BEHAVIORAL SCIENCE AND SYSTEM DYNAMICS: THE PROSPECT OF A SYMBIOSIS

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Summary

The majority of system dynamics models include representations of decisions and actions of people. The standard formulation, since Forrester's heroic assumption, is the "systemstate - perception - decision - action - systemstate" loop together with perception delays and adjustment times. One might call this the "people as discrepancy reducers" formulation. Forrester originally restricted the use of this formulation to organizational behavior, but the applications have since been extended considerably.

Though an improvement over earlier assumptions about people as goal maximizers, the standard formulation is still inadequate, because the models are unable to allow for the effect of the subtlety and complexity of human behavior. Subtleties and complexities that will play increasingly important roles as the general conditions for mankind, at

least in the luxurious west, are said to become more turbulent and much harsher.

The reason for the crude and simplistic incorporation of human behavior in models of social systems is that very little is known about behavior. At least with the confidence and the precision needed to represent an improvement over current formulations. Human behavior is, however, not in principle an "unknowable" subject. Rather, it's examination has been too fragmented, too concerned with details, too normative and too much impressed with the image of human uniqueness to yield usable results.

To improve matters in the behavioral sciences, system dynamics can play the role of a catalyst by providing both the holistic view which is needed to understand the behavior of human beings and not just bits and pieces of their actions and the necessary technical tools to map behavior over into managable models. In return, system dynamicists will learn how to include a more differentiated and thus more realistic representation of human behavior in their models of social systems.

How is human behavior represented in system dynamics models?

If one goes back to the beginning, there was no system dynamics. It was only developed in response to the failure of a Monte Carlo type simulation whose aim had been the design of policies to stabilize profits, production and employment from one of the product lines in the Sprague Electrical Company (1). The research team found it necessary to model the pressures and reactions of people and groups, the information stream that linked them, and the influences of their actions explicitely. It was under those conditions that Forrester postulated the now classical negative loop linking systemstate through perception, decision, and action, back to systemstate. The origin of the formulation can therefore be attributed to the direct observation of managerial behavior. This represented a radical departure from microeconomic theory, the heretofore dominant representation of behavior, which had consistently thought of people as economic maximizers.

One finds theoretical support for Forrester's formulation in the work of Festinger (2), who at about the same time published his theory of cognitive dissonance, although I doubt that Forrester and Festinger were aware of each other's work. Festinger postulated that people, not just managers, will always engage in behavior aimed at reducing any discrepancy between reality and their value system. Festinger further argued that people are

more likely to change their values then reality. System dynamicists are, in contrast, much more fond of having people change reality in the face of fixed goals such as the desired inventory, the desired backlog, the desired level of liquid assets or any number of desired system states.

When the applications of system dynamics spread from industrial problems to urban, global, corporate, public, regulatory, biological, and just about any other question, the standard behavior formulation followed into all those areas unquestioned and untested. Therefore, one has today a situation where people are represented as discrepancy reducers not after careful evaluation of reality but simply as a matter of course.

Is the standard system dynamics formulation of behavior adequate?

Despite it's theoretical connection to Festinger's dissonance theory, the standard behavior formulation has not much more of a claim to validity than any of it's competitors. Both the system dynamic and the microeconomic view of human behavior (as did the religious, feudal, or marxist view before) rest on sweeping assumptions which mainly through their simplicity appear to have some validity, but are not more then working hypotheses in need of corroboration and improvement. All simplistic views of behavior have a certain appeal for some time precisely because their heroic simplicity make them powerful tools of analysis. One tends to forget rather quickly that they, at best, are only proxy variables for human behavior which one does not understand.

Reality is, in fact, people observing, participating, deciding, contemplating, acting, manipulating, investigating, distorting, lobbying, and much more. The microeconomist believes that all that can be summarized by saying that people behave as if they tried to maximize a goal. System dynamicists believe, at least equally strongly, that people behave as if they tried to reduce discrepancies. Initally one tends to be aware of the words "as if". Later on, however, it becomes a truism that people maximize goals or reduce discrepancies.

The consequence is that economists, for example, quite seriously calculate the payback-time of energy conservation measures in the private housing sector (3). They unwittingly fall prey to the error of assigning a causative role to a mere descriptor of behavior. People do not conserve energy if and only if certain payback criteria are met. Rather, they may choose for whatever reason to renew the windows in their house. If the analyst then chooses to look at that action as if it were an energy conservation measure alone, then a certain payback-

time may be calculated. One must keep in mind, though, that this is merely a post-facto descriptor, and not a predictor of behavior in the future or under different conditions.

System dynamicists are similarly fond of searching for data that gives clues about peoples adjustment- and perception times. Again, people do not have or develop such times as part of their personality make-up. Only when their behavior is interpreted through the system dynamics paradigm do such descriptors appear.

The uncritical use of the idea of people as discrepancy reducers carries with it considerable risks. A careful examination of the conditions that have to be met is usually not done. Results from such models can be no more convincing then extending projections from regression analyses past their base data. In one as well as the other case are implicit assumptions about the continued validity of some model aspect made that may, but equally well may not, hold true.

It may well be that one of the contributing factors to the continued and much lamented (4) credibility problems that system dynamics after more 20 years still has, can be found in the crude representation of behavior. An inadequate incorporation makes it necessary to shield the results from close scrutiny. System dynamicists, routinely extoll the virtues of the long-term, the average, and the qualitative aspects of their work. Unfortunately, model clients still look for short-term, detailed, and numerical answers. Answers that system dynamics cannot provide until a more differentiated appreciation of human behavior is reflected in more sophisticated model formulations.

Can the standard behavior formulation be relied upon to become more adequate on it's own?

There are three ways that the representation of human behavior could improve. First, a new brilliant insight could provide a quantum improvement, similar to Forrester's original giant step. Second, the simuland, the social systems that system dynamicists tend preferably to deal with, may change in a way that the original formulation as it stands today becomes more adequate or adequate more often. Third, one could embark on a concientious effort of gradual but continous improvement.

The first way is, of course, not subject to analysis or projection. The widespread complacency about the problems with the current formulation does not, however, create an environment in which such a step would be appreciated. One should therefore welcome brilliant

insights when they happen, but not rely on them.

As for the second way, there are indications that the simuland will change, but unfortunately not in the right direction. Many predict instead that the future will be more difficult and less orderly than the past. Both Forrester arguing from his national model and Meadows arguing from his resource depletion models predict that the general conditions under which decisions have to be made will become worse. In times of crises, or even just difficulties, however, people's decisions and actions become more diverse, more irrational and more concerned with the short-term. Averages in times of crises are more meaningless then usual. Concern for the survival of the human race over the next 200 years vanishes when one's own well-being is at stake. And driving forces that cannot be explained by appealing to economic, or, for that matter, any other, rationality gain in importance.

The last possibility seems to hold the most promise. System dynamics is a modest methodology since it does not claim to reflect "the truth", but only wants to be judged on it's claim of being better then the rest (admittedly for well defined problems only). This philosophy would seem to favor a search for improvement in the basic building blocks of itself. This is unfortunately not routinely the case. As long as system dynamicists spend more time advising people how to use their models then on making models that people can use, special efforts have to be undertaken to lead to an improvement.

If system dynamics wants to retain (or gain) an edge over other tools of inquiry it must evolve quickly to take account of changes in the simuland. For it is reality that ought to define the domain of a model and not vice versa.

Why is there no better representation of human behavior in formal models?

Unfortunately, the problem is larger than merely adopting more adequate representations from the behavioral scientists, because they do not have much of a clue to human behavior either. Only because so little is known with any degree of confidence could simplistic views gain such extensive and uncritical acceptance. There simply was nothing better. The choice has so far been between this crude and wrong view on one hand and nothing on the other. It has never been between the crude and the elegant.

The lack of knowledge about human behavior can be attributed to three main causes. First of all, there is the image of the uniqueness of human beings which has hindered a thorough scientific analysis of human behavior. Second,

when confronted by an admittedly complex object, research activity has become extremely fragmented. Today there are physiologists, neurophysiologists, physicians, psychopharmacologists, psychiatrists, psychologists (of all the different schools), sociologists, criminologists, and anthropologists (plus some professions I forgot to mention) involved in the study of human behavior. It is not surprising that the niche carved out by each one has come to be rather small. Third, communication between them has not been able to compensate for the lack of vision in each single discipline. Though multidisciplinary symposia are arranged with increasing frequency, participants often talk past each other because there is no common language, no shared research paradigm, and no common forum in which the relative merits of each contribution could be assesed.

The Prospect of a Symbiosis

The dilemma for the behavioral sciences is that they have no organizational framework at a time when there is an immense number of little bits of information. This situation is analogous to the one in the traditional management sciences where, in Forrester's words, "we are flooded and overwhelmed with information" and suffer "from lack of organizing principles for the structuring of information" (5). But in traditional management as in the behavioral sciences, system dynamics can provide a way out of the dilemma. One can, for a specific purpose, select the relevant information about the problem from all the disciplines, arrange it in a set of feedback loops and gain a more complete understanding of behavior then through the study of any one single discipline.

This process is made especially simple by the appreciation of the central role of feedback in the biological and behavioral sciences. The concept of homeostasis has in fact been originally developed by a physiologist (6) and by neurologists (7) in the 1930's.

Initial system dynamics work in the behavioral sciences has already been undertaken (8,9). In a study of the pathogenesis of alcoholism, done by my collegues and myself, we found, for example, that the economic cost of alcohol plays a highly variable role across the spectrum of users and the development of the disease. A finding that is crucial, but so far consistently ignored, for social models for the prevention and reduction of alcohol abuse. There the connection between price or income and consumption is made without regard to an alcohol user profile, much less an alcohol abuser profile. Not surprisingly, projections of the effect of a change in price policy based on such models are notoriously wrong.

We also found that alcohol consumption, which initially reduces perceived stress, which is one of the goals of the system, undermines at the same time the person's later ability to do so. Therefore, the behavior is actually discrepancy amplifying, rather than discrepancy reducing.

Backus (9) has found that repeated identical discrepancies do not lead to behavior that reduces them, but leads to expectations of their continued appearance. This process is of course more commonly known as learning and in the context of this paper it is of the utmost importance to note that learning is not an act of discrepancy reduction. System dynamics models that model human behavior as discrepancy reducing do therefore not allow for "learning" to take place. This is forcefully demonstrated in an experiment by Bossel and Strobel (10) where they added rudimentary cognitive processes and changing normative criteria to the World2 model and were able to improve the performance of the global system considerably.

These examples are only anecdotes, and as such have no statistical significance. Still, they illustrate the symbiotic relationship between behavioral models and modeling behavior. Much more work, many more resources, and much more commitment is needed, however, before this relationship will yield its full rewards. The prospect, at best, is that such work will significantly improve one's understanding of human behavior under a wide variety of conditions. In return, one can then include the "human factor" more realistically into models of social systems rather then rely on brilliant, but untested and unpredictable quantum leaps in the understanding of human beings.

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