Some Thoughts at the Boundaries of Classical System Dynamics: Structuration and Wholism

Peter M. Senge

May 26, 1998

All methods of social inquiry and change have strengths and limits. In some ways, we only understand the strengths when we appreciate the limits.

David Kantor, a leading systems family therapist, has argued that "boundary profile" inquiries are among the most difficult and most important in the evolution of methodologies for understanding complex human systems. By more sharply demarking the edges of one approach's usefulness, we avoid misapplication. We also lay a foundation for the more effective extension of the method, and for integration and synthesis of multiple approaches.

Much of my work for the past 20 years has focused on identifying such boundaries in classical system dynamics and exploring possible complementarities with other approaches. For example, system dynamics lacks any theory of the processes whereby management teams might effectively inquire about complex, conflictual issues -- such as those illuminated by good system dynamics modeling. This led many of us to explore approaches to collaborative inquiry, like that developed by Chris Argyris and his colleagues (e.g., Argyris et. al. 1985), and Schein's process consultation (Schein 1987). Today, many recognize the importance of disciplines of reflection and inquiry such as "working with mental models" and "dialogue" as natural counterparts to system dynamics (e.g., Senge 1990, Senge et.al. 1994, Isaacs 1994).

This article briefly considers briefly two quite different boundary profile alternatives to classical system dynamics: (1) "structuration" and related views, which suggest processes for how the structure of social systems arises and (2) "wholism," which illuminates the "enfolded" nature of reality, the whole present in all parts. Both have potentially important implications for how the system dynamics approach might evolve.

Structuration

Classical system dynamics looks at the effects of structure on behavior, the way that operating policies interact with material stocks and flows to produce observable patterns of change. But, system dynamics says little about the genesis of the operating policies.

Structuration theory, as originally proposed by Anthony Giddens (Giddens 1982, 1984) argues that people, collectively, enact underlying structures into existence

through their daily practices. "...man actively shapes the world he lives in at the same time that it shapes him." (Giddens 1982) In so doing, Giddens bridges the polarization in sociology between "subjectivist" and "objectivist" views, the former emphasizing human interpretations and the later emphasizing institutional factors and forces. Giddens suggests that both views are valid, and in fact are interdependent. He proposes a *duality of structure*, by which "the structure or institutional properties of social systems are created by human actions, and then serve to shape future human actions." (Orlikowski and Robey 1991)

System dynamicists can find much in common with Giddens' integrative perspective. First, of course, is the emphasis on the importance of structure. Second is the emphasis on the part played by human actors in any social structure. "Structure cannot exist apart from the human actors who enact or interpret its dimensions," (Orlikowski and Robey, p 147). Could not the same statement be said about "operating policies," the traditional term in system dynamics for the ways that human decision makers transform information into action? A critical feature of the system dynamics perspective is the view that these operating policies are an essential element of all social systems. In other words, human decision makers are an element <u>of</u> the system, not just something operated on by the system. Third is the integration of the micro and the macro, a long-time goal in system dynamics studies seeking to explain how "macro-behavior arises from micro-level decision making" (e.g., Forrester 1980). By showing how human actors shape as well as are shaped by social structures, structuration necessarily "integrates multiple levels of analysis" (Orlikowski and Robey, p. 149) Last is the transparency of structure to most human actors: "Actors often believe they act freely within organizations, and hence structural properties remain unacknowledged as the conditions for their actions." (Orlikowski and Robey, p 149) Moreover, because we are largely blind to structural forces shaping our behavior we are equally blind to how we are creating or reinforcing those structures.

This emphasis on both how human actors both create and are influenced by structure in social systems is Giddens' most important point for system dynamicists to consider. Giddens emphasizes "three modalities" of the joint creating and functioning of social structure: the interpretative, resources (or productive), and the normative. He sees all three operating in all settings, interacting with one another.

The interpretative modality revolves around interpretative schemes, which "... form the core of mutual knowledge whereby an accountable universe of meaning is sustained through and in the process of interaction." (Giddens 1979, p. 83). This is the domain of mental models. The importance of mental models has long been acknowledged in system dynamics. In <u>Industrial Dynamics</u>,

Forrester recognized the importance of the "mental models... of skilled managers," and saw these as shaping the guiding or operating policies governing decision making: "Most of the guiding policy is informal... It depends on habit, conformity, social pressures, ingrained concepts of goals, awareness of power centers within the organization, and personal interests." (Forrester 1961, p 116, 97) But structuration theory draws attention to how mental models are shaped as well as how they in turn shape decision making. Through their interaction, as well as their decision making, human beings are continually recreating or reinforcing their interpretative schemes, while at the same time being influenced by them. This does not mean that the interpretative schemes are entirely plastic, shaped anew in each moment. On the contrary, interpretative schemes are " stocks of knowledge that human beings draw on..." according to Orlikowski and Robey (1991, p. 149), manifestations of the underlying "structure of signification," in Giddens terms. In system dynamics terminology, we could say that the interpretative schemes are system stocks, continually shaping decisions and, in turn, being reinforced or altered by our decision making.

The resources modality and the normative modality operate in similar ways. The former concerns how people "accomplish outcomes" and the resources they utilize in accomplishing outcomes.[1] This is where what Giddens calls "power" comes into play, by which is meant the "transformative capacity" whereby humans "transform the social and material world." (Roberts and Scapens 1985, p. 449) In so doing, they both employ resources and generate resources. Similarly, system dynamics focuses on the material (e.g., energy and material inputs to production, productive capital, labor, cash) and non material resources (e.g., goodwill, knowledge based on experience, product quality reputation, etc.) But Gidden's resource modality of structuration also emphasizes the asymmetry of resource distribution and the ways that people either reinforce or alter that asymmetry (what he calls the "structure of domination"). The normative modality concerns the norms and the underlying "structure of legitimation." Once again, system dynamics recognizes the role played by norms in decision making but pays less attention to how norms are reinforced or altered through people's actions over time.

---

[1] Giddens actually uses the term"resources modality" rather than productive modality. I have changed the terminology because resources are the stocks that are both created and drawn upon in productive activities. Giddens also identifies this as the defines power as "transformative capacity." For him it has to do with the ability to command resources, tangible and intangible, to produce change in the "social and material" world. I have used the term productive instead of power, because the later is often interpreted too narrowly as political power.

From a system dynamics perspective, structuration can be seen as an expansion of the "boundary" of traditional system dynamics analyses. Interpretative schemes, norms, and traditional distributions of resources have in effect been "inputs" to system dynamics models. Structuration theory suggests that they should themselves by seen as part of the feedback processes in human organizations.

Wholism

System dynamics, along with other approaches to system analysis, focus on interrelationships. Such approaches are "extensive" insofar as they *extend* our awareness to focus on feedback interactions beyond the normal frame of the actors in a system. By contrast, wholism looks "intensively," to discover the deep, implicate patterns that give rise to the diversity of manifest systems.

Wholism has a long history in philosophy and science, but it constituted a minority view over the past 300 years. This may be starting to change with new views emerging from quantum theory in the past 30 years. Curiously, they are leading back to sensibility that is far older than the atomistic, mechanistic world view that has dominated the scientific-industrial age.

The essence of wholism can be understood starting with the paradoxical statement, "The whole is in each of its parts." The hologram illustrates this principle because information about the whole of the image represented by a hologram is contained in each of its parts, no matter how finely they are divided. A hologram is created by the interference pattern on a photographic plate of reflected light from an object illuminated by a light source (traditionally a highly coherent light source like a laser) and the light source itself. The reconstructed object appears visually to be fully three dimensional. But what is especially interesting and counter to our everyday experience with photographs, if the photographic plate upon which a holographic reconstruction appears is broken, and each broken fragment is illuminated by the laser, it shows the entire original object. There is nothing missing, although the image is blurrier.

But, in fact, we don't need the technical apparatus of lasers and holograms to experience the core principle of wholism. Consider walking out under a beautiful star-filled night sky. As you look up, you see the entire sky. But how is this possible? The opening of the pupil is less than a centimeter. This must mean that the entirety of the sky is present in the light passing through a space less than a centimeter in diameter, or for that matter no larger than a millimeter, or for that matter no larger than ... Moreover, the same is true of every centimeter, or millimeter, of space. For the night sky does not appear for only one fortunate observer, but for every one. As the physicist David Bohm expressed it, the entirety of the sky is *enfolded* in every element. (Bohm,1980) Or, as philosopher of science Henri Bortoff puts it, "here is everywhere and

everywhere is here. The night sky is a 'space' which is one whole, enfolded in an infinite number of points and yet including all within itself." (Bortoff 1996, p. 5) [2]

Now, to say, "Here is everywhere and everywhere is here," is for most of us simultaneously a strange and yet wholly sensible statement. We all understand the everyday nature of viewing the night sky. Likewise, we all have many everyday experiences which, upon reflection, reveal many more examples of the enfolded nature of reality -- are not our experiences of sound and smell similar to sight in this regard ? Yet there is something profoundly strange to most of us to think of all the night sky as existing in any element of it. This strangeness reflects our conditioning to think in terms of a Newtonian universe made up of separate objects.

Yet, even the world of objects itself may be more enfolded than we realize. Here our everyday sense experiences may deceive. Touch and taste appear to be "localized" phenomenon, bringing us sensory data about what is immediately in contact with our finger or tongue. These immediate objects, we have been taught to think, are separate phenomena, existing independent of one another, a table surface upon which my hand rests or piece of carrot in my mouth. Yet, the "strange" world of modern physics suggests that such separateness may be illusory. Matter itself, on both macroscopic and microscopic levels, appears to have similar holistic properties. For example, we have been taught to think of mass as a property of separate objects, which objects in turn interact with one another -- such as being attracted to one another through the force of "gravity." But, as Bortoff points out, modern physics suggests a very different viewpoint, that mass " is not an intrinsic property of a body, but it is in fact a reflection of the whole of the rest of the universe in that body. Einstein... imagined that a single particle of matter would have no mass if it were not for all the rest of the matter in the universe." (Bortoff, p. 6)

Again, the strangeness of such statements reflects our conditioned thinking not our direct experience. This is why the practice of wholism requires a serious discipline sufficient to de-condition habitual ways of thinking. One such serious practitioner was Goethe. Famous as a literary figure, Goethe actually regarded his scientific work as more important than his novels, stories, and poetry. Evidence suggests he spent more of his time as a scientist than as a writer. But most of his scientific writing was dismissed by the 18th century scientific community because it differed so radically from the dominant Newtonian paradigm. One reason, was that he believed that coming to

---

[2] Just as the hologram becomes less distinct as the "pieces" get smaller, so too does the night sky become less distinct as the aperature through which the light "carrying" its images gets smaller; a telescope increases magnification, in part, because it captures more light (technically, more information) through a larger aperature.

understand the wholism of a phenomenon required a cultivation of the scientist's capacity to *see* that was very different than the analytic skills considered the essence of good science.

The mainstream science of Goethe's time, and still to a large extent today, advocates a distant, dispassionate stance of the scientist relative to the phenomenon being studied. Ultimately, in this scientific paradigm success was gauged by the extent to which the phenomenon could be replaced by a mathematical representation, which "illustrates," as Bortoff puts it, "the extraordinary degree to which science stands outside of the phenomenon." By contrast, Goethe's "worked to achieve an authentic wholeness by *dwelling in the phenomenon* instead of replacing it with a mathematical representation... Goethe's method was to extend and deepen his experience of the phenomenon until he reached that element of the phenomenon which is not given externally to sense experience."(Bortoff, 1996, 20,22)

For example, one area in which he concentrated his attention was plants. In Venice, he found a "coltsfoot," a plant he had studied in many locations over many years. But this plant was very different than the ones he had studied in Weimar, and in turn very different from ones he had seen in the Alps -- it had spikes, leatherlike leaves and a fat stem. What he "saw", however, was not just another of many variations of a common plant. Rather, he saw "One plant which is many," the archetypal plant which continually manifests itself in countless unique forms. In this awareness, the unity of all manifestations of the plant was apparent to him, not as an abstract concept but as a direct experience -- just like the experience of the entire night sky in each place. Goethe eventually came to see this as the generative dynamic of life: "The One plant ... manifests in each single one -- it manifests wholly in each but not completely. It is inherently dynamic and consequently ever unfinished... It is only by becoming other that it remains itself."(Bortoff, 263)

Reflecting on the development in himself that led to this awareness, he wrote in 1786: "It is a growing aware of the Form with which again and again nature plays, and in playing, brings forth manifold life."(Bortoff, p. 265)
Goethe's sensibility toward wholesness cannot "be reached by a process of intellectual thought," writes Bortoff, but by a cultivation of "intuition" -- etymologically, literally "seeing into." In this sense, Goethe reinvigorated another very old idea core to science, theory -- which derives from the Greek *theoria*" which simple means "seeing." As Cassirer put it, "The mathematical formula strives to make the phenomena calculable, that of Goethe to make them visible."

Implications: Towards a more Generative System Dynamics

At this stage, it is impossible to offer more than some very preliminary speculations about the possible implications of structuration and wholism for the theory and practice of system dynamics. But there are some interesting possibilities about which to conjecture.

For system dynamics, structuration theory:

1. directs our attention to how actions reinforce or alter norms, interpretative schemes, and distributions of resources, all of which become critical elements in operating policies;

2. suggests that shifts in norms, interpretative schemes, and resources distributions may be critical to alter operating policies; and

3. implies that such shifts can only arise through new actions, not based on espoused views or intellectual understanding: human beings enact their way into new structures, just as current structures were shaped by historical actions.

Wholism is less exclusively focused on social realities, so its implications are more broad. For system dynamics applications to social systems, wholism raises some unique questions. In particular, wholism

1. illuminates the "enfolded nature" of manifest reality, the presence of "the whole in each part:"

   To what extent are social realities holographic in this sense: might deep system-wide patterns of thought and action manifest locally and might it be possible to illuminate these system-wide phenomenon through understanding their local manifestation ? Does this offer an alternative strategy for system dynamics models aimed at understanding large scale phenomenon (e.g., understanding company-wide issues through studying their manifestation within individual teams?

   Might this offer another way of thinking about the origins of generic structures, especially those recurring structural patterns that arise across diverse social settings?

2. suggests that analytic understanding is limited and must be complemented by deep intuitive appreciation to grasp the process of the universal becoming particular, what David Bohm called the "unfolding of an implicate order:"

   What is the role of intuition in the type of understanding that system dynamics fosters?

Are system dynamics theories abstract statements that "stand outside of the phenomenon" they purport to explain or is system dynamics a way to "see into" these phenomenon ?

3. concludes that the ability to "see" reality is inseparable form the cultivation of intuition beyond analytic skills.

What are the implications for the training of competent system dynamicists, whose training has traditionally concentrated on conceptual and analytic skills, rather than the cultivation of intuition and empathy ?

Taken together, structuration and wholism offer intellectually rich and provocative perspectives which could significantly enhance system dynamics theory and practice. Both are challenging to understand. The fact that each has emerged from distinct academic traditions, primarily sociology on the one hand and physics and biology in the other, heightens the challenge. But, there are also potentially significant areas of overlap and complementarity.

In the spirit of provocative speculation, let me suggest how a few of these complementarities might lead to a more generative system dynamics. To do so, let me take an example drawn from a multi--year project conducted at the former MIT Center for Organizational Learning, now the Society for Organizational Learning (SoL) (Roth and Kleiner, 1996).

"We eventually got all of this into a complex chart (causal loop diagram). We all understood the whole system as it related to us, and we had all contributed to this map. The map became critical..." (Roth and Kleiner, p. 13) The speaker was the program manager for a large car development team of about a thousand engineers. The particular causal diagram identified multiple feedback processes for correcting "parts behind schedule" as a team approached a prototype build. Timing on these builds was crucial in order to keep the overall car on schedule; yet less than 50% parts were available on schedule at key prototype builds in the company. The program manager's senior engineering team realized through their "map" that no corrective actions could be taken until problems were reported but "...before the 'reporting of lateness,' there's usually a delay.... We all saw the same picture and we all came to the same conclusion. This (delay) was a leverage point for us."

This discovery of how their own system worked to ensure that parts would be late was revelatory, not just conceptually but because of the meaning it had for the Program managers' senior team. As the Program Manager put it, "The reason for the delay is: people are afraid to be criticized. There is a basic cultural commandment in engineering -- don't tell someone you have a problem unless

you have the solution... that delay automatically compounds delays in other loops going on through the system."(Roth and Kleiner, p. 13-14)

This new awareness, along with many other developments in the team, led to a host of new actions by many people aimed, in the Program Managers' words at "... improving the communication process, improving honesty, and improving trust." (Roth and Kleiner, 13-14) The changes were gradual but eventually significant. Several months later, a content leader commented, "If people know they're not going to get punished (for taking risks) they'll try harder. We had all kinds of ideas coming out of the woodwork. . engineers (on other projects) don't generate ideas like that; they wait for you to tell them what to do, so if it screws up they can say it wasn't their idea." (Roth and Kleiner, p. 18) A vehicle development engineer commented, "Some of the appeal (of the team) may have to do with the word 'failure.' If you stumbled it wasn't perceived as a failure." (Roth and Kleiner, p.21) The eventual results achieved by the team were equally striking: the team achieved 85% parts on time at its subsequent prototype build 8 months later, roughly twice the company average and 50% better than any previous car development team.

The outcomes achieved by this team are impossible to explain in a traditional analytic, normal science perspective. However, they are more explicable when one considers the tenants of wholism and structuration. The map was powerful because of the depth of meaning it evoked; and meaning, as Bortoff points out, is not the result of analysis but of "seeing into." The ensuing change process was no normal "implementation" of a new plan. Countless actions were taken, but they were not part of a coordinated plan. Rather, they arose out of a coordinating awareness. Many team acting in spontaneous yet aligned ways enacted new interpretative (and perhaps normative) structures. The eventual results achieved by the team suggest that these structures were real and eventually shaped new resource structures leading to new power or capability.

Is it possible that the wholistic way of understanding illustrated by Goethe captures the generative capability of system dynamics? Many system dynamics practitioners have experienced the "ah ah" of this type of insight. It has been my experience that when a group of people discover for themselves how their <u>own</u> actions are generating major problems they are experiencing (and usually attributing to forces outside their control), the experience can be genuinely powerful. As with the engineering team above, they invariably say "Look at what we are doing to ourselves." Moreover, seeing how they created a systemic structure that is shaping their reality is a powerful force for creating new actions and new structures.

Yet, this represents a very different view of system dynamics practice. The implicit theory of practice in classical system dynamics is technocratic: expert

system dynamics analysts gather data through interviews and observation, develop system dynamics models, and then recommend solutions to "policy makers" based on their analysis of the models. In recent years, new practice theories have emerged in system dynamics, emphasizing "the process of model building" (Richmond 1987), "managerial microworlds" (Morecroft 1988), and "group model building" (Richardson and Anderson 1994) Still, the nature of the understanding produced by system dynamics in the process still tends to be seen as analytic. And there is little explicit theory of how insight eventually leads to change in the structures that are producing current problems. I believe wholism and structuration might contribute significantly in these areas: wholism by clarifying the nature of the insight that successful system dynamics enables, and structuration by illuminating the nature of the processes that can lead to structural change.

These ideas are tentative and offered in the hope of sparking reflection, debate and further inquiry. Obviously, any real impact of structuration and wholism on system dynamics will be a long-term process. As substantial as the potential may be, so too will be the effort. Hopefully, at least, I have succeeded in sparking some curiosity about these two fascinating areas and that the above example has at least suggested the practical consequences.

Taking structuration and wholism seriously, would, at least, bring to the fore two questions which I believe have received too little attention in classical system dynamics-- namely, "How do human systems can evolve?" and "What is our theory of change?"

References

Argyris, C., B. Putnam, and D. Smith, Action Science, San Francisco: Jossey-Bass 1985.

Bohm, D., Wholeness and the Implicate Order, New York: Routledge, 1980
Bortoff, H., The Wholeness of Nature, Hudson, New York: Lindesfarne Press, 1996

Forrester, J.W., "Information Sources for Modeling the National Economy," in Journal of American Statistical Association, 75:371, 555-574, 1980.

Giddens, A., Central Problems in Social Theory: Action, Structure, and Contradiction in Social Analysis, University of California Press, Berkeley, Calif., 1979.

Giddens, A, Profiles and Critiques in Social Theory, Berkeley, Calif: University of California Press, 1982.

Giddens, A, The Constitution of Sciety: Outline of the Theory of Structure, Berkeley, Calif: University of California Press, 1984.

Isaacs, W., "Taking Flight: Dialogue, Colectibve Thinking, and Organizational Learning," Organization Dynamics, 1994, 24-39.

Morecroft, J.D.W., "System Dynamics and Microworlds for Policymakers," European Journal of Operational Research, 35, 1988, 301-320.

Orlikowski, W., and D. Robey, "Information Technology and the Structuring of Organizations," Information Systems Research, 2:2, 1991, 143-169.

Richardson, G.P. and D. Anderson, "Teamwork in Group Model Building," System Dynamics Review, 11:2, 1994, 113-137.

Richmond, B., "The Strategic Forum," High Performance Systems, Hanover New Hampshire, 1987.

Roberts,J. and R. Scapens, "Accounting Systems and Systems of Accountability: Understanding Accounting Practices in their Organizational Context, Accounting, Organizations, and Society, 10:4, 1985, 443-456.

Roth and Kleiner, "The Learning Initiative at the Auto Co Epsilon Program , 1991-1994," Society for Organizational Learning Learning History, 1996 (webpage: www.SoL-NE.org)

Schein, E., Process Consultation II, Reading, Mass: Addison-Wesley, 1987

Senge, P. The Fifth Discipline, New York: Doubleday/Currency, 1990

Senge, P., A. Kleiner, C. Roberts, R. Ross, B. Smith, The Fifth Discipline Fieldbook, New York: Doubleday/Currency, 1994.