4 Overview: Methods for Process Research

WE HAVE MADE SOME PROGRESS on our journey to understanding change and development processes. The first part of our itinerary has been devoted to exploring the conceptual and theoretical grounding of organizational processes. The remainder of the excursion will be devoted to methods that put the concepts of Part I to work.

In Part I we established that both process and variance approaches have important roles in the study of organizational change and development. Part II will cover methods appropriate to both process and variance research. We will not attempt to describe every possible method that could be used in research on development and change. Instead, we identify novel and emerging approaches that seem well suited for the particular problems encountered in the study of organizational processes. We hope that our elaboration of these methods will demonstrate how researchers can modify existing approaches to meet the special demands of process research.

The following chapters introduce methodologies in generally accessible terms as they can be applied to process questions. Most of the methods in this volume are covered in other books and there is no need to discuss them in great detail here. Instead, we focus on potential applications and on the steps and choices that must be taken in tailoring the methods to particular questions about development and change. In addition, we provide numerous references to good original sources for readers who find the methods useful for their own research. Our discussions assume familiarity with traditional statistical techniques, but beyond this we have attempted to give readers an account of these methods in common language.

PROCESS RESEARCH METHODS

Perhaps the most stringent requirement for process research methods is that they must work with event sequence data. Analysis of event sequence data enables researchers to evaluate process theories on their own terms or, alternatively, to derive narrative models inductively. This data can also be transformed into formats suitable for variance analyses. Variance methods can be used to test hypotheses regarding characteristics of the sequence and process-outcome relationships that are suggested by one or more plausible narrative models.

As developed in Part I, methods are needed that enable researchers (1) to identify events; (2) to characterize event sequences and their properties; (3) to test for temporal dependencies in event sequences; (4) to evaluate hypotheses of formal and final causality; (5) to recognize coherent patterns that integrate narratives; and (6) to evaluate developmental models. Achieving these tasks is in part a function of how researchers gather and record their data and in part a function of analytical methods.

Event Identification

Identification of events provides the substance for process analysis. Events are generally not simply "there"; the researcher must engage in the interpretation of raw data such as interviews or historical records to recognize relevant events. Identification of events requires that researchers have a clear definition of the central subject of the narrative (i.e., who or what the events are relevant to) and a sense of what is relevant to the change process under study. Event identification occurs through iterative analysis, moving from raw data to a set of incidents (meaningful occurrences) which serve as indicators for events, and then back again in circular fashion. This is facilitated by development of systematic coding rules that make the process transparent to other researchers; systematic procedures also enable an assessment of reliability and validity of classifications. Chapter 5 discusses methods for distilling event data from a record of the process.

In some cases events are layered. As chapter 2 indicates, events in the same process may have different duration and differ in the range of actors and contexts they span. In such cases, higher-order (more macro) events can be coded from lower-order (more micro) events. Chapter 5 discusses coding procedures that can be applied for this purpose. Chapter 7 covers phasic analysis methodology, which identifies coherent phases (macro events) from sequences of shorter (micro) events.

Characterizing Event Sequences

Once we have identified one or more event sequences, the next step is to describe their properties. Several different kinds of properties may be captured:

1. *Type of sequence.* Does the sequence follow a certain path? This may be determined deductively, by comparing a model that implies a specific ordering of events to the sequence, or retroductively, by exploring the data with several models in mind. The result is a classification of sequences into types. These nominal types can then be related to contingency factors that produce them and to outcome variables.
2. Events may also function as indicators of *event variables,* such as the level of idea development in an event or the degree to which an event indicates interventions in the innovation process by outside resource controllers. Coding procedures may be used to generate values of the variable for each event, such as whether the event indicates resource controller intervention (a nominal variable), or the degree to which the event contributes to positive morale on the innovation team (an interval variable). Once individual events have been coded for the variable, researchers may also calculate the value of the variable for longer segments or subsequences (e.g., the total number of resource controller intervention events in a one-month period; the average level of morale across all events in a segment). Coding events for variables transforms the events into a time series of values that can be analyzed with various statistical methods.
3. *Summary properties of a sequence,* such as how long it is, the degree to which it matches a particular ideal-type sequence, or the amount of idea development in the sequence. This results in one or more variables, in which the sequence itself is the unit of analysis, allowing for comparison of different event sequences.
4. Another option is to identify the occurrence of *specific subsequences of events,* such as periods of interaction with outside regulatory agencies or sets of transactions to form joint ventures. These can be extracted and studied in their own right, as independent sequences.

Chapter 7 discusses methods for phasic analysis which are suitable for the analysis of entire sequences. These methods can also support the identification of subsequences and comparison of different sequences. Chapters 8 and 9, on event time series analysis and nonlinear event time series analysis respectively, describe procedures for analyzing time series of variables which characterize event sequences. They can also generate summary indices to describe event sequence properties.

Specifying Temporal Dependencies

To trace enchainments and linkages, it is useful to identify event-to-event dependencies. The simplest such dependency is sequential contingency, such that one or more events increase the probability of the occurrence of a succeeding event. For example, creating a citizen review board may be necessary for a social service program to build the community support required to garner government funding. One-step contingencies among a series of successive events could indicate that this particular sequence occurs regularly, suggesting a developmental type. Contingencies may also indicate causal linkages, such that event 1 leads to event 2 (efficient causality) or, alternatively, that event 2 is the purpose for which event 1 occurs (final causality).

There are two approaches to evaluating claims concerning dependencies and enchainments among events. The first retains the nominal categorizations of events and identifies dependencies among events. Stochastic modeling techniques, discussed in chapter 6, support this type of analysis. The critical incident technique offers a qualitative approach to the same question. It is also possible to generate time series event variables, as described above. Methods described in chapter 8, including time series regression and cross lag time series analysis, can then be used to analyze the event series or summary event indices for segments of the timeline.

Evaluating Hypotheses of Formal and Final Causality

Hypotheses of formal and final causality are assessed (a) by comparison of the overall pattern in the event sequence to the pattern implied by the formal or final cause and (b) by tests for additional conditions or factors that must operate for a given formal or final cause to operate. For example, assume researchers wish to evaluate the hypothesis that the model of social program startups from chapter 1 described a set of cases. They would (a) determine whether the phases of the observed programs matched those in the Program Planning Model, and (b) search for evidence for the operation or application of this pattern (e.g., evidence that key actors explicitly thought in terms of this rational, stepwise model, or that resource controllers required satisfaction of the steps in the model to qualify for funding).

The stochastic modeling methods of chapter 6 and the phase analysis methods of chapter 7 are both well suited to determine fit between hypothesized and actual patterns of development and change for events classified at the nominal level. Time series methods described in chapters 8 and 9 can be used to detect patterns in continuous data based on event variables.

Recognizing Patterns That Integrate Narrative Explanations

Information gained from carrying out the first four requirements of process research is an invaluable support for pattern recognition. The hermeneutic circle, with its part-whole cycling, is the key to discovering integrative patterns, and ultimately, this depends on a critical insight on the part of the researcher. However, checking the validity of this insight and refining the narrative explanation is greatly facilitated by the application of systematic methods for pattern evaluation and characterization of sequences and their interdependencies. Systematic methods may also help researchers cut through the undergrowth of details to discern consistent and striking patterns in event sequences; this clears the way for the ultimately creative insights on which narrative coherence depends.

Distinguishing Among Alternative Generative Mechanisms

In chapter 3 we described four basic models of development and change which incorporated different generative mechanisms. As we noted, any particular change or development process may be explained in terms of a single model or in terms of a combination of interrelated models. The question immediately arises as to how we might empirically assess whether one or more of these models operate in a given process. Several methods are available to test the plausibility of process theories and to determine which motor(s) are operating.

Table 3.3 listed the conditions necessary for the operation of each generative mechanism. These conditions imply that the following tests might be performed to determine which of the generative mechanisms operate for a given case or sample:

(a) *Does the process exhibit a unitary sequence of stages which is the same across cases?* Life cycle models posit a definite sequence of stages. Teleological models may exhibit stages, but the stages do not have to occur in a particular order; stages must occur and cumulate to satisfy the final goal or form of the process, but the order in which they are satisfied is not particularly important. Evolutionary and dialectical models do not have to exhibit distinguishable stages (though they may). The steps in the activity cycles for each generative mechanism may overlap so much that clear stages are not definable.

The methods for phase analysis introduced in chapter 7 can be used to identify phases that may correspond to developmental stages, if any exist. Phase methods also enable researchers to evaluate sequences to determine whether they display a unitary ordering and to cluster sequences into types. Stochastic modeling (chapter 6) and time series methods (chapter 8) can also support the identification of stages.

(b) *Is there a patterning device, such as a program, routine, code, or rule* *system that determines the nature of the change sequence?* As noted in chapter 3, life cycle models of organizational processes require a program or code either immanent within the developing entity or enforced by some external agency. Teleological models do not require such governing patterns; though the central subject may be oriented to such patterns, its activity is a result of willful choices and is not forced to follow a set sequence by internal or external patterns. Dialectical models, by definition, do not adhere to patterns, because they rely on emergence for resolution of conflicts. Evolutionary models are governed by patterns that drive enactment, selection, and retention.

Evidence for programs, routines, codes, or rule systems must be garnered from sources outside the event sequence. The event sequence may contain evidence of these patterning forces, but the patterns themselves will be found in factors influencing the sequence. For example, in medical innovations, one powerful patterning force is the testing sequence mandated by the FDA for new medical devices. The role of the FDA in various events and participants' actions and testimony vis-à-vis the FDA provide clues to its importance, but the FDA's procedures themselves must be investigated and described as an adjunct to the event sequence.

The same is true for patterning forces internal to the developing entity. Some evidence of the existence of a "blueprint" (Pondy & Mitroff, 1979) is required. It may be a logical scheme that defines why stages must logically unfold in a particular way. For example, it is necessary to generate an idea before it can be debated and modified. Alternatively, the process may be organized by an explicit patterning device, such as a strategic plan organized along the lines of the rational process discussed in chapter 1. Evidence of this plan and its use can be garnered from event data.

(c) *Is there a goal-setting process?* The teleological model requires a goal-setting process. It is the means by which purposes are set and is the first step in orchestrating unified action. Life cycles may include goal setting as one stage. Evolutionary and dialectical models do not exhibit goal setting; though goal setting may be undertaken by individual units within the process, it is not part of the generative mechanism in which the units interact.

Goal setting can usually be identified as part of the event sequence, but some adjunct evidence may be utilized as well. Coding and phase analysis methods, described in chapters 5 and 7, are useful for the identification of goal-setting activities. Adjunct evidence, such as a mission or goal statement or outsiders' reportage of goals, may also be useful to establish goal setting.

(d) *Is (are) the central subject(s) an individual entity or a set of interacting entities?* One of the critical steps in process analysis is defining who the central subject(s) are. This is necessary in order to define events that are relevant to the process. This step, discussed in chapter 5, requires interpretive analysis of the process. The model and general theoretical assumptions favored by the researcher usually imply a certain type of central subject and a choice of one versus several subjects. In addition, the process data itself conveys important information on which reading of the situation is most plausible. A researcher determined to find two interacting central subjects in a dialectic may find that his or her data clearly indicate the presence of only a single significant agent. In this case, the researcher should abandon the dialectical model in favor of either the life cycle or teleological models.

Interpreting raw data to derive events and larger narrative patterns is a cyclical process that follows the hermeneutic circle, tacking between particular facts and larger interpretive constructs and patterns. Cycling between raw data and narrative models provides the researcher with numerous opportunities to identify candidate subjects and to evaluate her or his choice. Chapter 5 addresses issues of design and coding that can support researchers in their quest to define the proper central subject.

(e) *Are individual cases to some extent unpredictable, so that the best level of analysis is the total population of cases?* For some change phenomena, it is not possible to predict accurately the behavior of individual cases. This may be because each case is influenced by "internal" factors or dynamics that are difficult to measure or access, such as individual decision-making processes based on private preference distributions. There may also be a truly unique, unpredictable element in the case. While individuals may be difficult to explain or predict, the behavior of a population of individuals may exhibit more regularity and allow the construction of theories of the population. In such cases, the evolutionary model is most appropriate. It explicitly deals with population-level dynamics, providing a theory of how the population of cases will evolve over time.

This test requires multiple cases in order to assess regularity at the individual case level. Stochastic modeling, discussed in chapter 6, and time series diagnostics, discussed in chapter 9, provide tests for the predictability of individual cases based on the event sequence data. Other evidence for predictability beyond what is available in the process data may also be employed.

(f) *Do conflict or contradictions influence the development or change process?* The dialectical and evolutionary models give conflict an important role. The teleological model takes the opposite tack, assuming that the consensus which underpins concerted action can be achieved; conflict is either nonexistent or short-lived in a process governed by the teleological model. Life cycle models may allow for conflict in one or more stages. Evidence for the presence or absence of conflicts can be obtained from event sequence data utilizing coding procedures described in chapter 5. Stochastic modeling, phase analysis, and event time series methods can all be used to explore the role of conflict in a process. Evidence external to the event sequence may also be utilized to establish the degree to which conflict is important in the process.

Summary

Table 4.1 summarizes the tests that can be used to establish the plausibility of the four models. Notice that each row has a different pattern of answers to the questions, thus ensuring that if all questions are validly addressed a unique model can be established. A development or change process shaped by one model is relatively simple. As we noted in chapter 3, development and change theories often combine more than one model in their explanations. In such cases, it is important for researchers to "localize" tests and to

Table 4.1 Tests for the Four Basic Change Models

TEST	LIFE CYCLE	TELEOLOGICAL	EVOLUTIONARY	DIALECTICAL
Is there a unitary sequence?	Yes	No	Possible	Possible
Program, code, sequencing device?	Yes	No	Yes	No
Is there a goal-setting process?	Possible as one stage	Yes	Possible in units	Possible in units
Is the central subject an individual or set of interacting entities?	Individual	Individual	Set	Set
Are individual cases unpredictable?	No	No	Yes	Possible
Is conflict or contradiction important to the change process?	Possible as one stage	No	Yes	Yes

eliminate as much interference as possible in the evaluation of each individual model.

For each specific version of the four models, there will be additional assumptions that must be tested, such as the particular number and types of stages in a life cycle model, how consensus is reached in teleological motor, how entities clash in a dialectical motor and how resolution occurs, and how retention occurs in an evolutionary model. In some instances, these tests can be conducted from the event sequence data, while in other instances special supplementary data will be required.

Postscript

Table 4.2 indicates which process research tasks are addressed by the methods discussed in subsequent chapters. As the table suggests, process research may require a combination of several methods.

We will use a common dataset to illustrate how the various methods enable researchers to tackle different process research problems. This should

Table 4.2 Methods and the Tasks They Address

TASK	EVENT CODING	STOCHASTIC MODELING	PHASIC ANALYSIS	TIME SERIES ANALYSIS	NONLINEAR MODELING
Event identification	✔		✔		
Characterize event sequences			✔	✔	
Identify temporal dependencies		✔		✔	✔
Evaluate formal/final causal hypotheses		✔	✔	✔	✔
Recognize overall narrative patterns		✔	✔	✔	✔
Is there a unitary sequence		✔	✔	✔	
Program, code, sequencing device?					
Goal-setting?	✔		✔		
Single or set of central subjects?	✔				
Are individual cases unpredictable?		✔		✔	
Is conflict/contradiction important?	✔	✔	✔	✔	

facilitate comparison of the methods and help researchers make judicious choices that match their own preferences and presumptions about the process. The next section describes this dataset in more detail.

A PROCESS DATASET

The data used in most of the examples in this book come from the Minnesota Innovation Research Program (MIRP). As described by Van de Ven, Angle, and Poole (1989), this program consisted of longitudinal field studies undertaken during the 1980s by 14 different research teams (involving over 30 faculty and doctoral students). These studies tracked the development of a wide variety of product, process, and administrative innovations from concept to implementation or termination.

Although the research teams adopted different methods and time frames, depending on their unique circumstances, they adopted a common conceptual framework. This framework focused on tracking changes in five concepts that were used to define innovation development. The process of innovation was defined as the development of new *ideas* by *people* who engage in *transactions* (or relationships) with others within a changing environmental *context* and who change their behaviors based on the *outcomes* of their actions. Comparisons of innovations in terms of these five concepts permitted the researchers to identify and generalize overall process patterns across the innovations studied. Many of these patterns are discussed in Van de Ven, Angle, and Poole (1989).

More specific evidence for some of these developmental patterns was gained from a few innovations that were studied using detailed real-time observations of the innovation process. In this book we will take as our example a fine-grained study of the development of cochlear implants by the 3M Corporation that was conducted by Garud and Van de Ven (1989). This example will be carried through the rest of the book to provide a common frame for exemplifying process research methods. We will describe this study and its data in some detail here in order to set the stage for subsequent chapters. Specifically, we will introduce the nature of the data gathered, the basic event constructs, and how they were operationalized. We will also discuss the theory that Van de Ven, Garud, and Polley developed to explain new product development processes. Definitions of constructs in the dataset and coding categories are detailed in the appendix to this chapter.

The cochlear implant program (CIP) ran from 1977 to 1989 as an internal corporate venture to create an implanted device allowing profoundly deaf people to hear. Following the event sequence methods discussed in this book, this longitudinal field study focused on the events that occurred throughout the development of the cochlear implant program until the termination of the project.

This study, and a related study of therapeutic apherisis technology (TAP) in 3M by Van de Ven and Polley (1992), examined a model of trial-and-error learning for explaining the process of innovation development. The core of this model focuses on the relationships between the actions taken and outcomes experienced by an entrepreneurial unit as it develops an innovation from concept to reality, and the influences of environmental context events on these action-outcome relationships. Following March (1991), the model assumes that people are purposeful and adaptively rational. To develop an innovation, entrepreneurs initially take a course of action, for example, A, with the intention of achieving a positive outcome. If they experience a positive outcome from this initial action, they exploit it by continuing to pursue action course A; if a negative outcome is experienced, they will engage in exploratory behavior by changing to a new course of action, B, for example. Subsequently, if positive outcomes are experienced with action course B, they exploit B by continuing with it, but if negative outcomes are experienced, they continue exploration activities by changing again to another course of action, C, for example, which may appear as the next best alternative course at that time. This anchoring-and-adjustment process of negative outcomes leading to changes in the prior course of action continues until positive outcomes are experienced, which, in turn, serve as the retention mechanism for continuing with the prior course of action.

MIRP researchers (Garud & Van de Ven, 1992; see also Van de Ven & Polley, 1992) tracked events in the development of the CIP as they occurred from the time funding and efforts began to initially develop the innovation ideas until the innovations were implemented and introduced into the market. The researchers collected their data by attending and recording the proceedings of monthly or bimonthly meetings of the CIP team and periodic administrative reviews by top managers, by conducting semiannual interviews with all innovation managers and questionnaire surveys of all innovation personnel, and by obtaining documents from company records and industry trade publications throughout the developmental periods of the CIP innovation. Each raw observation was termed an *incident*. Observations were defined as incidents when changes were observed to occur in the innovation idea, innovation team personnel and roles, the activities and relationships they engaged in with others, the external context beyond the control of the innovation team, and judgments of positive or negative outcomes associated with these events.

These incidents were entered into a qualitative computer database which recorded its date, the action that occurred, the actors involved, the outcomes of the action (if available), and the data source. Chronological event listings were shared with innovation managers in order to verify their completeness and accuracy. The CIP database contained 1,007 event records.

Events were then coded according to a number of conceptual categories in the learning model. These included:

- *Course of action:* The direction of actions that occurred in each event were coded according to whether they represented (a) a continuation or expansion (addition, elaboration, or reinforcement) of the course of action underway on the topic, versus (b) a change in the action course through a contraction (subtraction, reduction, or deemphasis) or modification (revision, shift, or correction) from the prior event.
- *Outcomes:* When events provided evidence of results, they were coded as either (a) positive (good news or successful accomplishment), (b) negative (bad news or instances of mistakes or failures), (c) mixed (neutral, ambivalent, or ambiguous news of results), or (d) null (events provided no information about outcomes).
- *Context events:* This category includes external environmental incidents that occurred beyond the control of the innovation participants but were reported by participants as relevant to the innovation.

These and a number of other event constructs utilized in the CIP and TAP studies are outlined in the appendix.

Two researchers independently coded the events into the relevant categories of each event construct. Garud and Van de Ven (1992) agreed on 93% of all codings of CIP events (Van de Ven and Polley [1992] agreed on 91% of all event codes for the therapeutic apheresis project). The researchers resolved all differences through mutual consent.

In chapter 5 we will present more detailed examples of procedures for creating event sequence files, including coding categories and procedures and various transformations of the data that can be undertaken to convert it into forms appropriate for different types of analysis.

To put the data into perspective it is useful to know something about how the investigators interpreted their results. Two temporal periods reflecting very different patterns of relationships between actions and outcomes were found in the development of CIP: (a) an initial premarket development period of mostly expanding activities undertaken once decisions were made to launch the innovation efforts with corporate venture capital support, followed by (b) an ending market-entry development period of mostly contracting activities that concluded with decisions to terminate CIP. This delineation of the event sequence into two stages was based on qualitative interpretation of the time series, supplemented by quantitative analyses discussed shortly. Chapter 7 illustrates the application of more systematic, formal phase mapping procedures to the attempts that the CIP team made to form alliances and joint ventures with researchers and other businesses.

Event time series analysis (chapter 8) supplemented qualitative interpretation to suggest the following narrative for the CIP innovation process: The initial development period began when the innovation team was formed and funded to explore an innovative idea. This was an ambiguous period where it was not clear which of several possible technical designs should be developed. During this initial ambiguous period, external environmental events (not the actions of entrepreneurs) had a significant negative effect on outcomes. When negative outcomes occurred, they subsequently led the entrepreneurs to continue with, and not change, their prior course of action. These actions, in turn, had no effect on subsequent outcomes in either positive or negative directions. These findings suggest a faulty learning process of action persistence, despite the occurrence of negative outcomes during the beginning development period.

Major problems of market entry punctuated the beginning and ending development periods; in particular, product failures necessitated a product recall for CIP. The ending period largely dealt with uncertain but less ambiguous problems of scale-up manufacturing and market entry of the technical designs that were chosen in the earlier period. During this period, strong evidence for the learning model was found for CIP, as well as for the therapeutic apheresis effort. Adaptive learning was evident in the positive reciprocal relationships between actions and outcomes.

In explaining these results, Van de Ven and Polley (1992) concluded that the process of learning seems random and unpredictable during the initial period of development, but not during the concluding period of development. Garud and Van de Ven (1992) speculated that trial-and-error learning seems to guide innovation development under conditions of uncertainty (i.e., when it is not clear what means to pursue to achieve known ends), but action persistence appears to occur when the developmental process is ambiguous (i.e., when it is not clear what specific ends are worth pursuing). Finally, Cheng and Van de Ven (1996) applied some of the methods described in chapter 9 to reexamine the event sequence time series for nonlinear patterns. Their findings suggested a chaotic process during the initial period of development and more orderly periodic patterns in the ending developmental periods of the two innovations. One set of methods that were not used to study the CIP process are the stochastic modeling approaches described in chapter 6. We will rectify this oversight by presenting a detailed example of how CIP can be illuminated through stochastic modeling.

With these preliminaries behind us, we are ready to continue our journey. Our road will take some unusual twists and turns, and it may be a bit bumpy at times. At some points we will have to slow down, as we pass through a zone of "methods under construction." We hope that readers will find this an interesting and rewarding journey. And we fully expect that when this road is traveled twenty or so years from now it will be an interstate highway, rather than the treacherous two-lane country road we now embark.

APPENDIX: DEFINITIONS AND CODING RULES FOR CIP EVENTS

This appendix is adapted from the codebook for the CIP event data file. It specifies rules for defining events and definitions and coding rules for event constructs, the variables that capture various characteristics and properties of events. These events and event constructs will be used in the illustrations of each type of analysis in subsequent chapters. The original codebook has been changed as little as possible; most changes were intended to maintain subject confidentiality.

Critical Incidents

An event sequence file contains records of the critical incidents in the development of the innovation. *Incidents* can be divided into *events* and *observations on events* that occur on specific dates over the course of an innovation's development.

- *Events* are major cyclical activities and changes in the core MIRP concepts of innovation ideas, people, transactions, context, and outcomes.
- *Observations* are judgements or interpretive statements about events made on specific dates by key stakeholders (innovation participants, resource controllers, and researchers).

Some subjective judgment is involved in determining whether an incident is critical. Incidents will be judged as critical (and therefore recorded in the event sequence file) (a) when the events or observations are important (i.e, are stated by a stakeholder to have a noticeable impact) and (b) when they approximate the level of specificity (from fine to coarse grain) called for in the conceptual categories or coding rules for key concepts in the research framework (defined below).

Discrete Time

We take a discrete view of time when incidents occur. This means that events and observations are actions that take place at a particular time; incidents are a function of the unit of time measurement. For example, if an action takes less time than the smallest unit available to measure it, then the action may be attached to the closest measurement unit. In our case, the day of an incident is our temporal unit of measurement.

Thus, the occurrence of each critical incident in the event sequence file is coded by *day/month/year*, with two columns for each variable.

- Where the specific day, month, or year of an incident is not known, this will be stated in the incident description.
- Where events take longer than one unit of measurement, they may be said to have duration. This problem is handled by specifying the dates and incidents that started and concluded the event.
- When exact dates of changes cannot be ascertained, they are estimated based on the information obtained and are entered in the incident date field. Only as a last resort is the date when the information is received used to indicate the date of an incident.

We reserve the terms "patterns," "trends, "paths," and "trajectories" for processes that represent aggregations across several related events or observations. An example would be when several related observations of competitive action are given the label of "competitive awareness."

Coding of Critical Incidents

A coding scheme refers to the set of labels that are used to identify critical incidents into either event or observation types or to identify characteristics or types of events. The data may be coded multiple times into whatever constructs are useful for further research and theory construction and evaluation. To permit comparisons of incidents across MIRP studies, the following major types of classifications will be made. Additional codings may be added as necessary.

Events versus Observations

Incidents are coded as *events* when the actions are either major cyclical "milepost" activities or when changes are observed in the core MIRP concepts of innovation ideas, people, transactions, context, and outcomes.

Incidents are coded as *observations* when judgments or interpretive statements are made by key stakeholders (innovation participants, resource controllers, and researchers) about events. Coding incidents as observations requires a referencing of the event (by number) on which interpretive statements are made, the stakeholders making the observation, and what the statement is about (i.e., the innovation idea, people, transaction, context, and outcomes).

The reason for distinguishing events from observations is to capture both objective—or factual—descriptions of events and the more subjective, cognitive, and partisan perspectives of various stakeholders about events. Both factual events and interpretive observations are needed to have a complete story or narrative of the development of an innovation.

Activity Events

Throughout the MIRP project, we have conceptualized events as incidents when changes occur in the core MIRP concepts of ideas, people, transactions, context, and outcomes. In addition, it is useful to consider a classification of events that includes *activities* that represent major cyclical "mileposts" in the innovation's development, even though they may not represent changes in the other constructs.

- Examples of activities include administrative reviews, resource procurement and budgeting cycles, strategy meetings, major trade or professional conferences, and other recurrent "mileposts" that are structured to direct or evaluate the innovation's development.
- A less obvious example of an activity is when a previously determined goal (outcome) is publicly communicated to upper management via a management review. This might be subsumed as a change in context, but it assumes effects not necessarily in evidence and is different from resource allocations or organizational changes that would otherwise constitute contextual events.

Idea Events

An incident is coded as an idea event when there is a change in the ideas that are deemed to be significant to the overall development of the innovation by the innovators. Changes in innovation ideas are classified into those that pertain to core or related ideas.

- *Core* ideas are those that pertain to the central technology, product, program, or service that makes up the essence of the innovation.
- *Related* ideas are those that support the development of the innovation, but do not constitute a change in the core embodiment of the innovation.

In general, changes in core innovation ideas often represent new pathways or trajectories of the innovation (as drawn in our charts), whereas related ideas often pertain to organizing, coordinating, or funding a given pathway or trajectory.

- For example, a change in the core idea for CIP was the shift from claiming to develop an implant device to that of forming a Hearing Health Program that included the CIP device. A related idea to this core idea change was a reallocation of resources in the program.
- Evidence of idea changes is most often marked by debate at management meetings or general announcement by management responsible for the overall innovation. This may also suggest that when a potential change is considered and not implemented it should be coded as an idea event.

People Events

An incident is coded as a people event when there is a change in the staffing (turnover) or assignments (roles) of people holding key positions in the innovation (as suggested by the innovators). In addition, key individuals responsible for the management of the innovation environment would also be included. (This relates to the definition of context given below.)

Transaction Events

An incident is coded as a transaction event when there is a change in the legal or social contracts associated with the innovation. This may relate to key transactions between the innovation and other organizations in the environment and also to transactions between people within the innovation unit. Efforts to change or modify existing transactions may also receive this code. For example, when the company initiates efforts to create a new contract or relationship involving the innovation, it is coded as a transaction event.

- *Resource controller interventions* is one form of transaction we want to track over time. Resource controllers may be venture capitalists, top managers, or board members who have invested capital in the innovation being studied. When a resource controller is behaviorally involved in activities or administrative reviews of the innovation unit, it is defined as a transaction event and coded as a resource controller intervention.

Context Events

A context event is an external incident that is related to the innovation but occurred beyond the control of the innovation team. It may involve an environmental change in technology, structure, or market that is related to the innovation's development. Context events are subdivided into *organizational* and *external context*. The line of demarcation between these falls at the boundary of the working organization that houses the innovation. For CIP, the internal context includes the strategic business unit and all organizational elements under their control. Other environmental changes (such as changes at 3M or changes in resource availability) are allocated to the external context.

Outcome Events

An incident is coded as an outcome event when a change occurs in the criteria or values of criteria used to judge the progress or outcomes of the innovation. Outcomes include both tangible results of innovators' courses of action and completions of innovation components or products, as well as less tangible value judgments about the success or failure of an innovation's development by key resource controllers and innovation managers.

Outcomes are further coded as representing either:

- *positive* (good news or successful accomplishments),
- *negative* (bad news or instances of failures or mistakes), or
- *mixed* (neutral or ambiguous news or results indicating elements of both success and failure).

These categories for coding outcomes are useful for empirically examining the success-failure action loops model of innovation development.

- Another outcome event category is *dates*, which refers to changes in schedules, milestones, or anticipated dates for meeting objectives. This category is added to the coding of outcomes in order to measure the progress of an innovation in meeting its timetable. Thus, changes in dates that merely extend proposed timetables for courses of action are to be coded as changes in outcomes-dates.
- Outcome events are also recorded when there is a *shift in outcome criteria*. When an innovation team leader or resource controller states a goal or an outcome criterion for judging the innovation's success that is different from the past, it is recorded as an outcome criterion shift event.

Course of Action

The directions of the actions that occur in each event will be coded according to whether they represent a continuation or change in the course of action from the previous event related to the topic. Specifically, the course of action involved in each event will be coded according to whether it represents an

- *expansion*—an addition, elaboration, reinforcement,
- *contraction*—subtraction, reduction, deemphasis,
- *modification*—revision, shift, correction, or
- *continuation*—repetition or ongoing progression

in the current direction of the course of action underway on the topic.

This coding of event action course requires identifying the prior event pertaining to the topic, and then judging if and how the action course in the present event differs from the prior event.

Summary List of Core MIRP Codes

In summary, the event sequence files for all MIRP innovation studies consist of the following core Fields (columns) and Labels (or categories):

- Incident Number
  A sequential numbering of incidents in chronological order
- Incident Date
  Month/Day/Year
- Record Entry Date in File
  Month/Day/Year
- Data Source
  Sources of data on incident
- Incident Type
  Event or observation
- Core MIRP Index
  Activity (major recurrent events; e.g., reviews, funding)
  Idea-Core (the central product, program, or business idea)
  Idea-Related (to the development of the core innovation idea)
  People (turnover and role changes)
  Transaction (relationships with other units and organizations)
  Resource Controller Intervention
  Context-Internal (in the organization housing the innovation)
  Context-External (to the organization housing the innovation)
  Outcome
  Action Course (change in direction from prior event on topic)

Unique Innovation Codes

Each innovation contains numerous incidents about substantively different topics, products, programs, pathways, or trajectories. In order to examine developments in each of these substantively different areas, more specific content codes are needed for each incident in the event sequence file. These content codes are unique to each innovation study and represent another layer of classifications under some of the major classification categories listed in the previous section. The codes in this section are unique for the CIP case.

- Activity (major recurrent events; e.g., reviews, funding)
  Actions: Types of behaviors that occurred in an incident (each of these has a more specific definition in terms of the parenthetical terms, which are in turn defined in a coding manual):
  Introduce (search, study)
  Propose (report, claim)
  Evaluate (judge, review)
  Negotiate (offer/discuss/modify terms of relationship)
  Commit (agree, appoint, grant, confirm, acquire)
  Execute (perform, carry out, administer)
  Correct (adapt, revise, problem solve)
  Conflict (disagree, fight)
  Withhold (forebear, table, defer, reject)
  Functions: Topics of action, that is, the innovation function it serves:
  Overall development of organization/program
  Links between organizations
  Financing
  Competence development/training
  Technological R&D and design
  Testing/comparing technologies
  Clinical trials/Regulatory approval
  Manufacturing and quality control
  Marketing/Endorsement/Distribution
- Idea-Core (the central product, program, or business idea)
  Device: A number of particular devices were listed. [These are not given here to protect subject confidentiality.]
- People
  Actors: A list of specific actors involved in the case; they are listed by name and also classified into general types (e.g., Associations, Regulators, Firms, Funders, etc.). [This list is not included to protect subject confidentiality.]
- Context-External (to the organization housing the innovation):
  Industry/Technology Development Patterns: Incident types pertaining to the following patterns of technology and industry development:
  Uncertainty: Evidence of uncertainties perceived by innovation participants about action outcomes and technologies.
  Market: Estimates of market size and potential by industry participants.
  Anticipatory retardation (or postponement): Incidents where actors declined or deferred innovation adoption in anticipation of a future improved version.

Upgradability/design continuity: Efforts or incidents to make generations of products, services, or structures compatible with each other.

Creative destruction: Efforts or incidents that made existing products, services, or structures obsolete.

Barriers: Blockage, patent protection, or preemptive tactics used by actors to secure protection or private gains from their developmental or commercial efforts.

Substitutes: Any product or service that acted as a substitute for cochlear implants.

Transfer: Exchange or sharing of information or competence between firms.

- Outcome:
  - Outcome-Positive (good news)
  - Outcome-Negative (bad news)
  - Outcome-Mixed (neutral or mixed good and bad news)
  - Outcome-Date (shfiting schedules)
  - Outcome Criteria shift (change in goals or evaluation benchmarks)
- Action Course (change in direction from prior event on topic):
  - Expand path (add, elaborate, reinforce)
  - Contract path (subtract, reduce, deemphasize)
  - Modify path (revise, shift, correct)
  - Continue path (in current direction)

The categories and subcategories listed here will be used in the example analyses in later chapters.