Complex Systems

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There are many kinds of complex systems. Some involve primarily machinery – your car or jet airplanes, with multiple electronic subsystems – but oftentimes complex systems directly involve people, such as the air transportation system, economic systems, or political systems.

Consequently, there are many ways to define complex systems because complexity has always been in the eye of the beholder. Since complex is a common adjective, the term has conventional meaning and should really not be coopted by science. However, we must recognize that there are formal, scientific definitions used by scholarly journals and conferences – and there is even a Ph.D. in complex systems. Here, however, we will use an informal approach and will focus on our ability – or inability – to understand and control these systems.

But first we should start with Marshall McLuhan (1911-1980) and George Grant (1918-1988), contemporaries who both refer (directly or indirectly) to complex systems. In *Understanding Media* McLuhan uses a version of "complex" 52 times – not a lot for 392 pages – and the only time that he specifically refers to a complex system it is in the following: "Words are complex systems of metaphors and symbols…" (McLuhan 873)[1]. He also claims that "fragmented Western man" is being transformed "into a complex and depth-structured person emotionally aware of his total interdependence with the rest of human society" (785) via electric technology. This is in concert with his claim that humans are undergoing an "extension of consciousness" – where "all technologies are extensions of our physical being" (2599, 2659, 2745) and in his reference to "the electronic world of the seamless web of events" (3046). In other words, McLuhan recognized the extended human, sensing the world via electronic means, to be connected with a complex web of interconnections. I will assume that this complex web constitutes a complex system, even though he did not state it in those exact words.

George Grant was a Canadian philosopher and a contemporary of McLuhan. In *Technology and Justice* he wrote that "… modern technology is not simply an extension of human making …, but a new account of what it is to know and to make in which both activities are changed…" (Grant 13)[2]. In addition, he said that "… technology is the pervasive mode of being in our political and social lives". (17) Grant's reference of knowing is similar, I think, to McLuhan's reference to consciousness and they also overlap in terms of the "extension" of humans.

Both McLuhan and Grant recognized that we are being altered in significant ways through technology and that we are becoming more and more connected to external things – extensions of our physical and emotional being. McLuhan saw the increasing interconnectedness of life as a source of anxiety, "that compels commitment and participation". (McLuhan 45) And

[1] Indicates a location in the Kindle version of *Understanding Media*.
[2] Indicates a page number in the paper copy of *Technology and Justice*.

Grant recognized that both our knowing and our being are transformed by technology (which McLuhan called "electric technology").

Also, both writers recognized that technology simplifies this complex system to conform to its assumptions and goals. Consequently, the system often behaves badly because the messy (often, human) elements are simplified to fit the assumptions and goals of organizational structure, terminology, or methods.

Attributes

Our impression of complexity, I will claim, is connected to our ability (or inability) as observers or participants to both know and to control the system. And I will assume that the most complex system will "own" both our knowing and controlling, which severely constrains the role of observer or participant.

Knowing is related to not only what can be known but how it is known and to what degree. Similarly, controlling is related to not only what can be controlled, but how it is controlled and to what degree. As our inability to know and control goes up, our impression of complexity also goes up.

An Aside

As an aside: It would have been better to name the paper "Complicated Systems", since the notion of complicated seems more appropriate than complex. In other words, knowing (related to epistemology) seems closer to complicated, whereas being (related to ontology) seems closer to complex.[3] However, we will stay with complex here.

Problems

There are several problems with complex systems that are associated with knowing and controlling. In general, the worst problems are often created when we think that we know (or control) but we really cannot do either (e.g., the banking system and the Federal Reserve during the recent Great Recession). Since these catastrophic problems occur infrequently, we can convince ourselves that they will not occur – and then when they do occur we are surprised and blame the forecasters or the regulators.

Several situations can cause major problems with complex systems: When we

- Expect them to be
  - Predictable
  - Stable
- Equate the absence of evidence (e.g., problems) with the evidence of absence (e.g., no problems)
- See "meaningful" connections among system elements (where connections do not exist)

[3] Rogers

Antifragile Systems

These particular situations (and their related problems) have been addressed by Nassim Taleb (b 1960)[4] in his book, *Antifragile*. (His other book, *The Black Swan: The Impact of the Highly Improbable* was quoted extensively during the Great Recession.) He is an essayist, scholar and statistician whose work focuses on problems of randomness, probability and uncertainty. He attended the Wharton School at the University of Pennsylvania, was a financial trader for 20 years, and taught briefly in a university (but disliked the environment).

Taleb argues that a complex system should be seen for what it is (often volatile and random) and not what we often imagine it to be (stable and deterministic). In particular, he advocates making decisions (and building systems) that are antifragile, i.e., capable of benefiting from random events, errors, and volatility. He also warns against cause-effect predictions with complex systems, recognizing that "… the notion of cause itself is suspect; it is either nearly impossible to detect or not really defined."

An antifragile system is the opposite of a fragile system. An antifragile system is not simply a robust, strong, or unbreakable system (which all convey something neutral) – but a system that can take advantage of stressors. In other words, an antifragile system gets better (not worse) when it "breaks", becoming more valuable than it was before. A package that would be antifragile would be labeled, "Please mishandle", in other words, it would expect to be jostled. (Taleb 731)

Stress is a form of "breaking" and there are good stressors and bad stressors. When someone lifts weights – a form of acute stress -- their muscles become stronger. Between times to the gym their muscles partially break down and are built up stronger. The time between visits is important for the body to respond positively to the acute stress. On the other hand, chronic stress, such as constant time pressure in your job, financial problems, or a long daily commute, can adversely affect your health. Your body really cannot take advantage of chronic stress.

Chronic stress creates fragility (Taleb 1211) A fragile system will eventually break and a complex fragile system will break "with a bang", often jeopardizing the entire system. It is similar to someone who has never lifted weights -- when forced to lift a very heavy weight their muscles tear.

Stability and equilibrium are bad for an antifragile system, because they both avoid all stressors, both good and bad. Consequently, the system cannot benefit from acute stress. Our temptation is to make a system stable in the presence of stress, which creates a fragile system.

What does a fragile organization look like? First, it assumes (and tries) to follow an "exact, planned course, with as little deviation as possible" (Taleb 1433). In other words, the organization strives to be "very predictive" – a form of stability and equilibrium. Furthermore, the chronic stress that is likely present is suppressed – building up over time to create a Black Swan. Black Swans are "large-scale unpredictable and irregular events of massive consequence – unpredicted by a certain observer". Such a failed observer "… is generally called a "turkey" when he is both surprised and harmed by these events." (Taleb 386)

[4] "Nassim Nicholas Taleb is a Lebanese-American essayist, scholar and statistician, whose work focuses on problems of randomness, probability and uncertainty", Wikipedia, accessed: 9/26/2014

What does an antifragile organization look like? First, it not only anticipates stressors but acute stressors are valued for the information that they convey and for the good that they can effect. Stresses reveal problems that should be addressed. For example, every error uncovered in a system should make the next version of the system better. A truly antifragile system, however, would not have large errors that jeopardize the entire system, but small errors, when fixed, makes the system stronger. Also, these small errors should ideally be independent as possible, "or .. negatively correlated to each other …" (Taleb 1456)

What role does the probability of stress play in all of this? First, the focus should be on fragility, rather than "predicting and calculating future probabilities" (Taleb 653). Second, the purpose behind the use of any prediction should be to achieve Mediocristan rather than Extremistan (Taleb 1773). In other words, we want a system that allows for a lot of variation but no extreme variations – not a system with few variations where the variations are extreme.

Financial systems and human history tend to be from what Taleb calls "Extremistan". Antifragile systems, on the other hand, are from "Mediocristan". Systems that are from Mediocristan (i.e., with controlled volatility) are closer to the "bell curve", whereas those from Extremistan (i.e., move mostly by jumps called "fat tails") have low-probability events that play a disproportionate role. (Taleb 1792). In other words, Extremistan systems have probabilities that cannot be represented by the "bell curve" (i.e., a Normal distribution) because the unlikely events, when they do occur, cause results that are extreme compared to the typical events. (See Fig. 3.)

Any system with constrained volatility lives in Extremistan. For example, top-down systems attempt to control or eliminate volatility, consequently top-down systems typically block antifragility and growth. However, bottom-up systems "thrive under the right amount of stress and disorder" (Taleb 368)

Probability cannot be used to predict future events in the absence of simple, clear facts and rules. Complex systems, as I have defined them, do not always have simple, clear facts and rules. Therefore, probability should be used with caution with complex systems. Also, it is easy to conclude that a system will remain in its current state, when in fact its current state says little or nothing about possible future states. For example, you could conclude (wrongly) that the PEX water pipe in your attic will not burst since your plumber has told you that they have been successfully using PEX for the last 10 years. "In Extremistan, one is prone to be fooled by the properties of the past and get the story exactly backwards." (Taleb 1807)

When a fragile system collapses it is often seen as a result of "poor forecasting", which is incorrect (Taleb 2486). This happened when Egypt fell in 2011. We are living in a more fragile world, while thinking [that] it is more and more understandable." (Taleb 2428)

Taleb makes the claim that "most of history comes from Black Swan events … [yet] we worry about fine-tuning our understanding of the ordinary, and hence develop models, theories, or representations that cannot possibly track them or measure the possibility of these shocks." (Taleb 386)

Summary

Significant difficulties associated with complex systems could be alleviated by avoiding fragility, or rather, building anti-fragile systems. In the long run the systems will be less likely to generate Black Swans and the systems should improve over time. In particular, for complex systems

- Build them to benefit from random events, errors, and volatility
- Avoid cause-effect predictions
- Avoid making them stable in the presence of stress
- Do not allow chronic stress to build up over time
- Avoid top-down systems (they typically block anti-fragility)
- Do not use probability in the absence of simple, clear facts and rules
- Be aware of epiphenomena

References

1. Grant, George, *Technology and Justice*, University of Notre Dame Press, 1986.
2. McLuhan, Marshall, *Understanding Media: The Extensions of Man*, Gingko Press, 1964.
3. Rogers, Glynn, "Complex Systems vs Complicated Systems", accessed 9/25/2014, http://www.dar.csiro.au/css/documents/CSS_02_rogers.pdf
4. Taleb, Nassim Nicholas, *Antifragile*, Random House, New York, 2012.