly visible property that can be used to probe and measure the relationships between assemblages, and it was especially useful when seriation was accomplished with simple algorithms and manual effort. With modern algorithms and computing power, multiple ordering principles can be employed to better understand the spatiotemporal relations between assemblages. Ultimately, the expansion of seriation to additional ordering algorithms allows us an ability to more thoroughly explore underlying models of cultural contact, social networks, and modes of social learning. In this paper, we review our progress to date in extending seriation to multiple ordering algorithms, with examples from Eastern North America and Oceania.

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1 Introduction

Seriation is a set of methods which uses patterns in the occurrence or abundance of historical classes to construct an ordering among otherwise unordered assemblages or objects (Dunnell, 1970). Traditionally, the orders constructed by seriation were intended to be chronological, since seriation was intended for use as a relative dating method by its early 20th century developers (O'Brien and Lyman, 2000, 1998; Lyman and O'Brien, 2006; O'Brien and Lyman, 1999; Lyman et al., 1997). But traditional seriation techniques also create orderings which incorporate the effects of spatial variation in addition to temporal change, as James Ford often pointed out (Ford, 1938; Phillips et al., 1951; Ford, 1935), leading Ford and others to recommend minimizing the spatial area of a seriation in order to maximize the degree to which a seriation order represented chronology (Dunnell, 1970; Rouse, 1967).[1]

Despite the success of seriation in enabling the construction of regional chronologies throughout the New World (along with stratigraphy)(Beals et al., 1945; Bluhm, 1951; Evans, 1955; Ford, 1949; Kidder, 1917; Mayer-Oakes, 1955; Meggers and Evans, 1957; Phillips et al., 1951; Rouse, 1939; Smith, 1950), the method has largely been ignored since the advent of radiocarbon dating given its primary association as a relative dating method. But seriation is only a dating method in the sense that chronology is one possible inference from mapping the spatiotemporal pattern of change in cultural variants. Other inferences are possible, and in particular, there is a growing understanding that seriation is one of several methods for inferring historical and heritable continuity and thus documenting the evolutionary history of past populations.

Several researchers, starting with Fraser Neiman in his dissertation and later his seminal 1995 article, noted that the unimodal patterns that form the core of the traditional frequency seriation technique are produced by cultural transmission of cultural traits (Neiman, 1995; Lipo et al., 1997). In order to make this connection both rigorous and useful in empirical work, we began a research program aimed at exploring the connection between cultural transmission models and seriation methods, which has resulted in numerous publications, new seriation software algorithms, and many conference papers (Madsen and Lipo, 2014; Lipo and Eerkens, 2008; Lipo and Madsen, 2001; Lipo, 2001, 2005; Madsen and Lipo, 2015; Lipo et al., 1995; Hunt et al., 1995; Madsen et al., 2008; Lipo and Madsen, 1997; Lipo et al., 2015; O'Brien et al., 2015).

The core of the seriation method is a set of "ordering principles" which describe how the data points making up each assemblage or object are rearranged in order to achieve a valid seriation solution. Traditionally, there are two (Dunnell, 1970;

[1] In contrast to previous writers who believed that the effects of spatial variation could be eliminated from seriations by restricting the scope of a seriation to assemblages from the same "local area," Dunnell correctly appreciated that if seriation measures heritable continuity, we can never eliminate the spatial dimension in our seriations, we can simply minimize its effects (Dunnell, 1970) by minimizing spatial extent, or better, by comparing seriations created with multiple sets of historical classes (presumably with different spatiotemporal distributions) and extracting the ordering common to all.

Rouse, 1967; Whitlam, 1981). The “occurrence principle” states that a valid ordering leaves no temporal gaps in the distribution of the historical classes used, and thus that temporal orders are continuous. The “frequency principle” builds on the continuous occurrence principle, and states that in a valid ordering, the frequencies making up the continuous distribution of each historical type will be unimodal, possessing a single peak of “popularity.”

These principles date from the earliest work on seriation by Kidder (Kidder, 1917) and Kroeber (Kroeber, 1916), and are empirical generalizations rooted in common sense observation.

2 The Seriation Method

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3 Ordering Algorithms and Unimodality

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4 Alternatives to Unimodality for Seriation Orders

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4.1 Continuity in Class Frequencies

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4.2 Continuity in Character State Changes

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4.3 Computing Continuity Seriations

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5 Discussion

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6 Acknowledgements

Lorem Ipsum

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