PART VI: ARTIFACT ANALYSIS

15

Introductory Remarks on Artifact Analysis

CHRISTOPHER CARR

This section discusses quantitative approaches to artifact seriation (Braun, chapter 16; Jones, chapter 17) and artifact classification (Hoffman, chapter 18). Each chapter illustrates in detail some of the logical processes involved in defining a data set with a relevant subset structure and specifying its relevant relational structure in preparation for choosing an appropriate analytic technique, as discussed by Carr (chapter 2) and Read (chapter 3). Additionally, Braun introduces a new set of techniques for achieving seriation, and Hoffman introduces a stepwise analytic design for selecting variables to develop a classification scheme.

In regard to the logic involved in developing a seriation, Braun and Jones each use deductive and CEDA strategies to specify variables and observations that are relevant. Braun's orientation, however, is toward deductive argumentation, whereas Jones relies primarily on the CEDA approach.

DEDUCTIVE SPECIFICATION OF SERIATION CRITERIA

Braun argues that the one or several variables (ordering criteria) that are chosen to develop an artifact seriation should not only change their states monotonically over time (a standard minimal requirement of seriation variables), but also have three other characteristics. 1) They should be sensitive to a *single* biophysical or cultural process over time. This characteristic is necessary to avoid the blurring or distortion of the true chronological relationships between archaeological entities that can occur when multiple processes with different rates of change are tracked by the individual or multiple variables. It is also necessary for establishing the relevance of the constructed seriation model to new observations that remain to be ordered. 2) The variable(s) should be insensitive to the behavioral phenomenon that is ultimately of interest. This is necessary to avoid circular reasoning in documenting and studying the process of interest. 3) The variable(s) should vary on an interval or ratio scale. This requirement derives from the nature of the evolution of cultural-environmental systems and systems in general. Individual components or subsystems of a cultural-environmental system sometimes change in a punctuated fashion, from quasi-steady state to quasi-steady state, rather than slowly and uniformly over time (von Bertalanffy, 1968; Rappaport, 1979). Also, different components can change at different times, sequentially or dialectically, rather than simultaneously (Slobodkin & Rapoport, 1974; Braun & Plog, 1982; Leach, 1954). To monitor such diagnostic patterns of change *within* an evolutionary trajectory, rather than simply the initial and final states of the system, it is necessary that the time of events be determined on a scale as close to continuous as possible.

In line with these principles, and given Braun's general commitment to documenting and explaining patterns of social organizational change (Braun, 1977; Braun & Plog, 1982), he selects certain technological characteristics of ceramic cooking vessels (e.g., their wall thickness, tempering characteristics) to develop a seriation model for west central Illinois. These variables are sensitive to a single process (changing subsistence and cooking practices), are insensitive to the social phenomena of interest, and vary meaningfully on a ratio scale. Elsewhere, Braun (1982) outlines additional principles of ceramic technology that he uses to deduce tempering variables relevant to tracking the single subsistence process.

The observations that Braun uses to develop a seriation model for west central Illinois are selected primarily deductively, on the basis of several arguments. These pertain to the relevance of datable carbon samples and pottery samples to their proveniences of deposition, the relevance of the assayed ages of carbon samples to their dates of burning, and the cultural contexts of deposition. Some observations, however, are eliminated from analysis on the basis of criteria arrived at within a CEDA framework. These criteria pertain to the probable girth of the vessel from which a sherd was derived, the disuniformity of a sherd in its thickness, and the geographic area/subsistence system in which the observation occurs.

INDUCTIVE SPECIFICATION OF SERIATION CRITERIA

Jones, like Braun, is concerned with developing seriation models that use continuous variables and that track a single process through time. The approach she uses to select relevant variables and observations, however, is largely an inductive, CEDA approach rather than a deductive one. She starts with a range of lithic technological indices (variables) that are currently thought to vary *among* Levantine Mousterian assemblages over time for all chipped stone artifact classes or that are potentially of interest. She then determines whether such indices also vary significantly over space, depth, or artifact classes *within* assemblages. Significant variation of an index along any of these intrasite dimensions is used to infer that it varies with phenomena/processes other than some single process in time to which artifact manufacturing methods were sensitive, and that it defines multiple intrasite artifact populations. These other phenomena/processes include variation in artifact function, and whether the artifacts represent the endproducts (tools) or byproducts (debitage) of artifact manufacture. Both of these extraneous processes can be controlled for, in part, by calculating indices within artifact classes. For a given class, indices that still vary over space or depth within an assemblage are eliminated as candidates for developing a seriation model. In this way, Jones sorts through the particular processes (reflected in particular indices) and particular populations (artifact classes) to find those that are relevant for developing a time seriation.

In most cases, Jones is unable to state the specific nature of the processes and populations to which inappropriate or appropriate indices are sensitive. She does, however, identify variation in the length:width ratio for Levallois points—an index relevant for developing a time seriation—as being related to changes in core preparation techniques and reduction strategies over time.

NEW METHODS FOR SERIATION: TIME SERIES APPROACHES

Braun's chapter introduces the use of certain new techniques for constructing seriations. These fall within the field of time series analysis. Time series analysis is a diverse set of alternative methods used to describe, partition, and/or predict variation in a series of observations over time (Rich, 1973) or space (Holloway, 1958; Castleman, 1979). It includes the methods of autocorrelation analysis, spectral analysis, Fourier analysis, and a wide diversity of filtering procedures. Archaeologically, many of these methods have been or are being applied to the analysis of spatial series and distributions of soil resistivity, magnetometry, and soil chemistry observations within sites (Scollar, 1970; Carr, 1977, 1982a; Gladfelter & Tiedemann, chapter 14); intrasite artifact distributions (Carr, 1982b; 1983; 1984; in press, this volume, chapter 13); and regional artifact distributions (Hodder & Orton, 1976, pp. 174-183; Ebert, 1983). The methods have not, however, been used previously in archaeology to analyze observations in a time series for seriation purposes, although the parallel to geological stratigraphic applications (Davis, 1973, pp. 222-256) is clear.

Of the many methods that are encompassed by time series analysis, those that Braun has chosen for developing a seriation model include 1) a PROBNORM running filter (smoothing) function, which is used to segregate a trend from stochastic and local variation in the values of the seriation variable over time, and 2) inverse-prediction regression procedures, which are used to model the smoothed time series, with age as a function of the seriation variable.

These methods are concordant with several aspects of the relevant relational structure that probably characterize seriation data of the kind that meets Braun's requirements (above) and that involves absolute carbon dates. 1) The methods accommodate one variable or dimension as a function of time—that seriation variable which presumably monitors a single process. 2) They assume that the seriation variable has a ratio scale, which is in line with the aim of developing a continuous seriation model. 3) The filtering methods take into consideration error in the measurement of the time variable. 4) They also accommodate uneven spacing of observations along the time scale, as is characteristic of datable carbon samples from a region. 5) The use of an inverse prediction approach for defining a final regression with age as a function of the seriation variable acknowledges that archaeological samples for developing a seriation model are usually collected not as if age were the dependent variable and the seriation criterion were the predictor variable, but rather vice versa. The values of the predictor seriation variable are not selected in accord with an appropriate regression design, but rather by the availability of observations of the dependent time variable. This situation results from the limited number of independently datable samples from uncontrolled times that are offered by the archaeological record.

Finally, an additional advantage of Braun's time series approach must be mentioned. The regression methods that he uses allow one to calculate an estimate of the error of the predicted date of a new observation to which the seriation model is applied. This feature is not currently available in other seriation methods.

DEDUCTIVE SPECIFICATION OF CLASSIFICATION CRITERIA

Hoffman's chapter on artifact classification contributes to the areas of both analytic process and technical development. Considering analytic process first, his chapter, like Braun's, illustrates the use of primarily deductive argumentation to specify the relevant variables and observations to be used in an analysis. Hoffman's orientation toward this mode of defining a relevant subset structure is evident in three ways.

1) At a general level, Hoffman argues against the normative-empiricist stand that artifact classes are naturally inherent in a population of artifacts. Instead, following Dunnell (1971) and Vierra (1982), he stresses that artifact classes are arbitrary groupings, created by the typologist through his act of selecting a particular set of variables that are used as a basis for classification. Under these circumstances, for classification to be a purposeful endeavor, the typologist must select classification variables carefully and deductively. They must be selected in concordance with his research goals, the nature of organization and content of the phenomena of interest as expected theoretically or known, and the meaning and relevance of the variables in relation to those goals and phenomena.

2) At a more specific level, Hoffman suggests that morphological variation in chipped stone artifacts (particularly points) can reflect several sources of varia-

tion: (a) variation in their function, (b) the ethnic affiliation and norms of their manufacturers, (c) the individual motor habits of their manufacturers, and (d) their stage of maintenance/recycling. He stresses that to build a classification of chipped stone artifacts that directly reflects one of these phenomena of interest, it is necessary to determine the meaning of the different kinds of morphological variation that the artifacts encompass—in terms of function, ethnicity, motor habits, and maintenance—and to select variables for classification accordingly.

3) In practice, Hoffman differentiates various point forms using a variable (a dimension defined by blade edge angle and blade size) that he takes to indicate the stage of maintenance of a point on the basis of a deductive argument. To deduce the meaning of the variable, he uses a principle of lithic technology. This principle is concerned with (a) pressure flaking as a means for resharpening points when efficient utilization of lithic raw materials and minimization of risk of damaging the point are important and (b) the effects of pressure flaking on point form. Also, Hoffman concludes from his analysis the different meanings that morphological variation in the stems, as opposed to the blades, of points can have in relation to ethnicity and tool maintenance, respectively. He notes the importance of this difference in deductively selecting variables for building classifications that reflect ethnicity or tool maintenance.

NEW METHODS FOR ARTIFACT CLASSIFICATION

In regard to technical development, Hoffman's chapter makes two contributions.

1) It distinguishes the kinds of analytic tasks to which factor analysis and canonical correlation are suited, and then proposes the integration of both techniques in a CEDA stepwise analytic design for selecting appropriate variables for constructing artifact classification schemes. The proposed design involves (a) the initial exploratory use of factor analysis to determine the basic dimensions of variability in an artifact data set, (b) the assignment of probable behavioral meanings to those dimensions using the principles of lithic technology, (c) the testing and refinement of those meanings using canonical correlation to document the relationships among variables that pertain to different dimensions, and (d) the selection of classification variables that are relevant to the phenomena of interest on the basis of the several multivariate analyses. It should be made clear that although Hoffman proposes for the initial use of factor analysis as an inductive *pattern-searching* device, following Christenson and Read's (1977) use of it for this purpose, Hoffman's experimental analytic work, which leads to this recommendation, does not employ the method in this manner. Instead, Hoffman uses the technique primarily as a devise to *summarize* multiple morphological measures as single dimensions that are already known to exist in the input data set.

2) Hoffman enumerates the advantages and disadvantages of using polar or Cartesian coordinate measures of point morphology. Among the issues he discusses is the degree of concordance between the assumptions that the measures make about point form and the formal attributes that the researcher wishes to analyze. Many Cartesian coordinate measures of points assume that the points have a symmetrical outline and well defined junctures between blade, haft, and other elements. When this is not true, polar coordinate measures are to be preferred.

Hoffman's chapter also provides a good illustration of the argumentation that is appropriate when selecting and justifying the selection of one factor analytic method relative to another: principal components analysis, factor analysis with orthoganal rotation, or factor analysis with oblique rotation. His logic (a) allows for either inductive or deductive uses of these methods, (b) expresses concern over representing the structure of a data set in its own terms, and (c) recognizes alternative philosophies about whether fundamental processes can correlate. His analysis of a point morphology data set using all three factor approaches vividly illustrates how different factor approaches can vary in their appropriateness for analyzing a particular data set, given the data's relevant structure and the philosophical perspective of the researcher.

Finally, Hoffman's chapter makes two contributions at the levels of middle range theory and the substantive. It documents a significant negative relationship between the edge angle and size of point blades, but not hafts. This supports studies of a number of other researchers on the nature of point maintenance. Also, the chapter clearly documents the need for reassessment of traditional point typologies in the eastern United States, a conclusion foreshadowed in an earlier work by Binford (1965).

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For Concordance in Archaeological Analysis

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