2 SACS Toolkit—Theoretical Framework

2.0 Overview of the SACs Toolkit

The *SACS Toolkit* is a new approach to modeling social systems. It is comprised of three basic parts: a set of working concepts, a ready-to-go procedural outline for modeling social systems, and a short list of recommended techniques and methods currently used in sociology and complexity science.

- The set of working concepts is designed specifically to give researchers a practical framework for organizing their empirical inquiries into the structure and dynamics of most social systems. We call this framework *social complexity theory*.
- The procedural outline is the algorithm we created for assembling, from the "ground up," a working model of a social system. We call this method *assemblage*. Assemblage is a step-by-step set of guidelines that works hand-in-hand with the conceptual framework of social complexity theory.
- The recommended toolset of techniques and methods come from sociology and complexity science. As we discuss later, one of the main strengths of the assemblage algorithm is that it can be used with just about any methodological technique. Still, despite this flexibility, some techniques are better than others—or, at least we think—when it comes to modeling the complexities of social systems. The SACS Toolkit therefore has a short list of relatively indispensable techniques. In terms of the new techniques in complexity science, this list includes agent-based modeling (Gilbert and Troitzsch 2005), data mining, specifically the self-organizing map (Bigus 1996; Han and Kamber 2001), fractal geometry (Mandelbrot 1983) and the new science of networks (Newman, Barabási and Watts 2006). In terms of sociology, it includes cluster analysis, social network analysis, hierarchical regression, grounded theory (Glaser and Strauss 1967) and Foucault's archeological genealogy (1977).

2.1 Overview of Chapters 2 and 3

In the next two chapters we introduce readers to the SACS Toolkit. In Chap. 2 we review *social complexity theory*, our theoretical framework. In Chap. 3 we review *assemblage* and our recommended toolset, which, together, constitute the methodological component of the SACS Toolkit. Chap. 10 includes several figures we will use in this chapter, including two flowcharts, a Venn diagram, and a couple of maps and graphs.

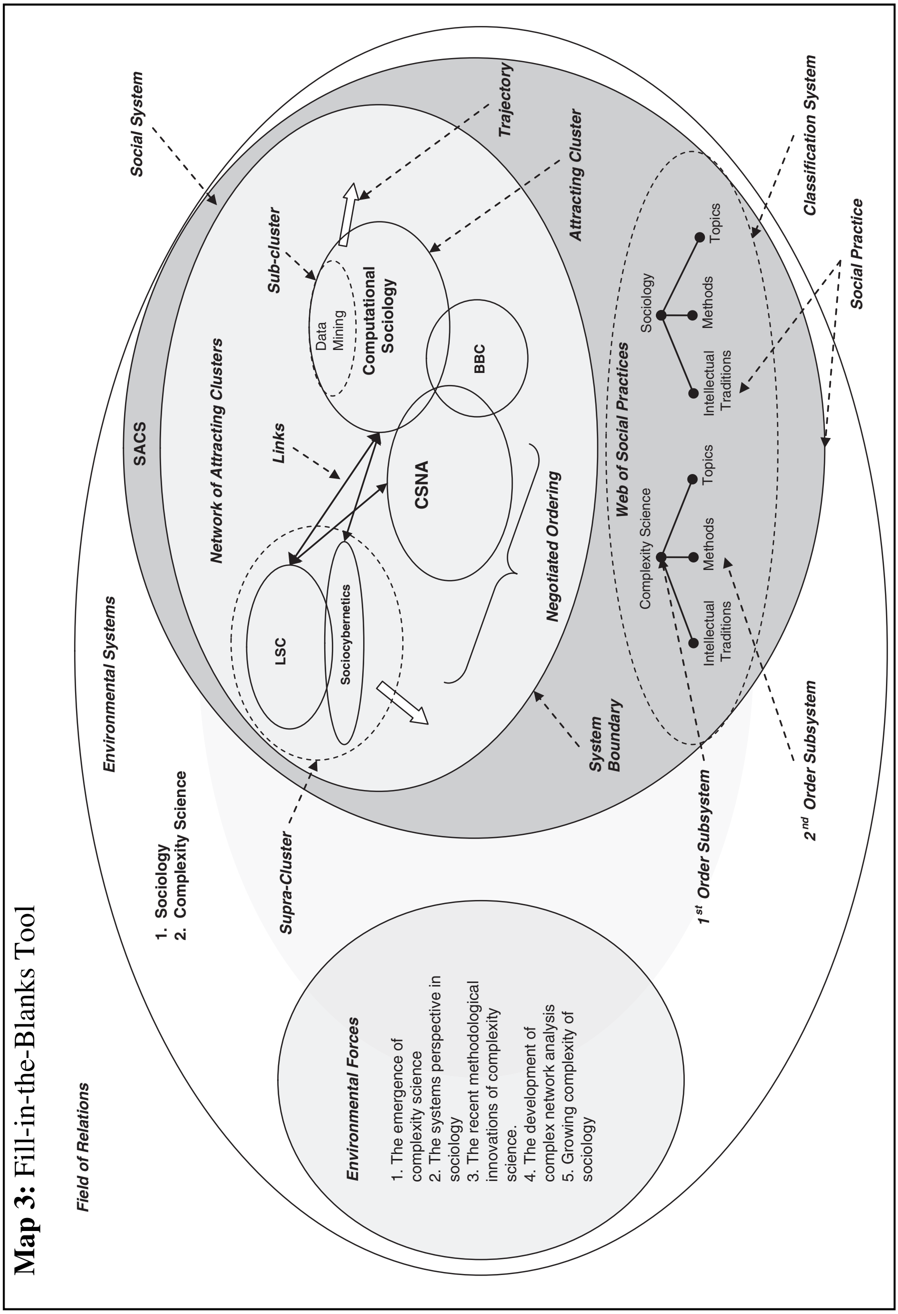
2.2 Social Complexity Theory

Social complexity theory is more a conceptual framework than a traditional theory. Traditional theories, particularly scientific ones, try to explain things. They provide concepts and causal connections (particularly when mathematical) that offer insight into some social phenomena. When one thinks of sociological theories, for example, one thinks of Max Weber's work on rationalization and bureaucracy (1946, 1968); Karl Marx's work on capitalism and class conflict (1970); Erving Goffman's work on social interaction and impression management (1959, 1967); or Anthony Gidden's theory of structuration (1984). These theories are held in high esteem because they explain the world to us, helping us see things a little bit better.

Scientific frameworks, in contrast, are less interested in explanation. They provide researchers effective ways to organize the world; logical structures to arrange their topics of study; scaffolds to assemble the models they construct. When using a scientific framework, "theoretical explanation" is something the researcher creates, not the other way around. An excellent example of such a "framework," is Anselm Strauss's general theory of social interaction, as outlined in *Continual Permutations of Action* (1993). Unlike his grounded theoretical work with Barney Glaser, which gives specific "accounts" (explanations) of such social processes as grieving or chronic illness, Strauss's general theory is an "all-purpose" toolkit designed to help researchers explore a variety of sociological topics.

Similar to Strauss, social complexity theory is a scientific framework. It is an all-purpose scaffolding designed to help researchers (1) organize and arrange, (2) categorize and sort, (3) classify and label and (4) manage and control their empirical inquiries into the structure and dynamics of various social systems. Social complexity theory does this by providing researchers a theoretical filing system and an associated vocabulary that they can use to create their own model of a social system.

As shown in Map 3 (SACS Toolkit Map), the filing system of social complexity theory consists of five organizational folders: (1) field of


Map 3: Fill-in-the-Blanks Tool
Field of Relations
Environmental Forces
1. The emergence of complexity science
2. The systems perspective in sociology
3. The recent methodological innovations of complexity science.
4. The development of complex network analysis
5. Growing complexity of sociology
1. Sociology
2. Complexity Science
Environmental Systems
Supra-Cluster
Social System
SACS
Network of Attracting Clusters
LSC
Sociocybernetics
Links
Sub-cluster
Data Mining
Computational Sociology
Trajectory
BBC
CSNA
Attracting Cluster
Negotiated Ordering
System Boundary
Web of Social Practices
Complexity Science
Intellectual Traditions
Methods
Topics
Sociology
Intellectual Traditions
Methods
Topics
1st Order Subsystem
2nd Order Subsystem
Classification System
Social Practice

relations, (2) web of subsystems, (3) network of attracting clusters, (4) environment, and (5) system dynamics. In turn, each folder contains its own subfolders. The environment folder, for example, is subdivided into two major headings: (a) environmental systems and (b) environmental forces, both of which are further subdivided according to: (i) type, (ii) relevance and (iii) impact. Using this filing system, researchers can empirically investigate the structure and dynamics of a social system, confident that they have an effective way to manage their study.

The researcher's confidence is further secured through the vocabulary of social complexity theory, which consists of a concise list of terms for thinking, talking and writing about the structure and dynamics of a social system. Some of these terms, such as attractor points, phase transitions or environmental forces are borrowed from complexity science (Capra 1996). Others, such as negotiated ordering, trajectory or differentiation are modifications of recognizable sociological terms (Strauss 1993). Still others, such as the web of social practices, network of attracting clusters or multi-singularity are new. Of the various terms relevant to social complexity theory, one of the most important is social practice. Before discussing our filing system, we therefore need to explicate this term.

2.2.1 Social Practice

In the fields of sociology, anthropology, and continental philosophy, a new branch of social theorizing has emerged called *practice theory* (Ahearn 2001; Castellani 1999; Dreyfus and Rabinow 1983; Jenkins 1992; King 2004; Reckwitz 2002; Stueber 2006). The most well known theorists in this branch are Anthony Giddens (1984), Pierre Bourdieu (1990) and Michel Foucault (1980). Despite the numerous differences amongst these scholars, they are united by a common concern and strategy.

In terms of concern, they seek to avoid what Dreyfus and Rabinow, in their review of Michel Foucault call "the Scylla of hermeneutics" and "the Charybdis of structuralism" (1983). The Scylla of hermeneutics has to do with the tendency to treat the human subject as the ontological basis for social reality, as typically is done in cognitive science, psychology, and humanistic philosophy (Giddens 1984). In contrast, the Charybdis of structuralism has to do with the tendency to treat social reality (e.g., society) as independent of human agency, as is typically done in European sociology, functionalism, structural anthropology, and systems thinking (Dreyfus and Rabinow 1983). Another way to express this dual concern is that practice theorists seek to overcome the structure/agency dualism. That is, they seek to avoid turning social reality into either the study of structure or of agency (For a more in-depth review, see Giddens, 1984, Chap. 1).

As a common strategy, practice theorists approach the structure/agency dualism in three important ways. First, they conceptualize social reality as social practice. Bourdieu, for example, has his concepts of practice and field (1990); Giddens his duality of structure (1984); and Foucault his concepts of organizing practice and dispositif (1980). Second, they define social practice as some combination of structure and agency (Ahearn 2001; Jenkins 1992; Reckwitz 2002; Stueber 2006). Foucault, for example, has his theory of knowledge and power (1980); Bourdieu his theory of habitus (1990); and Giddens his theory of structuration (1984). Third, they treat sociological inquiry as the study of social practice. As Giddens notes, "The basic domain of study of the social sciences, according to the theory of structuration, is neither the experience of the individual actor, nor the existence of any form of societal totality, but social practices ordered across space and time" (1984, p. 2). As this statement suggests, theorists such as Giddens, Bourdieu and Foucault consider basic rituals such as brushing one's teeth or saying "hello" as types of social practice. So too are major topics like health care, economics, or politics. In fact, the entire sociological landscape—dispositif (Foucault 1980)—is made of social practice. Social practices can vary in length of time, from a quick cell phone conversation to the long-term life of a religion. They can vary in size, from the micro-politics of caring for oneself to the macro-dynamics of global society. They can vary in level of stability, from the spontaneous emergence of a crowd to the more entrenched patterns of family and government. And they can vary in complexity (a point we will come back to later), from such simple phenomena as using a pencil or pronouncing a word to more complex practices such as creating SACS and its five major areas of research.

Given its conceptual utility, Foucault, Giddens and Bourdieu all treat social practice as their critical concept. We follow suit. For us, sociology is the study of social practice. We do, however, have our own take on social practice.

While Foucault, Giddens and Bourdieu do an excellent job articulating three very useful (although somewhat different) definitions of social practice, none were to be the basis for a theory of social systems. During the course of our investigations we therefore found it necessary to construct our own definition.

First, we use Foucault's definition as our base. In comparison to Bourdieu and Giddens, it does a much better job clarifying how agency and structure couple to create social practice. Furthermore, Foucault's approach is the most "systems" oriented of the three. In fact, we find in Foucault a wealth of ideas useful for building a theory of social systems, specifically his concept field of relations (one of our theory's primary terms) and his theory of interaction (Foucault 1983). Foucault's concept of social practice, however, is slightly biased toward the structuralist side of the agency/structure dualism. To counteract this bias, we infuse Foucault's definition with symbolic interactionism, specifically the work of Herbert Blumer (1969) and Anselm Strauss (1993). This infusion not only emphasizes the role agency plays in social practice, but opens the door for such important concepts as negotiation, resistance, and difference—all of which, as we explain later in this chapter, are central to our theory of social systems. (For a more detailed discussion of our integration of Foucault and symbolic interactionism and the advantages of this infusion see Castellani 1999.) Finally, we integrate this infusion with several key thinkers in complexity science, particularly Maturana and Varela (1998) and their concepts of knowing and coupling. This last modification helps us connect social practice with some of the major epistemological advances complexity scientists have made, particularly in linking the natural and social sciences (Ehrlich 2000).

Based on these modifications, we define social practice as follows: Social practice is any pattern of social organization that emerges out of, and allows for, the intersection of symbolic interaction and social agency. In addition, we note the dual dimensions of "allows for" and "emerges out of" in this definition. Social practice is both the cause and the consequence of symbolic interaction and social agency. In fact, they cannot exist without each other. Symbolic interaction provides social practice its structure, while social agency provides social practice its dynamics. In turn, social practice provides symbolic interaction and social agency an organizing framework. As stated above, social practice is any "pattern of organization" that allows for the intersection of symbolic interaction and social agency. By "allowing" we mean that social practice, as an emergent phenomenon, is a conduit. It defines, constrains, limits, controls, regulates, disciplines, obligates, enables, facilitates, permits, creates and makes possible the intersection of symbolic interaction and social agency (Castellani 1999).

2.2.2 The Five Components of Social Practice

Our definition of social practice is comprised of five basic components: (1) inter-action, (2) social agents, (3) communication, (4) social knowing and (5) coupling. While these five components move beyond the confines of the structure/agency dualism, they align themselves with the terms of this dualism as follows: social agents and inter-action are subsumed under the general heading of social agency; communication and social knowing are subsumed under symbolic interaction; and, coupling becomes our technical term for the intersection of symbolic interaction and social agency.

We will now review each component, focusing on how it helps us understand more fully the structure and dynamics of social practice, as well as how it helps us navigate a course between the Scylla of hermeneutics and the Charybdis of structuralism.

1. Social practice is comprised of interaction. Interaction refers to the movements, behaviors, processes and interdependent actions of social practice, along with the actions of the agents and communication strategies of which a social practice is comprised. Interaction also refers to the various types of relationships that can exist through social practice—for example, relations of power—as well as the various forms and expressions these relationships can take, such as conflict, negotiation, domination, and contract (Castellani 1999). The entire package of interactions involved in a social practice is referred to as its *dynamics*. Borrowing this term from physics, we use it to refer to interaction in the plural sense: dynamics as a web of "inter-actions" of which a social system is comprised, and the course of actions a social system takes.

2. Social practice is comprised of social agents. We use this term to overcome the structuralist leanings of Foucault. Social practice is not just the enactment of macro-level social structure (Foucault 1977). Social practice includes all types of social agents, from small groups to businesses to educational institutions to nation-states and so forth. As a side note, a social agent also can be a social practice.

3. Social practice is comprised of communication. Social practice cannot exist without the sharing and exchange of information. Language, in turn, is an instrument of communication. There are formal languages, scientific languages, biochemical languages, paralanguages, etc. There also are discourses, codes, rules, formulas, etc. The smallest unit of communication is a *communication strategy*. A communication strategy can be a single letter, word, facial gesture or machine code, or it can be something more extensive, such as a monograph, handbook, etc. The main criterion of a communication strategy is that it constitutes a single act of symbolic exchange, one that cannot be broken down into something simpler or more basic without losing the intention of the strategy itself.

Our definition of communication is distinctive because it moves us away from the hermeneutical leanings of most sociological theories of symbolic interaction. Our definition does this in two important ways. First, we are able to explicitly separate symbolic exchange from interaction. This is helpful because, in so doing, we can make inter-action a more comprehensive process. Interaction is not just the behavior of humans in relation to themselves, others, and the world. It also is the interaction of discourses, codes, social institutions, cultures, nation-states and so forth (See Castellani 1999). Second, we are able to replace the term symbolic with the term communication. We do this for three reasons. First, we want to accent the fact that symbolic interaction is far more inclusive than just verbal and nonverbal language. It involves the entire spectrum of symbolic exchange, including machine and biological communication. Second, we want to highlight the relational property of symbolic interaction. Communication is specifically defined as the exchange of information. Finally, we want to emphasize the fact that communication is not limited to human actors. In the information age, governments communicate with each other; websites communicate with each other; traffic patterns communicate with each other, and so forth, with little to no human involvement.

4. Social practice is comprised of social knowing. Social knowing is the human element of social practice. Social knowing can be facilitated by artificial intelligence and by various forms of machine communication—one example is the phone or computer, another is assistive technology for people with disability. Still, social knowing is something living organisms do. The most advanced form of social knowing is human social knowing (at least on planet earth).

Social knowing involves aligning social practices with the worlds in which humans live. Said another way, in order for a social practice to do its job, it has to "line up" with the world. That is, it has to work for the needs, desires, interests, concerns, or wants of humans; otherwise it is useless and discarded. The job of social knowing—defined as social mind in action—is to make sure that each and every social practice, from a pragmatist perspective, works.

The idea that social practices have to "work" comes from the pragmatist tradition, which extends from William James, Charles Sanders Pierce and John Dewey to the Chicago School of Sociology and symbolic interactionism, to recent neo-pragmatists such as Richard Rorty and Cornel West (Denzin 1992, 1996; Rorty 1999; West 1989). As these scholars argue, a social practice has to be useful to remain part of the human repertoire. Social practice has to help us get along in the world. It has to help us get the things we want done, such as staying alive, overcoming illness, finding a job, managing or controlling our enemies, having fun, creating new technologies, satisfying our excesses and addictions, explaining to us the purpose of our lives, or just passing the time. In other words, the purpose of social practice is to help humans manage their socio-biophysical lives.

It is important to point out that our definition of social knowing does not conceptualize the utility of social practice in terms of moral or ethical obligation. Neither does it worry about a social practice's "truth" in the abstract. Truth is an adjective assigned to social practices that work. Furthermore, there are no Spencerian overtones of the "survival of the fittest" in this approach to social practice. Utility can be more than a matter of might or right. From a pragmatist perspective, "useful" simply means "works." If a social practice helps some person or group accomplish their goal, it continues to exist, even if it is deemed by "others" to be deviant, immoral, untrue, anti-social, unhealthy, destructive, irrational or dumb—unless these others (and here is where "might" and "right" step in) have the power to stop or eliminate the social practice. The public health campaign in the United States against smoking is a good example.

The process of creating, learning, adapting, adjusting, developing, improvising, combining, discarding or replacing social practices so that they "line up" with the world is the job of social knowing. The concept of social knowing, at least as we employ it here, comes from the work of Maturana and Varela (1980, 1998) and, to a lesser extent, Chomsky (2000), Fodor (2000) and Ehrlich (2000). Of the various mental processes connected to the brain-based knowing of humans, there is a set of modules (see Fodor's use of "module" in his computational theory of mind) that help us navigate our existence as social animals. These modules consist of processes such as self, language, cognition, the "I," emotional intelligence, and so forth. Together, these modules constitute the social mind. Social mind is distinct from other forms of human knowing, particularly those ways of knowing that are not brain-based, such as the immune system, nervous systems, cardiovascular system, and so forth (Maturana and Varela 1998; Varela, Thompson and Rosch 1991).

The literature in social psychology and cognitive science have empirically identified and demonstrated the existence of a modular social mind in two important ways. First, without social interaction these modules do not emerge. The best example is feral children, where many of the modules associated with social mind are not developed (such as language) or are severely impoverished (such as a sense of self). Second, when the modules of social mind do not work appropriately, they result in social incompetence. Social incompetence is the behavioral manifestation of a failure of effective social knowing. Examples of modular impairment leading to social incompetence include cognitive or mental disorders such as autism, schizophrenia, anxiety, or Alzheimer's disease (Sacks 1995). The social practices of daily life—communicating with people, getting to work on time, paying the bills, managing one's emotions, etc—are extremely difficult for the people who suffer these modular disorders, creating the possibility for stigma and the label of incompetence (Goffman 1959).

As the above empirical demonstrations suggest, social mind is a brain-based process, an extension of our biological existence, that emerges through our interactions with other humans and the various environments in which we are situated (Maturana and Varela 1980, 1998). That is why social mind is given its name. It is that part of our brain-based knowing that seems to have emerged and developed to capitalize upon and manage our relatively unique existence as complex social animals. Moreover, in the absence of social interaction, social mind has no reason to exist (Ehrlich 2000; Mithen 1996).

What our two empirical demonstrations do not make clear, however, is that mind is an action. Given the structure of the English language, social mind, although written and spoken in sentences as a noun, is not a thing (a noun or an object). Instead, it is a verb (a process or a dynamic system). That is why, to highlight the active, dynamic and relational character of social mind, we use the term *social knowing*. Social knowing is social mind in action. It is the activity of living social minds, as they interact with themselves, the world, and other forms of human-based knowing. More important, social knowing is the activity of social minds in interaction with other social minds and, let us not forget, the social practices these interactions need and create. We must remember that social mind and its social knowing have no reason to exist, and cannot fully develop, without social practice. In this way, social mind and social practice are sui generis. One cannot exist without the other. Without a social mind and its social knowing, there is no need for social practice. Without social practice, social minds cannot emerge, act, develop or interact.

Finally, social knowing is fundamentally interpretive because it is the unique product of human, brain-based knowing. Here we once again draw from the work of Maturana and Varela (1980, 1998) and, to a lesser extent, Chomsky (2000), Fodor (2000) and Ehrlich (2000). We also lean heavily on the traditions of symbolic interactionism, ethnography, cultural anthropology, culture studies and, most importantly, pragmatism. Empirically speaking, the activity of "making social practices work" by "lining them up with the world" is not the same thing as "creating social practices that accurately represent the world as it truly is." Language, for example, does not have to accurately represent the world "as-it-is" to work. It need only allow us to interact with the world in a successful way—which still is a rather amazing accomplishment. Said another way, if we were to trace our evolutionary tree backwards, it does not seem, empirically speaking, that there ever has been a need for our social mind to achieve a strict understanding of the world "as-it-is" (Ehrlich 2000). Nor has there been a need to obtain what the naïve realists refer to as a "one-to-one" correspondence with objective reality in everything we do. A case in point: our knowledge of the world, like our minds, is constantly changing, constantly evolving. It never ends because the world, in all its complexity, cannot be contained in any one "conceptual net" of understanding. Furthermore, as the theoretical biologists and complexity scientists, Maturana and Varela point out, our knowing in many ways is species specific (1998). Human knowing—

or, to be more exact, human social knowing, as expressed by our social mind through its dialogue with the world via social practice—is only one type of knowing. Other forms of knowing include insect, plant, machine, and so on. Understanding the structure and dynamics of social practice and, more specifically, social systems depends on this empirical point. The term "interpretation" highlights the fact that human social knowing is a human project grounded in our particular unique socio-biophysical arrangements and makeup.

5. Social practice involves coupling. This term refers to the plasticity of social practice. Social practices are good at connecting, linking, attaching, merging, joining and uniting with other social practices. So are their components. The interactions, social agents, communication patterns and social knowing of one social practice are easily coupled—that is, shared, glued, fastened, exchanged or combined—with those of another. Social practices also are good at coupling with the biophysical worlds in which they take place, including the human bodies that enact them and the various environmental systems in which they are situated. Social practice is not divorced from the biophysical world. It is simply another level of emergent biophysical organization. In fact, one might even say that the study of social practice (and therefore sociology) is a branch of biology. Reframed in this way, sociology is the branch of biology that studies (1) the emergence and development of social mind and social practice; (2) the interactions between social minds and social practices (symbolic interactions, impression management, exchange theory, game theory, etc); (3) the aggregate byproducts of social minds and social practices (societies, economies, cultures, personalities, oeuvres, historiographies, etc); and (4) the interactions amongst these various areas of socio-biophysical existence.

6. We have one last point. Social practices are good at creating other forms of social practice. In other words, a social practice can emerge out of the union and intersection of other smaller (and sometime larger) social practices. An intellectual community like SACS, for example, is made up of a long list of smaller social practices, such as colleges and schools, department and units, work teams and project groups, occupational statuses and work roles, areas of research, scholarly methods, etc. Like molecules, social practices are constantly colliding and combining to form other social practices.

2.2.3 Social Systems as Social Practice

As stated earlier, we will use social practice as the critical concept in our theory of social systems. We therefore turn to a discussion of how social practice forms the basis of our theoretical framework.

Social complexity theory begins with the assumption that a social system is a type of social practice. For us, the term "social system" is really an adjective, a way of organizing our understanding of certain types of social practices that are best described as system-like. Based on current research, social systems are said to have the following properties. They are emergent, self-organizing, bounded, functionally autonomous, thematically centered, differentiated, agent-based, rule-following and complex (that is, they are comprised of a dense number of connections and interactions and often a large number of variables). They are also dynamic, evolve across time-space, and are situated within and impacted by a variety of environmental systems and forces. For a more thorough overview of this definition, see Byrne (1998), Cilliers (1998), Luhmann (1995) and Urry (2003).

The town of SACS, for example, as a type of social practice, meets the criteria for the category of a social system. First, SACS is emergent; the whole of the field is more than the sum of its parts, including its scholars, areas of study, educational institutions, websites, journals, etc. Second, SACS is self-organizing; it has coalesced into a field of study with little to no external guidance or control on the part of some specific conference, committee, department or school. Third, SACS resides in bounded form on the "outer bank" of sociology and just outside the city of complexity science. Unlike medicine, law, or clinical psychology, however, one does not need a specific credential, degree or disciplinary permission to do work in this field. Instead, SACS's boundary is informal, relaxed and unincorporated. Fourth, SACS is functionally autonomous (although not independent): while SACS has obvious connections to sociology and complexity science, it nevertheless is its own area of study, with its own journals, conferences, departments etc. Fifth, the scholars of SACS have a common set of concerns around which their work revolves, including: (a) addressing one or more of the six challenges of complexity, (b) figuring out how to integrate the intellectual traditions, theories and methods of sociology and complexity science to enhance sociological inquiry; and, (c) treating social complexity in systems terms. Sixth, and related, SACS is differentiated into a network of attracting clusters, each representing one of the various ways its dominant theme is practiced. These are: (1) sociocybernetics, (2) Luhmann School of Complexity (LSC), (3) computational sociology, (4) the British-based School of Complexity (BBC), and (5) complex social network analysis (CSNA). Seventh, SACS is agent-based with dense, local connections within the major research communities and with semideveloped connections amongst them. Eighth, SACS has a past, present and future trajectory within the systems tradition in sociology. As we will argue throughout the rest of the book, SACS is the latest stage in the systems tradition within sociology. And, finally the trajectory of SACS has emerged and evolved within the larger environmental systems of sociology, complexity science, western society and (more recently) global society. Given these characteristics, SACS is a social system.

2.2.4 Overcoming the Agency/Structure Dualism

The second assumption with which social complexity theory begins is that social practices are the building blocks of a social system. As we explained in our review of coupling, many types of social practice, particularly those that are more complex, tend to emerge out of the coupling of some set of smaller (but sometimes larger) social practices. The social practice of writing, for example, emerges out of the coupling of such various practices as typing, working a computer, reading the current literature, conversing with colleagues, using language, forming sentences and paragraphs, etc.

There are several advantages that come from the idea that social systems emerge out of the coupling of two or more social practices. One of the most important (and the one we will discuss here) is our ability to avoid a major flaw found within both the systems tradition and complexity science: the perpetuation of the structure/agency dualism. Systems theorists are faced with the Charybdis of structure (that is, conceptualizing social systems from the top-down, as already existing emergent structures) while complexity scientists have their Scylla of hermeneutics (that is, conceptualizing social systems from the bottom-up, as the product of micro-level interactions alone).

The Charybdis of structuralism within the systems tradition extends back to our short list of canonical scholars reviewed in our introductory chapter. For example, this bias can be found in the organicism of Spencer and Durkheim, and in Marx's dialectical materialism. We also see it in Weber. Despite all Weber's emphasis on verstehen, his analyses primarily were conducted from a top-down, macro-level perspective. Fifty years later, Parsons made the same structuralist mistake. Furthermore, and for all of his criticisms of Parsons, the contemporary sociologist and complexity scientist, Niklas Luhmann (See Sect. 6.3) fell into the same structuralist trap. In fact, reading Luhmann (1995) one wonders if humans even exist.

Complexity science reflects an opposite bias. Here, scholars drift toward treating social agents as the ontological basis of social systems (the

Scylla of hermeneutics). The major thesis underlying most complexity science is that social systems emerge out of the micro-level interactions of a network of rule-following agents (Axelrod 1997; Holland 1998; Wolfram 2002). In fact, complexity scientists are so adamant about this point that they call their approach *agent-based*, and they talk about building social systems from the ground-up (as opposed to the top-down)—all in an effort to distinguish their work from the structural biases of older systems thinking (Cilliers 1998; Gilbert and Troitzsch 2005; Holland 1998). In so doing, however, complexity scientists fall prey to treating social systems as little more than the aggregate product of symbolic interaction.

While we strongly endorse an agent-based view, and while we consider it a major advance over previous systems thinking, we nevertheless think that, at least when it comes to the study of such complex systems as human organizations, health care systems, professions, global economies, and so forth, greater empirical yield comes from thinking about social systems as practice-based; that is, from thinking of social practice as the fundamental building blocks of a social system, rather than rule following agents. In many ways, the remainder of this chapter and this book is an attempt to defend this point.

Consider, for example, SACS. One could easily construct a map of the network of actors in this social system. The system, however, does not emerge out of these actors. Instead, it emerges out of the two dominant social practices that are coupling to create this new field of study, namely sociology and complexity science—we will have much to say about these two social practices in Sect. 2.2.6 of this Chapter. From this perspective (e.g., social practices as the building blocks of social systems) each scholar—such as Nigel Gilbert or Duncan Watts or Niklas Luhmann—is more than just a social agent. Each scholar constitutes one of the numerous ways the social practices of sociology and complexity science couple to create the new field of SACS. In other words, the names of particular scholars in the system of SACS do not just represent individuals (social agents); they represent specific expressions of social practice, including interaction, communication, social knowing and coupling—as enacted by these scholars. In other words, while different agents make different social practices unique, it is only because they already are part of these social practices. Said another way, social systems are more than just agents following rules. They are agents involved in the coupling of social practice.

To make our theory of "social systems as social practice" clearer, let us turn to an overview of the major filing system of social complexity theory. We begin with the *field of relations*.

2.2.5 Field of Relations

As shown in Map 3 (SACS Toolkit Map) and Fig. 1 (Venn diagram), social systems are situated in a field of relations. The field of relations is defined as the intellectual arrangement and bracketing of all information necessary to construct a model of a social system. We borrow the term from Michel Foucault, the practice theorist we discussed earlier (See Dreyfus and Rabinow 1983). For us, this term has three functions: conceptual, organizational and methodological.

1. Conceptually, the field of relations functions as the grid of analysis—something Foucault calls a dispositif (See Dreyfus and Rabinow, 1983, pp. 118–125). Its purpose is to articulate the space in which all the elements a social system of study— along with their relationships—can be located and coaxed into coming together. In this respect, the field of relations simultaneously is an artificial product of the researcher and something externally real, which the researcher legitimately studies.

Our metaphor of SACS as an intellectual community is a good example of this duality. While SACS is not literally a town, the term "SACS" illustrates or captures the intellectual space in which the intersection of complexity science and sociology currently is taking place. This analogy of an intellectual town also is a useful way to treat the connections SACS has to the intellectual tradition of systems science. Examples being our discussion of the Old Parsons Highway or our situation of Luhmann's new social system theory near the intellectual remains of Harvard's Department of Social Relations.

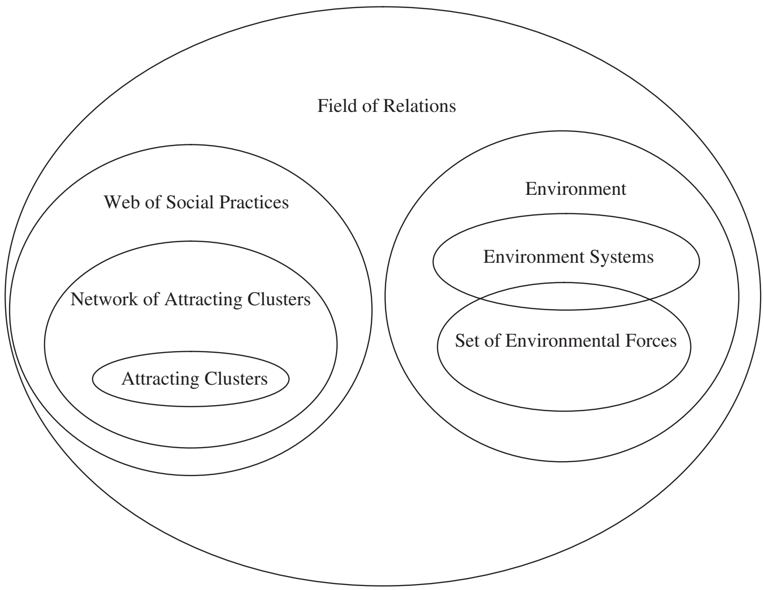


Figure 1: Venn Diagram of SACS Folder

2. The second purpose of the field of relations is organizational. As we explained above, social complexity theory is a rigorous framework of organization. Social complexity theory provides a way for researchers to make sense of the chaos of modeling social systems, which is does by giving the researcher a set of conceptual folders, sub-folders, a filing system, and so forth for organizing everything in a set of predetermined format. The assemblage algorithm, in turn, provides the researcher a set of procedures for collecting and analyzing these files, sub-files, etc.

Perhaps one of the best filing systems available to modern science is set theory. Set theory is the study of the proper ways to think about, organize and discuss the collection of objects (sets) and the relationships these object (as sets) have with themselves and one another (Clapham and Nicholson 2005). The field of relations, therefore, operates as the universal set for any social system of study such that:

$$F = \{x_1, x_2, x_3 \ldots x_n | x_n \text{ is relevant to some social system of study}\} \quad (2.1)$$

In this equation, *F* stands for the field of relations and x_n stands for any piece of information relevant to the study of a social system. Any collection of x_n taken from *F* to model a social system constitutes a subset of *F*. In fact, the web of subsystems folder, network of attracting clusters folder, and environment folder are culled out of *F*. In short, these folders are subsets of *F*.

The formal arrangement of *F* and its subsets is shown in Venn diagram (Fig. 1). Beginning with *F*, each subsequent folder used to model a social system is visualized as a subset to the Nth order. For example, the environment and web of subsystems folders are 1st order subsets of *F*. In turn, the network of attracting clusters is a subset of the web of subsystems, and as we discussed earlier, environmental systems and environmental forces are subsets of the environment folder.

Map 3 provides an example of how we use the field of relations to organize our study of SACS. The field of relations constitutes the entire map, which we define as all things relevant to constructing a model of SACS. Within this general field are several key subsets: (1) there is the subset called sociology, which is one of the two environmental systems (the other being complexity science) in which SACS is situated; (2) there is the subset of environmental forces (the growing complexity of sociological work) that defines the external forces impacting the formation and development of SACS; (3) there is the web of social practices, which contains the building blocks of SACS; (4) and, finally, there is the network of attracting clusters—a subset of the web of social practices—in which we identify five subsets, one for each of the five major areas of research in SACS.

3. The third purpose of the field of relations is methodological. The strength of using the field of relations is that it can be directly applied to the organization and management of one's database, as well as the collection and analysis of empirical data. This is of particular importance when collecting, organizing and analyzing quantitative data, primarily because there is no theoretical slippage moving from theorization to quantitative data collection and analysis—a major bonus strength of the SACS Toolkit. In fact the field of relations, when coupled with set theory and matrix algebra, is the organizational equivalent of the database formats used in such software packages as SPSS® and MATLAB®, both of which are used by the SACS Toolkit when studying quantitative data.

As a side note, to help organize the model building process, assemblage (the methodological component of the SACS Toolkit) uses the folder systems of social complexity theory to organize the field of relations database. Here, again, we turn to the data mining literature and the idea of active data management. Active data management is one where the database is constantly updated, developed and revised based on the changing needs and concerns of the researcher. Passive is the traditional approach, wherein once a database is created, it is not significantly changed in any way.

Taking an "active" approach to data management, the subsets of the field of relations become their own databases—each, of which, is also a major folder in social complexity theory: environmental systems, environmental forces, web of subsystems, network of attracting clusters and system dynamics.

In the case of SACS, for example, database #1 contains the five environmental forces impacting SACS—see Map 3 for a list. Database #2 contains the two environmental systems in which SACS is situated, sociology and complexity science. The third database contains all the information necessary to build a model of SACS. The third database, in turn, is comprised of two smaller databases: the data for the web of social practices and the data for the network of attracting clusters. The web of social practices database contains the twin practices out of which SACS emerges, sociology and complexity science. Both of these social practice databases are further divided into three major sections: intellectual traditions, methods and topics—See Map 3.

The network of attracting clusters database is comprised of the five dominant ways that the social practices of SACS couple together. These "couplings" corresponds to the five areas of research in SACS: complex network analysis (CNSA), the Luhmann School of Complexity (LSC), sociocybernetics, computational sociology and the British-based School of

Complexity (BBC)—See Maps 3 and Figure 2 for a visual rendering of this database.

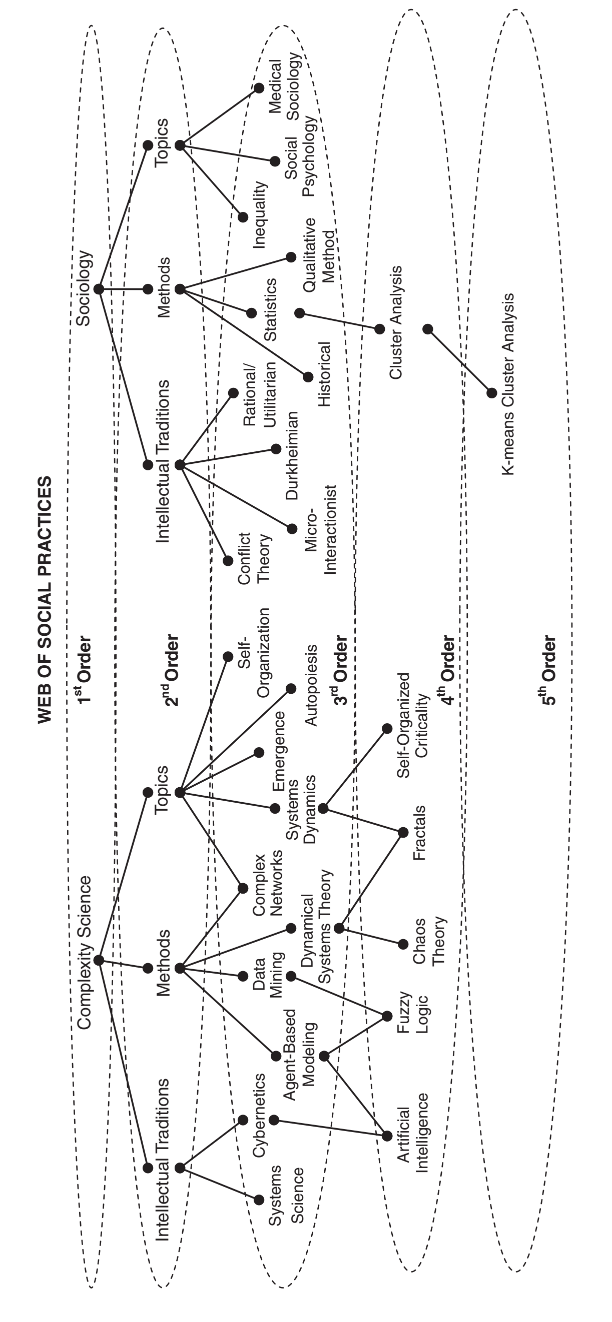
Before proceeding further, we need to introduce the dimension of time-space. Social systems rarely are studied at a single moment in time-space. Instead, the usual goal is to model a social system as it evolves across time-space. One of the distinguishing features of complexity science is the significant emphasis it places on dynamics: how things change across time-space (Holland 1998; Wolfram 2002). In fact, as we discuss in detail in Chap. 5, this emphasis is what makes complexity science such a powerful methodology (Axelrod 1997; Casti 1999). For complexity scientists, it is one thing to outline structure, but quite another to understand how this structure actually unfolds. The SACS Toolkit has the same orientation. It ultimately is interested in the dynamics of social systems; how they emerge, self-organize, and evolve. The same is true of SACS. The reader will note that, even in our introductory chapter we emphasized the evolving tradition of systems thinking in sociology and the place of SACS in that tradition. Our databases also reflect this bias toward dynamics. Each database contains information at several key points in time, starting in the late 1990s and ending with the present, 2008.

2.2.6 Web of Social Practices

The web of social practices is the folder used to manage one's empirical inquiries into the set of practices that couple together to form a social system of study. We use the term "web" in this concept to highlight the interdependent, relational nature of social practice.

As we previously discussed, social practices are the building blocks of a social system. As building blocks, they come in all shapes and sizes, varying in type, length of time, level of stability, number of agents, type of agents, forms of communication, ways of knowing and complexity. A system's social practices can themselves be treated as systems; something we refer to as a subsystem; or, systems within a system of study. These subsystems however, are not necessarily a smaller unit of social reality than the system of study. As shown in Map 3, for example, SACS is comprised of two major social practices—sociology and complexity science—both of which are social systems. These systems are much larger and more widely practiced than SACS. Nonetheless, they are part of the building blocks of SACS and are therefore treated by social complexity theory as part of its web of social practices. (They are also, as a side note, treated as environmental systems, which is a point we will clarify in Sect. 2.2.8.)

Figure 2: Web of Social Practices for SACS



Although the web of social practices can take a variety of visual forms, we have found that the organizational chart or tree diagram is the most useful representation—see Fig. 2. In such a diagram, the system's social practices are ranked according to their relative importance and position, with each additional ordering of practices subsumed under the previous order (remember our discussion of set theory). The subsystems of sociology and complexity science, for example, are divided into their own subsystems and social practices—See Fig. 2. We refer to these successive subdivisions as the Nth order of subsystems and sub-practices. Theoretically speaking, the ordering of subsystems and sub-practices can continue ad infinitum. In SACS, for example—see Fig. 2—one can "tool down" (to use a data mining term) into the subsystem of sociology, going on to method (2nd order subsystem), then statistics (3rd order subsystem), then cluster analysis (4th order social practice) and then, finally, k-means cluster analysis (5th order social practice). One could imagine going even further (although our diagram does not) to a 6th order social practice that specifies different usages of the k-means cluster analysis, such as our own integration of this technique with neural networking (Castellani, Castellani and Spray 2003).

While a structural diagram of the web of social practices is organizationally efficient and productive, it does not in-and-of-itself make a social system. Dynamics also are needed. At this point, however, the web of social practices is purposely devoid of dynamics. It avoids dynamics at this point so the researcher can focus on getting everything in order. Let us explain.

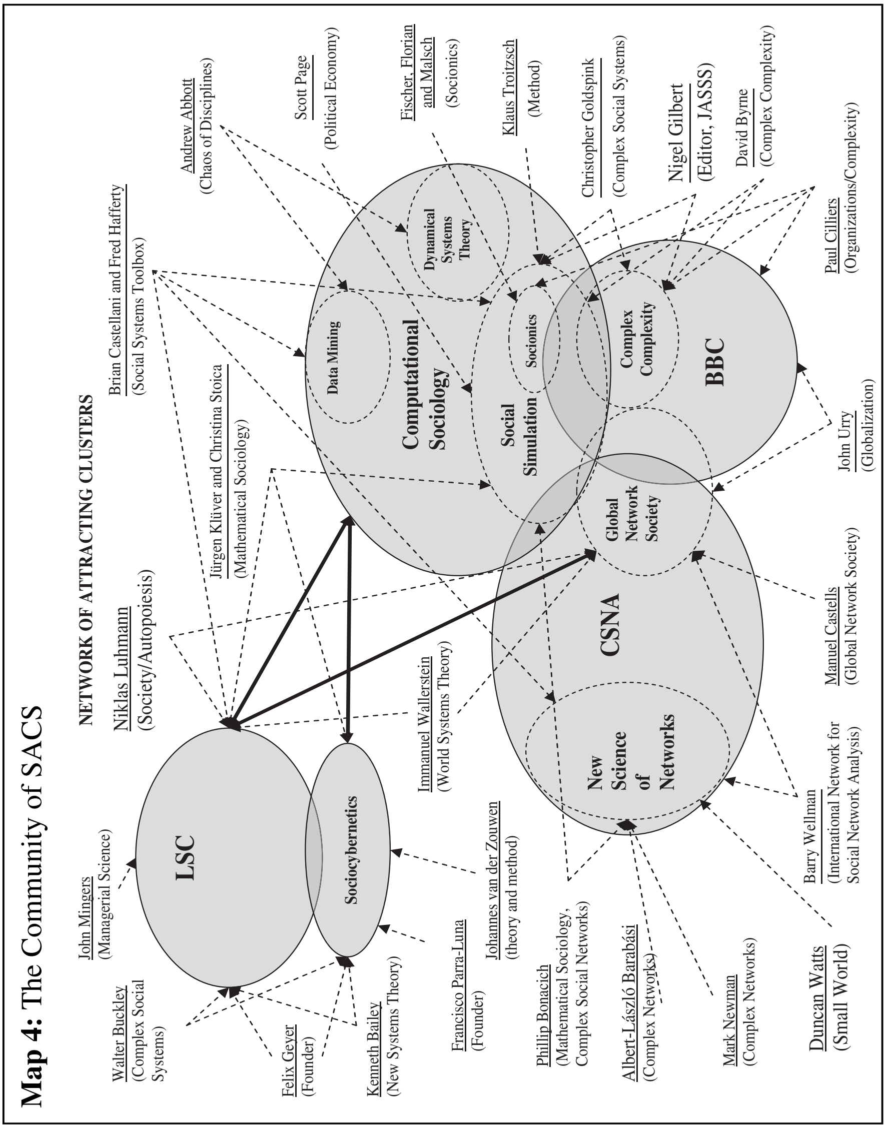
As an analogy, one can think of building the web of social practices as akin to opening a board game and first having to arrange all of its pieces before ensuing play. A more socially nuanced analogy would be hosting a party. Behind every successful party (even the most casual) is a host of preparations and checklists. Once the game or party starts, however, it is all about dynamics and interaction. You do not want to exit the game or party because you forgot something, or worse, you do not want everything to stop because a key element is missing. The same is true when studying social systems. One wants to have everything in order before turning to a study of the coupling process and its consequent dynamics. The job of getting all the relevant social practices into place, including the key social agents, interactions, communications and social knowing relevant to these social practices is the purpose of the web of social practices. At this point, the only thing missing is the coupling of these social practices. This brings us to our next major folder, the network of attracting clusters, which is all about dynamics.

2.2.7 Network of Attracting Clusters

As shown in our Venn diagram (Fig. 1), the network of attracting clusters is a subset of the web of social practices. As a subset, it provides a list of the different ways the web of social practices tends to couple. In turn, each "coupling" constitutes one of the numerous ways a social system is practiced. As we explain later, the goal of assemblage (our method) is to reduce our list of couplings to the most salient (i.e., outstanding, prominent, significant, leading, major) ways a social system is practiced at any given moment in time-space. Drawing upon the language of fractal geometry, chaos theory, and the new science of networks, each of these major couplings/practices is defined as an attractor point in the social system, a hub around which a variety of similar couplings tend to cluster. When assembled together, these major couplings/practices form a network, hence the name of this folder, the network of attracting clusters.

Map 4 depicts the network of attracting clusters for SACS. Each oval on this map represents one of the major ways that SACS is practiced; that is, one of the major ways that the intellectual traditions, methods, and topics of sociology and complexity science tend to couple. Together, these ovals represent the five major research communities in SACS at a particular moment in time-space; specifically SACS in Europe and North America, circa 2008. In the language of fractal geometry, each oval in our map is an attractor point around which a more exhaustive list of minor couplings (in this case, scholars and subfields of research) gathers. In fact, these minor couplings represent the scholars hovering around these five communities. Remember our point about social practice being the building blocks of a social system? Based on this idea, the scholars in SACS are empirical expressions of the numerous "couplings" taking place within and between the five research communities of SACS. In other words, the scholars of SACS (at least for the purposes of social complexity theory) are not just people; they are expressions of the coupling of social practice.

To understand more fully the network of attracting clusters, we need to spend time discussing the concepts of coupling, attractor points, difference, and system boundaries. We therefore turn to a brief overview of these concepts.



Map 4: The Community of SACS
NETWORK OF ATTRACTING CLUSTERS
Niklas Luhmann
(Society/Autopoiesis)
Brian Castellani and Fred Hafferty
(Social Systems Toolbox)
Andrew Abbott
(Chaos of Disciplines)
Scott Page
(Political Economy)
Fischer, Florian and Malsch
(Socionics)
Klaus Troitzsch
(Method)
Christopher Goldspink
(Complex Social Systems)
Nigel Gilbert
(Editor, JASSS)
David Byrne
(Complex Complexity)
Paul Cilliers
(Organizations/Complexity)
John Urry
(Globalization)
Manuel Castells
(Global Network Society)
Barry Wellman
(International Network for Social Network Analysis)
Duncan Watts
(Small World)
Mark Newman
(Complex Networks)
Albert-László Barabási
(Complex Networks)
Phillip Bonacich
(Mathematical Sociology, Complex Social Networks)
Francisco Parra-Luna
(Founder)
Johannes van der Zouwen
(theory and method)
Kenneth Bailey
(New Systems Theory)
Felix Geyer
(Founder)
Walter Buckley
(Complex Social Systems)
John Mingers
(Managerial Science)
Immanuel Wallerstein
(World Systems Theory)
Jürgen Klüver and Christina Stoica
(Mathematical Sociology)
LSC
Sociocybernetics
Computational Sociology
Data Mining
Dynamical Systems Theory
Social Simulation
Socionics
Complex Complexity
BBC
Global Network Society
CSNA
New Science of Networks

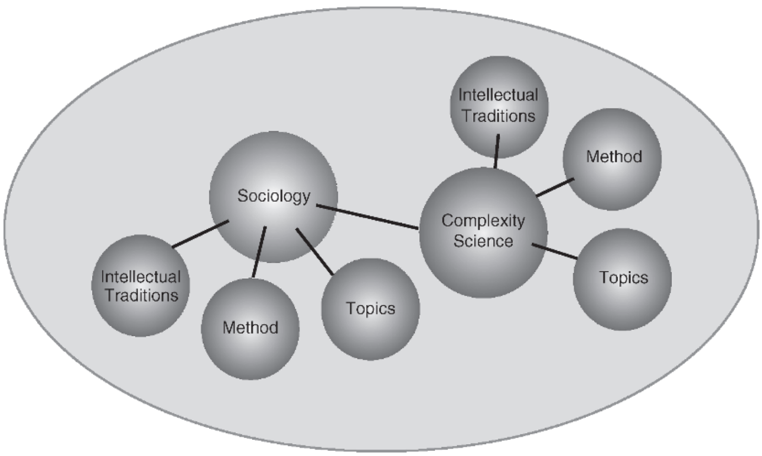
2.2.7.1 Coupling

As we explained earlier, coupling refers to the plasticity of social practice and its characteristic habit of connecting, linking, attaching, merging, joining and uniting with other social practices. Like a form of sociological DNA, social practices can be combined to form just about every possible "manifestation" of social reality, including social systems.

Think, for example, of those "tinker toy" models of various molecules students build in grade school. Social complexity theory views systems in a similar way. One might imagine—being fantastical for a moment—a computer program containing a list of every type of social practice in its toolbar for modeling SACS. In this computer program, one could click-and-drag these various social practices onto a three-dimensional grid where they could be merged, positioned and linked to one another until some basic "molecular" model of their configuration emerged. The result would be a system's web of social practices. Such a molecular model might look like Fig. 3. Furthermore, in constructing this model, the researcher could show how the different couplings of these various social practices "express" the system in different ways. This is an important statement and the crux of what we need to discuss now.

So far in our review of social complexity theory, we have established the following: (1) social systems are situated within a field of relations; (2) social systems are a type of social practice; (3) social practices are the building blocks of a social system; (4) social systems are comprised of a web of social practices; and (5) social systems emerge out of the coupling of two or more social practices. While each of these five theoretical

Figure 3: Web of Social Practices as Molecule



points is unique in the complexity science literature, and while all five go a long way toward establishing the utility of social complexity theory, they are a theoretical prelude/introduction for the next two points: (6) at any given moment in time-pace, a social system is multiply expressed and (7) this multiplicity of expression comes from the different ways that a system's social practices couple together. Let us explain.

2.2.7.2 Attractor Points

As an isolated point, the idea that social systems are multiply expressed is not new. Even the most basic of social practices, such as saying "hello," can be expressed in a variety of ways. The same is true of macro-level practices such as corporations or governments. None of these large-scale systems can easily be determined ahead of time, primarily because they possess the ability for multiple forms of expression.

What complexity science has added to this idea is that a social system's multiple forms of expression emerge out of the collective behavior of micro-level interactions. (Remember, however, that we disagree with a strict agent-based approach.) A network of adaptive social agents, following a simple set of rules, can create all sorts of complex outcomes, many of which cannot be predicted or repeated with certainty.

An excellent example is the work on agent-based modeling by Craig Reynolds. At his website (http://www.red3d.com/cwr/boids/), Reynolds provides several dozen examples of how a set of primitive agents (he calls them boids), following a simple set of rules (avoid the red boids, slow down at the wall, etc), can create endless variations of basic social practices such as following the leader, queuing at a doorway, or forming a line. While predictable within a certain set of parameters, the dynamics of Reynolds's boids are never the same. They are multiply expressed.

At the macro-level, an excellent example is the work on agent-based modeling by Joshua Epstein and Robert Axtell (Epstein and Axtell 1996). On a computer-simulated planet called *Sugarscape*, Epstein and Axtell have created a colony of social agents. The world of these agents revolves around a basic resource, sugar. Agents eat sugar, trade sugar, fight over sugar, migrate to find more sugar, split off into separate colonies over sugar, and even consume too much sugar and die. The population of Sugarscape ebbs and flows like an epidemiological study of predator-prey models. Similar to Craig Reynolds' boids, the dynamics of Sugarscape is confined to a rigid set of parameters. Still, and despite this containment, the expressions of this system are never the same. New things are always happening. And it is absolutely fascinating to watch.

In complexity science, a social system's tendency toward multiple forms of expression is captured by the concept of attractor point. This concept comes from physics and a branch of mathematics known as dynamical systems theory, something that extends back to calculus and Newton's study of the movement of objects in time-space, such as planets orbiting the sun. Currently, the two most popular areas in dynamical systems theory are chaos theory and fractal geometry, both heavily involved in the study of attractor points and nonlinear dynamical systems; that is, complex systems that operate in a position far from equilibrium. (As a side note, social systems are a type of nonlinear, dynamical system.)

Nonlinear, dynamical systems are categorically distinct because they are multiply expressed. In mathematical verbiage, this means they do not "settle" into a single solution. Instead, they self-stabilize (self-organize) into multiple solutions called attractor points. In nonlinear dynamical systems, attractor points can have a fractal appearance. They also often act in a manner that is, mathematically speaking, strange. Unlike the attractor points of simple systems (a pendulum, for example), strange attractors are neither exact nor permanent solutions. Instead, they are temporary "solutions" toward which a nonlinear dynamical system is drawn. One can see this process take place, for example, when a simulated system is iterated by computer in time-space (Érdi 2007).

As a side note, the life of a system's multiple solutions (its set of attractor points) is a function of the system's relative stability as it evolves across time-space. Highly chaotic systems, like storms or hurricanes, lack the stability one would find in a city's daily traffic patterns; which, in turn, lack the stability one would find in the changing political or economic control of most western governments.

Furthermore, there also tends to be more than one attractor in a nonlinear dynamical system. This is another reason why nonlinear dynamical systems are strange and the main reason why they are important for complexity science. In a nonlinear dynamical system—otherwise known as a complex system—each attractor point represents one of the myriad of possible ways the system can be solved/expressed.

This is the crux of our sixth point. Following the insights of complexity science and fractal geometry, we recognize that, at any given moment in time-space, a social system is being multiply expressed. What we take issue with, however, is the idea that this multiplicity is grounded in aggregate patterns created by a network of rule-following social agents. Instead—and this is our seventh point—this multiplicity comes from the various ways a social system's web of social practices couple.

2.2.7.3 Difference

As Klir explains, the term “system” can be applied to any set of things and the relationships amongst them—from card catalogues to airplanes to economies (2001). As long as the focus is on a set of things and the relationships amongst them, one is focusing on a system. Given such broad application (we touched on this point in our introductory chapter) a primary task of systems scientists is to identify and catalogue the different types of systems that exist or can be created.

In the field of systems science, the term “social system” refers to a particular type of system, namely those comprised of humans, their various aggregate creations (groups, formal organizations, economies, social institutions, etc), and the relationships amongst them. A modern society for example—think of the work of Durkheim or Parsons—is a system of differentiated social institutions (economy, government, health care, education, family, work, etc.) and the relationships amongst them. In turn, a formal organization is a collection of social roles and social groups and the network of formal and informal relationships, all created and designed for some specific purpose, such as educating students or making cars. In this classic sense of the term, “social system” refers to any human activity where the whole is more than the sum of its parts; that is, where the relationships amongst a set of humans and their various aggregate creations result in something more than the sum total of their interactions.

While we embrace this line of inquiry, we want to move in a different direction. For us, this traditional definition, while necessary, is insufficient. What is missing is the network of attracting clusters. Said another way, the traditional definition of a social system does not take us beyond the web of social practices.

If one were to frame the traditional definition of a social system (a la Durkheim, Parsons or more recently Luhmann) in the language of social complexity theory, we would say that systems emerge out of the collective interactions of a set of social practices. For these scholars, however, any concerns with the multiplicity of expression within a given system, or to issues of difference, would be confined to the manner in which this emergent social system changes across time-space. These scholars have no interest in the coupling process and the simultaneous differences this coupling produces at any given moment in time-space. It is here, therefore, that we part ways with traditional systems theorists.

For us, social systems ultimately emerge out of the coupling of social practice and the differences this coupling produces. From this perspective, the “things” of which a social system is comprised are not its social practices per se, but their couplings. Moreover, the system’s “relationships” are not just the interactions between these social practices, but (more important) the interactions between their various couplings. Said another way, a social system emerges out of the complex interactions in the different ways it is practiced. It emerges out of the network of attracting clusters.

Consider SACS. While the common theme in SACS is "integrating sociology and complexity science for the purposes of enhancing sociological inquiry," there is no one way to do this. As shown in Fig. 2, SACS emerges out of the coupling of two major social practices: sociology and complexity science. More specifically, SACS emerges out of the coupling of their respective intellectual traditions, methods and topics. The coupling of these two social practices does not, however, result in only one type of research—a singularity. Instead, it produces a wide variety of research agendas—a multiplicity. In the vernacular of complexity science, each of these research agendas constitutes one of the major attractor points in SACS. In turn, the numerous research agendas cluster around each attractor point. Map 4 visualizes this perfectly. On this map are the five main areas of research, including the smaller subfields located within, across, or between them. Also, orbiting around these five areas are the smaller research agendas of the key scholars in SACS.

The concept of *difference* is critical to our definitional approach to social systems. A social system is not a singularly. Instead—and this is our eighth point—it is a *multi-singularity*. A system, as a whole, is grounded in the interactions amongst its different forms of expression. While the researcher ultimately is studying a system (a singularity), the focus is always on the complex ways that this system's multiple forms of expression (coupling) interact—and thus create the system. Hence, a social system is a multi-singularity.

This does not, however, end our discussion of the network of attracting clusters. The possibility for multiple outcomes does not mean "anything goes." While, theoretically speaking, sociology and complexity science could be coupled ad infinitum; in practice this never happens. In the past ten years, for example, only five major areas of research have emerged in SACS, and of these five, only two are widely embraced: computational sociology and complex social network analysis. In this respect, while social systems are multiply expressed, over time they tend to constrain themselves. Why this is the case has yet to be empirically detailed. Nevertheless, as shown in the work of Luhmann (1995), Abbott (2000), Gunduz (2000, 2002) and others, social systems tend to place limits on themselves. These limitations tend to emerge in the form of dominant attractor points around which the majority of minor expressions cluster.

This "limitation in expression" is another defining feature of a social system, and also represents our ninth major point. While social practices can couple to form a potentially limitless number of solutions, these different ways of "practicing" a social system tend to constantly organize and settle down into a smaller network of attractor points (solutions). In terms of specifics, social systems couple to create, at minimum, two internal attractor points—this is our tenth point. The maximum number of attractor points, however, is a matter of empirical inquiry and utility, a point we will address in our review of our method, assemblage.

2.2.7.4 Boundaries

The last term we need to address in our review of the network of attracting clusters is *system boundary*. Just as a system emerges out of the coupling process, the system's boundaries are determined within the process of coupling.

We have, however, a challenge. While the concept of boundary is a problematic term for sociologists (and something we will discuss in a moment), it is absolutely essential to the study of social systems. Only when boundaries are established can everything else about a social system be determined with any degree of certainty. This includes: (1) identifying the system/topic of study; (2) determining how it is positioned in time-space; (3) examining what lies inside and outside the system; (4) reviewing the larger environmental systems at play; (5) identifying the impact of these environmental forces; (6) assessing how the system responds to these environmental forces; and (7) studying the nature of the system's internal dynamics, including its evolution over time; that is, its past, current and future trajectory. As such, articulating the definition of system boundary is a delicate task. We turn to this task now.

The concept of system boundary is heavily influenced by its usage in the natural sciences, particularly biology. Within this context, only physical systems have boundaries. Planets, molecules, cells, bodily organs, brains and animals all have definable insides and outsides that one can physically study. Social systems appear different. A system's network of attracting clusters does not result in the creation of a physical boundary in the same way that a body or tree has a boundary. Or does it?

For us, social systems have empirically definable, legitimately real boundaries. The problem is that they do not emerge at the perimeter of a social system. They emerge at its center. Thus, our eleventh major point: the boundaries of a social system are defined as and emerge out of the limits of its coupling process. As such, a social system's boundaries come from its center, not its edge.

Consider SACS, for example. This intellectual town emerges out of the coupling of complexity science and sociology. Where, however, does this coupling end? Theoretically—never. There always is the possibility for one more expression of the system; one more way of coupling its social practices. In another respect, however, the coupling does end. It ends through the emergence of the dominant attractor points around which a system's minor variations in practice cluster. In other words, it ends with the network of attracting clusters for a given moment in time-space.

In this way, the social system of SACS does have an empirical boundary—albeit a temporary one. While there always is the theoretical possibility for one more coupling, the empirical reality (as noted above) is that, at any given moment in time-space, the network of attracting clusters for SACS tends to settle into an identifiable system with (remember our biological definition of a boundary) definable insides and outsides that one can study. Change, add to, or replace SACS's web of social practices and the network of attracting clusters will change. It may even morph into an entirely different system of study.

For example, if the social practices of SACS evolved to include the complex organizations and management studies—two disciplines similar to but different from sociology—its coupling process would change, thus impacting the major attractor points in the system. This, in turn, would not only create a new and different network of attracting clusters, but also, in turn, new and different boundaries for SACS, or something other than SACS.

As this example illustrates, in order to identify the boundaries of a social system, one begins with the web of social practices, attempts to construct the network of attracting clusters and consequently map them. Once mapped, the boundaries for the system are defined at a particular moment in time-space. As shown in Maps 4 and 8, we even can visualize these boundaries by creating a map of the network of attracting clusters. The level of detail one wants in such a visualization of a system's boundaries depends upon the detail one achieves (or needs) in the network of attracting clusters. In SACS, for example, we defined the boundaries according to the most widely practiced areas of research, along with their major research subsets and the scholars orbiting these five areas. One could, however, push this further, and examine any one area of research (for example, computational sociology) to create an even more detailed map, including each and every scholar and their numerous programs of research. It all depends upon the information needed. Whatever the detail, the constitution of the boundary for a given system would follow the same process. With this final point, we turn to our next folder.

2.2.8 Environment

The fourth folder in social complexity theory concerns the environment within which a social system functions. Social systems are situated in a larger set of environmental systems and interact with and adapt to those forces.

1. *Environmental systems* can be larger, smaller or similar in size to the social system of study. An environmental system can also be an internal dimension of a social system, which is momentarily treated as external or "outside" the system of study. Take, for example, SACS. While sociology and complexity science are the twin social practices from which this town emerges, they are also the twin social systems within which SACS is situated. In this way—and we follow Luhmann (1989)—sociology and complexity science are both internal and external to the boundary line of SACS. When coupled together, by SACS scholars, these two social practices produce a unique social system called SACS. When practiced on their own, they form their own systems, called sociology and complexity science.

2. *Environmental forces* are any factors treated as externally relevant to the coupling and internal dynamics of some social system of study. Although not entirely accurate, one can think of these "external forces" as independent variables. What one is trying to understand, in this case, is the impact these independent (environmental) variables have on some social system of study, which is our dependent variable. The only limitation in this analogy is that external forces do not so much impact a social system as much as they interact with it.

In the case of SACS, for example, there are five major environmental forces: (1) the emergence of complexity science as a field of study; (2) the evolution of the systems perspective in sociology; (3) the recent methodological innovations of complexity science; (4) the sudden popularity outside SACS and complexity science of network analysis; and (5) the growing complexity of sociological work. Our study of SACS primarily is interested in how its network of attracting clusters has responded to these forces and how these interactions have shaped SACS's past, current and future trajectory, particularly within the larger social systems of sociology and complexity science.

2.2.9 System Dynamics

The final folder in our theoretical framework is dynamics: the relationships, forces and motions that characterize the "play" in a social system—all of which occur, at least for social complexity theory, within and amongst its network of attracting clusters.

Reiterating a previous mantra, the analysis of a social system is not limited to identifying its network of attracting clusters. It requires, for example, one to understand; (1) how the attracting clusters in a network interact with themselves and each other; (2) how these interactions impact the social system of which they are a part; (3) how these interactions change over time; and (4) the influence and impact environmental forces and systems have on the network of attracting clusters. Without such an analysis of a system's dynamics, one has only a partially useful model: a discrete, cross-sectional snapshot of the system at a particular moment in time-space. To build a full model, one must assemble numerous discrete moments (cross-sectional snapshots of the system in time-space) to form a moving picture, a systems-movie. As we will explain shortly, the purpose of assemblage is to help the researcher create this "moving" model.

In our study of SACS, for example, we did not feel it sufficient to identify the five major research communities currently in existence, circa 2008. We also were interested in the point at which SACS emerged as a legitimate field of study, the areas of research that existed at that time, the environmental forces that contributed to this emergence, and the changes that took place in SACS between its formal emergence and today. We needed more than a dynamics folder, however, to answer our questions. We also needed a list of dynamic terms.

2.2.9.1 Dynamic Terms

Social complexity theory employs a variety of terms to discuss the dynamics of a system. The most important are (1) trajectory, (2) negotiated ordering, (3) differentiation, and (4) self-organized criticality. Given the constraints of space and time, we will provide only the briefest definitions. For more information, see our website.

1. The concept of *trajectory* is taken from the work of Anselm Strauss and colleagues (See Strauss 1993). We developed this term to refer to the course, movement and evolution of a social system within time-space and within any environmental system(s) in which it is situated or with which it is co-evolving. For us, this term also refers to the interactions and individual trajectories contained within the network of attracting clusters, including the trajectories of a social system's subclusters and supra-clusters. For example, one can analyze the trajectory of SACS within the systems tradition in sociology or complexity science. One could also examine the trajectory of computational sociology within the community of SACS—see Map 3, for an example.

2. *Negotiated ordering* comes from our development of a key concept in the theoretical repertoire of Anselm Strauss: negotiated order (Strauss 1993). We use Strauss' term as follows.

First, we turn the term into a verb, changing it from negotiated order to negotiated ordering. Second, we define negotiated ordering as the sum total of arrangements amongst a network of attracting clusters, including the various negotiations responsible for this order. By arrangements, we mean: (1) the conceptual and spatial layout of the major and, if deemed important, minor attracting clusters in a social system; (2) the patterns of relationship that form amongst these attracting clusters; (3) the evolving trajectory of these various clusters and their patterns of relationships (interactions, ties, links, etc.) across time-space; and (4) the impact all of these patterned relationships and their conceptual and spatial layout have on the social system of study, including its trajectory within some larger environmental system. For example, as explained in Chap. 10, all of the maps used in the current book are pictures of the negotiated ordering of SACS. Each map provides some insight into how SACS is ordered within time-space.

3. The concept of *differentiation* combines the work of Niklas Luhmann (1995) and fractal geometry. It also draws upon Abbott's (2000) creative usage of the concept fractal cycle. For us, differentiation refers to the method social systems use to handle their increasing complexity; and to the processes by which the attracting clusters in a social system subdivide, disappear, or emerge in response to various internal and environmental challenges that the system faces as it evolves through time-space.

For example, prior to 1998, SACS was not a formal community or field of study. Instead, it was an informal, intellectual system revolving around the intersection of two key clusters: sociocybernetics and the Luhmann School of Complexity (LSC). In fact, one could argue (as we did in the introductory chapter) that this was what the systems tradition looked like in sociology during the 1980s. Computational sociology is off to the side, not yet formally developed, sort of floating on its own. All of a sudden, circa 1998, the systems tradition differentiated into a whole new topography that created the network of attracting clusters we identify with SACS today: the new systems tradition in sociology.

4. The last concept is *self-organizing criticality*. Social systems are not static. Instead, they operate in a position best characterized as far-from-equilibrium (Bak 1999; Capra 1996; Cilliers 1998). One of the major advances made by complexity science—contra Parsons and the early systems thinkers—is the empirical realization that complex systems do not seek a state of equilibrium or stasis (Bak 1999; Holland 1998; Luhmann 1995). Neither, however, do they collapse into chaos (Cilliers 1998). Instead, they seek a position somewhere between these two states. Complex sys-

tems achieve stability by settling into a particular phase state that allows them to manage their relative entropy, chaos and stasis. Ilya Prigogine—one of the leading thinkers in complexity science—received the Nobel Prize in chemistry in 1977, in part, for his theory of dissipative structures, which—condensed—explains how complex systems (particularly chemical and biological) achieve their self-organizing order through their chaos (Prigogine and Stengers 1984).

A similarly successful (albeit more highly contested) theory on system stability is that of Per Bak and colleagues (See Bak 1999). This theory asserts that many complex systems manage their internal dynamics by achieving a critical state, which they call self-organized criticality.

Self-organized criticality is important because it allows complex systems to “weather” small-scale and large-scale change without falling apart or collapsing into chaos. This is not to say that complex systems do not vary in their degree of stability or that they cannot fall apart, because in some cases they do go through radical change or pass some tipping point beyond which they can never return. In fact, one of the main undertakings of complexity scientists such as Geoffrey West, president of the *Santa Fe Institute* (www.santafe.edu), is to catalogue how biological organisms, at varying levels of scale, maintain their respective functional and structural designs in the face of so much internal and external dynamics. For example, why do human cells stay a certain size? Does stability in size allow cells to preserve what they are? How about social systems? Is there a limit to how large a government or society can become before it falls apart? In the words of Luhmann (1995), how much complexity can a social system handle before it needs to differentiate into another form?

Drawing on the work of Per Bak and colleagues (See Bak 1999), we use self-organized criticality to refer to the tendency of the network of attracting clusters in a social system to arrive at and maintain (without external guidance or an overseer) a state of relative stability. More important, as we explain in Chap. 8, we also use this term (in combination with the power law—remember our discussion of Pareto and the power law in our introductory chapter) as a measure of a social system’s relative stability and robustness as it evolves through time-space, particularly as it goes through important phase transitions.

In the case of SACS, for example, we use this concept to ask: What events caused this field suddenly to differentiate and emerge in 1998? Furthermore, and in the aftermath of this tipping point, how stable has SACS become? Is SACS relatively well defined?

It is with these final questions that we come to the end of our discussion of social complexity theory. We now turn to a discussion of our algorithm for modeling social systems, *assemblage*.

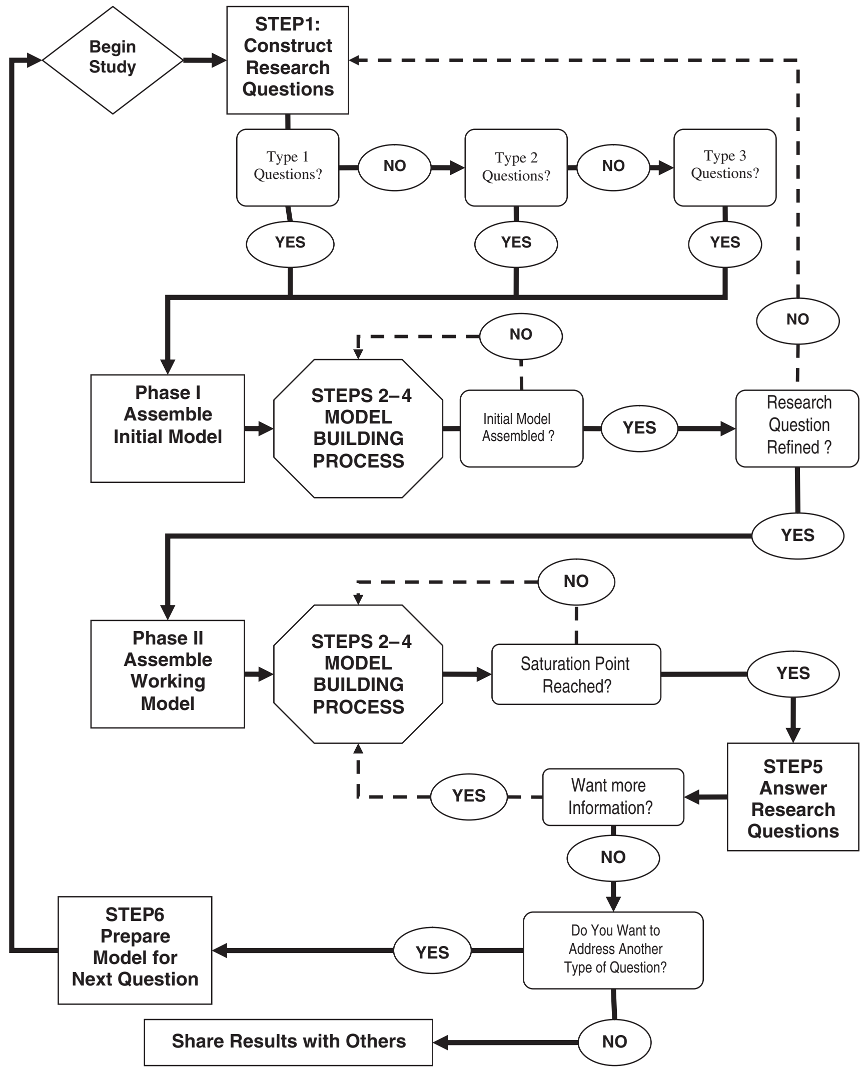
3 SACS Toolkit—Assemblage

3.0 Introducing Assemblage

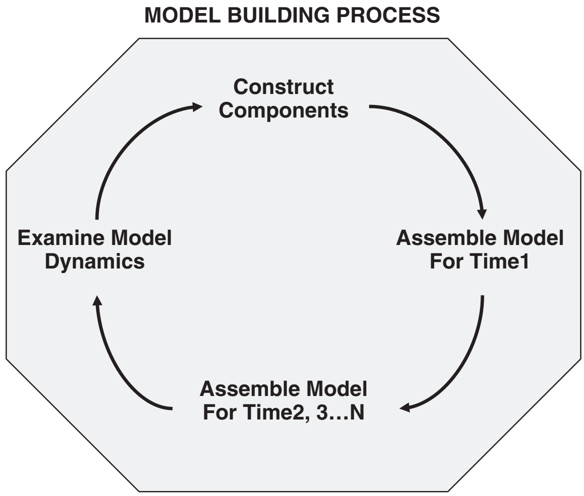
Assemblage is a case-based, system-clustering algorithm for modeling social systems. It is built on the organizational framework of social complexity theory and represents the procedural component of the SACS Toolkit.

As shown in Flowcharts 1 and 2 (See also Chap. 10), the goal of assemblage is to move researchers through a six-step algorithm for constructing a model of some social system of study. This algorithm roughly proceeds as follows: (1) help the researcher define a set of research questions in systems terms; (2) establish the social system's field of relations and determine the web of social practices out of which it emerges; (3) use this information to catalogue the numerous ways the system is coupled/expressed at a particular moment in time-space; (4) condense/cluster this catalogue into a smaller grid of the system's most important practices to create the network of attracting clusters; (5) examine the internal dynamics of this network for a particular moment in time-space, including its interactions with key environmental forces and its trajectory within key environmental systems; and, finally (6) assemble these discrete, cross-sectional snapshots of the system into a moving model, concluding with some overall sense of the system as a whole. Once done, researchers can "data mine" this model to answer the initial study questions or to generate new questions or models.

Flowchart 1: The Assemblage Algorithm



Flowchart 2: The Core Steps



3.1 The Key Features of Assemblage

As a set of procedures, assemblage has seven key features which, when combined, make it unlike any other complexity science method available today. This is not to say that some of the features of assemblage (such as its case-based approach to analysis) are not found in other methods and techniques. But, it is to say that no other complexity science method has all seven features.

1. Assemblage is specifically designed for modeling social systems. One of the hallmarks of complexity science is the realization that all complex system, be they biological, sociological or ecological, share a similar set of characteristics. For example, all complex systems are emergent, self-organizing, dynamic, and evolving (Cilliers 1998; Klir 2001). Not all complex systems, however, are the same. The complexity of human agents and their communication abilities, for example, present researchers with a unique set of theoretical and methodological challenges (Byrne 2001; Cilliers 1998; Klir 2001; Luhmann 1995). We created assemblage because of these challenges. Assemblage is designed for modeling social systems; nothing else.

2. Assemblage is theoretically grounded. As shown in Flowcharts 1 and 2, the purpose of assemblage's six-step algorithm is to operationalize the folder system of social complexity theory.

3. Assemblage has no data preference. Unlike the majority of complexity science methods, assemblage works equally well with numerical, qualitative, and historical data. Despite frequent references to being multidisciplinary or

even trans-disciplinary, complexity science method is strongly biased toward the analysis of numerical data (Bar-Yam 1997). In fact, one could count on two hands the number of qualitative or historical studies done in complexity science. Assemblage has no such bias.

One of the powerful contributions sociologists make to the study of complex systems is the awareness that statistical and computational methods are (at best) limited and (at worse) powerless for modeling certain dimensions or types of social systems. For example, if you want to understand a social agent's subjective experience of living within a particular social system (say, a poor, urban community), you will find the tools of statistics and computational modeling rather limited. You gain a much richer understanding of these experiences, for example, through the techniques of ethnography and qualitative interviewing.

Assemblage recognizes this sociological point. Assemblage also recognizes that different types of social systems, such as the dynamics of governments, cultural fads, or professions are often best handled when non-numerical forms of inquiry are included in the model build process. As such, assemblage is designed to work with all types of modeling processes: qualitative, historical, statistical, computational, and their various combinations. In our study of SACS, for example, the data ranges from archival and historical to personal communication to quantitative data culled from the *Web of Science Citation Index*.

4. Assemblage can be used with a variety of methodological techniques. From mathematical modeling and hierarchical regression to cluster analysis and causal modeling to ethnography and historical method, assemblage works well with and makes use of just about any qualitative, historical, statistical or computational tool or toolset available in sociology and complexity science. Researchers can use, add, remove or augment the tools they use to build their models, based on the type of social system being studied, the data collected, or the model being constructed.

The reason assemblage can be used with such a wide variety of tools and toolsets is because these tools do not drive the model building process. Instead, the six-step algorithm of assemblage, along with the theoretical framework upon which it is grounded, drives model building. Any tool can be used as long as the researcher uses it in service of modeling a social system.

5. Assemblage is unique in that it takes a case-based approach to modeling complex social systems. As we explained earlier, there is no one way the social practices in a social system couple. Neither is there any one social practice that explains how a social system works. Instead, a social system emerges out of the complex relationships amongst a set of social practices.

We have found that the most methodologically useful way to handle this level of complexity is to use a case-based approach. A case-based approach treats a social system as a set of cases, each of which represents one of the multiple ways that a web of social practices couples to express some social system of study.

At this point in our review, the connection between cases and coupling should make sense. From the perspective of social complexity theory, a case is a synonym for the coupling of social practice. A case represents one example, expression, instance or illustration of a social system of study. Said another way, if we define a social system as a network of attracting clusters, a "case-based" approach is useful because it allow us to build a social system from the ground (cases) up.

In the case of SACS, for example, each scholar or group of scholars is a case—one example of how the social practices in SACS couple. As one clusters these cases into similar groups, one begins to create the network of attracting clusters.

The trick, however, is figuring out how to identify, collect, and describe the right set of cases. Sometimes, as when analyzing a social system qualitatively or historically, the trick is to look first for the most widely practiced cases. In other instances, as when analyzing a social system statistically or computationally, the trick is to analyze hundreds or thousands of cases at a time.

Regardless of the number of cases considered or the particular technique used, the procedure of assemblage is basically the same: you consider and use representative cases as a method to profile and catalogue the various ways that a web of social practices is expressed. You continue doing this until the best set of cases and the necessary number of social practices is determined. Once this process is complete, you are ready to move to the next major step in the assemblage process, which also happens to be the final way in which assemblage is unique in the world of complexity science method.

6. Assemblage is a data-compressing, system-clustering method. As we have said several times and in different ways, the ultimate goal of assemblage is to help the researcher create a social system's network of attracting clusters and to model the dynamics of this network across time-space, particularly as this system is situated within some set of environmental systems. To accomplish this task, the researcher has to cluster the social system into its key attractor points. Using a case-based approach to modeling, each case not only is an expression of coupling, it also is an attractor point in the social system, insomuch as it represents (as just discussed) one possible way the web of social practices is coupled, expressed, etc.

The goal of assemblage, however, is not to map each and every attractor point. While multiple cases need to be considered, mapping all or most of them usually is not necessary, and sometimes contraindicated. There are several reasons why. First, as discussed in the data mining literature—which assemblage draws upon rather extensively—mapping a larger number of cases is too time consuming or expensive (Han and Kamber 2001). Furthermore, as discussed in the complex network analysis literature, a large number of cases tend to create an overly busy map which makes interpretation cumbersome if not impossible (Nooy, Mrvar and Batagelj 2005).

Most important, however, an overly dense map seldom yields additional empirical insight. Generally, a network that contains the most dominant, important, or widely practiced clusters is sufficient. Occam's razor (the principle of parsimony) applies: all things being equal, the simplest solution is the best. In this way—and here we draw directly from Kohonen (2001) and his self-organizing map technique—assemblage is a *data reduction technique*. It tries to reduce and compress the complexity of a social system into a simpler and more understandable form. The product is a network of the key attracting clusters, including: (1) an internal profile and thick description of each cluster; (2) an overview of the distribution of the various cases within each cluster; (3) a map of any additional sub- or supra- clusters; and (4) an overview of the interactions, relationships, and conceptual distances of the clusters in relation to one another and the system as a whole.

Once this network of attracting clusters has been created, it is then reconstructed over a series of discrete moments in time-space and put together to create (as we discussed earlier) a moving picture of the system's dynamics, along with its trajectories within various environmental systems. If greater detail is needed, this can be done post hoc. Or, if one wants a more complete picture, one can "drill down" (to use a data mining term) into a particular cluster to construct a more refined and focused map of a particular section of some social system of study.

7. Finally, assemblage provides a novel approach to visualizing social systems. We specifically designed the SACS Toolkit to provide a sophisticated series of visual aids to help the reader grasp the structure and dynamics of any given social system of study. The most important visual aid is the map. For more information on the map and the visual orientation of the SACS Toolkit, see Chap. 10.

3.2 The Six Steps of Assemblage

Now that we have a basic understanding of what make assemblage unique, we quickly will review its main steps—see Flowcharts 1 and 2 (For a more detailed overview of these steps, see our website). We also will address these steps in varying degree of detail throughout the rest of the book.

In fact, subsequent chapters are ordered around the six-step assemblage algorithm. Chapter 4 provides an overview of our results; Chap. 5 addresses environmental systems and environmental forces; Chap. 6 uses the web of social practices to create the network of attracting clusters for SACS; Chap. 7 creates a moving picture of SACS between 1998 and 2008; Chap. 8 uses the new science of networks to examine SACS as a system; Chap. 9 summarizes our study, situating SACS within the larger environmental systems of complexity science and sociology; and Chap. 10 contains all of the visual aids upon which our study relied.

3.2.1 Step 1: The Research Question

The assemblage process begins with the researcher constructing the empirical questions that will guide the study. These questions can be organized into one of three types.

1. Can I learn something from modeling my topic as a social system? The first type of question is the one most scholars will probably use assemblage to answer. In this case, a scholar wants to address some sociological topic of interest in complex systems terms and is therefore interested in modeling the topic as a social system.

Our study of SACS is an example of this first type of question. During the course of our investigations, we realized scholars were integrating the theories, methods and topics of sociology and complexity science in multiple ways to create a rather diverse set of research programs. While differences existed, we also could tell that the interactions amongst these research areas were self-organizing into some type of larger field of study. The questions however were how, why, where, and to what extent? We also knew there were external factors impacting the formation of this new field, but we were unsure how and in what ways. We were also aware that this new field drew from, and yet was situated within, the larger fields of sociology and complexity science. The question for us was how best to represent all of this complex information? The answer was to treat SACS as a social system. Once we did, our study began to coalesce.

2. Is the social system I am studying unique? While social systems are isomorphically similar, their structure and dynamics often are quite different.

Chapters 2 and 3 from Castellani and Hafferty 2009 Sociology and Complexity Science: A New Field of Inquiry. Germany: Springer

For example, while academic fields like SACS and medical sociology share similarities, they are different from other types of social systems such as cities or governments or cultural movements. The second type of question focuses on the similarities and differences amongst different types of systems.

For example, in seeking to generalize our findings about SACS, one might want to examine the dynamics of academic fields in general. Questions one might ask are: Is there a limit to the number of competing research areas an academic system can manage before the field (or at least parts of it) differentiates into a new field of study? Also, why has so much of science gone the direction of increasing specialization? Correspondingly, why is it that even a science like complexity mimics the same type of specialized behavior, with fields like SACS emerging, even though the work done in these fields is resolutely interdisciplinary?

3. Does my social system of study tell me anything about social systems in general? The third type of questions is a general version of the second. Here the focus is on the structure and dynamics of a social system. For example, what do we know about the general process of emergence or self-organization within social systems? Or, how do social systems evolve? A variant of this third question is discerning how social systems are similar to or different from other types of complex systems.

These, then, are the three major types of questions the researcher can ask. They are by no means mutually exclusive and, in some cases, the researcher may want to address all three at once. Common to all three types of questions, however, is the need to think about some topic in systems terms.

3.2.2 The Core: Steps 2 through 4

As depicted in Flowchart 1, once the researcher has defined the study's questions, it is time to construct the model. The model building process is comprised of two major phases; (1) the initial model and (2) the final model. As shown in Flowchart 1, the researcher moves through Steps 2 through 4 to create the initial model and then repeats these steps until a final model is achieved.

3.2.2.0 Phase 1: Constructing the Initial Model

Assemblage is unique in that it requires the researcher to begin with (as best as possible) a holistic, working knowledge of the system of study, even if this knowledge is very basic and rough. Without some initial understanding of the model, researchers run the risk of getting lost or (worse) finding themselves unable to see the "forest for the trees." Studying a social system is, after all, complex. It therefore is important to begin the study with some global understanding of the topic and one's model of it. This is why building the initial model requires the researcher to do a basic run through Steps 2 through 4.

Consider, for example, our study of SACS. Below is a section of a paper we wrote for a 2004 conference, which provides a sense of how we originally conceived of our model. In the paper we identified and named our new field of study and outlined its major areas of research; that is, its network of attracting clusters:

> There is a new field of study that has emerged in sociology. It is best named the sociology of complexity. It is comprised of seven major areas of research: (A) socionics, which integrates sociology and social simulation; (B) new sociological systems theory, which draws from systems theory and second-order cybernetics; (C) socio-cybernetics, which integrates social systems theory, second-order cybernetics and complexity theory; (D) artificial societies and social simulation, which focuses on the theory and method of social simulation; (E) sociology of complexity theory both mathematical and theoretical; (F) sociology of complexity method, which integrates sociology with artificial intelligence and mathematical sociology and includes, for example, fuzzy method, neural networking, fractals and power laws; and finally (G) sociology of organizational complexity, which studies formal organizations as complex systems.

While our initial overview was wrong, we were close. Research areas A, D and F all became computational sociology and G was discarded because it was not sociological enough—90% of the research done in this area is by scholars in organizational and management science, not sociology (Capra 2002). Still, we had something to work with and this initial conception was very useful as we refined our inquiry in the second phase of research. By 2006 we had arrived at the following:

> A new field of inquiry has emerged, which we call the sociology of complexity. At present, the sociology of complexity is comprised of four major areas of research: complex social networks, new social systems theory, sociocybernetics, and computational sociology.

This model was a major improvement, but it still needed work. And so we proceeded. Finally, by 2008, we settled on the specific network of attracting clusters we use in this book.

One research area, however, that took considerable time to define was the British-based School of Complexity (BBC). We had gone back and forth about some type of BBC. At one point we even considered a more general cluster, which we tentatively called the "European-based school of complexity." Then we came across McLennan's 2003 article about "Sociology's Complexity" and he confirmed our suspicions. His discussion outlined what ostensibly is the "BBC," which includes researchers in other parts of Europe and Australia, but nevertheless, is centralized in England.

We also decided to rename new social systems theory as the Luhmann School of Complexity (LSC). Two reasons: there is a long list of systems theories in sociology and complexity science, and they are rather different from one another; second, since Luhmann's death, his ideas have been developed further by a growing list of scholars in the social sciences and the humanities, turning his work into a new school of thinking, the LSC. With these two revisions done, our picture of the network of attracting clusters was complete.

Finally, we decided by the spring of 2008 that our new field was not the sociology *of* complexity (SOC) as it was the intersection of sociology *and* complexity science (SACS). This last insight, in particular, illustrates well the importance of developing an initial, working model. Although our initial inclination was to adopt some "sociology of" label, our network of attracting clusters kept reminding us otherwise, pushing us toward a more inclusive and dynamic sociology "and" complexity.

From here we were able to move to our final model. But we are getting ahead of ourselves. We need to review Steps 2 through 4 to explain how we achieved the model we had by spring 2008.

3.2.2.1 The Core: Steps 2 through 4

As shown in Flowchart 2, Steps 2 through 4 are the core of the model building process: (a) constructing the basic components of the model (which includes the field of relations, the web of social practices and the network of attracting clusters), (b) assembling the model at each discrete moment in time/space, and (c) organizing these discrete moments in time (these snapshots of the system) into a comprehensive "moving" picture of the system's dynamics across time-space, including the system's relationship with the environmental systems in which it is situated. Let us review each step in more detail.

3.2.2.2 Assembling the Components

Referring once again to Flowcharts 1 and 2, to build a model of a social system, one must proceed through a somewhat extensive series of steps, even in the initial stages of modeling building. This process follows the filing and folder system of social complexity theory.

It begins by our developing a field of relations. Here our concern is with standard methodological issues. What data will we collect? How will it be stored? How will we organize (update etc.) our database? What will be our study design, including how many discrete moments in time will we analyzed and why? What analytic techniques will be used—qualitative analysis, historical method, agent-based modeling? And, what types of maps are going to be constructed to develop the visual depiction of the model?

It is important to point out that all these types of "methodological" questions go hand-in-hand with the initial construction of the model's web of social practices, network of attracting clusters, key environmental forces and environmental systems. Assemblage is more like engineering and architecture than it is theoretical science. When building a model, one's list of supplies and the various tools and techniques one needs evolve as the project unfolds. In other words, the database and initial model are developed simultaneously; each informing the development of the other. In the case of SACS, our database continually changed over time as we identified, dropped, and added new clusters and as we redefined, catalogued and prioritized our web of social practices. We also revised our list of environmental forces several times as we struggled to determine which aspects of sociology and complexity science SACS drew upon, as well as how the researchers in SACS simultaneously treated these two fields, particularly mainstream sociology, as outside to their work.

The iterative nature of assemblage makes the case-based approach something the researcher employs from the beginning. Here we draw upon an important lesson from the field of data mining. While data mining often is associated with a particular toolset (neural networking, decision tree analysis, cluster analysis), it really is a strategy for data management and analysis (Han and Kamber 2001). The goal of data mining is to use various computational algorithms to create and develop a database that researchers can use to generate sequential and timely information about an ongoing area of inquiry. This is why data mining is so useful to the modeling of social systems. By building the database and model at the same time, the researcher allows them to become "smarter" about each other. The cases chosen for analysis help to make important decisions about what to analyze next and also how.

3.2.2.3 Assembling the Model at $Time_1$ through $Time_N$

Once the basic folders (components) have been constructed, the next step is to assemble the folders (components) for a discrete moment in time-space. We generally designate this first discrete moment as Time 1. For Time 1, the goal is to use the case-based system clustering techniques of assemblage to construct the network of attracting clusters for the model, including a thick description of: (1) each cluster, subcluster and supra clusters; (2) the network of attracting clusters, including the interactions, relationships and conceptual distances amongst its clusters; (3) the relationships the network of attracting clusters has with key environmental forces; and (4) the impact these relationships have on the system of study. Once these pieces of information are complete, the researcher then turns to a full description of the social system for the first time period of study. The researcher's description of the entire system is globally and holistically oriented, including its relative level of stability, its trajectory within the various larger systems of concern and so forth.

If additional time periods are being studied, the above steps are repeated, including beginning with the construction of the web of social practices and environmental forces. In our study of SACS, for example, we not only were interested in the system circa 2008, but also its formal emergence in the late 1990s, which is when the major *complexity turn* took place in the social sciences (Urry 2005b). We therefore constructed our model at two major time periods: the late 1990s and 2008. Once we had a holistic picture of these time periods we integrated them to gain an overall view of SACS. This holistic view was than situated in the larger time-frame of the systems tradition within sociology, making the formal emergence and development of SACS the latest stage of a systems trajectory within sociology.

3.2.2.4 Examining the Model's Dynamics

Once the discrete time periods in which the researcher is interested have been approximated, the next step is to put them together to examine the model's internal and external dynamics; that is, the relationships, forces and motions that characterize a social system as it moves through the researcher's predefined period of time-space. The study of dynamics focuses on two major areas: (1) the network of attracting clusters and its interaction with key environmental forces (those external factors impacting a system of study) and (2) the system as a whole and its movement within various environmental systems (the larger settings in which a system of study is situated).

In the case of SACS, we were very interested in this community's internal dynamics. Specifically, we wanted to know which areas of research were the most dominant and why. Furthermore, we wanted to know what impact their dominance was having on the current and future trajectory of SACS. In terms of the impact of certain environmental forces on SACS, we primarily wanted to know how the current vogue of complexity science is helping the momentum within SACS; that is, how is the widespread adoption of complexity science helping to legitimate the work being done in SACS by sociologists and likeminded scholars? Finally, in terms of environmental systems, we wanted to know the impact SACS is having on sociology today and, more specifically, the systems tradition within sociology. Before we could answer any of these questions, however, we had to do a validity check.

3.2.2.5 Validity Check

An important part of assemblage is stopping to perform a validity check. Despite all the hard work one might put into the initial model, the researcher still needs to periodically stop and ask the basic question "Is my topic of study best studied and modeled as a social system?"

To answer this question, we turn to the methodological work of Glaser and Strauss (1967), particularly Glaser's later work on the topic of emergence versus forcing (1992). Drawing on Glaser (1992), one must ask: "Have I forced my topic to fit the framework and procedures of the SACS Toolkit or does the model of my topic naturally emerge?"

To answer the above question, we need to examine various aspects of our model. For example, do the identified attracting clusters that I identified actually interact with one another to form a social system, or are they disparate areas of inquiry I am forcing into a network of my own making? Or, does the web of social practices I have created make sense? Does the model "hold together" relatively well or does it keep falling apart? Can I really use such terms as self-organization, emergence, tipping point, attracting clusters and so forth to describe my topic, or am I forcing these terms on my data? Finally, am I just saying the same thing about my topic as everyone else, albeit with the fancy new tools of complexity science?"

As shown in Flowchart 1, if the answer to any one of these questions is "no" then the researcher needs to revisit the study questions, revise the initial model, or switch to a different methodological toolkit. If one can answer "yes" to all of these questions, then one can proceed to the final model.

In the case of SACS, for example, it took us a while to say "yes" to all of our questions. One barrier (which we mentioned earlier in this chapter) that kept us nervous about the utility of our toolkit to study SACS, was our name for this new community. For the first two years of our study, we kept calling SACS the sociology of complexity, which was inaccurate and misleading. The problem was that too many scholars from other fields were involved in SACS. Also, many of the sociologists involved in this town sought to be free of the disciplinary confines of sociology and were therefore uninterested in creating yet another "sociology of" something. Once we stopped forcing our model, however, the idea of calling this community sociology *and* complexity science introduced itself and things emerged more exactly. With these types of issues resolved, we were able to finish our model.

3.2.2.6 Iterative Looping Disorder

When it comes to modeling complex systems, there is an important counterpoint to the validity check. We call this counterpoint Iterative Looping Disorder (ILP). The symptoms of ILP include an obsessive need to "get it right," particularly during Phase I; an inability to trust the process and allow things to change, including one's initial research question(s); a fear that if one does not understand everything upfront then one is "data fishing" or making things up as one goes along; a failure to maintain a global picture of the problem; a strong tendency to be overwhelmed by the complexity of it all; and, most dangerous, a false belief that one's model will or must address everything.

The threats of ILP thus require that assemblage once again make use of the tools of data mining and grounded theory. Active data management, staying grounded, and allowing the model to self-organize at its own pace are all important practices if one is to effectively model some social system of study. Without such an "active" approach to model building, everything can easily fall apart. Like any algorithm, assemblage has its normal pace. Moving out of Phase I takes place only when the researcher has (1) a good sense of the questions being asked and (2) a basic sense of the model, primarily as a function of the initial cases considered, the web of social practices created, the environmental forces identified, and the initial network of attracting clusters constructed. With one's initial model assembled, the researcher is ready to move on and repeat the whole process again in Phase II.

In the case of SACS, we had to let go of the idea that our model would be perfect. We had to admit that others may organize this new field in different ways, according to a different set of social practices, and so on. Our model was an introduction. It was something others would have to confirm or deny in varying degrees, as it was studied over time. Once we acknowledged this point, we were able to move a lot quicker.

3.2.3 Step 5: The Working Model

With the initial model developed, the goal of Phase II is to arrive at a refined model of one's topic of study. To achieve this model, the researcher returns (multiple times if necessary) to Steps 2 through 4 until a point of saturation is reached. Saturation is defined as the point at which any additional information obtained in Stages 2 through 4 does not result in any significant new insights to the study.

In the case of SACS, for example, we realized we were done when no new additions to the network of attracting clusters were achieved. We could have kept changing names or moving scholars around, but such moves did not yield any new insights. At this point, we were able to refine our set of environmental forces and work on our understanding of SACS as an extension of the sociological systems tradition.

3.2.4 Step 6: Conclusion

As shown in Flowchart 1, the final two steps in the assemblage process are to share one's results with others and, if necessary, prepare the model for another set of questions. Often times, these two processes happen simultaneously.

One challenge of the SACS Toolkit is determining how to share one's results with others. To repeat an earlier point, the study of social systems is complex. During the course of even the most routine model building, a tremendous amount of data is amassed. There are lots of questions to answer, even in the simplest model construction. This is why, as we mentioned above, the SACS toolkit, like many complexity science theories and methods, places so much emphasis on visual representation. Drawing on the adage that "a picture is worth a thousand words," we strongly recommend that researchers use the extensive visualization techniques we used in the current book, many of which we borrowed from social network analysis, neural networking, qualitative method, cluster analysis and visual sociology, to name a few. We also highly recommend using the internet to augment published studies—as we have done with the companion website for this book. The advantage of the internet, for example, is that one can provide movies and simulations of one's data, as well as house the entire model and its database for others to use. Finally, we recommend extensive usage of visual aids. As stated earlier, see Chap. 10 for a review of the visual component of assemblage and the SACS Tolkit.

With this said, we have reached the end of our introduction of SACS Toolkit. We hope this introduction is sufficient to allow you, the reader, to following our review of SACS. If you need more information, please see our website or contact us. We now turn to our study.

Chapters 2 and 3 from Castellani and Hafferty 2009 Sociology and Complexity Science: A New Field of Inquiry. Germany: Springer