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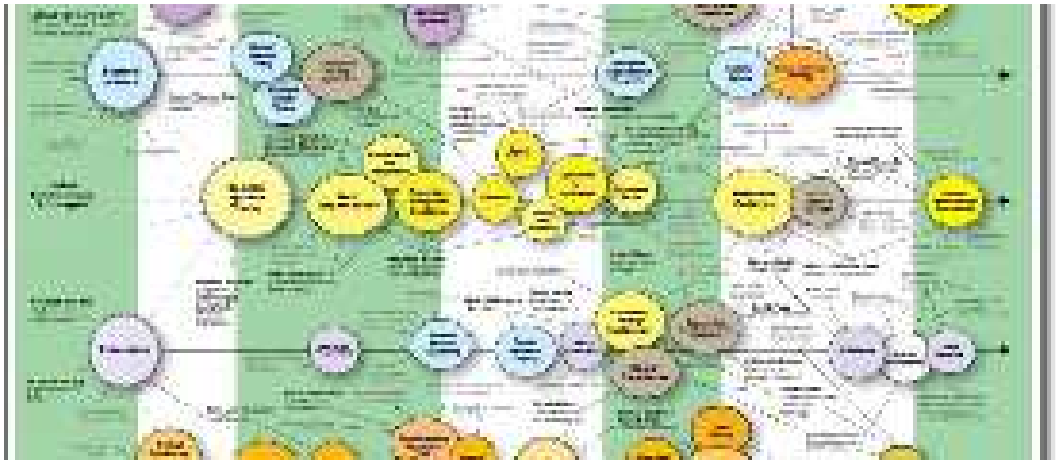
Brian Castellani on the Complexity Sciences - Theory, Culture & Society



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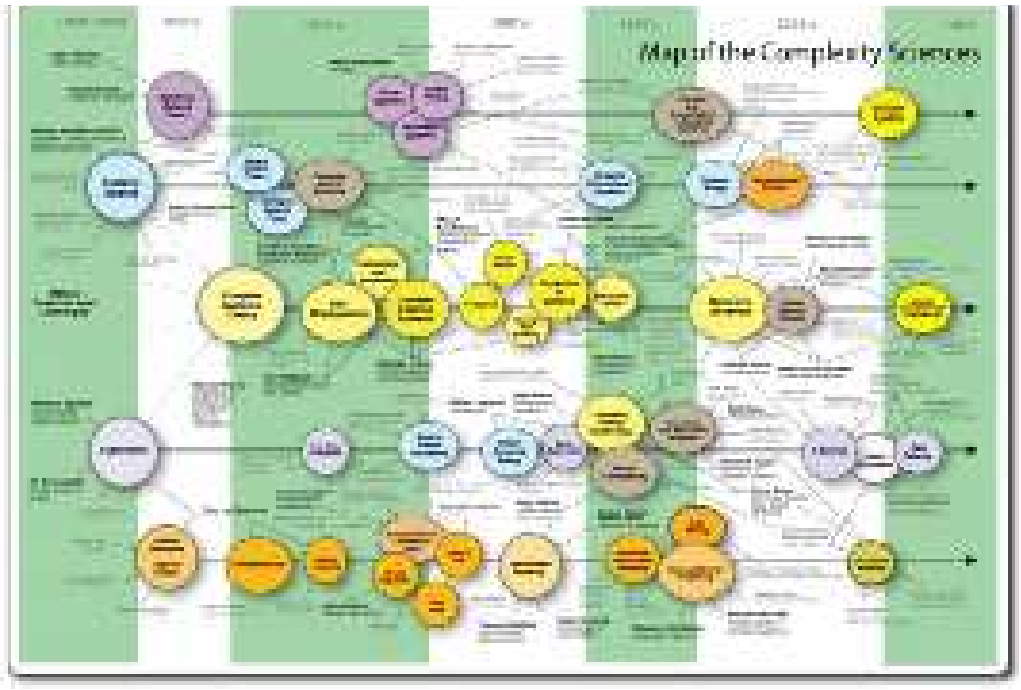
Brian Castellani on the Fast Growing Complexity Sciences and their Controversial Tangle with Social Inquiry

In this commentary piece for the TCS website, Brian Castellani reflects on the fast growing complexity sciences (particularly over the last two decades) and their provocative and evolving tangle with social inquiry.

Fifteen Years a Complexity Scientist

Mapping the Complexity Turn

Complexity theory and complexity science, computational modeling and the new science of networks, swarm intelligence and big data, agent-based simulation and artificial neural nets, geospatial complexity and complex systems theory, e-science and ecological systems theory, global network society and post-humanism, socio-cybernetics and social physics – what do all these major innovations (along with those shown in Figure 1 below) have in common? A lot actually!



First, each claims to offer, in its own way, a provocative *prescription* for what currently ails social inquiry. Second, and despite differences, each grounds its prescription in a similar concern with social complexity. In fact, when combined, these innovations have been hailed as a revolution in thinking – a paradigm shift, if you will, that has arrived, just in time, for the new globalized society in which we now live, as well as the complex set of social problems that come with it (See Byrne & Callaghan 2014; Capra & Luisi 2014; Castellani & Hafferty 2009; Mitchell 2009).

The British Sociologist, Urry called this paradigm shift and its evolving tangle with the social sciences the *complexity turn* – with a nod, of course, to previous turns, most notably (*pace* Rorty) the linguistic turn and postmodernism. And he did so, appropriately enough, for a 2005 special issue of *Theory, Culture & Society* on complexity, which he edited. Urry dates the *complexity turn* to the late 1990s. I agree with this date and think a good starting point is Byrne's 1998 *Complexity Theory and the Social Sciences*, published the same year as Cillier's *Complexity and Postmodernism*. Or, the Gulbenkian Commission's 1996 report to *Open the Social Sciences,* published the same year as Capra's *The Web of Life*.

Regardless of the exact date, it seems fitting, almost two decades later, to ask, "What is one to make of the *complexity turn* and its tangle with social inquiry?" Is it, for example, mostly rhetoric and fashion, or is there something useful and new to it? Having spent the last fifteen years involved in the complexity turn, that is the question I review in this essay, including how it has impacted my own work.

The Complexity Turn, 15 Years Later

As a way of review, here is my TOP TEN LIST of things about the complexity sciences and the *complexity turn* that you may not know, but should! Some things on the list focus on the history of the *complexity turn*, including its roots in old-school social systems thinking; others focus on the current state of the complexity turn, including strengths/weakness; while others highlight the up-to-date challenges that the *complexity turn* and, by default, the social sciences face. So, let's get started. Drum roll please!

1. First, in terms of the current state, as Mitchell points out in *Complexity: A Guided Tour* (2009), the *complexity turn* does not constitute a singular science or theory. Instead, there are numerous (albeit overlapping) complexity sciences and theories. A good illustration is my map of the complexity sciences (2014a,b) shown above – which is now in its fifth major iteration. I created the first version, on paper, back in 2007, when I wrote *Sociology and Complexity Science* (2009) with Frederic Hafferty. Since then, and out of due diligence to the project, I have not stopped revising it! (Some folks even email me to demand that their font size be increased to acknowledge how important they are!).

2. Still, in terms of history, while the *complexity turn* is new, the social science embrace of a *systems perspective* is not (Hammond 2003). In sociology, for example, one can trace the emergence of a systems perspective to the founding of the discipline, as in Spencer's evolutionary theory; Marx's dialectic; Durkheim's social fact; Pareto's 80/20 rule; and Comte or Quetelet's social physics (Castellani & Hafferty 2009).

Despite this long history, and perhaps because of it, the tangle between *systems thinking* and the social sciences has been rather consistently contentious, and, in large measure, for good reasons. Too much systems thinking has gone off in the wrong direction, embracing highly problematic views of society. Examples include an imperialist view of social evolution, as well as a near-hagiographic appropriation of old-school biology and its homeostatic and functionalist view of structure. And, unfortunately, the list continues from there: conventional; tautological; highly abstracted and therefore void of utility; predictable; unable to deal with power relations or inequality; retrospectively descriptive and therefore causally useless; devoid of an empirically accurate theory of instability or social change; wrongfully focused on grand narrative. And, it keeps going, culminating, for most scholars, in the work of Talcott Parsons.

Of all the systems theorists – including, of late, Luhmann – perhaps Parsons is the best nominee for systems thinking's intellectual errors – or, perhaps not! I remember, as an undergraduate, how utterly unintelligible my professors made Parsons to be. Then I read Collin's brilliant *Theoretical Sociology* (1988). In a

handful of pages, Collins made Parsons immediately clear! In abbreviated form, Parsons was a systems theorist who built his theory out of equal parts old-school, European sociology and (circa the 1940s – 1950s) new-school systems science and cybernetics. What ultimately doomed Parsons, however, was not his embrace of system science or cybernetics. It was, amongst other things, his abstracted and dogged *functionalism*. In other words, what got Parsons into trouble (as well as the lineage of sociological systems thinking on which he drew) was the type of complex system he defined society as, not the idea that society is a complex system! And, if one is to truly appreciate the challenges of the *complexity turn*, it is this point that needs to be understood.

Unfortunately, over the last sixty years, most social scientists seemed to have missed this point. Worse, in failing to miss it, they threw Parsons and, in turn, systems science into the dustbin of intellectual history, putting themselves – some four decades later – on the outside of the complexity sciences and the *complexity turn* (Castellani & Hafferty 2009; Hammond 2003). Put simply, while Parsons was very much wrong, he was also very much right: there was (and currently is) much to be gained from grounding social inquiry in a *complex systems framework*, particularly as it would be developed through the traditions of cybernetics and systems science, which would become the complexity sciences – or, at least that is the argument of those involved in the complexity turn.

3. In less than two decades, the plurality of the *complexity sciences* went from a few key intellectual lineages (which Capra faithfully outlined in *The Web of Life*) to an intellectual movement that now, in its current state, crosses the entire academy, including numerous and intersecting minor histories, such as network science and postmodernism, systems ecology and poststructuralism, fractal geometry and ecofeminism, case-based modeling and complex realism, computational biology and cognitive science and so forth; all of which continue to push the field toward chaos, as well as making clear Foucault's point about genealogy: with so many new fields entering (almost yearly) into the fray, folks find themselves appropriating the *complexity turn* to legitimate where they came from and how they got here; resulting in ever new histories of the 'complexity' present.

4. Now, don't get me wrong. In terms of its current state, all this interdisciplinary appropriation and collision is a good thing, pushing social inquiry, as Abbott argues in *Chaos of Disciplines* (2001), into new areas of thinking. But, it does lead to a key point one needs to grasp: the *complexity turn* has spun social inquiry into something of an intellectual *free-for-all*, leading to Byrne and Callaghan's (2014) important warning: *not all complexity sciences or theories are the same; and all are not equally useful for social inquiry*. For example, Luhmann's old-school usage of cybernetics and systems theory is not the same as Lyotard's postmodern

usage of chaos and catastrophe theory. In turn, Allen's usage of physics or Gilbert's usage of agent-based modeling is not the same as the Human Dynamics Lab's call for a new social physics – which the latter seem unaware was created in the 1800s by Comte and Quetelet!

And then there are the big epistemological differences: first between what Morin calls *restrictive* versus *general complexity*; and between what Weaver calls *disorganized* versus *organized complexity*. And, that does not even get us into methods and methodology, as in the differences between the epistemological assumptions guiding Epstein's generative social science versus Marres's digital actor-network theory; or, as another example, studying complex networks versus complex systems (Newman 2010). I can keep going. Bottom line: one needs to know (and report when writing) the type of *complexity turn* one is making, as well as the epistemological, theoretical and methodological assumptions upon which it is based.

Despite these significant differences, in terms of its current states, there are a number of commonly held views amongst those involved in the complexity turn.

5. First, it is generally agreed that, from ecological collapse and data warehouses filled with terabytes of information to globalization and an endless streaming of digital data to the instability of global financial markets and the threat of pandemics, the complexity of our *globalized, data-saturated present* is far beyond the pale of conventional social science theory and method (See Capra & Luisi 2014). The 21st century and its science, as Steven Hawking noted, is shaping up to be the century of complexity! In terms of method, a good example is Burrows and Savage's three-article exposé on big data and the crisis of empirical sociology (2007,2009, 2014). In terms of theory, a good example is Walby's *Globalization and Inequalities: Complexity and Contested Modernities* (2009).

6. It is also generally agreed that most social complexity (including the global) is of a particular type. In stark contrast to conventional quantitative method – and in parallel with qualitative method – the common view amongst complexity scholars is that social complexity is best viewed as *idiographic*. In his brilliant 1948 article, "Science and Complexity," Weaver alternatively defined idiographic complexity as *organized*. According to Weaver, nuances aside, the problems of science can be organized, historically speaking, into three types: (1) *simple systems*, (2) *disorganized complex systems,* and (3) *organized complex systems*. The hallmark of classical and modern science was finding ingenious ways to model the first two, including the development of The Calculus, field research, and statistics. Finding ingenious ways to model the third, however, would require, for Weaver, a postmodern science. He put it this way:

These new [organized complexity] problems, and the future of the world depends on many of them, requires science to make a third great advance, an advance that must be even greater than the nineteenth-century conquest of problems of simplicity or the twentieth-century victory over problems of disorganized complexity. Science must, over the next 50 years, learn to deal with these problems of organized complexity (1948, p. 540).

So, what is it about organized complexity that Weaver (and complexity scientists) find so challenging? The challenge is twofold: (a) like disorganized systems, these systems are comprised of a large number of dynamic variables, which make microscopic prediction near impossible; (b) however, unlike disorganized systems, one also has to take into account the links and connections amongst these variables and the larger, self-organizing, emergent whole they create – which also tends to be highly dynamic, nonlinear, evolving, context-dependent and comprised of multiple causal models. As such, unlike simple or disorganized systems, organized complex systems do not lend themselves well to mathematical formulas, qualitative description or statistics. Needed, instead, are entirely new *approaches to science*, along with new methods, grounded in the forthcoming age of the computer, which Weaver, in 1948, saw on the horizon – which takes us to our next two points.

7. In terms of a new approach, it is agreed that organized complexity is best understood in *complex systems terms*. In other words, social complexity and the data and models used to study it are best seen as complex social systems, which (contra old-school systems theory) are self-organizing, emergent, nonlinear, evolving, dynamic, network-based, interdependent, qualitative and non-reductive. The same holds for complex networks, which are generally seen as a way to study the structure (self-organizing patterns) and dynamics of complex systems (Newman 2010) – even though, as Latour has pointed out, given "the way they are usually drawn," most complex networks "have the great visual defect of being" what he calls "anemic" and therefore not particularly good at visualizing social complexity.

8. New methodologies are also needed, grounded in an interdisciplinary, mixed-methods framework (See Complexity and Method in the Social Science). As Capra and Luisi explain (2014), in many ways, the complexity sciences are more a revolution in method than theory. We have always known the world was complex; the challenge, however, was figuring out how to model it more effectively! Enter the computational algorithm, high-speed computers, and a capacity to store immense amounts of digital data. Suddenly, entirely new methodological possibilities emerged: agent-based modeling, artificial neural nets, fractal geometry, network science, data visualization, geospatial modeling, computational

complexity, genetic algorithms, qualitative complexity, case-based modeling, and so forth (see map above). And here is the kicker! These methods not only effectively model organized complexity – as well as the data gathered to make sense of it – but they also model aspects of complexity traditionally, outside the domain of conventional quantitative method – as in the case of complex networks, emergent behavior, and temporal, nonlinear dynamics (Rajaram & Castellani 2012, 2014).

9. Furthermore, in terms of current challenges, to embrace this mixed-methods approach, the social sciences require significant and immediate methodological overhaul, grounded in computational and complexity science (Byrne 2012; Castellani, Hafferty & Schimpf 2013). To put it simply: when it comes to modeling complexity, the social sciences are far behind current trends, leaving most social scientists grossly outmatched by their fellow complexity scientists in physics, computational modeling, data science, and mathematics – resulting, in many instances, with the latter often having the upper hand in constructing the *complexity turn* narrative (Castellani 2014). The problem with this, as Duncan Watts (the famous network physicist) pointed out in *Annual Review of Sociology* (2004), is that most natural and computational scientists are poor social scientists, with little to no knowledge of social theory – which takes us to the final point.

10. The other major challenge today is that the social sciences need to be, in one way or another, 'opened up' into some type of complexity-based, post-disciplinary science. If, as Hawking claims, this century is about complexity, then the social sciences need to evolve accordingly – which is not a new point: Weaver made it in 1948; Parsons did the same with the Department of Social Relations in 1946 at Harvard; Wallerstein and Prigogine made the point in the Gulbenkian Report; and, more recently, Christakis argued the same in his 2013 article Let's Shake Up the Social Sciences.

So, that is our top-ten list. And, as I hope to illustrate next, it has had a profound and lasting impact on my research. While the nuances of this impact exceed the limits of this essay, I will highlight a few, hoping readers may be likewise inspired to explore the *complexity turn* for their own work.

Complexity and Health: A Case-Based Modeling Approach

As a social scientist, my training is in sociology and clinical psychology. For me, understanding health is ultimately about the complexities of the case and at multiple levels, from global health to the health of patients. In turn, treating these complex cases is ultimately about the intersection between theory, method and application. Here, then, are a few examples of how the complexity turn has been

of use to my work:

In terms of theory, the *complexity turn* has helped me in two key ways:

1. First, it helped me realize that, while their work is not labeled as such, a lot of social science theorists have made important insights into social complexity. For example, in terms of my work, I am primarily interested in the structure/agency intersection, integrating Foucault and post-structuralism with Strauss and symbolic interactionism (Castellani 1999). In particular, I find Foucault's *dispositif* and Strauss's *negotiated ordering* useful ways to think about complexity: dispositif helps me think about macroscopic systems shifting from one heterogeneous field of operations to another, as grounded in social practice; while, via negotiated ordering, I can see these shifts simultaneously emerging, from the bottom-up, through the negotiations of interacting agents. Also, *pace* Derrida, I am very much interested in the issue of *difference and différance* – given how different etiological models of health lead to different treatments.

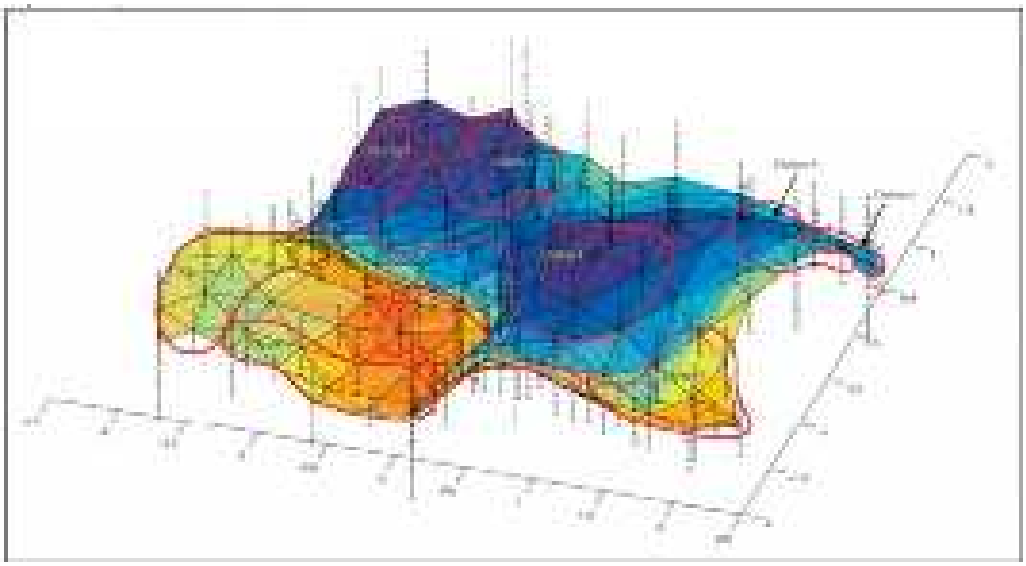
2. It wasn't until the *complexity turn*, however – with its concepts of emergence, self-organization, tipping points, etc – that I was able to develop these ideas into a working theory of social complexity (Castellani & Hafferty 2009). For example, I was able to redefine dispositif (e.g., community health) as an evolving, low dynamic, organized complex system that suddenly (due to the combined influence of microscopic interactions and occurrences) goes through a phase shift, wherein (crossing a tipping point) it shifts from one field of relations (a negotiated ordering) into another (as in the case of a poverty trap) – and, I could do so in very concrete and empirical terms that translated my theorizing directly into a computational model. Furthermore, I was able to translate Derrida's idea of *difference* into the idea that complex systems are comprised of multiple causal models. To make this translation, I employed the complexity theory of Cilliers (1998). I likewise translated *différance* into the idea of modeling the *deferred traces* of complex systems, as no one model effectively captures the complexity of social inquiry. To make this translation, I employed the complex realism of Byrne (2005).

The complexity turn has also impacted my method.

For the past decade, my colleagues and I have been developing a new way to model social complexity. The approach is called *case-based modeling* and the platform for its use is called the *SACS Toolkit* (Castellani & Hafferty 2009; Castellani, Hafferty & Schimpf 2012; Castellani & Rajaram 2012; Rajaram & Castellani 2012, 2014).

Case-based modeling is based on Byrne's innovative integration of Cillier's complexity theory (1998), Ragin's case comparative method (Byrne & Ragin 2009) and Harvey and Reed's complex realism (1996). The premise for his integration, while simple enough, is groundbreaking: cases are the methodological equivalent of complex systems; and alternatively, complex systems are cases and therefore should be studied as such.

As a type of case-based modeling, the *SACS Toolkit* is a case-based, computationally-grounded, mixed-methods platform for modeling complex systems. It functions as a variation on Byrne's general premise regarding the link between cases and complex systems: for the SACS Toolkit, case-based modeling is the study of complex systems as a set of k-dimensional vectors (cases), which researchers compare and contrast, and then condense and cluster (using computational methods) to create a low-dimensional model of a complex system's topography and dynamics across time/space, while preserving the complexity of the system studied. (Figure 2 is an example: it is a topographical map of the main clusters in a study on allostatic load.)



To date, we have applied the SACS Toolkit to a variety of health topics, including community health (Castellani et al 2014), international health (Rajaram & Castellani 2014) allostatic load (Buckwalter et al 2014) and medical professionalism (Hafferty & Castellani 2012). Across all of these studies, the advantages of employing the SACS Toolkit have been several: it has allowed us to (1) employ multiple methods; (2) map the complex, nonlinear evolution of ensembles (or densities) of cases; (3) classify major and minor health clusters and time-trends; (4) identify dynamical states, such as attractor points; (5) plot the speed of cases along different states; (6) detect the non-equilibrium clustering of case trajectories during key transient times; (7) construct multiple models to fit

novel data; and (8) predict future time-trends and dynamical states.

Still, despite these strengths, as with any new intellectual development, neither case-based modeling nor the *complexity turn* are a panacea for the errors of contemporary social science. Nonetheless, they do seem to offer a number of important tools for improving social inquiry in the global century of complexity in which we currently live. And that, to me, is sufficient reason for anyone to explore the utility of this turn.

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Readers of this commentary may also be interested in the following material from the journal *Theory, Culture & Society*:

Special Issue on Complexity

Edited by John Urry

October 2005; 22 (5)

http://tcs.sagepub.com/content/22/5

Antony Bryant, 'Liquid Modernity, Complexity and Turbulence'

January 2007; 24 (1)

http://tcs.sagepub.com/content/24/1/127.abstract

Oliver Human & Paul Cilliers, 'Towards an Economy of Complexity: Derrida, Morin and Bataille'

September 2013; 30 (5)

http://tcs.sagepub.com/content/30/5/24.abstract

And, more recently, from the TCS Website:

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