Implications of complex adaptive systems theory for interpreting research about health care organizations

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Abstract

Rationale—Data about health care organizations (HCOs) is not useful until it is interpreted. Such interpretations are influenced by the theoretical lenses employed by the researcher.

Objective—Our purpose is to suggest the usefulness of theories of complex adaptive systems (CASs) in guiding research interpretation. Specifically, we address two questions. (1) What are the implications for interpreting research observations in HCOs of the fact that we are observing relationships among diverse agents? (2) What are the implications for interpreting research observations in HCOs of the fact that we are observing relationships among agents that learn?

Method—We define diversity and learning and the implications of the nonlinear relationships among agents from a CAS perspective. We then identify some common analytical practices that are problematic and may lead to conceptual and methodological errors. Then we describe strategies for interpreting the results of research observations.

Conclusions—We suggest that the task of interpreting research observations of HCOs could be improved if researchers take into account that the systems they study are CAS with nonlinear relationships among diverse, learning agents. Our analysis points out how interpretation of research results might be shaped by the fact that HCOs are CASs. We describe how learning is, in fact, the result of interactions among diverse agents and that learning can, by itself, reduce or increase agent diversity. We encourage researchers to be persistent in their attempts to reason about complex systems, and learn to attend not only to structures, but also to processes and functions of complex systems.

Data about health care organizations (HCOs) is not useful until it is interpreted. Theoretical lenses shape researcher interpretations. Recognizing that HCOs are complex adaptive systems (CASs) should prompt researchers to interpret results of research in HCOs in light of the fact that understanding the nonlinear relationships among diverse, learning agents is a key to understanding CASs. We build on the recent analysis of how research design may be shaped with knowledge that HCOs are CASs.(1) We address the following questions:

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- What are the implications for interpreting research observations in HCOs of the fact that we are observing relationships among diverse agents?

- What are the implications for interpreting research observations in HCOs of the fact that we are observing relationships among agents that learn?

We define diversity and discuss some common analytical practices that are problematic and may lead to conceptual, developmental, and methodological errors. We then suggest strategies for interpreting the results of research observations given that we are observing relationships among diverse agents. We then do the same for learning. This analysis is presented to help researchers consider how their interpretation of research results might be shaped by the fact that HCOs are CASs.

What are the implications of the fact that we are observing relationships among diverse agents?

CASs are made up of agents that are meaningfully different from one another on important dimensions and that relate to each other in nonlinear ways.(2) Diverse agents encountering disturbances in a complex environment are able to generate a variety of creative and flexible responses through their relationships, thus increasing the resilience and robustness of the CAS.(3) In HCOs, diversity exists in multiple forms and at several levels. Not only are agents diverse from one another across roles, agents within the same role are diverse. This diversity is necessary for quality relationships to be enacted, and plays out in how agents relate to each other, how they perceive the world and events, and how they solve problems. (4)

Problematic common analytic practices—diversity of agents

In their efforts to simplify models, researchers commonly use analytic strategies that obscure diversity among agents. One strategy for simplifying is to group agents together based on apparent similarities, for example, clustering all RNs in one category, "nurse." Such a grouping can lead to misunderstanding of the nature, roles and effects of nurses' behaviors. Similarly, researchers simplify models by over-relying on averages to represent system attributes. Scientists understand that statistics such as the mean and standard deviation of attributes in a population can be misleading, yet we commonly overestimate what we know about a system from statistical averages. Additionally, it is easy to lose track of the fact that the same average can be computed from very different distributions. For example, the average age of the nurses in two hospitals may be similar even when the distribution of the age of the nurses may be so different that the organizations look completely different in terms of age diversity among nurses. One is likely to find that fundamental relationships such as relationships between nurses and physicians or patients may be markedly different in each of these HCOs. Therefore, knowing something from an observation of relationships of the "average" nurse to the "average" physician may not be helpful in understanding either HCO. Even when we recognize variance around an average it is often viewed as deviation from what is common, usual, or typical and is counted as "error" in many statistical models.

Because of their familiarity with well developed Gaussian-based analytical tools, health care researchers often assume that the distribution of variables in a population is nearly normal. But CASs, with their nonlinear interdependencies, typically have many variables that are not normally distributed. Over-generalizing from Gaussian models can bias health care researchers toward favoring similarity above diversity and mislead by potentially obscuring important aspects of diversity in HCOs. This can lead to misinterpreting important aspects of relationships between diverse agents.

Strategies for interpreting data about relationships among diverse agents

Health care researchers taking a CAS perspective on HCO should make an effort to recognize the diversity within the HCO they are studying and to label that diversity in a number of ways. This will lead to seeing the relationships among agents in a richer manner. Researchers should develop strategies for sensitizing themselves to the differences among members of HCO, fostering appreciation for variety, discouraging overgeneralization, and re-conceptualizing the functions and effects of diversity among agents in HCO.

One strategy for incorporating agent diversity when analyzing and interpreting data from HCOs is to pay attention to the ways in which we group agents and to try grouping agents together in a variety of ways. By grouping individuals into both fine- and course-grained clusters, we may come to recognize diversity in agents on a variety of dimensions. We may also see how the relationships among agents vary as we group agents in different ways on a variety of dimensions. This has the potential for uncovering new insights about how work gets done, problems get solved and an HCO copes with its environment.

Health care researchers should pay attention to results that reveal differences because this may help to identify parameters that really matter—a difficult task.(5) The characteristics of HCO that we at first thought were most critical may not turn out to be the most critical. Thus, we need to give ourselves more options as we interpret data instead of always trying to determine the critical variables up front. Instead of computing only the average age of clinic members in an organization, attend also to the differences in their ages, educational backgrounds, and other variables of possible interest.

CAS theory calls our attention to how the uncommon, unusual, or atypical can have huge effects in scalable distributions, disproportionately impacting "the aggregate or the total…." (6) Rather than focusing only on averages and standard deviations, health care researchers should also pay attention to outliers because it is often the exceptional that drives change in CAS. An additional benefit accruing from analysis of extreme cases is to help, as Starbuck puts it, "disturb oneself."(7, 149) Researchers can disturb their unexamined assumptions about normality and commonality when they investigate extreme or disparate cases. An analysis of two cases in a study of nursing homes revealed two very different organizational approaches to regulation and each had important implications for how mindful staff *could* be about resident care.(8) Additionally, researchers should pay attention to both the potential benefits and detriments of diversity on health care outcomes and on the quality of relationships in HCOs they study. There is currently considerable energy focused on creating systems and processes aimed at reducing variance and homogenizing practice.(9) Researchers can easily adopt the idea that reduction of variance and homogenization of practice is fundamentally a positive thing. CAS theory cautions us to pay attention to how systems can be structured to encourage heterogeneity and the ways in which that heterogeneity can be lead to stability or change,(5) positive or negative effects on HCOs.

What are the implications of the fact that we are observing relationships among agents that learn?

A central outcome of relationships among diverse agents in CAS is that the agents learn. By learning, we mean that agents can process information from exchanges among themselves and with their environment and change their behavior in adaptive ways as a function of that processing.(10–12) Agents in HCOs are not static entities; rather they learn, continuously changing themselves, their relationships, and thereby changing the system(s) in which they are embedded. In HCOs, information processed for learning comes from multiple sources including accumulated knowledge from the field and practice experience with each

presenting patient.(9, 12) Agents in HCOs encounter information in well-structured problems in which the uncertainties are well understood as well as in ill-structured problems that present much more ambiguity and uncertainty.(13) Health care managers must, therefore, design systems that foster processes for the well structured problems but that will also capture the ill structured problems so that human problem solving can occur.(9) Bohmer suggests that both types of problems and processes should incorporate continuous learning by members of HCOs. The relationships among members of HCOs facilitate that learning. Because things in CASs may not often repeat themselves exactly, HCOs must often learn from samples of one.(14) Such learning requires looking at each occurrence from multiple perspectives, and agent diversity enables this to take place.

Problematic common analytic practices—agents that learn

An error commonly made in analysis of data from HCOs is behaving as if the agents in a HCO are internally static rather than recognizing that agents in the HCO change over time as a result of processing information encountered in interactions with other agents and with the environment. Health care researchers typically act as if they find out what a participant knows, believes, or does at time t, then they know what that participant knows, believes, or does at time t + infinity—they do not take change over time into consideration. When researchers think of an agent as being, instead of as becoming, they may fail to recognize that at a second observation point the agent will not be the same as at the first observation point, and that the agent will often be different in ways that are very relevant for the research question. Assumptions of static agents are implicit in research approaches such as analyses of single administrations of measures, surveys, and reports of attitudes, behaviors, or traits. While these practices are inherent in many cross-sectional studies, even pre-post and other forms of longitudinal analysis may fail to take unintentional and/or unintended learning into account.(15)

Even with common knowledge of Heisenberg's uncertainty principle and the Hawthorne Effect, researchers usually aim to conduct research observations without disturbing the agents. Attention is focused on designing so as *not* to disturb agents, instead of carefully observing to ascertain *how* agents are disturbed during the research. Even when researchers recognize the propensity to disturb an agent (or HCO), for example while collecting data—a time during which the researcher is most intently aware of it—they may forget to take these disturbances of the system into account during interpretation and analysis of the data.

Dynamics of CASs vary. Patterns of learning vary with patterns of relationships and other factors. Looking at variation in patterns of learning over time will explain something about an organization. For example, in our nursing home case study we found that in one organization with a tight network, learning from research interviews occurred quickly. When we asked the nurse about guideline use in the nursing home she said that guidelines were not used. By the time the MD was interviewed shortly thereafter, the MD stated that the nurse had recently suggested using guidelines and they were pursuing this. This says something about how this organization learned as compared to organizations in which the information does not flow as effectively.(16)

Strategies for interpreting data about agents that learn

Because learning is a key process in CASs, health care researchers should take care to recognize learning in HCOs. Researchers would benefit by thinking of HCOs as learning systems,(9) and remaining sensitive to the affect of learning on the variables of interest. To understand learning in HCOs, researchers must understand the nature of the agents' learning as it is facilitated by relationships.

Learning by agents is not like the predictable responses of a thermostat responding to changes in the temperature of a room. In other words, a top down approach to "teaching" people something or giving them information may not lead to proportional increases in knowledge or to the intended behavior changes. Learning requires a confluence of events. It often requires that agents notice things and then interact with each other about those things, making learning dependent on local interactions and the relationships in the system.(17) As an example, in one case study, (18) we were told by a manager about a nurse aide that the manager observed "scrubbing" a patient to the extent that the skin was very red. She asked that nurse aide why she was scrubbing so hard. The nurse aide said that she heard (learned from others) that patients needed scrubbing and took this to mean literally "scrubbing." Through conversation facilitated by their relationships(11) the manager and the nurse aide came to a common understanding of the degree of pressure needed for effective cleansing. Learning explains much of what occurred. Observing only one aspect of the system—the nurse aide scrubbing a patient, for example—would not account for the dynamics of learning in this system.

Researchers attempting to understand HCOs should expect agents to change as a result of interactions and in accordance with the quality of relationships among agents within the system and between those agents and their environment. They should recognize that the thing being observed at time zero is not the same thing observed at time t+1 and that changes may have occurred in between because the agent has learned. Seeing agents in HCOs as constituting CASs leads one to interpret single-point measures, observations, or interviews as representative of a participant at the point at which the observation was made. Given that agents in HCOs are learning, researchers should give some consideration to whether the variable being observed is relatively stable or variable with agent learning; not the intentional learning that the researcher may be trying to induce, but just the fact that the agent (e.g., individual, group, and organization) is a learning entity.

Researchers of HCOs who wish to take a CAS viewpoint should recognize that they are likely to disturb agents by their efforts to observe because they exchange information with those agents and because they are a part of the relationship system in which those agents are embedded and from which agents interact and learn. Learning can come about as a result of efforts to collect data. Therefore, when researchers are interpreting data, they should try to figure out in what ways their research disturbed the agents in an observed HCO. For example, research results may be affected by the fact that individuals learn from being interviewed. Because it takes time to conduct a set of interviews, individuals learn from talking to one another about the interview process and influence later interviews, and this should be taken into account as researchers analyze and interpret interview data.

Intervention research, often undertaken for the purpose of disturbing clinic members in particular ways and observing the affects of doing so, can also lead to unintended learning consequences. An example of such an effect is the role of conversation in the implementation process. Individuals learn through informal conversation that takes place around an intervention—conversations not planned by the researchers or facilitators of an intervention but that may nonetheless affect the implementation of that intervention. The nature of what is learned will be highly dependent on the nature of the relationships among agents in an HCO.(11) One limitation of the survey method is that a researcher may not be told about critical conversations and so will not know how learning is demonstrated in the data.

Conclusions

We have suggested that the task of interpreting research observations of HCO could be improved if researchers take into account that the systems they study are CAS with nonlinear relationships among diverse, learning agents. We identified common analytical practices that are problematic given these characteristics of CAS, and we recommended strategies for taking account of diversity and learning in interpretation efforts. Perhaps the biggest obstacle for researchers wanting to take a CAS perspective on HCO is their own set of assumptions about the nature of the organizations they study. It is certainly difficult to develop intuitions about diverse learning agents who influence and are influenced by their nonlinear relationships. It is difficult to recognize that learning is, in fact, the result of interactions among diverse agents and that learning can, itself, reduce or increase agent diversity. We encourage researchers to be persistent in their attempts to examine their ingrained, ensconced, established, well-worn set of assumptions, to move "beyond the centralized mindset,"(19) develop the ability to reason about complex systems,(20) and learn to attend not only to structures, but also to processes and functions of complex systems.(21).

Acknowledgments

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