Two Generic Areas of Methodology for the Application of Cybernetics to Human Science Research

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Abstract

The conduct of scientific inquiry may be described in terms of a general research cycle that consists of several specific feedback loops. Scientific inquiry is a feedforward cycle within the larger context of science, which in turn is embedded within many scientific and societal interests and constraints. These intertwining cybernetic relations provide insight into successively higher orders of cybernetics and the strategies scientists use to pursue their interests.

1 Introduction

Since its formulation and introduction [Ashby, 1963; Wiener, 1961], cybernetics continues to provide a useful perspective and set of theoretical constructs to study and describe a wide range of human phenomena [Buckley, 1968; Checkland and Scholes, 1990; Collen, 1994; Rescher, 1997; Senge, 1990; Smith and Smith, 1966; Trappl, 1990, 1992, 1994]. It is with this persistent interest that the application of cybernetics to scientific inquiry itself would appear to have promise and relevance.

Although scientific method, as a standard and ideal that assists scientists in formalizing ways of doing science, continues to be the methodological point of reference, in practice multiple variations of scientific method occur. When applied to the study of human phenomena, this methodological diversity is especially apparent, and increasingly controversial, as scientists form distinguishable and successive arenas of inquiry, each indicative of a cogent set of paradigmatic assumptions which enables them to pursue their multiplicity of interests [Collen, 1995b; Oliga, 1988]. These arenas may compete, conflict, and evolve [Kuhn, 1977; Miller, 1985], entail various forms of programmatic research [Lakatos and Musgrave, 1970], stimulate isomorphic translation and metaphoric comparison [Bertalanffy, 1975], and suggest bases for methodology construction from compatible combinations among methodological components [Collen, 1994, 1995a].

With the globalization of humanity, the inevitable presence of the human element in all aspects of life on this planet and in all paradigmatic arenas of inquiry is gaining wider acceptance across the sciences, and thereby, providing an unifying undercurrent and more recent reformulation of the phrase "the human sciences," understood here to mean in part the transdisciplinary collaborative study of human phenomena [Collen, 1990, 1995ab]. In this regard, we may reconsider former treatment by Popper of his three worlds of science [Miller, 1985]. As a metadiscipline and the generic field of study of the human sciences, human science research methodology may adopt cybernetics as one approach to the study of its contents (e.g. methods of researching human beings). The implication is that the dynamics of scientific inquiry, viewed as a particular kind of process for the discovery, production, and creation of knowledge, may be described in terms of reciprocal relationships among those entities researchers conceptualize to define their process of inquiry, and that these relationships can be designated feedback and feedforward, and positive and negative, relative to a) the inquiry process, and b) the broader contexts in which inquiry is situated.

The purpose of this paper is to articulate two generic areas in which a representative set of generic cybernetic relationships are inherent in human science research methodology. Although I doubt most scientists bother to explicate the content of this paper for themselves in the course of doing science, they must have some knowledge—in some conceptual form and language equivalent—of the cybernetic relationships in which they are enmeshed, in order to pursue successfully their scientific interests. Nevertheless, for scientists and students of science alike, unquestionably, it is advantageous that these relationships be highlighted, so that we might better understand: a) the nature and dynamics of a scientific study, and b) its place within the larger systemic contexts of science and society.

2 General Research Cycle

Despite numerous renditions [*p. ex* Fox, 1969; Scott and Wertheimer, 1962] which continue to suggest that the conduct of scientific inquiry is a linear process, it is more accurately and pragmatically conceptualized in terms of a general cycle [Collen, 1994; Rescher, 1977; Runkel and McGrath, 1972]. One version of the cycle is shown in Figure 1 with illustrative feedback (←) and feedforward (⇒) loops. The cycle consists of eight general phases. Separations between adjacent phases often are blurred, depending on the variation of scientific method employed. Further, working simultaneously on aspects of various phases often brings into question the generalization of such a prototypical cycle for inquiry. Moreover, the chief point is that the researcher usually has a general idea where in the cycle a specific research project is, regardless of the ambiguity surrounding the project. Finally, the outcome of the cycle, whether a negative or positive (±) feedforward contribution to programmatic research, can only be known from hindsight evaluation.

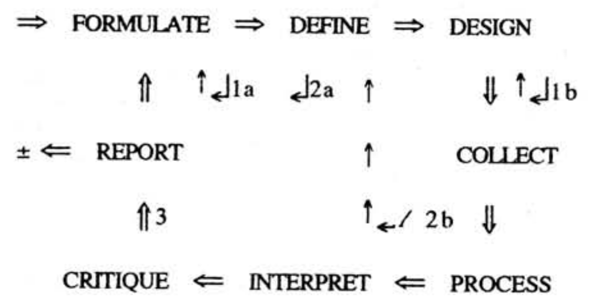

Figure 1. Feedback and Feedforward Loops of the General Research Cycle.

With this general notion of the cycle in mind, it begins when the researcher pushes into the foreground of consciousness a preoccupation with the topic area, problem focus, and research questions. With some formalization to the first phase, the project enters into operationalizing, followed by designing and planning, and the research proposal becomes the more salient task. As the proposal reaches approval and hopefully funding, the emphasis shifts to implementation. Earlier phases drop increasingly into the background of consciousness. As the project proceeds around the cycle, there is a swell from the context of the focal phase to foreground as the previous phase recedes to background.

However, from the cybernetic and systemic points of view, each phase has an important connection with every other phase. Generally, the researcher becomes increasingly aware of these relationships as more experience is gained in doing research, such that work done in any single phase is examined for its impact on all other phases. Also, engagement in any one phase may be informed by drawing upon resources of all other phases. Specifically, we must note a feedback loop between one phase and that immediately before it. Additionally, we must note the other feedback loops from other phases, those recently completed for the current investigation, as well as those completed from previously completed investigations. The confluence of feedback loops contribute to the eventual feedforward progression to the next phase of the cycle.

The loops illustrated in Figure 1 show two kinds of feedback loops and one feedforward loop. Loops 1a and 1b are within-phase feedback. Loops 2a and 2b are between-phase feedback. Loop 3 indicates a feedforward from one phase of the general cycle to the next phase. Of course, all loops are not shown in the figure; those shown are illustrative only. Doing a critical review of the literature (Loop 1a), for example, positions the researcher to make informed decisions in defining constructs and designing the study. Operationalized constructs must be checked against the research question (hypothesis) formulated (Loop 2a). Comparing conditions by means of equivalent groups of participants, repeated observations of the same persons, or both is a design decision (Loop 1b). Asking pilot participants to perform a task that is a crucial part of the study, in order to confirm the clarity of the instructions, is often necessary before collecting data in bulk (Loop 2b). Negative valence indicates impedance and corrective action, where positive valence indicates corroboration and explication. Positive and negative valences may be assigned when applied to describe a specific study.

In summary, the general research cycle may be considered a feedforward loop comprised of between and within phase feedback loops. All loops depicted are of the first cybernetic order.

3 Science Strategy

The feedforward movement of the general research cycle is pursued with the intent not only to bring closure on the research question posed, which prompts and guides the inquiry of the current cycle, but also to position the researcher strategically to formulate the investigation for the next cycle. Consequently, programmatic research may be considered a series of feedforward loops, somewhat vividly pictured as the many links forming a chain. However, this chain itself is expected eventually to form a loop or cycle of a higher order, thereby fulfilling the overarching interest of the researcher through a series of studies addressing a general research question and problem in a topic area. This meta-cycle is a feedforward loop of the second cybernetic order, which has important feedback connections of the second order with the researcher's scientific community. The researcher makes these connections principally through reading published reports of other research teams working on the same problem, participating in professional meetings, conversing via electronic media, visiting and corresponding with colleagues.

Research strategy in science is a primary methodological construct for maximizing the advance of knowledge, theory construction and revision, while using resources prudently. Among several strategies proven successful in the history of science, the researcher usually latches on to one or two for purposes of furthering the research program (chain of investigations). For the purposes of this paper, three such strategies are illustrated in Figures 2, 3, and 4, showing feedback (←) and feedforward (⇒) loops.

Figure 2 depicts the primary cybernetic feedback and feedforward loops of one established general science strategy. From personal observation, previous studies, and published research literature, the scientist generates a hunch or hypothesis concerning the phenomenon. This formulation is expressed formally as a research question, hypothesis, or objective. Regardless of its stated form, let us say, the hypothesis must be tested and rendered worthy of continued research through scientific investigation, typically the experiment.

A PRIORI
OBSERVATION

↑ ↓

± ±

HYPOTHESIS ⇔ KNOWLEDGE ⇔ THEORY

↑ ↓

EXPERIMENTATION

Figure 2. Scientific Research Strategy 1
to Build Knowledge and Theory.

However, it is important to emphasize that there are many human science research methods other than experimental method in use with this strategy, in order to provide sufficient and essential description for theoretical purposes. Repeated confirmations of the hypothesis tend to elevate its stature to knowledge status, which makes it a prime candidate for integration into existing theory. Conversely, current theory may be tested by deducing an hypothesis that should be confirmed by means of experimentation, if the hypothesis follows from the theory and the theory has explanatory value in respect to the phenomena it purportedly explains. Typically, the former more inductive use of the strategy complements the latter more deductive use of the strategy, and as a team these two applications have provided an effective and potent combination for knowledge production and theory building. This strategy is a familiar and tight knit set of cybernetic loops, which feedforward programmatic research, the growth of scientific knowledge, and theory development in the human sciences. The process is ongoing, periodically forcing scientists to reconsider theory (–) by experiment and reformulated hypotheses as well as revising theory (+) in light of the same. An outstanding example of the first strategy is the rise of empirically-based theories of human development and their continued subjection to revision and refutation through scientific investigation.

The second and younger strategy, shown in Figure 3, is separated here artificially from the first strategy. The second strategy draws attention to the careful consideration of influences that may jeopardize the validity of the research project, termed rival hypotheses, which may lead the researcher astray into unwarranted interpretations and explanations of research findings [Campbell, 1988]. This important emphasis of the second strategy I consider a negative feedforward loop, which complements the positive feedforward to construction of theory from a nest of empirically supported causal linkages. It is the scientist's intent to tease out these causal linkages among researcher-defined aspects of the phenomenon under study, guided by the research hypothesis. And should any rival find support, then the researcher may have to accommodate by executing future research more carefully, and if necessary, revise the research hypothesis appropriately. A salient example of the second strategy is the extensive use of experimental method to compare a treatment thought to diminish, even cure, human suffering with other possible "treatments" which might equally well account for the effect.

+

⇒ HYPOTHESES ⇒ EXPERIMENT ⇒ CAUSATION ⇒

↑ ↓ ↓

RESEARCH HYPOTHESIS ⇒ RIVAL HYPOTHESIS ⇒

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Figure 3. Scientific Research Strategy 2
to Make Causal Inferences and Eliminate Rivals.

A single investigation, that is, one movement through the general research cycle, is rarely adeuate to answer the question posed. Cybernetic loops of a higher order must become visible. In present day practice, both Strategies 1 and 2 are mixed together. Working a scientific research strategy appears to be one means researchers have to fulfill their programmatic interests.

Of course, use of these strategies implies the researcher's effective use of methodology. Lest one be left with the impression that experimental method only is scientific method, which is typically the bias, it must be emphasized that the researcher may use a wide variety of human science research methods, and in select combinations, to further the progression of inquiry.

One common progression in human science research is shown in Figure 4. To illustrate, this progression may involve the interface of observational, correlational, and experimental methods for modeling and formal theory building, as much as it can entail combinations of hermeneutical, phenomenological, and constant comparative grounded theory methods for detailed description and a deepened understanding; or combinations of archival, observational, and interview for ethnography; or survey, focus group, and participatory action research for theory-in-use and institutional reform [Collen, 1994].

⇒ EXPLORATORY, DESCRIPTIVE RESEARCH

⇓+ ⇑– ↑↲

EXPLICATIVE, RELATIONAL RESEARCH

⇓+ ⇑– ↑↲

⇐ INTEGRATIVE, EXPLANATORY RESEARCH

↑↲

Figure 4. Scientific Research Strategy 3
Revealing the Productive Use of Methodology.

The cybernetic feedback and feedforward loops shown in Figure 4 are of the second order. After reviewing the published research literature of a specific topic area devoted to the study of a human phenomenon and human problem, this trend toward increasing sophistication and complexity of methodology, causal inference, and putative knowledge readily becomes evident. Exploratory and descriptive research soon give way to more focus on the interrelations among the key constructs. Eventually, explanatory interests supersede to dominate inquiry.

However, this is not to say, that movement from exploratory to relational research, for example, abandons exploratory inquiry, or that a priority given to integration ignores newly discovered interrelationships, for methodology feedback goes on continuously within each level of the progression. And the progression is more expansive, encompassing former phases within latter phases. This more systemic view of embedded phases, which become apparent with positive feedforward, also applies to more complete depictions of all the figures in this paper. In the case of the third strategy, it complements a negative feedforward, for example, when the methodology used for a more advanced phase of the strategy cannot fulfill the aims of the research; the researchers must accept the more modest accomplishment and the temporary regression to the earlier phase in order to reconsider their methodology.

4 Implications for Science and Society

The success of any given project and scientific research strategy depends not only on the careful attention to the many feedback loops constituting the general cycle, but also on the feedback loops which embed the cycle in the larger context. Here, a few examples, among many possible, may serve to illustrate the chief point to be made in this section of the paper.

The general research cycle may be coordinated with funding cycles of the parent institution, local and national government funding agencies. The speed of movement through the research cycle may depend on such matters as proper completion of bureaucratic procedures for the dispersion of funds, the availability of qualified participants, and methodological procedures justifying the termination of data collection. Whether the outcome of an investigation makes a positive contribution to programmatic research is a matter to be judged not only by the researcher, but also by the scientific community and societal agencies in reference to previous research, current theory, ongoing research of others, funding priorities, and contextual relevance. These latter vantage points for scrutiny and judgment are actually feedback loops of the third order that situate the investigation within its science and societal contexts, where the chain of investigations threading together the programmatic research cycle describes a second order cybernetics. Within these two levels of consideration is embedded the current investigation—the most visible activity for the scientist of first order cybernetics. In short, these cybernetic links comprising three orders of complexity accentuate the interdependence of the research process in the investigative, sociocultural, political, and economic contexts.

It is also important to note the implications of cybernetic and systemic relations in regard to the contributions from philosophers of science, who have debated over much of this century on the rise of western science, the growth of scientific knowledge, and the reciprocal symbiotic relation between science and society. Of particular interest here is Popper's articulation of the hierarchical nature and cybernetic ties among the three worlds that preoccupy scientists: 1) physical states, 2) states of consciousness, and 3) problems, problem situations, theories, and critical arguments [Miller, 1985]. These worlds have presence in all applications of the general research cycle and the three science strategies presented in this paper. Furthermore, coupled with advances in technologies, the philosophers of science noted at the start of this paper, namely Kuhn, Lakatos, and Popper, are representative of several who have given us a fuller understanding of science, thereby aiding others to follow with a more critical and informed perspective to map out and apply various science strategies.

The implications of the ordered and reciprocal relationships noted in this paper are to make the scientist, as well as those who work with them, more aware of the human relationships that must work cooperatively and collaboratively for the human sciences to be an effective part of and contributor to society. An intimate knowledge of the cybernetic relationships strengthens the methodological expertise of the scientist to design, plan, and conduct more informed inquiry, which tends to bring more resourceful, efficient, and ethically conscious decision making into scientific research.

5 Conclusion

Although the research cycle may seem more virtual than real, it provides a useful methodological device for conceptualizing the process of inquiry. It also enables researchers to propose, monitor, and report the course of inquiry to the scientific community and funding agencies. Additionally, it is a helpful pedagogical model for training novice researchers, and it offers experienced researchers general guidelines in anticipation of forward movement to closure of a specific research project.

Collectively, the interrelationships described in this paper reveal a first, second, and third order of cybernetic loops. It can become evident to the researcher that phases of the general research cycle are linked into a programmatic cycle, which in turn is linked into science and societal contexts. The cycles are part of a more encompassing systemic perspective that emphasizes implentation of various science strategies to further scientific interests. Cybernetics contributes the dynamic quality to systemics and to our understanding of the nature of the inquiry process, thereby rendering it more comprehensible to those who engage in human science research.

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