Historical Methods: A Journal of Quantitative and Interdisciplinary History

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/vhim20

Sequences of Social Events: Concepts and Methods for the Analysis of Order in Social Processes

Andrew Abbott [a]

[a] Department of Sociology , Rutgers University

Published online: 06 Feb 2013.

To cite this article: Andrew Abbott (1983) Sequences of Social Events: Concepts and Methods for the Analysis of Order in Social Processes, Historical Methods: A Journal of Quantitative and Interdisciplinary History, 16:4, 129-147, DOI: 10.1080/01615440.1983.10594107

To link to this article: http://dx.doi.org/10.1080/01615440.1983.10594107

Historical Methods, Volume 16, Number 4, Fall 1983

Sequences of Social Events:

Concepts and Methods for the Analysis of Order in Social Processes

Andrew Abbott
Department of Sociology
Rutgers University

How can we generalize about sequences of social events? In the past, such sequences have generally been the territory of historians. Yet, historians are little given to generalization. It is the sociologists who generalize, and they have said little about sequences. This paper aims to bridge the gap. Of course, there is already work in this area. Comparativists are building out from their side of the river, taking on two or three or ten cases at once. Sociologists are moving out from the other shore, using Markov models to generate classes of social narratives. This paper throws a line across the remaining water by giving a temporary survey of the conceptual and methodological problems of generalizing about sequences of social events.

The fundamental properties of such sequences are familiar. They are stories with beginnings, middles, and ends. In these stories, the outcome of events depends not only on the immediate, but also on the distant past and on its sequential development. Order makes a difference. Historical narratives usually involve several such sequences or stories at once and find considerable volatility in their overall combination. Although underlying causes are at work in each of the separate sequences in such a narrative, it is the accidental interplay of various sequences at a given moment that moves the narrative forward.

These are the properties that must be preserved in any generalizing about sequences of social events—narrative order, sequential dependency, interlocked contingencies. As we shall see, the problem of order alone is sufficient to occupy the bulk of this paper. I shall deal with multiple sequences only briefly, at the end. The paper begins by discussing current theoretical models for sequences and outlining the general theoretical issues involved in a sequential approach to the social process. It then examines the place of sequences in current mathematical and statistical sociology and shows how one might directly formalize the sequential view itself.

Before starting, I must make some general comments about the form of the discussion. First, my argument must borrow widely. Not only history and sociology address the idea of order, but also literary theory, the philosophy of history, and the philosophy of science. Correlatively, the audiences of the analysis are many and diverse. Specialists in these various areas may find me superficial towards their own interests even as they find me unduly concerned with those of others. These seem to me to be the inevitable costs of such a survey. Second, throughout the discussion I have used history and sociology as convenient labels denoting two polar types of analysis—one particular, one general; one temporal, one atemporal. I am, of course, aware that the labels no longer correspond to anything like disciplinary realities, either intellectual or institutional. I am also aware that sociology is by no means all of social science, which would be the proper opposite in such an archetypical pairing. But to me, as a sociologist, they are convenient labels, and as long as the reader knows that they merely refer to ways of thinking without attributing those ways to anyone in particular, there will be no misunderstanding.

I. Current Sociological Concepts of Sequences

Historians assemble events by telling stories in which the order of events makes a difference. In their attempts to

generalize about sequences, sociologists generally conceptualize event order quite differently. To understand their conceptualization, one must analyze the theoretical vocabulary sociologists apply to sequences.

General theoretical models for sequences of events have usually been implicit rather than explicit. Among the most important theoretical models for sequences are those implied by certain commonly used explanatory strategies, in particular by functional and historicist explanations. Functional explanations make a social action contingent on the function it serves and allow for random or exogenous disturbance of that function. They imply equilibrating sequences of events; jolts away from equilibrium are followed by active approximation to it. In historicist explanations, the performance of a social action allows groups to consolidate the means to perpetuate it. The result is a sequence with social inertia, often a sequence of elite formation and consolidation. Michels's iron law of oligarchy is a celebrated example.[1]

Of the other models for sequences, the most general has been the evolutionary one. Common to both the Parsonian and Marxist traditions, this model has also appeared in such diverse areas as race relations, development, and religion, where it has created a host of "-ization" nouns—professionalization, modernization, secularization, rationalization, and so on. The evolutionary model is usually assumed to imply a continuous sequence of ever-similar events. Partial sums of these sequences are sometimes called stages, although given the similarity of events, finding discrete cut points is always a problem. Evolutionary models are often mere labelings; a series of discrete events is called a long-term trend without any attempt at explanation.[2]

In reaction to these continuous models for sequences, some theorists have suggested discontinuous ones. Thus, some argue that random events accumulate continuously until a threshold is reached, whereupon radical change ensues. This alternating sequence of change and continuity is central to Kuhn's and Lakatos's models of scientific change, as it is to the relative deprivation theory of revolutions. A closely similar model of sequences, one that smoothes the transitions between continuous evolution and sudden change, is sometimes applied to functional systems where successful service of function undermines its own conditions. Another discontinuous approach models sequences as unstable series of gestures and responses in which two actors become gradually opposed. Elegantly elaborated by Bateson as a model for Iatmul sex ethos, this oppositional model is also at the heart of the labeling theory of deviance and is the essential constituent of the Marxian dialectic.[3]

Nearly all these approaches focus on sequences of sufficient conditions. A few sociologists have treated sequences of necessary conditions. Thus, Smelser's analysis of collective behavior expects different levels of collective behavior insofar as certain necessary conditions are met.[4] These necessary causes are placed in an inclusively ordered hierarchy. Such models acquire analytical rigor at the expense of direct contact with the actual events. They are no longer models for the actual sequence of events or the process generating it, but rather models for the structure that allows it to occur.

These models all describe the general form of sequences, irrespective of content. They concern classes of sequences involving classes of events, and in general, do so implicitly, the sequence being implied by the posited underlying mechanism. (Thus, it is possible for two of these models, the historicist and the evolutionary, to entail sequences of the same short-run form.) Sociologists have written more directly about classifying narratives involving particular events. Much of this literature concerns classification of sequences in terms not only of their form but also of their content. Thus, implicit in Smelser's series of nested necessary causes is a classification of social movements, riots, and revolutions in terms of their "most extreme" event. Papers by Mayhew and others have characterized sequences of interaction in terms of their domination by certain actors. Girod, in discussing the difficulty of sequential analysis, has indicated the importance of sequences that return to their starting points.[5]

A number of literatures have approached this problem of classifying sequence form and content by simply seeking an ideal type. Usually referred to as a career or life cycle, this ideal type comprises a set of typical events in a typical order and is usually delineated by a mixture of deduction and induction. Literatures strongly influenced by this model include organizations, professions, family, occupation, and revolutions. The recent proliferation (or perceived proliferation) of alternative career patterns, especially among families and individuals, has led most of these literatures to serious self-criticism in the last decade, although life cycle approaches seem to be reviving in management studies.[6]

A number of authors have attempted to address the problem of ideal typing in more formal terms. Thus, Stinchcombe has recently called for a Weberian, ideal type approach utilizing comparisons between sequences. The important elements of a sequence of events are identified by "detailed analogies" between intermediate points and endpoints. The sequences themselves are classified in terms of the similarities between their endpoints rather than by similarities in the intervening processes themselves. In an alternative approach to ideal typing sequences, most of the considerable ethnomethodological writings on sequences have basically cast them in conversational terms, as question-answer or other common sense sequences into which various types of side sequences, prefatory sequences, locational sequences, and other insertion sequences are interpolated. At the micro level, sequences have been a common topic (e.g., for symbolic interactionists), although the focus has been more on content than on form.[7]

These scattered approaches of theoretical sociology to the conception and classification of sequences of events may be summarized as follows. At the formal level, talk theory has implicitly divided sequences into continuous and discontinuous. Continuous sequences have been theorized as equilibrium centered (functional), or inertial (historicist), or unidirectional (evolutionary). Discontinuous sequences have been theorized as unidirectional with occasional redirection (thresholds) or as divisive (oppositional). Some have contrasted convergent and divergent sequences, and a few have considered ways of classifying sequences with particular contents—actor dominance, return to origin. By far the most common approach to classifying sequences with actual content has been the attempt to establish ideal typical sequences—careers or life cycles.

These models for sequences have difficulty articulating some of the basic facets of sequences analyzed above. To be sure, they consider processes with beginnings, middles, and ends. But they do not consider parallel sequences that are separate in some ways but mutually influential in others. They do not emphasize volatility in sequence evolution, but rather regularity. Most importantly, they do not see a sequence as an evolving set of events whose further evolution reflects influences of varying temporal depth and order. Rather, they generally regard sequences as reducible to generating models—functional, historicist, dialectical. The course of events is surface separated, a priori, from the generating model. This is as true of the voluntaristic ethnomethodological models as it is of macroevolutionary models.[8]

II. A Theory of Sequences

Sociology's difficulty in retaining the contingent nature of sequence effects follows from simplifying assumptions made in an attempt to generalize about social causality. These assumptions—some theoretically grounded, others enforced by the necessities of formalization—renounce certain properties of the social process in order to achieve certain kinds of generalizations. Although these assumptions are most clearly seen in formal models, they are evident in the talk models so far discussed.

In these talk models, sequences are conceptualized as successions of particular events (i.e., of values of variables) that are generated by the modeled relations between variables. The variables are themselves conceived as the underlying "reality" of which the actual events are an example or iteration. The order of these conceptual steps is important. In the first step, the variables themselves generalize by categorizing the diverse properties of the cases analyzed. The model then makes the further general statement that one category of properties (one variable) relates to another category of properties (another variable) in some uniform way (perhaps one of the general models already discussed). Particular successions of events are then generated (or modeled) by a probabilistic version of the relations the model describes. The social process is thus conceptualized in two steps: first, by the categorization of cases in terms of their variable attributes; second, by the postulation of a general relationship between these category systems or variables. The crucial assumption here is that an event (i.e., a particular *value* of a variable) has a given meaning irrespective of its antecedents or context. (That is, a profession with 40 percent of its manpower included in the national association is in the same situation whether it used to have 10 percent of its manpower in the association or 100 percent.) As any working historian knows, this is a radical assumption.

Only by making a different set of assumptions, or rather by performing the same generalizations but in a different order, may one develop an adequate framework for generalization about social sequences. Rather than first generalize in terms of variables, one must first generalize in terms of stories. To develop such a framework, one must specify the notion of "generalization in terms of stories" and describe the properties and characteristics of social sequences that must be preserved in such a generalization.

Assumptions

Generalization in terms of stories rests on two assumptions: first, that stories have a unity and coherence analogous to that of variables, and second, that that unity forms a sufficient basis for generalization. The first of these assumptions has been extensively debated by philosophers of history. In his discussion of the problem, Hull argues that stories are unified and coherent because they describe events involving a single historical particular or "central subject."[9] The unity of the story is the unity of this central subject, be it an individual, an organization, a particular class of occupations, or anything else. Unlike the purely conceptual cohesion of sociological variables, this unity is concrete. Indeed, we express its particular continuity in social time and space by a proper name. Concepts denoting collections of central subjects in this sense are common in sociology—"professions," "bureaucracies," "workers," and so on. Causal inquiry in sociology generally proceeds by relating attributes of these concepts (i.e., variables) to one another. In some areas—such as those using the career or life cycle metaphors—not generic attributes, but generic stories concerning these concepts are collected and analyzed. In such areas, the unity and coherence of generic stories are accepted as given.

The story of a central subject is coherent within a particular time framework. In typical narrative history, the flow of time is roughly divided into three levels. There is a level that does not change throughout. Above this, there is the level of causal or historical analysis whose

shifts form the subject matter of the work. Above this still is a level of random fluctuations. The normal rhetoric is that each level places determining, necessary conditions on those above it, and that, given these conditions, sufficient causality may be traced within the middle level by studying the interlocking sequences. The temporal continuity of a central subject is thus defined at a particular level of time.[10]

One might object to this conception of sequences of social events as stories by arguing that stories do not uniquely locate events. Thus, A. C. Danto has stressed the coexistence of infinitely many possible narratives of "the same" elemental events and indeed of infinitely many possible descriptions of those events. One's choice of narrative or description depends on one's interests. Yet, this objection applies as well to the conception of the social process as a stream of observed values of variables. A given event can be subsumed under many different variables much as it can be located in many different stories. The objection thus conflates the problem of multiple meanings of social events with the contrast of narrative and non-narrative analysis.[11] Given the separation of these issues and given the accepted coherence of stories, there is no evident reason why stories should not be generalizable forms of social data. But if one wishes to generalize in terms of stories, one must carefully examine the basic constituents and characteristics of social sequences.

Sequence Properties

These fundamental properties and characteristics have been widely studied outside social science. The most extensive recent work on the subject comes from the structuralist literary critics.[12] For the structuralists, a story is a beginning, followed by an enchainment of events, which leads finally to an end. At beginning and end there is rest, although in discourse (in the actual telling) a narrator may choose to leave either one unexpressed. The means of this enchainment of events can be a wide variety of things. It can be sufficient or necessary causality, contingency, or sheer accident. Bremond and, to some extent, Barthes, believe that the primary story line always runs through a set of essential events or kernels. These kernels either present important alternatives or raise or answer essential questions about the flow of events. The structuralists further argue that the elements of a story are defined by their function in the story line as a whole. (That is, they do not possess an autonomous value, such as sociologists assign to variables, but rather a value relative to a particular story location.) Given this, they argue that one ought, in principle, to be able to develop a grammar of narrative. They have commonly separated narrative sequences into states and actions, and some have attempted to classify the means of passing from one state to another via action. Others have argued that while such a grammar of narrative is a useful tool, in fact, readers classify sequences not by breaking them into units, but by classifying them under cultural model plots, a process first postulated by Frye, and elaborated, with respect to historical narratives, by Hayden White.[13]

Enchainment. This structuralist analysis suggests a number of focal points for the analysis of sequences of social events. The idea of social processes with beginnings, middles, and ends is already common in sociology, both in the general formal models of sequences and in the literature using career models. There is less sociological work dealing with the varieties of enchainment. Sufficient cause is the most important and is implicit in the historicist, functional, oppositional, and threshold explanations and their associated sequences. A few have used necessary cause. Although common in history, pure chance as enchainment is not common in sociology. More common is the normative enchainment implicit in most career theories. At a more specific level, each of the general sequence forms can be seen as generating particular links in social sequences. The social sequence described by a developing profession like nursing may thus be broken down into functional, historicist, and other links. New health care organizations create new functions for nurses; the matrons' power in hospitals served, in historicist fashion, to develop further dominance over nonhospital nursing and so on. (A clear difficulty with this analysis is the obvious simultaneity of some of these links, which introduces the problem of multiple sequences.)

These varieties of enchainment are important. For a given social sequence may be "emplotted" in a variety of ways. The various plots imply different definitions of these very events, as the structuralists argue, and imply as well different questions about both the events themselves and the forces shaping them.[14] Indeed, one of the uses of classifying the means of enchainment in sequential analyses is to distinguish these questions. Sufficient links project forward in time, asking how events make other events happen. Necessary ones project backward, asking which events might have prevented the present state of things from happening. Separating the two makes a sequential analysis much clearer.[15]

Most sociological models for sequences employ only one type of enchainment. Nonetheless, there are a few that involve changes in enchainment. Thus, the concept of institutionalization delineates a sequence that starts with functional links and shifts to historicist ones over time.[16] Clearly, one of the properties differentiating types of social sequences is the variety and order of enchainment. In the concept of institutionalization, sociologists have a label for one particular sequence of enchainments. There are many others, which need equally convenient labels. For example, in the second half of the nineteenth century, the relation of medicine and nursing began with a dialectical, oppositional sequence that

eventually hardened into a subordination maintained over time by normative links. There is no conventional label for this very common sequence in the development of the so-called semiprofessions.

Order. The focal properties of sequence structure are order and convergence. The first is the more important, for if the order of a sequence has no effect on its future development, then there is no need to worry about sequences at all. The orderedness of social sequences may be specified in several ways. It may apply within parts of a class of sequences but not over the whole of their length. Occupational careers, for example, often have inchoate origins that may involve parental or acquaintance example, undergraduate work, summer or part-time employment, formal recruitment, and informal study in no particular order. Formal entrance to the occupation usually leads to a rigid sequence of training events. This period in turn is followed by a much less ordered late career, although in professions like law or academics, the duration of the rigid order in career sequences varies directly with position in intraprofessional status hierarchies. Some social sequences order events in large subgroups that are not themselves internally ordered. Evolutionary explanations of professional or of national development often imply this kind of ordering. Each successive stage differs from the last in several attributes, but the succession of stages is not thought to be altered by the order in which those attributes change. Another property of order is its strictness. Necessary cause sequences imply strict order—simultaneity is not allowed. In other sequence forms, it may be allowed, so that only reversal changes the outcome of events. Thus, in careers in the so-called helping professions, field experience either during or after formal education and certification has one kind of consequence for a career, while field experience prior to education and certification has quite another. In other sequences, it is simultaneity itself that has special causal consequences, as in the case of working and parenting.

Order has other aspects as well. Within a certain general class of sequences, it may matter only if particular kinds of events occur. Thus, in professions where knowledge increases rapidly, the ultimate structure of the profession may vary by whether this rapid change precedes or follows other events—national association, university affiliation, and so on. But perhaps no such sequence effects would be predicted if knowledge change is less than rapid, irrespective of where in the rest of its range it falls. (I shall return to this example in discussing panel designs for sequence effects.) Finally, order itself has a depth or history. The range of dependence may reach merely the immediate past, or it may reach the more distant future. That range itself may vary as the sequence progresses. For example, search and promotion committees, which determine the courses of academic careers, at one stage in those careers merely inspect the institution of a candidate's degree (the immediate past), but at another they construct the actual course of ten years of work as evidence of "strong potential," "flash in the pan," and so on.[17]

Convergence. Thus, the analysis of sequence structure requires not only the differentiation of types of sequence links, of enchainment, but also the types of order. A final property of a social sequence (or class of sequences) is its convergence. Convergence matters at two levels of sequence evolution. At the deeper level, convergence (or divergence) involves the central subject itself. Deriving the unity of a story from the unity of its central subject does not rule out stories in which new social actors (central subjects) are created or old ones abolished. The creation plot is a familiar one. There are many books on the rise of modern medicine or law out of an inchoate past. Abolitions and transformations of central subjects are less well known, although not less common.[18]

At a less profound level, convergence labels a sequence's approach to some steady state. This steady state may be conceptualized as a routine set of enchainments that imply a stable future, as in the notion of institutionalization. It may be an achieved ending point ("full professionalism," "adulthood").[19] However convergence is defined, its interest lies in the conditions that guarantee its appearance. Thus, there are a number of typical endpoints to sequences of professional development—dominant jurisdiction over a wide problem area, subordination under such a dominant profession, dominance within a narrow area, and so on. One might ask under what conditions sequences arrive at these particular endpoints. The most obvious possibility violates our implicit assumption that one profession's development is independent of another's. Dominance may simply reflect priority of intellectual and organizational development. But relative priority must be weighed against other possibilities. Perhaps the internal ordering of the sequences determines their type of convergence. Perhaps strong intellectual development preceding organizational development leads to limited jurisdiction, the reverse to subordinated jurisdiction, and simultaneity to broad jurisdictions. Perhaps the type of convergence reflects more complex orders of values of professional attributes or perhaps a simple inertial process without order determination at all.

Convergence, moreover, is not the only possibility. Sequences of social events may diverge or oscillate as well. Yet, the questions of interest are again the same. Is the divergence or oscillation invariant given different sequence orderings? And to what degree? Are there ranges of values of central subject attributes that dictate, either directly or by their sequential order, divergence as opposed to convergence? In the case of divergent oscillation, a particularly important condition is set by the timing of responses. They may be such as to

damp the fluctuation or amplify it. Such a timing mechanism may be observed determining interprofessional border relations. Routine, common professional issues that force law and medicine into confrontation have generally been institutionalized within the offices of coroner and public health official. Issues where the professions confront each other only rarely (e.g., malpractice prior to the current era) have generally led to massive, specific efforts at compromise. In between are issues common enough to create recurrent conficts between the two professions but too rare to command institutional solution. These generate oscillatory conflict. The legal status of the insane is perhaps the best example. In such cases, the timing or period of response determines the convergent or oscillatory behavior of the sequence.[20]

A full conceptualization of sequences of social events thus requires not only an analysis of the varieties of enchainment and of the nature of sequence order, but also of the conditions of sequence convergence or divergence. These three properties of enchainment, order, and convergence are the core that must be preserved under any attempt to generalize in terms of stories. We must now consider means for formalizing these sequence properties. This examination must begin by assessing the current status of sequence effects in formal sociological models.

III. Current Methods for Sequence Analysis

Current mathematical and statistical techniques in sociology study the passage of time using three general strategies—models originally developed for cross-sectional analysis, models developed for temporal analysis, and models explicitly aimed at discontinuous or contingent events. The first are the most common. Many scholars have applied the standard cross-sectional technique, the general linear model, to temporal variation. With qualitative variables, this leads to the log-linear model for a cross-classification of variables with time as one of these categorical variables. In general, such models do not order time but merely subdivide it. Since time periods can be resubscripted (reordered) without affecting the coefficients, sequence effects exist in the theory alone and cannot be directly tested. In fact, only certain special forms of constraints directly impose temporal order on contingency tables.[21]

The case of quantitative variables is much the same. As in the qualitative case, the ordering of variables comes from the theory alone. However temporal order may appear in the specification of effects, no temporal dependence can be inferred from the mathematics of the general linear model. Even in the special case of recursive equations, where effects are ordered in a causal or temporal sequence, the modeling of variable sequences is only as effective as the theoretical specification. The variables can be resubscripted randomly and the equations reworked to appear again like a recursive system, under a different temporal order. If the temporal order of variables is not theoretically unambiguous, the general linear model attributes the effects of all possible orders to the one specified, whether it is unique or not.

Yet, there are at least two major reasons to expect more than one possible (i.e., temporally nonabsurd) ordering of variables. The first involves what may be called the time horizons of the variables. Models for social processes frequently involve variables with quite different periods of fluctuation. A good example occurs in assessing the relative roles of personal mobility, professional organization, growth of knowledge, and social function in shaping the evolution of professions. Mobility can be specified over fairly short intervals, professional organization over medium ones; but knowledge shift and social function, although at any given time very important, achieve measurable change only over a much longer time period. Clearly, the presence of these variables together in a single model challenges the implicit assumption of orderability. A second reason to expect ambiguous orders has often been noted in applications where the causal model represents an aggregate of individual histories. The aggregation implies a unique ordering common to all cases, although this is obviously seldom the case. Sometimes effects go one way, sometimes another.[22]

In the more general (nonrecursive) quantitative case, the investigator seeks to test a model structure, temporal and causal, that predicts current values of endogenous variables from a set of predetermined variables—past values of endogenous variables and past and present values of exogenous variables. Non-zero correlations among current endogenous variables are expected, and typically two or three time periods are involved. Variables are implicitly presumed to have given (and roughly equal) time horizons, and their causal and temporal order are presumed to be both knowable in principle and fixed across cases. The effects generated by sequential dependence among *particular values* of variables (i.e., among "events") emerge in such single or structural equation models as a tangled mixture of legitimate and illegitimate effects.

An illustration may make this clear. Consider the various effects on professional evolution of rate of knowledge growth, degree of professional control, amount of geographic mobility of professionals, and degree of professional association. Assume these variables to be of roughly equivalent time horizons and to possess a fixed causal order. Suppose, further, that we have data on a large number of professions measuring these variables at three points in time on interval scales in which we have some confidence. Suppose, finally, that there are some true, theoretically expected effects of sequences in the development of individual professions. These are sequences of particular values of vari-

ables—that is, of events—that we expect to have specific outcomes. Consider the following four possibilities:

1) If rapid expansion in knowledge predates growth of local professional associations, a profession will begin and remain tightly controlled.
2) If rapid expansion of knowledge coincides with, or is followed by, rapid mobility, decreased professional control of all kinds will result.
3) Difficulties in professional control tend to persist.
4) Rapid knowledge expansion coinciding with tight professional control will not decrease professional control in the immediate future, although later mobility may undermine it.[23]

Hypotheses 1, 2, and 4 would normally be specified as product or interaction effects, each involving combinations of variables between time points. If we fill out this model of professional development with some standard hypotheses about variable stabilities and intrawave codetermination, these interwave products create major problems of identification through correlated errors. Furthermore, the entry of these product terms makes the interpretation of most direct effects very difficult. From other studies, we know that knowledge change, professional association, and professional control tend to covary both within and over time. This covariation implies multicollinearity that undermines our confidence in direct effects, creates correlated errors, and changes the coefficients of the interaction terms in ways too complicated to interpret. Of course, the econometric tradition has a variety of useful methods for handling the multicollinearity and underidentification that emerge when sequential effects are treated in the linear equation format. But the methods treat these problems as technical difficulties rather than as aspects of a fundamental generating process. Sequential effects may be handled in the general linear model, but the result is ungracious and atheoretical.[24]

In contrast to these attempts to apply the basically simultaneous general linear model to temporal analysis are attempts to build mathematical analyses of temporal change on sequences themselves. Here, the interdependency of variables and errors is not an analytic nuisance, but the central focus. The most general of these models are the autoregressive integrated moving averages (ARIMA) models of Box and Jenkins. More common in econometrics than in sociology, these models fit the sequential values of a single variable by allowing it to depend partly on past values of itself (autoregression) and partly on past random disturbances of itself (moving averages). (The historicist explanations of Section I are thus positively autoregressive processes, while functional explanations are negatively autocorrelated moving averages processes.) The idea of sequential contingency is central both theoretically and mathematically. But there is a price. The ARIMA model avoids the multicollinearity problem of the general linear model by generally restricting its attention to a single variable. Yet, the typical variable is affected by many others in the course of development, and one would like to view them as something more than the white noise of the moving averages process.[25]

In sociology, the most common model focused directly on sequential contingency is the Markov model, which can in fact be regarded as a special case of ARIMA, a "first order" autoregressive process. Markov models make the state of the studied system at time $t + 1$ dependent only upon its state at time t. They are defined by a matrix of conditional probabilities of transition from one system state to any other between time intervals. Temporal succession is thus built into the structure of the model. (This ordered succession of events is independent of the variables and classifications that partition the states of the system, although the Markovian character of the process may not remain after some reclassifications.) Despite their advantages, Markov models have serious disadvantages. First, the contingency allowed is only between adjacent time periods—the process has a history but only a first order history.[26] Second, Markov models are not really causal models, but merely bookkeeping devices. Various forms of elaboration—latent states, heterogeneous transition probabilities, time dependence—can be used to give them a quasi-causal nature, but they do not permit extensive inference.[27]

These difficulties with Markov chains are to some degree avoided by the recent elaboration of Markov methods known as "event-history analysis."[28] Here the causal issue is faced squarely by the introduction of exogenous variables into the likelihood equation for the transition probabilities. Yet, the model retains one-step dependence (although in continuous time). More importantly, the major constraints that themselves vary (and covary) contingently in time—for example, changes in structural forces—are built into the structure of the model, that is, into the likelihood equation. The contingencies of narrative are thus "regularized." They are trends built into the model structure, rather than sequences whose outcome depends on the exact succession of certain prior events.

This regularization is a generic, reductive feature of mathematical modeling that parallels properties of sociological theory noted above. In sociological modeling, a level of observable events is reduced, in the formal, logical sense, to a level of models. The observables are held to be deducible in principle from the relations of the model and its variables. In practical synchronic modeling, this means finding a model structure of reciprocal effects that reduces at least one and possibly several classes of observable events (the dependent and possibly the intervening variables) to specifiable functions of other variables. The model itself stratifies the observed data into a hierarchy of reduction, indicated

by the typical path model. In the diachronic case, the reduction is of endogenous to predetermined and, ultimately, exogenous variables.[29]

Yet, this reduction makes analysis of many historical sequences difficult. In considering sequence effects, I have, so far, implicitly limited them to the predetermined variables. If there should be a sequence of values of endogenous variables which for some theoretical reason might have powerful causal effects, there is no effective way of entering those effects into such a sociological model. Yet, this case is quite likely. Sequence effects do not necessarily induce the same stratification of variables as does a particular structural model, and indeed, it is apparent that in the methodology of history generally, sequence effects do not necessarily induce any reductive stratification of variables at all. Rather than worry about which variables are causally antecedent in general, history typically moves wherever the "causal action" seems to be in the case at hand. If structural determinants create a situation where a trivial event can have enormous consequences, the trivial level becomes the level of causal importance. Fay's analysis of the origins of World War I is an excellent example. An assassination variable would not do very well in predicting wars in general, yet following a certain sequence of structurally determined priors, it makes war a certainty.[30] Thus, even so elegant a formulation as event-history analysis is, in some ways, inimical to the formulation of sequence effects. The project of sociological modeling is to create reductive hierarchies of variables, to separate dependent from independent. Yet, sequence effects do not necessarily obey that or any other such hierarchy. It is, therefore, difficult for mathematical and statistical sociology to handle the property of sequential dependence.[31]

In summary, most mathematical study of time in sociology uses the general linear model, imposing arbitrary event order and interpreting sequential contingency as a problem. Although the less common ARIMA models do examine time dependency, they generally have a narrow focus. In Markov models and their elaboration in event-history analysis, the long sequence of events is an accidental surface phenomenon generated by a regular one-step logic. In keeping with their basic concept of the social process, mathematical and statistical sociologists have generally subordinated the study of event contingency and sequence to the study of regular relations between underlying variables. It seems necessary, then, to outline a formalization of sequence effects based directly on the theoretical properties outlined above.

IV. Formal Methods for Sequence Effects

Such a formalization of sequence effects must deal with two general classes of problems: first, the comparison and classification of existing sequences; second, the prediction of further sequence evolution. The first of these is the more important, since classification of the past is a necessary condition of specification of the future's dependence upon it. I shall, therefore, concentrate on classification here. Classification is not an easy task. In formal terms, a sequence is a mapping from the first n positive integers to some set of possible events (career events, life events, etc.). Since the number of possible sequences under such a definition rises with the factorial (for sequences of unrepeated events) or the power (for sequences of repeated events) of the number of possible events, the limits of manageability are reached early.

Despite its difficulties, this formal definition of sequences does conceptualize the social process in a way that differs sharply from the conception of that process in terms of variable attributes. In the simplest case, this model sees the social process as a sequence of unique, nonrepeatable events; either events do not recur or once having occurred they become enduring states. (A priori order cannot be used to distinguish events in this model. "Getting professional registration for the first time" and "getting registration for the second time" are *not* distinguishable.) This represents a radical simplification of the familiar conceptualization where a variable (registeredness) may vary over some defined range as time passes. At the same time, it allows a sequence concerning a particular central subject to involve at once what would be distinct variables (categories of properties) in the standard conceptualization (registration, university education, ethical procedures, etc.). Even a single sequence of unique events is "multivariate" in this limited sense. Most importantly, this model allows us to address directly the question of the order in which social actors, in this case the professions, typically acquire these several different characteristics.

By relaxing the assumption that events can occur only once, we change the situation radically. It is useful to show exactly how such a conception of the social process in terms of sequences of repeatable events differs from the conception implicit in standard multivariate techniques. We now have sequences with one event per time unit, that event chosen from anywhere in the set of possible events, the so-called state space. Returning to the example of developing professions, this formalization can ask what sorts of activities dominate a profession's life at a given time and in what order these dominant activities follow. But in this formalization, while education is dominating professional life, we lose sight of the state of ethics, association, and other attributes of professions. They can no longer be presumed to endure in a state once begun. We have gained verisimilitude by allowing repeated events but have lost the implicit multivariate quality. Only by introducing a vector-valued state space, in which the state of all these qualities is specified at each time point, may we ask questions about the succession of these dominant states that do not lose sight of these other characteristics.

Such a vector-valued state space is precisely the conceptual foundation of standard multivariate analysis. That analysis conceives of each profession as a point in such a space and, given repeated observations, as an ordered collection of such points, that is, as a sequence of points. Given this common formal foundation, the distinction between a sequential approach to that space and the standard one lies in the questions each asks and the implicit assumptions each makes. In general terms, the standard approach asks whether there is a single transformation, applying at all points in the space, that takes us from a profession's state at time one to its state at time two. As I noted in the preceding section, practical considerations usually dictate that this transformation be assumed to be time, as well as space, invariant. This question and assumption clearly translates into a general presumption that the causal implications of a variable attribute are independent of its particular context and antecedents, since those implications are determined by the transformation alone.

The space and time invariance of the transformation are profound and powerful assumptions. The issue of independence of present context (i.e., of spatial location), although an important one, is not technically central to the difference between sequential and standard conceptions. It is essentially the issue of interaction in its most general form. The implicit question underlying it is whether the transformations from one point to the next may not be location dependent. Professions in one part of the space evolve one way and professions in another in some different way. Methodologically, such questions may be addressed by a variety of measures, such as partitioning the space before applying standard techniques, entering interaction terms, and so on.

The focal difference between sequential and standard approaches to the vector-valued state space lies rather in the assumption of time invariance. In the simplest case, a sequential approach asks whether the transformation from one point to the next is not dependent upon prior transformations. Does professional pride go before a fall? Does a profession that has lost a position and then regained it (American medicine, for example) develop differently from one that has achieved and never lost? In the most general case, this approach asks whether there are not some "standard routes" through the vector space of attributes, connected sequences of transformations that represent alternative careers for professions. (These need not be full careers; they might be shorter standard patterns.) Such standard routes would be a regularity undiscoverable by an analysis assuming that the current meaning of a variable is independent of present or past context.

In summary, while the sequential approach here advocated and the standard approach taken by multivariate methods address the same underlying formalization of the social world, they do so with different questions and assumptions. Current methods recognize and capitalize on the power of assuming locational and temporal invariance. I have suggested here the theoretical importance of transcending that assumption.

I shall now discuss methods aimed directly at the sequence problem. These methods seem rather simple compared to standard multivariate techniques. There is good reason for this. Multivariate techniques advanced to their present state by pushing the invariance assumptions to the limit. They have begun to address sequence effects by relaxing those assumptions very slightly, admitting short-term sequence effects in a variety of ways that are all, as I noted before, somewhat ungracious and atheoretical. If one conceives of the social process as made up of a set of mutually contingent sequences, it seems silly to model that process by developing elaborate methods based on the assumption that such sequences don't exist and then relaxing that assumption slightly. The sensible, if difficult, approach is to forego the powers of the invariance assumptions and try to build up from the notion of sequence itself. This makes the sequence methods appear unreasonably self-denying. But this simplicity is an inevitable cost of further advance.[32]

Sequences of Unique Events

These sequences can be examined with methods that reflect the complexity of the case. The simplest is the "career" case, in which the state space consists of a finite set of nonrepeatable events. Sequences of fixed length made up of such unique events are usually abstract sequences, since the real social process involves much repetition.[33] An example is a profession's acquisition of national association, state licensure, monopoly of service, university degree, ethics code, and so on. In analyzing such sequences, we may seek answers to a variety of questions. Are the sequences generally alike? Do they closely follow an ideal pattern? Are there two or more standard patterns?

On the formal assumptions of fixed length and distinguishable events, we know that the observed sequences must be members of the set of all permutations of the events. A broad variety of relevant permutation statistics are available.[34] These may be used to address the general concordance problem or to develop distributions of sequence dispersion around some arbitrarily chosen prototype, distributions that may uncover a number of different standard sequence types in the data. By appropriate formulation and weighting of these statistics, particular subsections of a sequence may be emphasized and the relative importance of differences of varying size changed to suit the questions analyzed.

If one wishes to generalize the problem to orders of unique events in continuous time, thereby allowing interval measure of event proximity, there is an extensive literature on relevant scaling techniques. This is the so-

called seriation problem, which has long concerned mathematical archaeologists.[35] Seriation techniques have the important advantage that they can survive missing data and ties. Typical permutational methods are completely overthrown by missing data, while seriation methods still produce useful results. Like all multidimensional scaling techniques, they have the disadvantage of being largely exploratory, but, in effect, so are most standard multivariate methods; they are used in an exploratory manner, even if they are not so presented in print.

An alternative approach to unique event sequences might take advantage of another aspect of permutation theory. Assuming an arbitrary initial order, each sequence can be re-expressed as a product of disjoint cycles permuting that order. Although there are, in principle, many of these cycles, there cannot be, in any given dataset, more than nN distinct cycles, where n is the sequence length and N is the number of cases. The observed distribution of cycles provides a great deal of information about the sequences in the dataset. If there are cutpoints that separate completely independent subsequences, whole classes of cycles will disappear. If a certain subsequence always occurs in the same order, whether early or late in the sequence, the distribution of observed cycles will show that as well.[36]

Another possible technique, in sequences up to length four, is direct enumeration. Thus, Hogan, investigating a set of three events (completion of education, marriage, first job) in partly censored sequence data, reduced his problem to tractability by making all observed sequences of length one or zero "non-classifiable," by assuming that observed sequences of length two were completed by the third event, and by assigning the six possible sequences of the three events to three classes—a normative order (school, job, marriage) and two nonnormative orders differentiated by a particular inversion of two events (marriage and schooling). In general, partitioning a set of sequences by such a nested hierarchy of particular ordered pairs is an efficient, if strongly aprioristic, technique.[37]

These various techniques share a set of advantages and disadvantages dictated by the restrictive case they analyze. They cannot deal with repeated events or with "careers" of different lengths. They are effective with datasets of completed, abstractly defined sequences where events can be assumed to endure once they are first achieved. Relaxing the length restriction, but continuing to require unique events, leads to what may be called the open career case. Events still endure once they have occurred, but provision is made for "varying stages of development." The question of sequence similarity and dispersion here acquires a new complexity. One may ask whether all sequences of a given length have evolved the same way, either in terms of order or in terms of the events they contain. One may ask if all sequences start out the same way and then branch off, or if there are several different versions of starting out—as indeed there are professions built on bureaucratic foundations (social work, teaching), on free market foundations (medicine, law), and on hybrid foundations (accounting, engineering). Each one may have its own succession pattern. In this case, the set of potential careers of length n will involve more than n types of events. One may still apply multilinear permutation statistics by assuming that each n-step sequence "rates" the total number of events in $n + 1$ categories—1st, 2nd, . . . n^{th}, unoccurred. The same variety of weighting and formulation arrangements may then be applied to the same kinds of questions asked in the earlier case. (However, each of these analyses must be length specific.) The cyclical decomposition method is not applicable, since it demands a complete ordering in each sequence. Thus, analysis of the open career case reduces to successive applications of closed career analytic procedures, using successively restricted datasets—the first p events of sequences of length p or more. There is one exception. Because of their effectiveness with missing data, seriation techniques are particularly useful for open career data.

Sequences of Repeating Events

In the second general type of sequence analysis, the restriction on repeated events is relaxed. This radically reshapes the problem. First, enumeration becomes prohibitive with even a short sequence and a minimal state space. Second, the "multivariate" quality of sequences of unique, nonrecurring events is lost, since events do not necessarily continue once begun; a profession can go from registered and fee for service, to unregistered and salaried, to registered and salaried.[38] Third, one must set explicit probabilities on the relative likelihoods of the various events. In the case of nonrepeating events, one may implicitly merge the classification of possible sequences and the examination of an empirical dataset because there is a particularly simple null hypothesis; any as yet unobserved event has a probability of occurrence equal to one over the number of as yet unobserved events. When one considers repeating events, however, such a null hypothesis applies only when one knows nothing about the relative likelihoods of events. A number of sample measures of relative likelihood are possible.[39] But given a measure of relative likelihood, one has then to measure the dispersion of observed orders around expected ones. Enumeration is impractical and permutational methods inapplicable. Even the estimation of distributions for general parameters like the number of matches between two sequences or the number of events preceded and followed by similar events requires a significant combinatorial effort. (These estimates, of course, assume fixed likelihoods of possible events.) The problem is worsened by our intuitive knowledge that order is not really nested within relative likelihood as this combinatoric approach

requires. Yet, even under such an assumption, we could not measure resemblance except within sequences of uniform multinomial distribution. As a result, it is generally both easier and more parsimonious to study sequences of repeating events by projecting a generating set of relationships through time. This implicitly merges the tasks of sequence classification and prediction.[40]

Sequences of repeating events are thus usually formalized as stochastic processes. The analyst establishes a state space of events, estimates probabilities for transition between its elements, specifies the degree of dependence of future transitions on past history, and then generates expected sequence characteristics. These expected characteristics may then be compared with observed characteristics to measure goodness-of-fit. The central decision is the choice of dependence. If the future is independent of the past, there results the multinomial runs problem by itself. If the future depends on the immediate past, one has a Markov process, and if it depends on the last n states of the past, there results a multiple or n^{th} order Markov process. When the observed sequences are of fixed length, the Markov model is a regular chain (one with no dead-end or absorbing states), when of variable length, an absorbing chain (with one or more terminal states). Once a Markovian matrix of interstate transitions is estimated from data, a number of interesting sequence characteristics can be projected and compared with observed characteristics. In the absorbing chain, one may project mean recurrence of a particular event, probability of a given termination type, mean and variance of sequence length, and so on. In the regular case (where length is fixed), one may project time until a certain event occurs, mean and variance of number of recurrences of various events, and if the length is long enough, the limiting distribution of events. (Unlike all the other measures, this last is independent of how the sequence started.) The ramifications of Markov modeling are well documented, and I have already discussed them briefly. Here we are concerned with the strengths and weaknesses of the Markov model as a formalization of a sequence conceptualization of the social process.[41]

It is useful to assess these losses and gains with an example other than that of the development of a profession, which fits all too well the career model with its assumption of nonrepeating events. Consider instead the historical sequence described by a given social problem area as it passes from the jurisdiction of one profession to that of another. Marital problems, for example, have been at various times under the control of clergy, psychiatrists, social workers, marital therapists, and others. Suppose for the moment that we have a solid measure of jurisdiction that assigns a problem area to a given profession or type of profession in a given period. We may then think about sequences of professions with jurisdiction over a particular area. A number of questions about such sequences are of interest. Do neglected problem areas under dominant professions serve as poaching grounds for new professions, or do new professions enter the professional world by defining new problems? Are some jurisdictions (e.g., animal sickness) never exchanged? Do jurisdictions tend to flow from dominant professions to their subordinate professions? Are jurisdictions ever taken over from minor professions (like actuaries) by big ones (like accounting)? If we assume an unambiguous classification of professions into dominant, subordinate, minor independent, and new, and if we ignore the problem of motion within this classification itself, we have a set of sequences of transitions of problem areas between jurisdiction by various types of professions. These may be seen in Markovian terms. Although the model as stated is a regular chain model, given a measure of final jurisdiction, it could become an absorbing chain model.

The immediate gains of the Markov approach are considerable. Tractability is the most obvious. The welter of possible jurisdictional sequences is reduced to a transition matrix with sixteen (for the possible types of motion between the four states) elements. Under suitable assumptions, extensive differentiation can be induced in the state space, as the discussion of event-history analysis and other such methods attests. We might, for example, give the professions other attributes—sex of practitioners, education, percentage of solo practice, and so on. This allows rapprochement with the prevailing multivariate orthodoxy.

The losses, though more subtle, are no less substantial. The first is the ability to estimate depth of dependence. If one wishes to consider dependence of greater than one step, one must multiply the size of the state space by itself for every added step of dependence. In a sequence dataset with considerable regularity, however, many or most of the possible sequences in this state space will never be observed, and there will be consequent estimation problems. Some control may be induced by separating the state space into a small category of endogenous states and a large category of exogenous characteristics that affect transition rates among the endogenous states. But as we have seen, this prevents effects from endogenous to exogenous and ignores sequence effects among the exogenous variables as well. The net result may be seen in the example. The notion that long-neglected jurisdictions are particularly poachable involves dependence over several time periods. Although it is relatively easy to specify a direct time dependence model for this particular hypothesis, this requires simplifying the Markov model in ways that restrict its ability to consider other alternatives at the same time.[42]

The second general loss in a Markov formalization of sequences is of the intuitive or conceptual grounding of the idea of sequence resemblance. In the unique events case, seriation methods and multilinear permutation statistics produce measures of sequence resemblance

that relate fairly directly to our notion of what a sequence "looks like." The Markov measures of goodness-of-fit, such as mean percentage of time spent in a subordinate jurisdiction and time to first occurrence of such a jurisdiction, are specific to a particular starting state and cannot give the same sense of a "typical history" of jurisdictions that a seriation method gives us for the "typical development" of professions.

In general, the strength of the Markov formalization lies in its heuristic value. Most interesting sequence effects produce characteristic patterns of one-step transitions, and the best use of Markov modeling is to provide an exploratory analysis that can then be followed by stronger formulation. Thus, necessary sequences produce sequences of off-diagonal ones that can be arranged into a single superdiagonal sequence. Off-diagonal zeroes are evidence of more loosely linked necessary sequences. Inertial sequences will be evidenced by large diagonal elements. Isolated subsequences will produce block diagonal patterns. But in all these cases, sequence effects suggested by Markov investigation may be more strongly formulated and tested by other methods. In the necessary sequence case, there are the methods appropriate to careers; in the inertial case, where departure from state declines with time, one may directly specify that decline.[43] The most effective use of the Markov formulation is thus in indicating the proper direction for further analysis.

Like most methodological approaches, the formalizations here suggested permit the most elaboration when their assumptions are most stringent. At present, effective methods are available only for the unique events case. The repeating events case can be handled only with the conceptually unsatisfactory Markov model. Current usage of that model has largely ignored its heuristic qualities, using it instead to introduce some flavor of sequential dependency into analyses still focused on the complexity of the state space itself. We will not advance further in formalization of repeating event sequences until analysts are willing to forego the attractions of the well-elaborated methods formalizing that space and to concentrate on sequence itself.

V. Problems of Aggregation and Multiple Sequences

Given a theoretical conception of sequences and a variety of methods for formalizing and investigating them, one must finally consider two general problems in sequence analysis. First, one must ask what assumptions are made by the data aggregation presumed in the previous section. The argument that linear models err in aggregating across sequence types requires that we consider the analogous issue in the present discussion. Second, one must address the issue of multiple sequences raised at the outset. An effective approach to sequential contingency must allow for the accidental interplay of separate sequences.

The methods suggested for formalization all assume that sequence data can be aggregated without loss of information. There are two major cases in which this assumption fails. The first is the case of period effects. Consider again the case of professional development. Various professions began their developments at widely varying times. Supposing that they follow a characteristic sequence, one expects that at any given time they might be at varying stages along that sequence. Yet, general causes might introduce uniform development across all professions at once. An excellent example of this is ethics codes, which existed in relatively few American professions before 1910 but became universal following the Rotary-sponsored ethics enthusiasm of the early twenties. Such period effects insert a step "out of sequence" into most individual cases of professional development in America. Since such reforms are not unusual, effective sequence analysis requires methods for disentangling them from normal sequence evolution.[44]

The second important case in which aggregation of sequences implies loss of essential information is that of nonindependent sequences. An example of this was given earlier in the discussion of the conditions for convergence to various types of professional end states. The professions that become dominant over wide jurisdictions are those that *first* developed strong intellectual systems and organizations. In this sense, the evolution of the later professions, like nursing, is in no way independent of the evolution of earlier ones, like medicine. This possible lack of independence must be considered in any sequence dataset and must be directly handled if it exists, since most formal sequence analysis techniques assume casewise independence. In datasets like the professions, this issue is a major one. There are a relatively small number of professions and a finite set of social and human problems for them to control. The sequential evolution of communities in a given geographic area or of nations in the world are similar cases, as the dependency literature shows. In areas like child development or small group evolution, these problems of interdependence should be less important.

Throughout the discussion of formal sequence methods, I have placed no constraints on the relative temporal size or importance of an event. In general, stories tend to focus on a given level of temporal fluctuation, and it may be difficult to place events in an order if they differ too widely in size. (Is the rise of scientific medicine before or after the Flexner Report?) The issue of varying sizes of events may become important in aggregation, especially following the careers model, if some sequences in a dataset have been powerfully affected by relatively unique, "small" events while others have not. In some cases (sequences of collective behavior, for example), nearly all sequences have a triggering event of small size but large importance, and a

generic class of events may be created to cover it. But in sequences of political development, for example, some countries have revolutions that reshape their underlying political structure, while others do not have such an event. This creates strong problems for the kind of aggregation assumed here. Yet, it is important to preserve the ability of sequential analysis to move between temporal levels, for that flexibility to follow the causal action is a major advantage of the approach over standard sociological methods for temporal analysis.[45]

Having discussed these problems of aggregation, I must now turn briefly to the issue of multiple sequences. The discussion is necessary because multiple sequences are an important property of historical narratives; it is brief because models involving multiple historical sequences can be made sociological or general only with great difficulty. At best, I can suggest the issues to be confronted in that transformation.

As in the discussion of single sequences above, each of the separate sequences in a multiple sequence narrative is unified by its central subject. Yet, they may involve in common many of the same events. (Registration of nurses is as important for the evolution of the medical profession as it is for that of nursing.) The central questions involved are of the following form: given the constellation of states in each of these interrelated sequences at a given time, what are the possible outcomes in each at the next time, and what are their necessary and sufficient conditions? Such questions imply constraints on the independent evolution of the various sequences, and, of course, specifying the form of those constraints is the crucial task. (If the constraints are strong, then the situation is conceptually equivalent to a single sequence in a vector-valued space, discussed briefly above.) Although such sequences are methodologically intractable at present, it is important to understand the questions they can address. Such sequence systems would be characterized not by a complete description of all their variable attributes, but rather by the space of possible further evolutions they permit, as systems, at any given time. The majority of variable attribute data would be ignored as causally irrelevant under the *ceteris paribus* assumptions discussed above (note 38). The goal would be to predict general classes of historical evolution in different types of multiple sequence "bundles" rather than to develop an underlying model making certain variable properties of all such systems deducible from others.

There has been some work on modeling interlocks between multiple sequences.[46] This work has emerged out of the failure of Markovian approaches to effectively model individual occupational mobility. It was recognized early that the Markov model of individual movement, which is a model of sufficient conditions, does not take account of its necessary obverse, the existence of positions to which individuals might move. In his vacancy chain model, H. C. White successfully captured this contingent interplay of sufficient and necessary causes of mobility by recognizing that in job systems where individuals occupied particular positions, vacancies rather than individuals would have the initiative. Only given the opening of a position could the qualifications of an individual then be tested as sufficient predictors of mobility. The interactions of the dual sequences of mobility of men and of jobs were thus elegantly modeled by the simpler dynamics of vacancies.[47]

In general, the multiple sequence problem is too difficult for our present methods. At the same time, it must be recognized as an important step in the transition from historical to sociological methods implicit here. In formal terms, narrative historians discuss nonindependent multiple sequence systems involving particular central subjects. Discovering general classes of these systems is the complex generalizing problem I have just considered. In the interests of practical generalization, it is easier to consider single sequences with narrative dependency, which have been my main concern in this paper. The final step, synchronic modeling ignoring order, is the familiar ground of contemporary sociological methods.

My aim in this paper has been to outline an approach to generalizing about the social process that is based not on a hypothesized continuity of attributes, but rather on a visible continuity of central or causally important events. In belaboring standard methods, I have not meant to belittle them or their achievements. Those achievements are considerable. Rather, I want to point out the dangers of allowing these methods to begin to shape the way we see and conceptualize the social world or social process. The rapid evolution of social science methods has left most theorists, in sociology at least, unable to understand how this shaping occurs. They sense it but cannot label it. In the resultant two cultures, quantitative workers see a world of attributes and their interrelations, while theorists see a world of grand but particular concepts and events. It is a division that recapitulates the conventional distinction between history and sociology with which I began. In attempting to cross this gap, I have tried to show the difficulty with which sequential effects are comprehended in both theoretical and statistical sociology. In the rapid expansion of social history and historical sociology, this difficulty has been overlooked too often. I hope here to have called attention to that oversight and to have indicated some ways of taking order seriously.

ACKNOWLEDGEMENTS

Earlier versions of this paper have been presented to audiences at SUNY-Stony Brook, Princeton, Rutgers, and the Social Science History Association. Many readers have offered helpful comments, among them Harry Bredemeier, Randy Smith, Nancy Tomes, Doug Nelson, Sue Gal, Michael Kimmel, Bill Smith, Stan DeViney, and Allan Horwitz. Useful

ideas of various sorts have come from discussions with Phipps Arabie, Ron Angel, Paul Cleary, Pat Cox, Pat Tobin, and others.

NOTES

1. On functional and historicist explanations, see A. L. Stinchcombe, *Constructing Social Theories* (New York, 1968). In discussing theoretical sociology, I am referring to sociological theorizing outside of the statistical and mathematical realms. This includes not only the grand theory (or metatheory) generally denoted by the phrase "contemporary sociological theory," but also substantive theorizing within subfields such as organizations and deviance. Even during its most functional phase, such "talk theory" in sociology did not ignore sequential contingency. Functionalists recognized its importance in their focus on action and intention, on anticipated and unanticipated consequences (see, e.g., P. Selznick, *TVA and the Grassroots* [Berkeley, 1949]). More recently, Marxist approaches have helped reorient sociology towards temporal and historical development, but they have generally used the same basic sociological vocabulary for sequences as did the functionalists. An elegant mathematical model attributing Michels's iron law to chance alone is B. H. Mayhew and R. L. Levinger, "On the Frequency of Oligarchy in Human Interaction," *American Journal of Sociology* 81 (1976): 1017–49. That paper utilizes a formal model of interaction sequences first elaborated in B. H. Mayhew, L. N. Gray, and M. L. Mayhew, "Behavior of Interactional Systems," *General Systems* 16 (1971): 13–29.

2. The following citations are, of course, merely exemplary. On professionalization, see H. M. Vollmer and D. L. Mills, *Professionalization* (Englewood Cliffs, New Jersey, 1966). On the race relations cycle, see R. E. Park, *Race and Culture* (Glencoe, Illinois, 1950). On modernization, see C. E. Black, *The Dynamics of Modernization* (New York, 1966). On secularization, see P. L. Berger, *The Sacred Canopy* (Garden City, New York, 1967). For examples of stage theories with problem cutpoints, see W. W. Rostow, *The Stages of Economic Growth* (Cambridge, England, 1960) and T. Parsons, *The Evolution of Societies* (Englewood Cliffs, New Jersey, 1977).

3. T. S. Kuhn, *The Structure of Scientific Revolutions* (Chicago, 1970), I. Lakatos, *The Methodology of Scientific Research Programmes* (New York, 1977), and G. Bateson, *Naven* (Stanford, 1958). For an exemplary version of the labeling theory of deviance, see T. Scheff, *Being Mentally Ill* (Chicago, 1966). An example of a self-undermining sequence is the argument that American college education serves to give individuals competitive advantage in the labor force. Yet, when that functional loop has brought college education to most of the labor force, it no longer provides the differentiation that confers competitive advantage. The resulting "inflation of credentials" can be seen as a stepwise sequence generated by this self-undermining system.

4. N. J. Smelser, *Theory of Collective Behavior* (New York, 1967). For another example of a necessary cause analysis of sequences, see Z. Ben-Sira, "Toward a Facet Theory of Sequential Order of Societal Needs," *Quality and Quantity* 3 (1979): 233–53.

5. Smelser, "Theory," Mayhew, Gray, and Mayhew, op. cit., n2., Mayhew and Levinger, op. cit., n2., R. Girod, "Typologie Séquentielle de la Mobilité et Analyse Causale," *Sociologie et Sociétés* 8 (1976): 2:115–18.

6. On organizations, see J. R. Kimberly, R. H. Miles, et al., *The Organizational Life Cycle* (San Francisco, 1981). On professions, see T. Caplow, *The Sociology of Work* (Minneapolis, 1954) and W. Moore, *The Professions* (New York, 1970). On family life cycles, see E. M. Duvall, *Family Development* (New York, 1957), P. C. Glick, "Updating the Life Cycle of the Family," *Journal of Marriage and the Family* 39 (1976): 5–13, and G. B. Spanier, W. Sauer, and R. Larzelere, "An Empirical Evaluation of the Family Life Cycle," *Journal of Marriage and the Family* 41 (1979): 27–38. On individual development, see J. Loevinger, *Ego Development* (San Francisco, 1976), D. J. Levinson, *The Seasons of a Man's Life* (New York, 1978), and B. L. Neugarten, "Time, Age and the Life Cycle," *American Journal of Psychiatry* 136 (1979): 887–94. On occupational careers and life cycles, see B. G. Glaser, *Organizational Careers* (Chicago, 1968), and S. S. Angrist and E. M. Almquist, *Careers and Contingencies* (New York, 1975). Critical papers are the Glick paper just cited and L. Hirschorn, "Social Policy and the Life Cycle," *Social Service Review* 51 (1977): 434–50.

7. A. L. Stinchcombe, *Theoretical Methods in Social History* (New York, 1978). The classic ethnomethodological paper on sequences is H. Sacks, E. A. Schegloff, and G. Jefferson, "A Simplest Systematics for the Organization of Turn-taking in Conversation," *Language* 50 (1974): 696–735. Also important are various papers in D. Sudnow, ed., *Studies in Social Interaction* (New York, 1972). Emerging statistical methods of sequence analysis are tending to follow this model, since the basic problem generating them—the analysis of DNA sequences—is easily conceptualized in this fashion. See D. Sankoff and J. B. Kruskal, *Time Warps, String Edits, and Macromolecules* (Reading, Massachusetts, in press). A particularly elegant microlevel sequence analysis is F. Barth, "Models of Social Structure," Royal Anthropological Institute, *Occasional Paper* #23 (London, 1966).

8. Earlier versions of this paper have been criticized for shortchanging the contributions of the comparativist sociologists (and historians) to sequence analysis. It is correct that the comparativists have discussed contingent processes and conditional events in a wide variety of settings, thereby questioning evolutionary models such as modernization theory. Yet, traditional narrative historians have discussed contingent processes and conditional events for many years. At their most abstract, comparativists come under the "careers" heading; they give ideal typical alternative models for revolutions, or organizations, or whatever. They derive these models by contrasting the "conditions under which" things occur in one case, but not in another. Their work does not raise and consider the forms of theorizing about sequences, and these are my concerns here.

9. D. L. Hull, "Central Subjects and Historical Narratives," *History and Theory* 14 (1975): 253–374. For an overview of the philosophical literature, see the essays in P. Gardiner, ed., *Theories of History* (New York, 1959) and W. H. Dray, ed., *Philosophical Analysis and History* (New York, 1966).

10. See W. H. Dray, "Concepts of Causation in A. J. P. Taylor's Account of the Origins of the Second World War," *History and Theory* 17 (1978): 149–74. These assumptions about causal flows are not universal. Under certain conditions, cause may flow the other way, particularly where underlying conditions have created a structure vulnerable to contingencies at higher levels. For example, the Annales school follows this model formally, with *structure* as the lowest level, *conjoncture* as the middle, and *événement* as the top. The typical Annales

study looks either at the state of *structure* or the unfolding of *conjoncture*. Yet, in certain cases—the French Revolution, for example—it seems necessary to study how the events themselves reshape the *structure* and *conjoncture* that are parparticularly vulnerable to them (see, e.g., P. Bois, *Paysans de l'Ouest* [The Hague, 1960]).

11. A. C. Danto, *The Analytical Philosophy of History* (Cambridge, England, 1965). Demonstrating that narrative and non-narrative classifications both have to ignore multiple meanings does not end the matter. It may still be that multiple narrative location for events "is a worse problem" than is multiple variable classification for them. Perhaps this is so. Yet, perhaps such an answer merely reflects conventions of sociology that these variable classifications are clear, that salary, for example, "is" income. Yet, salary could be classified many ways—as income, as personal reward, as instrumental resource, as measure of self-worth, and so on.

12. Despite their often arcane terminology, theorists of narratives have usefully analyzed the essential qualities of those sequences of events we call stories. Basic surveys of this literature are S. Chatman, *Story and Discourse* (Ithaca, New York, 1978) and J. Culler, *Structuralist Poetics* (Ithaca, New York, 1975). Important particular sources are R. Barthes, *S/Z* (New York, 1974), C. Bremond, *Logique du Récit* (Paris, 1973), V. Propp, *Morphology of the Folktale* (Austin, Texas, 1975), R. Scholes and R. Kellogg, *The Nature of Narrative* (London, 1966), and T. Todorov, *Grammaire du Décaméron* (The Hague, 1969). Although most of their work concerns fictional stories, it is applicable as well to sequences of real events. Most structuralists assume that to understand stories one must understand how readers assemble the events presented as elements of stories. They thus separate the way a story is told (*discours*) from the underlying story itself, (*histoire*); see, especially, G. Genette, *Narrative Discourse* (Ithaca, New York, 1980). For the present, my concern is with story itself, although issues of discourse are equally important in other contexts (see note 19 below).

13. Barthes, *S/Z*, Bremond, *Logique*, N. Frye, *Anatomy of Criticism* (New York, 1966), H. V. White, "The Structure of Historical Narrative," *Clio* 1 (1972): 3:5-20, and *Metahistory* (Baltimore, 1973). For attempts at actual grammars of narrative, see G. Prince, *Grammar of Stories* (The Hague, 1973) and Todorov, op. cit., n12. Todorov also deals with the classification problem.

14. This situation is the same as in the purely positivistic conception of the social process as a succession of values of certain variables. The well-known relation between education and professional occupational status may be emplotted as an artifact of the determination of benefits by technique and power, as a simple sufficient cause, or as a dimension in an occupational classification space. See, respectively, J. B. Cullen, *The Structure of Professionalism* (New York, 1978), D. J. Treiman, *Occupational Prestige in Comparative Perspective* (New York, 1977), and A. P. M. Coxon and C. L. Jones, *The Image of Occupational Prestige* (New York, 1978). Each case constitutes a legitimate, yet quite different, use of the empirical relationship.

15. For an excellent example, see Dray, op. cit., n10.

16. See P. L. Berger and T. Luckmann, *The Social Construction of Reality* (Garden City, New York, 1966).

17. In this discussion of order, I have assumed linear sequences. This rules out sets of sequences that proliferate from a common origin or that concentrate onto a common termination. Thus, one might argue that all professions start out developing in the same order, say with education preceding associations, but that they then take a variety of different paths. These cases, which represent important historical genres, seem to be best considered under the heading of multiple sequences.

18. See, for example, R. L. Moore, "The Spiritualist Medium," *American Quarterly* 27 (1975): 200-21, A. LaVopa, "Status and Ideology," *Journal of Social History* 12 (1979): 430-56, and T. Haskell, *The Emergence of Professional Social Science* (Urbana, Illinois, 1977).

19. In historical writing, the arrival of a steady state normally leads to sharp shifts in focus. It often signals the end of a story. At other times, it leads to a sudden speeding of narrative time, in which the duration of the steady state is treated as a single, whole period to be analyzed at once. Such a separation operates only within the historical discourse, not in the social process itself.

20. See, for example, G. Zilboorg, "Legal Aspects of Psychiatry," pp. 507-84 in *One Hundred Years of American Psychiatry* (New York, 1944). See also the discussion of the relations between medicine, law, psychiatry, and the clergy, in Part IV of A. Abbott, *The Emergence of American Psychiatry* (Unpublished Ph.D. Dissertation, University of Chicago, 1982).

21. For general reviews of methods of temporal analysis, see M. T. Hannan and N. B. Tuma, "Methods for Temporal Analysis," *Annual Review of Sociology* 5 (1979): 303-28 and J. S. Coleman, *Longitudinal Data Analysis* (New York, 1981). A useful bibliography is N. E. Fitch, "Statistical and Mathematical Methods for Historians," *Historical Methods* 13 (1980): 222-31. For a defense of using cross-sectional methods with over-time data, see B. Laslett, "The Place of Theory in Quantitative Historical Research," *American Sociological Review* 45 (1980): 214-28. An application illustrating subdivision without order is R. M. Hauser, J. N. Koffel, H. P. Travis, and P. J. Dickinson, "Temporal Change in Occupational Mobility," *American Sociological Review* 40 (1975): 279-97. For a discussion of constraints ensuring that order is maintained in log-linear models, see Y. M. M. Bishop, S. E. Fienberg, and P. W. Holland, *Discrete Multivariate Analysis* (Cambridge, Massachusetts, 1975), especially pp. 261-79. These constraints may be applied where transitions between categories between time intervals are known. A Markov model may then be estimated by constraining the origin-row x time marginals. Other procedures, such as simple crossing of the observations at each time period, *do not work*. Examples are E. E. Brent and R. E. Sykes, "A Mathematical Model of Symbolic Interaction between Police and Suspects," *Behavioral Science* 24 (1979): 388-402 and R. W. Manderscheid, D. S. Rae, A. K. McKarrick, and S. Silbergeld, "A Stochastic Model of Relational Control in Dyadic Interaction," *American Sociological Review* 47 (1982): 62-75. If there are five dimensions, one for each of five time points, there are 5! orders in which the table itself can be viewed, each of which may be interpreted as generated by a Markov process. None of these is tested by the log-linear model, since without constraints, the five points are treated by that model as simultaneous.

22. Early path analytic studies were particularly cautious about this assumption, a caution that has vanished with time and use. For an excellent discussion, see P. Blau and O. D.

Duncan, *The American Occupational Structure* (New York, 1967), pp. 167–68.

23. It should be emphasized that these hypotheses concern sequences of particular values of variables, that is, sequences of events. One can also raise in this context questions about the sequences of *variables*, that is, about the proper structure of paths between the four variables at the three time periods. It is this order that must be presumed knowable, fixed across cases, and invulnerable to variation in the time horizons of the variables.

24. On interaction effects, see P. D. Allison, "Testing for Interaction in Multiple Regression," *American Journal of Sociology* 83 (1977): 144–53, K. E. Southwood, "Substantive Theory and Statistical Interaction," *American Journal of Sociology* 83 (1977): 1154–1203, and P. D. Cleary and R. C. Kessler, "The Estimation and Interpretation of Modifier Effects," *Journal of Health and Social Behavior* 23 (1982): 159–69. Standard fixups for multicollinearity and underidentification are discussed in J. Johnson, *Econometric Methods* (New York, 1972) and H. Theil, *Principles of Econometrics* (New York, 1971). I am here ignoring the problem of finding the proper lag between time periods, on which there is a large econometric literature. See, for example, P. J. Dhrymes, *Distributed Lags* (San Francisco, 1971). Although important here, that issue is more important in the context of the ARIMA models considered next. I should note that one method for handling sequential effects directly within the general linear model format is to categorize the independent variables (knowledge growth, professional association, and mobility in the present case) and then enumerate the sequences of categorical combinations that would bear out the hypotheses. The linear contrast of these with the rest would then test hypotheses 1, 2, and 4. (This is roughly the procedure suggested by S. Turner, "Modeling and Evaluating Theories Involving Sequences," *Quality and Quantity* 14 [1980]: 511–18.) If hypothesis 3 is included, then control must be categorized and the procedure fails, since a particular linear contrast involving several variables cannot be considered in the log-linear format without allowing all lower order effects into the model. Another possible fixup is the use of change scores, which enable the modeler to "get at" two time periods at once. The difficulties of change scores are well known. They double the measurement error by combining measures. They are collinear with any time one measurement used as a control. Again, while they do give the multivariate analyst a way of beginning to deal with sequence effects, they behave badly in actual practice.

25. See G. E. D. Box and G. M. Jenkins, *Time Series Analysis* (San Francisco, 1970) for a fundamental analysis of ARIMA processes. In arguing that the ARIMA model applies only to single variables, I am overstating the theoretical case and certainly contradicting econometric practice. In fact, the ARIMA approach is implicit in most common simultaneous equations models for multivariate time series data. Yet, the formal focus of ARIMA on sequential structures is usually lost in such models. Their multivariate character reintroduces collinearity and turns the interpretation of the serially correlated errors into a very difficult task—one that rests, essentially, on the personal judgments of the modeler. C. W. J. Granger and P. Newbold, *Forecasting Economic Time Series* (New York, 1977) provide a trenchant analysis of the problem (see especially chapter 6). Granger and Newbold present their own formal multivariate ARIMA model (in chapter 7) but note that the difficulties and constraints in the use of such methods are virtually insurmountable. I am indebted to Christine Kuduk for calling their work to my attention.

26. For a general overview of the use of Markov models in sociology, focusing on their most common application, see S. Stewman, "Markov Models of Occupational Mobility," *Journal of Mathematical Sociology* 4 (1976): 201–45, 247–78. Within the positivist view of event sequence here taken, where event sequences are series of nonoverlapping events with roughly similar time horizons, the one-step nature of Markovian dependence is a serious problem. However, it should be noted that an important line of philosophical and sociological thinking argues that there is an "immediate past" whose state contains the effects on the present of pasts of all lengths. That is, the effects of the entire past are summed up in the state of the immediate past; there is no historical "action at a distance." Mead argues that since individuals act in the present with respect to the past as they perceive it, the past is continually remade, and thus, the causally effective past is part of a durational present, which it determines at one step (as in the Markov process). Whitehead argues that "this immediate past is of overwhelming influence; for all routes of transmission from the more remote past must pass through it." These arguments imply the legitimacy of a first order (one-step) Markovian model for event sequence. See G. H. Mead, *Philosophy of the Act* (Chicago, 1938), pp. 351–53, 613–15, A. N. Whitehead, *Process and Reality* (New York, 1969), p. 373, and D. H. Porter, "History as a Process," *History and Theory* 14 (1975): 297–313.

27. On latent states, see L. M. Wiggins, *Panel Analysis* (San Francisco, 1973). On heterogeneous transition probabilities, see S. Spilerman, "The Analysis of Mobility Processes by the Introduction of Independent Variables into a Markov Chain," *American Sociological Review* 37 (1972): 277–94. On time dependence, see A. Sorensen, "The Structure of Intragenerational Mobility," *American Sociological Review* 40 (1975): 456–71.

28. N. B. Tuma, M. T. Hannan, and L. P. Groenveld, "Dynamic Analysis of Event Histories," *American Journal of Sociology* 84 (1979): 820–54.

29. On reduction, see W. Wimsatt, "Reductionistic Research Strategies," pp. 213–60 in T. Nickles, ed., *Scientific Discovery* (East Lansing, Michigan, 1980) and "Reduction and Reductionism," pp. 352–77 in R. D. Asquith and H. Kyburg, eds., *Current Research in the Philosophy of Science* (East Lansing, Michigan, 1979).

30. S. B. Fay, *The Origins of the World War* (New York, 1966). The argument that structural forces in the long run or over many cases obliterate effects of such "trivial" or "random" variables may or may not be true. Structural causes have a way of compounding and reinforcing sudden irregularities, as work on the baby boom has shown. See, particularly, T. Frejka, "Reflections on the Demographic Conditions Needed to Establish a U.S. Stationary Population Growth," *Population Studies* 22 (1968): 379–97. Further, World War I is an event worth predicting and one with great consequences at the structural level. It is, therefore, important to remember that structural forces may indeed create situations that are extremely vulnerable to what might otherwise be unimportant, minor variation. Centralization is an excellent general example of such a structural process. See also note 10 above.

31. I have omitted from consideration here the important class of models for sequences found in operations research

under the heading of dynamic programming. The general problem of this literature is to develop sequences of actions that fulfill a criterion, usually optimality, over the path of or at the termination of an alternating sequence of states and responses (actions) that is generated by the interaction of system structure, actor response, and random exogenous disturbance. In its normal form, dynamic programming is done under Markovian assumptions in discrete time with a fairly limited set of possible events. While the dynamic programming problem may be expressed much more generally, encompassing the general problem of sequential contingency, the standard solution strategy of backward induction from a known terminal state depends on the assumption of Markovicity. The technique has a number of diverse applications and has found specific use in decision theory. In general, dynamic programming has the strengths and weaknesses of other Markovian approaches. First, the one-step dependence implies the assumption that all of the causal past acts only through its shaping of the most recent past. Second, the actual observed sequences are treated as model-generated, as observables to be reduced to the succession of one-step transitions predicted by the model. On the general theory of dynamic programming, see K. Hinderer, *Foundations of Non-stationary Dynamic Programming with Discrete Time Parameter* (New York, 1970) and B. Gluss, *An Elementary Introduction to Dynamic Programming* (Boston, 1972). An interesting group of applications is found in M. L. Puterman, *Dynamic Programming and Its Applications* (New York, 1978), while examples in decision theory are D. M. Kreps and E. L. Porteus, "Dynamic Choice Theory and Dynamic Programming," *Econometrica* 47 (1979): 91–100, and R. M. Cyert and M. H. DeGroot, "Sequential Strategies in Dual Control Problems," *Theory and Decision* 8 (1977): 173–92.

32. A useful analogy to the distinction between these two conceptions of the social process is the distinction between harmonic and contrapuntal conceptions of polyphonic music. Classical harmonic theory treats music as a series of snapshot ensembles of sound (chords), whose successive relation is determined by formal rules analogous to causal laws in sociology. The first importance of a given note is synchronic; it helps determine the chord of which it is a part, just as causal variables in the general linear model are first understood in synchronic ensemble. As in that model, too, certain notes of the chord are more important than others, given the type of chord; and the focus of this importance may switch from one line to another as chords progress. The earlier, contrapuntal conception of music is more like the sequence approach. Each line is its own melody, and each note's first importance lies in furthering that melody. Lines are free to move at their own speed, rather than being subordinate to an underlying harmonic rhythm. Time horizons vary. As a result, there are no chords and no overall rules for their succession. The importance of different lines is a function of their inherent melodic interest and of their relation to other lines moving in parallel, contrary, or other relative motion. The intense conflicts and resolutions that make up the overall texture of a contrapuntal piece are not planned by harmonic design, but appear to arise out of the accidental confluences inherent in the relative motion of the voices themselves. The historical relation of the harmonic and contrapuntal conceptions is also similar to the relation of standard and sequential approaches to the social process. Counterpoint is the older style, but it was overwhelmed by the tremendous musical power of harmony after the seventeenth century. Only in the present century, when the possibilities of classical harmony seemed exhausted, did composers like Hindemith, Bartok, and Webern begin a conscious return to contrapuntal principles. To many modern listeners, their music seems, like the sequential approach to the social process, to deny itself many of the benefits of its alternative, the harmonic style.

33. I am, of course, ignoring all the theoretical issues involved in saying that two events are distinguishable. In empirical practice, these will be central issues of analysis. Is registration of a profession the same event as state-sanctioned monopoly of service? Not in England. Yet, functionally, the two are equivalent in the United States. Any cross-national study of professional development would have to deal with this problem directly, and more generally, it constitutes a major problem in this type of approach.

34. For theoretical reviews, see L. J. Hubert, "Comparison of Sequences," *Psychological Bulletin* 86(1979):1098–1106 and M. L. Puri and P. K. Sen, *Nonparametric Methods in Multivariate Analysis* (New York, 1971). The Spearman rank correlation coefficient is a familiar example, and permutation statistics may be developed to meet a wide variety of possible uses.

35. In fact, interval measure is not required, but only some form of order relationship that can be used to generate proximities. Seriation is essentially a one-dimensional version of multidimensional scaling. D. G. Kendall, "A Mathematical Approach to Seriation," *Philosophical Transactions of the Royal Society of London*, Series A. 269 (1970): 125–35, and "Seriation from Abundance Matrices," pp. 213–52 in F. R. Hodson, D. G. Kendall, and P. Tautu, eds., *Mathematics in the Archeological and Historical Sciences* (Edinburgh, 1971) has argued that the seriation problem is inherently two dimensional, despite the underlying known unidimensionality of time. Two-dimensional methods give more enlightening solutions. See also J. B. Kruskal, "Multidimensional Scaling in Archaeology," pp. 119–32 in the Hodson, Kendall, and Tautu volume, which contains a large number of useful essays dealing with the theory and practice of seriation and related problems. A useful review of the large literature of multidimensional scaling is J. D. Carroll and P. Arabie, "Multidimensional Scaling," *Annual Review of Psychology* 31 (1980): 607–49.

36. A cycle is a "loop" within the permutation. In a cycle the i^{th} element of the original sequence is replaced by the j^{th}, the j^{th} by the p^{th}, and so on until some element is replaced by the i^{th}. This closes the loop, which is said to have period (or length) r, where r is the number of replacements. Any permutation may be uniquely factored into cycles that have no elements in common (disjoint cycles). Cycles may be of any length, from one (an element stays where it is) to n, where n is the total sequence length. While the set of cycles generates the full symmetry group, which has $n!$ elements, it is itself considerably smaller, since many permutations are not cycles themselves, but products of cycles. Nonetheless, the number of possible cycles is large. It follows the sequence of the so-called logarithmic numbers, there being 3, 8, 24, 89, 415 possible cycles for sequences of lengths two through six. In datasets where any kind of overall regularity is present, observed cycle distributions will involve only a few of these. The problem with cycle decomposition as a sequence analysis technique is that regularity is inferred not by observed cycles but by unobserved ones. Thus, a regular, necessary subsequence of length r, whose elements always follow in immediate succession, will be evident because it will rule out all cycles of length greater than $n - r$. To be sure, this is a large exclusion, since there are many more long than short cycles. But immediate succession is a strict, and unusual, condition.

37. D. P. Hogan, "The Variable Order of Events in the Life Course," *American Sociological Review* 43 (1978): 573–86. For a general discussion of partitioning, see Turner, op. cit., n24.

38. It is useful here to note an essential reducing assumption of historical narratives, the means by which historians avoid dealing with this messy multiplication of states. Historical narratives assume that things not presently under analysis continue as they were left when last discussed. This is seen nicely in W. B. Gallie's vision of history as a cricket match (*Philosophy and the Historical Understanding* [New York, 1964]). Gallie sees history as a cricket game, somewhat more comprehensible to the expert than to the tyro, but still filled with exciting accidents. The metaphor is apt for a number of reasons. It emphasizes chance. It allows for structural causes—the skills of the players and the rules of the game. It well describes the shifts in narrative history from one area of concern to another as the game moves along. To a sociologist, of course, this flitting from one focus of interest to another as narrative advances seems questionable. Why are economic causes crucial at one point when social or political causes are at another? Why is persistence less interesting than change? The idea of followable narrative seems to imply a set of assumptions about the causes and events not looked at—that they continue as they used to, or as one supposes they might, or that they are for some reason irrelevant.

39. One such measure is Mayhew's coefficient of sequence inequality, a standardized sum of pairwise differences between event likelihoods. See Mayhew et al., op. cit., n1. Other measures might be based on modal events or on direct fitting of multinomial distributions using moments.

40. I am omitting any discussion of some other rescue strategies. One might, for example, solve the problem of repeated events by so refining the state space that events would not be repeatable. This would permit the techniques of unique event analysis, but at the price of distinguishing events (state registration and associational certification of professions, for example) that we might not really like to separate, or about whose order we have no hypotheses, or which haven't occurred in all cases. I also omit discussion of the approaches to this problem that base measures of sequence dissimilarity on "distance" in terms of elementary operations (insertion, deletion, substitution) required to transform one sequence into another. There is an important book in press on this subject (see note 7 above). I am indebted to Dr. J. B. Kruskal for providing me with draft material from this work.

41. On Markov processes generally, see J. G. Kemeny and J. L. Snell, *Finite Markov Chains* (New York, 1976).

42. The lack of efficient simplication methods for n^{th} order Markov chains follows from the fact that they are equivalent, as far as theory is concerned, to simple chains with vector-valued states or simply larger state spaces. See J. L. Doob, *Stochastic Processes* (New York, 1953). There is, therefore, little theoretical interest in them because the basic chain properties are independent of the size of the state space, and the size problem bothers only the social analyst who must deal with it empirically (but see Bishop, Fienberg, and Holland, "Multivariate Analysis" on n^{th} order chains).

43. The inertial case offers a useful illustration of the Markov model's weak formulation of a sequence hypothesis. Here the Markov model includes predictions about off-diagonal transitions that are not really part of the theory. If a jurisdiction is increasingly stamped as belonging to a particular dominant profession throughout its career, then if a new profession takes it over, we expect the erstwhile dominant profession to take *that* jurisdiction back more than we expect it to take over another jurisdiction of that new profession. Yet, under the Markov model, these two events have the same likelihood.

44. On the ethics code period effect, see A. Abbott, "Professional Ethics," *American Journal of Sociology* 88 (1983): 855–85. The problem of deciphering such period effects is entangled, at least in practical terms, with that of coding "true" first events. Again, ethics codes are an example. Both American medicine and law had had codes for some time by the teens, but both codes were revised during that decade in ways that might be interpreted as creating new codes. Similarly, both professions had had professional schools since the eighteenth century, but these were reformed in a general movement for the improvement (or the exclusivization) of professional education in the late nineteenth century. Thus, while one might speak of the event "first medical school" or "first law school" as dated 1765 and 1784, respectively, these organizations, in fact, bore little resemblance to those celebrated by Flexner and Reed in the teens. I should note that I have assumed throughout this paper that there is no measurement problem with sequence data. As this note indicates, this assumption is questionable, and I am studying it further using data on regional sequences of development in American medicine.

45. I have omitted two other issues concerning aggregation. One is the loss of information where there are several sets of cases, each group following its own typical sequence. Here aggregation hides the sequence effects. This problem may be handled by scaling or clustering the cases, before other analysis, to distinguish such groups. Another issue in sequence aggregation is the relative complexity and numbers of the sequences to be aggregated. Sequence datasets can be very small or very large. In the small datasets characteristic of historical sociology, such as in the study of professions or revolutions, there is considerable particular information about each case, of which much or most must be sacrificed for the kinds of aggregation suggested here. Large sequence datasets are often generated by survey methods that themselves perform this screening function. It is this difference in size and in relative importance of particular detail that has kept the two areas methodologically distinct despite their common theoretical interest in sequences, forcing historical sociologists to choose, in general, comparative methods (see, e.g., T. Skocpol and M. Somers, "The Uses of Comparative History in Macrosociological Inquiry," *Comparative Studies in Society and History* 22 [1980]: 176–97).

46. There are also some direct models for the kind of volatility characteristic of such sequence systems. An example are threshold models, recently elaborated in sociology by Granovetter ("Threshold Models of Collective Behavior," *American Journal of Sociology* 83 [1978]: 1420–443). (Granovetter's work takes a more general approach to relations previously investigated by N. Rashevsky, *Looking at History Through Mathematics* [New York, 1968]). In threshold models, a continuous underlying distribution of actions or thresholds of activity is investigated to discover its equilibrium points. Granovetter, for example, investigated various distributions of a "propensity to join a riot given that one is already taking place." The equilibrium percentage of a group actually rioting turns out to be extremely sensitive to the standard deviation of the underlying distribution of propensities to join, and indeed, sudden changes in that percentage emerge from slight shifts in such parameters. Threshold

models seem to be mathematically related to Thom's celebrated catastrophe theory. Like that theory, they have a general aim of interpreting apparent discontinuities in observed variables as necessitated by slight shifts in an unobserved, but continuous, reality of higher dimensionality. Like the Markovian models, then, such approaches seek to interpret surface volatility as an arbitrarily defined projection of underlying continuities.

47. H. C. White, *Chains of Opportunity* (Cambridge, Massachusetts, 1970). It is important to note that White found that time itself had a different meaning in the space of vacancy transitions than in that of men or of jobs. The measure of time for a particular transition is the number of prior sequential contingencies (vacancy transitions) that lead to it. Time is, therefore, no longer a real or integral measure, but rather a contingent one.