THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Worse than Complex

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Abstract

This thesis engages with questions on the boundary between what has traditionally been understood as *social* and *natural*. The **introductory essay** contextualizes the specific contributions of the included papers, by noting and exploring a reinvigoration of "naturalism" (the notion of a continuity between the human realm and the rest of natural phenomena) under the banner of Complexity Science. This notion is put under explicit light, by revisiting the age-old question of naturalism and connecting ideas in complexity science with the work of e.g. Roy Bhaskar, Mario Bunge, William Wimsatt, and David Lane. A philosophical foundation for a complexity science of societal systems is thereby sketched, taking the form of an integrative and methodologically pluralist "complex realism".

The first two papers provide a theoretical perspective on the distinction between social and natural: **Paper I** notes that societal systems combine two qualities that are commonly referred to as *complexity* and *complicatedness* into an emergent quality that we refer to as "wickedness", and that is fundamentally and irreducibly different from either quality in isolation. This explains the recalcitrance of societal systems to the powerful approaches that exist for dealing with both of these qualities in isolation, and implies that they indeed ought to be treated as a distinct class of systems. **Paper II** uses the plane spanned by complexity and complicatedness to categorize seven different system classes, providing a systematic perspective on the study of societal systems.

The suggested approach to societal systems following from these conclusions is exemplified by three studies in different fields and empirical contexts. **Paper III** combines a number of theories that can be seen as responses to wickedness, in the form of evolutionary developmental theories and theories of societal change, to develop a synthetic theory for cultural evolution. **Paper IV** exemplifies how simulation can be integrated with social theory for the study of emergent effects in societal systems, contributing a network model to investigate how the structural properties of free social spaces impact the diffusion of collective mobilization. **Paper V** exemplifies how digital trace data analysis can be integrated with qualitative social science, by using topic modeling as a form of corpus map to aid critical discourse analysis, implying a view of formal methods as aids for qualitative exploration, rather than as part of a reductionist approach.

Keywords: Complexity, Naturalism, Critical Realism, Wicked Systems, Transitions, Evolutionary Developmental Theory, Digital Trace Data, Social Movements, Innovation Society

List of publications

I. Claes Andersson, Anton Törnberg, Petter Törnberg. "Societal Systems - Complex or Worse?", *Futures* 63, 145-157 (2014).
CA, PT, AT developed the idea, and CA wrote the paper with contributions from PT and AT.

II. Claes Andersson, Petter Törnberg. "Innovation and the Anatomy of Wickedness", (Submitted).
CA, PT developed the idea, and CA wrote the paper with contributions from PT.

III. Claes Andersson, Anton Törnberg, Petter Törnberg. "An evolutionary developmental approach to cultural evolution", *Current Anthropology* 55, 2 (2014).
CA, PT, AT developed the idea, and CA wrote the paper with contributions from PT and AT.

IV. Anton Törnberg, Petter Törnberg. "Combining CDA and topic modeling: Analyzing discursive connections between Islamophobia and antifeminism on an online forum", *Discourse & Society* 27, 401-422 (2016).
PT, AT developed the idea, PT collected the data, PT developed and ran model, AT conducted qualitative analysis, AT wrote the paper with contributions from PT.

V. Anton Törnberg, Petter Törnberg. "Modeling Free Social Spaces - Diffusion of Complex Contention", *Social Movement Studies*, (online first).
PT, AT developed the idea, PT developed the model, PT conducted analysis, PT, AT wrote paper.

Publications not in this thesis

Claes Andersson, Anton Törnberg, Petter Törnberg. "Developing of the future: scaffolded Darwinism in societal evolution", *Behavioral and Brain Sciences* 0140-525X, (2013).

Claes Andersson, Petter Törnberg. "Fidelity and the speed of the treadmill: The combined impact of population size, transmission fidelity, and selection on the accumulation of cultural complexity", *American Antiquity* (2016), 81(3), 576-590.

Anton Törnberg, Petter Törnberg. "Muslims in social media discourse: Combining topic modeling and critical discourse analysis", *Discourse, Context & Media* (2016).

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The synthesis was discussed and contributed greatly to by the participants[1] at the workshops organized in Venice.

Of course, nobody, apart from myself, should be held accountable for the shortcomings of the arguments presented in this thesis.

Gothenburg, February 2017
Petter Törnberg

[1]Including Manfred Laubichler, Sander van der Leeuw, John Odling-Smee, and Kevin Laland. For full list of participants, see the workshop series at www.insiteproject.org/slides/new-data/.

Contents

Part I

Introductory Essay: On the Limits of Complex Naturalism

Introduction

The traditional boundaries between natural and social systems seem increasingly fragile and contested in a world that is now widely seen as having entered into the geological époque of the *Anthropocene* (Steffen et al., 2007; Waters et al., 2016), characterized by human society as the globally dominating shaping force on Earth's geology and ecosystems. The idea of the natural world existing independently of the social world is increasingly hard to sustain as profound transformations driven by human activity ravage global ecosystems (Moore, 2014). This changing relationship between the natural and social has highlighted a confounding asymmetry, between our capacity to transform the world through technological innovation, and our profound lack of understanding of the very world which our own strength has established. Humanity's effects on nature have been characterized as a "perfect storm" of interrelated crises of increasing scale and magnitude (Bai et al., 2015; Crutzen, 2002; Pievani, 2014).

Simultaneously, a host of parallel developments are unfolding in scientific theory. Old theory and assumptions, in a range of disciplines dominated by natural scientific methods, are being undermined by an explosion of new data and analytic methods, in particular centered around notions such as "Big Data" and "complexity" (e.g. Anderson, 2008; Ball, 2012; Laland et al., 2015). This is both opening up new opportunities and unveiling deep-rooted problems in traditional natural scientific approaches, challenging Humean[2] notions of causal law, pre-

[2]Hume is traditionally assigned to an understanding of *cause* based on regularity, defined as objects or events X and Y being "constantly conjoined", i.e. as a necessary connection between Xs and Ys such that whenever X occurs, Y must follow. This is seen as a precursor to the empiricist theory of causality, in which causation is reduced to empirical regularities. However, Hume's own – rather cryptic and ambigous – wording actually provides two separate definitions, one pointing to

dictability and hierarchy. The onslaught of new data and methods is undermining basic simplifying assumptions, upon which much of the apparent predictive and explanatory power of time-tested theory rested, and as a response, new theory and new models are developing to deal with the revealed complexity of the natural world. A related pattern of development can be seen in a range of disciplines traditionally dominated by quantitative and formalist approaches, e.g. in the collapse of the neoclassical paradigm and the pluralist explosion of economic theory (e.g. Fontana, 2010; Hodgson, 2014), in the Ancient DNA revolution in archeology and paleoanthropology (e.g. Larson et al., 2007; Meyer et al., 2014), in the questioning of the assumptions of time-scale separation between ecosystem and evolutionary dynamics in ecology (e.g. Fussmann et al., 2007; Odling-Smee et al., 2003; Post and Palkovacs, 2009), and in the growing recognition of the limits of the Modern Synthesis within evolutionary theory (e.g. Oyama et al., 2003; Pigliucci et al., 2010).

New methods developed to respond to the discovered messiness of these systems enable an extension of formalistic approaches to fields previously considered outside of their scope. This can be seen within the humanities and social sciences, where traditional approaches in various realms increasingly have to compete with computational modeling and large-scale surface studies of digital trace data. These shift the focus to motifs rather than meaning, but are capable of finding intricate patterns through brute-forcing of immense data quantities (e.g. Anderson, 2008; Conte et al., 2012; Macy and Willer, 2002). While these developments are sprawling and multifaceted, "Complexity Science"[3] can be identi-

an objective relation between the objects, and the second pointing to a relation between the objects and our minds: "Similar objects are always conjoined with similar. Of this we have experience. Suitably to this experience, therefore, we may define a cause to be *an object, followed by another, and where all the objects similar to the first are followed by objects similar to the second*. Or in other words, where, if the first object had not been, the second never had existed. The appearance of a cause always conveys the mind, by a customary transition, to the idea of the effect. Of this also we have experience. We may, therefore, suitably to this experience, form another definition of cause; and call it, *an object followed by another, and whose appearance always conveys the thought to that other*." (Hume and Beauchamp, 2000, p.60, emphasis in original), and it is subject to contention whether Hume in fact can be said to have subscribed to a "Humean" concept of causality (e.g. Baert, 2005).

[3]This term is contested and describes a discipline with many – often contradictory – directions. As used in this essay, the term will specifically denote an important direction within the larger discipline centered around, and developing from, the Santa Fe Institute (see Galison, 1997), representing a mainly formalist and simulation-based approach to complexity, with its roots in the natural sciences, that has proven highly capable of analyzing many types of complex systems that have otherwise been impenetrable to formal approaches. This direction is what Morin (2008) and Byrne and Callaghan (2013) refer to as "restricted complexity".

fied as one of its most important standard-bearers. Complexity Science focuses on abstract systemic dynamics that have proven to be powerful sources of analogies across various empirical domains, exemplified by how important factors in as diverse fields as urban innovation, human travel, animal metabolism, and basic physics have been found to conform to the same universal scaling laws (Bettencourt et al., 2007; Brockmann et al., 2006; Freedman and Index, 1971). This has been taken to imply a diminished methodological relevance of the boundaries between the natural and social world, as both are increasingly understood to be "complex" (e.g. Gilbert, 2010; Helbing, 2012; Lazer et al., 2009; Mitchell, 2009).

These parallel developments – (i) increasing entanglement between social, natural and technological systems, (ii) increasing understanding of the complex nature of many natural systems, and (iii) increased application of natural scientific methods in social systems with access to new data and methods – together lead to a situation in which the expanding impact of societal systems on nature – paradoxically – result in further coaching of society in terms of technological and natural scientific problems and methods (see also Malm and Hornborg, 2014). The increasingly fuzzy boundary between natural and societal systems is leading to a renewed expansion of methodology from the natural to the social sciences.

While there is nothing wrong *per se* with interdisciplinary transfer, these new methods come with hard-to-detect stowaways: implicit ontological assumptions – which may have been debated in their natural scientific contexts long ago but are now taken for granted – sneak into the study of social systems; meta-theoretical underpinnings about the nature and organization of systems that are rarely made explicit. These contain tacit and unexamined answers to questions like: What are the real entities of the social world (Byrne, 2002, p.136)? Are higher-level organizations (like firms, tribes, and states) fully explainable in terms of the preferences of their members, or are higher-level organizations also social individuals with their own properties and powers? Can individual action, meaning, and values be disregarded in the study of causality in human societies? Questions like these are not only matters of philosophical curiosity, but have profound implications for how we can and should research, manage, and think about social systems.

This essay revolves around revisiting, with new complexity-informed eyes, an age-old notion that is at the heart of all of these questions: *naturalism*, the idea of a continuity between the human sciences and the sciences of the rest of natural phenomena (see also e.g. Bhaskar, 1978; Danto, 1967). Naturalism signifies

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Furthermore, the word "science" deserves a note of its own: it is, in this essay, used in the broader sense, in line with the German "Wissenschaft", Swedish "vetenskap", or slavic "nauk", which do not include the positivist/formalist connotations of their English counterpart.

the completion of the Copernican dethroning of man from any meta-natural position, advocating that there is no need to appeal to extra-natural qualities – such as conscience, intentionality or meaning – to account for or understand human society. One of the more influential naturalist tendencies, which Khalil (1995) calls "crude naturalism", adds to this that the methodology of the natural sciences can and should be employed also within social science. This flavor of naturalism proposes a unification of the sciences in concordance with positivist principles. This has furthermore tended to imply a Cartesian-Newtonian paradigm[4], associated to reductionist and scientist notions, that ontologically incorporates a shallow realism, and, methodologically, the type of formalist, linear and equilibrium-based notions epitomized by neoclassical economics (Blaikie, 2007, p.178).

The defense from social science, to what from their perspective is seen as disciplinary imperialism (Vinck et al., 2010), has importantly been in the form of social constructionism, i.e. asserting the role of social action in the production of a variant social world, and emphasizing that all beliefs are constructions (Byrne, 2002). Influential here has especially been the program that Pawson and Tilley (1997, p.21) refers to as "hermeneutics II", which "adds the twist that we cannot, therefore, get beyond constructions". This anti-naturalist tradition, traceable back to Weber and Dilthey (see e.g. Dilthey et al., 1989; Weber, 2009), posits a methodological cleavage between the natural and social sciences, through a view of the subject-matter of the social sciences as consisting of meaningful objects, and hence suggesting that their aim is the elucidation of the meaning of these objects (Bhaskar, 1978).

The recent reincarnation of naturalism under the banner of Complexity Science has, however, come to be seen as a third direction in relation to naturalism, as it ostensibly does not bear the same "crudeness" as its predecessors. It subscribes to naturalism but brings a fundamental criticism against the linear, stasis-focused approaches of the Cartesian-Newtonian paradigm, and thereby manages to speak to both the postmodernist and the positivist traditions (Cilliers, 1998). Complexity Science has been described as going beyond the limits of what is often called "reductionism" by noting that "the ability to reduce everything to simple fundamental laws does not imply the ability to start from those laws and reconstruct the universe" (Anderson et al., 1972, p.393). Instead emphasis is placed

[4]This is closely related to the notion of a "clockwork universe" – the scientific paradigm based on the idea that exact and empirically testable predictions of the future state of a system can be had, given knowledge of initial conditions and of the universal laws governing the system. This furthermore includes the implicit assumption that external forces can be either controlled or excluded. The Cartesian-Newtonian paradigm is also associated with, and the foundation of, the linear modeling framework, which adds notions of equilibrium, additivity, and homogeneity.

on the study of how parts interact to form complex systems with global, novel, emergent qualities and patterns. As Ball (2012, p.IX) puts it, in the Complexity Science perspective, the traditional conceptualization of naturalism

> ... remains valid but it often drew on the wrong analogies. Society does not run along the same predictable, 'clockwork' lines as the Newtonian universe. It is closer to the kind of complex systems that typically preoccupy statistical physicists today: avalanches and granular flows, flocks of birds and fish, networks of interaction in neurology, cell biology and technology. (Ball, 2012, p.IX)

The focus is no longer stasis and equilibria, but non-linearity, far-from-equilibria, and self-organization (Waldrop, 1993). This has provided a naturalist account that to many seems more plausible, as social phenomena indeed seem to have more in common with *emergent* physical processes – i.e. "collective effect[s] [...] that cannot be deduced from the microscopic equations of motion in a rigorous way and that disappears completely when the system is taken apart" (Laughlin, 1999, p.863), exemplified by superfluidity or the fractional quantum Hall effect – than with classical Newtonian notions of particles and laws. What remains of traditional crude naturalism is a clear focus on formalist methods, and an underlying, implicit notion of complexity science as a step toward "making social science scientific": bringing it out from the crude infancy of discursivity and into the scientific adulthood of mathematical and algorithmic rationalism.

This essay aims to put the naturalist tendency of Complexity Science under the light of explicit study, and to explore to what extent this "middle way" naturalism can in fact be said to be less crude than its predecessors, as well as how it relates to the third direction to naturalism proposed by Bhaskar (1978, p.2), in the form of "a qualified anti-positivist naturalism, based on an essentially realist view of science". By connecting ideas in Complexity Science to the work of e.g. Roy Bhaskar, Mario Bunge, William Wimsatt, and David Lane, an alternative philosophical foundation for a complexity science of societal systems will be sketched, taking the form of an integrative and methodologically pluralist "complex realism" (Reed and Harvey, 1992).

This essay takes the position that the question of naturalism is fundamentally a question of ontology[5], and to explore it, we will need uncover and examine the ontological assumptions implicit in scientific practice. Bunge (1979a, p.15)

[5]"Ontology" is here understood as a specification of "the particular entities and processes postulated by some substantive scientific theory" (Bhaskar, 2013, p.30): an ontology describes what are the entities in the world, their attributes and powers.

argues that “Every theoretical view of society [...] has two components: an ontological and a methodological. The former concerns the nature of society, the latter the way to study it.” Complexity Science brings both of these to the table – meta-theory that speaks usefully to a social ontology and a toolkit of powerful methods – but the latter goes in important ways in the opposite direction of the former by being singularly focused on formalisms. Therefore, I join Elder-Vass (2007c, p.228) in arguing that what is needed in the Complexity Science study of society is a well-articulated social ontology that is open to revision, which would also be conducive to the improvement of the methodology (which is not the same as “the set of methods”).

The aim is thereby to cast light on the borderlands between the natural and social sciences with the purpose of developing a complexity-informed understanding of the ontological distinctiveness of social systems, by attempting “to analyze and to systematize the ontological categories” (Bunge, 1977b, p.12). This categorization is performed on a plane spanned by dynamical and structural complexity (Érdi, 2007), relating to Khalil’s (1995) separation between “artificiality” and “individuality”. Based on this, the essay argues for “a turn to ontology” (Perona, 2007) in Complexity Science’s study of society, by sketching a complexity naturalism that does not invoke the reductionism of ontological individualism[6]. This argument entails a degree of integration between the domains of the social and natural sciences, in the sense that we may be able to apply similar ontological frameworks to both – but not in the traditional reductionist or scientistic sense (as Khalil 1995 notes, the ontological implications of using ecosystems as a metaphor for society depends completely on how one views ecosystems). This may in fact mean that the epistemological conclusions of this metaphor may not be an ecology-inspired sociology, but just as well a sociology-inspired ecology.

The structure of this essay is as follows:

First, the exploration of the limits of complex naturalism begins with what Bhaskar (1979) refers to as the *ontological* and *epistemological conditions* of the social sciences, and specifically the question of openness[7]. This concept has been

[6]Following Khalil (1995), I will use “ontological individualism” rather than the more common “methodological individualism”, due to the ambiguity of “methodology” in this context.

[7]“Open”/“Closed” are here used in the critical realist sense, which, it should be noted, is quite different from the understanding in physics. Physics understands open systems as systems whose borders are permeable to energy, and emphasizes that closed systems must eventually attain a time-independent equilibrium state according to the second law of thermodynamics. This means that all living systems are – by definition – open, as they maintain themselves by increasing the entropy of their environment. The critical realist conception is instead of an analytical distinction, seeing a gradient between open and closed, and focuses on the isolation between structural levels of the systems that are the prerequisite for regularities, rather than on the direct exchange of energy/matter

seen as linked to complexity, but the linkage has been rather unclear: the social scientific understanding of complexity tends to see openness as a categorical subset to complexity, while the natural scientific approach tends to approach systems as closed. This essay uses what in practice amounts to a comparative case study between system categories to create a taxonomy of system ontologies, in which the open/closed dichotomy and the simple/complex is split into a higher resolution plane, spanned by *complicatedness* (or "structural complexity") on one side, and *complexity* (or "dynamic complexity") on the other. Following this, we look closer at the primary category of systems relevant for the study of society. This section leans on Paper I and Paper II.

Secondly, the essay focuses on how the complexity of societal systems plays out in societies, in particular relating to what Bhaskar (1979) called the *relational condition* of the social sciences. We focus on the dialectical relation between agency and structure by looking at the historical evolution of human society and the specifics of human cognition, bringing in notions of meaning and narrative understanding. This leans on Paper III (as well as on work that is still to be published, e.g. Törnberg and Andersson 2016)

Finally, this metatheoretical exposition is used as basis for a "turn to ontology" (Perona, 2007) in the complexity approach to societal systems, suggesting that while the complexity approach is certainly needed to study mass-dynamics in societal systems, they need to be based in epistemology and methodology compatible with the real ontology of such systems. Urry (2003, 2005, 2012) has famously argued that social science has experienced a "complexity-turn" – and now it may be due time for Complexity Science to experience a corresponding "society-turn". This section leans on Paper IV and V, as well as on contributions not included in this thesis (Andersson and Törnberg, 2016; Törnberg, 2016a,b).

(e.g. Danermark et al., 2001). This tends to be understood as to also include systems whose interaction with their environment is constant, stationary or orderly enough to allow fixed ontologies to be assumed. This conception can perhaps, as in Reed and Harvey (1992, p.359), be referred to as "ontological" – as opposed to "thermodynamical" – openness. See chapter 1 for more in-depth definitions.

Chapter 1

Epistemological & Ontological Limits

1.1 Beyond the Open/Closed Dichotomy

A central separation between social and natural systems emphasized by philosophers of science is that social systems tend to be more *open* than natural systems. Systems are considered closed if they are "cut off" and isolated from external influences, allowing them to operate under fixed conditions (e.g. Archer et al., 2013; Bhaskar, 2013; Collier, 1994; Von Bertalanffy et al., 1950). Bhaskar (2013) specifies two conditions for such closure: 1) *The inner condition*: no qualitative change in the object under study; its internal mechanisms will stay the same (Psillos, 2008); 2) *The outer condition*: the relationship between the causal mechanisms and the mechanisms in their environment in which they act, have to be constant (or at least stationary). This essentially means that the generative mechanisms of phenomena operate independently from intervening mechanisms, which leads to regularities in system dynamics.

Fleetwood (2016) attempts a definition of closure focusing on event-level regularity, based on how the concept is used in e.g. Bhaskar (2013), Lawson (1989, 2014) and Mearman (2006):

> Parts of the social world characterised by (stochastic and/or probabilistically specified) regularities between events or states of affairs of the form 'whenever event or state of affairs x then event or state of affairs y', are closed systems, and parts of this world not characterised by such regularities are open systems. (Fleetwood, 2016, p.1)

Simon (1991) also looks at the open/closed dichotomy, but on the basis of system structure, showing that closed systems can be described as “near-decomposable” – the reason that they can be seen as “isolated” from external influences is that they are separated into distinct organizational levels, and on those levels into distinct entities interacting through defined interfaces (see figure 1.1). Such levels bring separations of timescales, ensuring that the ontology of the system level will be relatively fixed during a relevant “short run” – a time scale that is long enough for interesting dynamics to occur, but short enough for the assumptions about the interfaces to remain valid. This is what allows one to study them as if they were cut off from external influences; rigorous quantitative analysis becomes viable because qualitative change happens on substantially longer time scales than those of the analyses. Due to this difference in time scales, we can assume and formulate a *fixed ontology* – a specification of the entities and the “rules of the game” – and see how it plays out. The greater the separation of scales between the internal and the external environment, the greater will the difference in size and speed of the dynamics on these two levels be, and the more generous will the short run be; i.e. the more interesting things will have time to happen. For example, a suitable “short run” for the study of traffic would be between minutes and hours. Over time scales shorter than minutes not much would happen – other than the movement of the pistons and rods in the engines of the cars – and if we move to several days, the dynamics would more or less repeat itself. Moving to even longer time scales, roads, types of vehicles, regulations and so on would begin to change.

In other words, what allows us to study these systems is that they have a number of distinct levels. On closer inspection, we see that such systems can be separated into two types, depending on the way that their levels emerge from the underlying components. This is basically the fundamental insight of Complexity Science: some systems are more like cars, others like flocks of birds (see Mitchell (2009) for an overview of complexity; see Bajec and Heppner (2009) for an overview on bird flock dynamics). In Paper I and II, we refer to the former as *complicated* and the latter as *complex*, a separation that corresponds to Érdi’s (2007) separation between “structural” and “dynamical” complexity.

As Paper I and II show, these system categories have distinctly different proximal causes: complicated systems develop through orderly pre-determined specifications of assembly or morphogenesis (Slack, 2009), and are characterized by, in general, having their distinct levels not through *emergence*[1], but its opposite,

[1]This difficult notion will be dealt with in more detail in chapter 3, but its frequent ambiguity warrants also more directly subscribing to a definition: as will be seen, I agree with Kaidesoja

aggregativity (Wimsatt, 2007, p.274-276), of their underlying elements: a smaller number of heterogeneous, functionally differentiated, adapted elements interacting in a relatively ordered way. Complex systems tend to develop through *self-organization* (Kauffman, 1993), and their structural levels form through emergence, i.e. the mass-interaction of a large number of simple and homogeneous entities (e.g. Goldstein, 1999). We will now look closer at these two categories of near-decomposable systems.

Complicated systems are exemplified by technology[2] and organisms: systems organized in level hierarchies that may pack a very large numbers of components into delineable compartments. This enables strongly simplified assumptions, as it limits the permitted patterns of component interaction, and hence very little knowledge about the surrounding system is needed to operate locally on its components. Components are slaved by the larger system, meaning that they are fully aligned, permitting adaptation into fine-tuned and non-redundant machineries: this is what allows us to build spacecrafts with the capacity to land with high precision on planets millions of kilometers away. These properties, in particular non-overlapping component functionality, also make them quite easy to study and predict, since the mechanisms are naturally isolated to specific components, and component interaction is simple. This means that we can reduce the system over its interactions and break it down to its components. Its lack of dynamical complexity is what allows us to make *ceteris paribus* assumptions, and isolate the function of each component. In other words, we may usefully test our theories through the use of controlled experiments[3], which works exceedingly well on such systems. Since each component is structured to perform certain functions, reality can be captured in analogous abstractions biting over the entire system; the use of what Hayles (1999), irreverently, calls the "Platonic backhand" is hence quite reasonable for approaching such systems. Closed systems include the realm that Khalil (1995) refers to as the "artificial", and, as Byrne (2002) concludes,

(2009) that both Bhaskar's and Bunge's use of the term suffer from certain ambiguity and imprecision, and instead use Wimsatt's (2007) understanding (quite compatible with both Bhaskar and Bunge's larger frameworks). Wimsatt (2007) defines emergence in negative terms, holding that a given system property is emergent if it breaks one or more of the conditions of aggregativity, implying a dependence on their mode of organization.

[2]E.g. any programmer will have intimate experience with attempting to construct *complicated* systems: they are basically the goal of object-oriented design (Calero et al., 2006; Riel, 1996).

[3]This understanding of experiments also shows clearly why they should not be considered "natural", but that they are models, with built-in assumptions about the target systems. They are virtual in the same sense as anything that is created for scientific use.

this includes also mechanistic scientific models; in other words, our models *can* in this case match the ontology of the system under study.

Complicated systems tend to display structural hierarchy, which links them to perspectives that have experienced a revival in the analysis of biology (e.g. Hull, 1980; Koestler and Smythies, 1972; Weiss, 1971) and social theory (e.g. Miller, 1978; Williamson, 1975). What we mean by hierarchy here is not the idea of an outside commander dictating the activity of the organization, but rather a nested system, where components are embedded within other components in a level-upon-level organization.

Complex systems are exemplified by herds, traffic, and social networks, and are well-described by Morin's (2008) "restricted complexity": phenomena that are the dynamically emergent product of interaction among a large number of relatively simple agents from a few component classes (Johnson, 2002). The emergence at play in such systems is specifically *micro-emergence*, in which the interaction occurs between elements on the same ontological level, resulting in macroscopic qualitative novelty (e.g. Bedau, 1997; Corning, 2002; Holland and Wolf, 1998). Such emergence, and dynamical emergence in general, appears "surprising" due to our inability to intuitively follow complex dynamics – long chains of causation undermine our ability to predict outcomes.

Since mechanisms are not located in specific components, complex systems are not characterized by precision, but rather by parallelism, adaptivity and feedback: this permits resilience over components – if one component breaks, others can dynamically step into its place (Scheffer, 2009). This clearly constrains the usefulness of experiments, and the Platonic backhand in general, since we cannot isolate mechanisms to specific components. Dynamical complexity means that, in a sense, mechanisms are complex and distributed *within the interactions between the components* rather than within single components: one does not find the intelligence of the anthill in any specific ant (e.g. Dorigo and Stützle, 2009; Wahde, 2008). In a sense, agency is all there is in complex systems, but it is a highly limited agency, which only plays out locally. Due to this, complex systems are much simpler than they may appear, at least given the tools to successfully deal with emergence in systems with very large numbers of interacting entities. Using simulation – Hayles' (1999) "Platonic forehand" – we can test our theories about system mechanisms by "growing" systems from models of the underlying entities (Epstein, 1996). Since studying individual components tends to give little clues, we are often forced to resolve to *ad hoc* assumptions regarding the behavior of these components. While this is a risky game, since such systems are characterized by both *equifinality* (a phenomenon may rise from radically different conditions) and *multifinality* (similar conditions may result in very different outcomes), it is made possible by the simplicity of the components. In other words, in the same way that we can reduce complicated systems over their dynamical simplicity, we can reduce complex systems over their structural simplicity. Even so, since complex systems are generally characterized by chaos – the flip-side of the resilience coin – and an inherent lack of precision, we cannot predict their future states, but only their general dynamics (e.g. Cvitanovic et al., 2005, p.146–149).

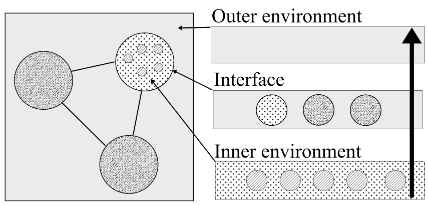

Figure 1.1: *A near-decomposable system, conceptually illustrated in two ways. Because of time scale separation, the outer environment can be regarded as static, and the inner can be similarly disregarded.*

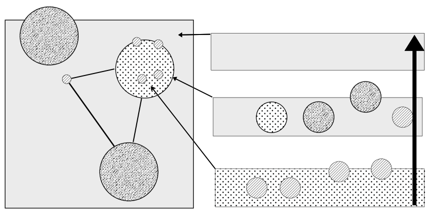

Figure 1.2: *An attempt to illustrate a poorly decomposable system. Because of lack of clear system demarcations and time scale separation, it can be unclear what outer and inner environment would even mean.*

Non-Decomposable Systems

As we have seen, our study of complicated systems relies on the assumption that they are dynamically simple, and our study of complex systems on that they are structurally simple. However, Paper I shows, there is no reason to assume that a system cannot display both complexity and complicatedness, which hence would mean that we cannot reduce it over either axis. This perspective, of viewing complexity and complicatedness as two separate system properties, allows us span a plane of system types, permitting a systematic categorization of ontologies in which both closed and open systems are represented, and in which open systems combine complexity and complicatedness (see figure 1.3.)

While complex and complicated systems differ in some important ways, they also share some similarities. A crucial similarity is that they are both structured into nested hierarchies, with each level forming the building blocks for the next, which is what allows the systems to be reduced downward into distinguishable subsystems (Simon, 1991). One important reason that systems can become decomposable is when they are what Khalil (1995) refers to as "artificial": they lack individuality of their own as they are fabricated, either through natural selection or by the hands of purposive agents, to fulfill a purpose. William Wimsatt's (e.g. 1986) concept of "generative entrenchment" shows how such selection will result in structured systems, where each level functions as an alphabet for generating the next, as this is the most adaptive and flexible system structure. This is also described by what in assemblage theory is called "coding" (DeLanda, 2006).

The components of open systems, on the other hand, are not completely artificial, but have at least some level of individuality. This means that, since there is no higher functionality of the system, and mechanisms therefore cannot be linked to a function, the generative mechanisms will not be located exclusively in neither relations or in components. This in turn implies that the messy real cannot be reduced to an abstract form, since such a form would require a functional ideal: hence, the Platonic backhand will not work, since their mechanisms are not located into specific components; the Platonic forehand will not work since their components are too complicated to be *ad hoc* deduced. They hence become non-decomposable, and there is, in the general case, no separation between time scales: anything may interact with anything, and a modification may therefore impact any part of the system. This means that invariant empirical regularities do not obtain, and open systems are therefore denied decisive test situations for their theories; *ceteris paribus* can never be assumed (Bhaskar, 1979).

Just as with closed systems, we can distinguish a number of different types of open systems based on their level of dynamical and structural complexity, again stemming from different developmental histories: *trans-complicated*, *trans-complex*, *sub-wicked* and *wicked systems* (see Figure 1.3 and Paper II).

Trans-complicated systems are complicated organizations of components with separate agendas, exemplified by organizations with human components, or biological individuals (e.g. of different species) with separate channels of reproduction. Complexity enters as an increased density, and lower regularity, of interac-

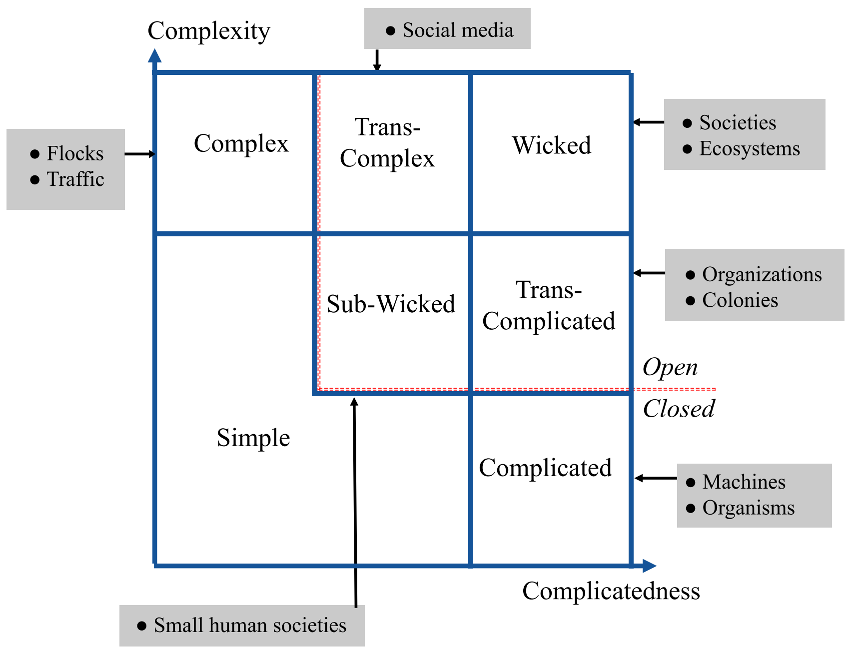

Figure 1.3: *A map over the ontological categories, as spanned by dynamical and structural complexity. See Paper II.*

tions: for example, while an exhaust manifold is precisely an exhaust manifold, a human component will connect a system to just about all sectors of society and in a wide variety of ways (a seamless web; Hughes 1986.) These systems do have some collective functionality, but also some level of internal competition between components, which tends to break down the level hierarchy. System alignment must be actively maintained by dedicated systems, which is costly and carries the risk of failure. Failure, i.e. components adapting to their own aims and goals at the expense of the whole (i.e. "defecting" in game theoretic terms), can go from having detrimental effects on system structure, to being exceedingly dangerous for the system. For example, when cells begin to compete with other cells within an organism, racing toward becoming the fittest unicellular phenotype within this selection environment – i.e. the cancer cell – this typically spells the end of both the organism and the cell germ-line, as their only long-term means of reproduction remains the holistic system (although there are fascinating examples of cancer evolving transmissibility, hence leaving the selection-pressure of the holistic system altogether, e.g. Pearse and Swift 2006, as well as immune responses evolved to combat this transmissibility, see Alderton 2016 – an example which highlights the quasi-porous boundaries between inside/outside systems, as well as between system levels; see below.)

The trans-complicated nature of organizations can be clearly seen in the tension between organizational and occupational perspectives in the study of behavior in organizations (see Orr, 1996; Van Maanen and Barley, 1982): while the former tends to describe a functional machinery with limited patterns of interaction between parts, the latter emphasizes informal story-telling and interactions cutting through organizational compartments. There is clearly also a broad spectrum of organizational forms, between the strict hierarchical military organization – close to Weber's (2009) *ideal bureaucracy* – to loosely organized open source groups, characterized by sub-wickedness (see below) rather than trans-complicatedness. These organizational forms afford different strengths and weaknesses: the former a high level of precision, predictability and stability, while the latter permits high levels of innovation and adaptability. Some process frameworks, such as *Scrum*, explicitly aim for self-organization, in some ways mimicking hunter-gatherer groups (Dingsøyr et al., 2012), by institutionalizing sub-wickedness through e.g. story exchange (Martin, 2003).

Trans-complex systems represent the harnessing of affordances of complex systems by adding elements of persistent complicated organization to complex systems, exemplified by various systems in the "sharing economy" (e.g. AirBnB, Uber, see e.g. Hamari et al. 2015), smart grids (see e.g. Clastres, 2011), social media movements (e.g. Anonymous, see e.g. Beraldo 2016), and terrorist networks (e.g. Bohorquez et al., 2009). If the epitomizing example for complex systems is flocks, the corresponding for trans-complex systems is an organized herd: the self-organization of the system is put under a simple scaffolding structure to align and direct it toward some central goal (Wimsatt and Griesemer, 2007). In other words, these are often loosely organized groups based on disseminated designs, shared views, and norms for alignment, rather than direct top-down control. By optimizing either structural features of the interaction between components (as in social media) or of the components themselves (as in selection-induced morphological change of animal behavior in literal herding, see e.g. Marshall and Weissbrod 2011), a level of structural complexity is induced. Non-decomposability develops specifically in the interaction between structural change and dynamical emergence in these systems (see also Lane, 2016).

Sub-wicked systems are wicked systems that are small enough to fit into the range of human cognition, and that have not outgrown our capacity to design or govern them. In other words, what delimits sub-wicked from wicked is the limits of human comprehension, which is, however, highly relevant in the methodological context. Sub-wicked systems can be exemplified by local social contexts such as families or workplaces, and early human societies. If *societal* systems – the realm of human politics – are wicked, then *social* systems – the realm of everyday human, and certain other mammal, interaction – are sub-wicked[4].

Sub-wicked systems exhibit wicked problems: they are recalcitrant to formal methods, but they are small enough for us to handle cognitively. It is no coincidence that we possess the capacity to do so: we are adapted specifically for dealing with sub-wicked systems, as human intelligence developed in, and perhaps even in response to, exactly such a context (e.g. Read, 2012; Tomasello et al., 2012; Van der Waal, 1982). The nature of wickedness is captured by the feedback interaction between emergence and the patterns resulting from that emergence, as individuals are capable of not only adapting to other individuals, but also to patterns emerging from precisely this interaction – what Goldspink and Kay (2007) call "reflexive emergence". Hence, acting demands the ability to deal with constant social innovation: intrigues, new constellations, secrets, lies, and the relations between others and between others and oneself (Read, 2012).

In human groups, the primary mean of dealing with this is the narrative, which is simultaneously a way of theorizing behavior, exchanging meaning, and structuring community, i.e. just like the interaction modalities of social platforms shape online communities, narrative is a naturally evolved interaction modality that constrains and shapes social communities (c.f. e.g. Brown and Duguid, 1991; Orr, 1996). Narrative thinking provides "the genetically transmitted possibilities for interaction, resulting in relations and patterns, provide the framework in which the single individuals can realize their specific behavior and thereby jointly create the group-specific social structure." (Hendrichs, 1983, p.739). Narratives are not only evolved to allow negotiation between the interests of individual actors and the collective, but are also a form of reasoning native to sub-wicked systems, as they embody an understanding of interaction of adapting systems:

[4] This separation between social and societal/political existed in Greek understanding, and resonates with Hannah Arendt's thinking: "This special relationship between action and being together seems fully to justify the early translation of Aristotle's *zōon politikon* by *animal socialis*, already found in Seneca, which then became the standard translation through Thomas Aquinas: *homo est naturaliter politicus, id est, socialis* ("man is by nature political, that is, social"). More than any elaborate theory, this unconscious substitution of the social for the political betrays the extent to which the original Greek understanding of politics had been lost." (Arendt, 1958, p.39)

narratives are capable of handling a number of key characteristics of sub-wicked systems such as heterogeneity, contingency and a multilevel nature (Richardson, 1990).

The resulting structure that forms from the interactions between such individuals are, like complex systems, robust in that, within limits, individuals and behavior are exchangeable without altering the social order (Hendrich 1983). Hence, the social order has a reality of its own which acts on individuals and their behavior. The structures preexist individuals, and form them to a greater extent than to which the structure is changed by their specific individuality (Hendrichs, 1983). As Khalil (1995) puts it, the organization of groups of humans or of her close relatives[5]

> is not an artificial entity or a vehicle used by organisms for preconstituted strategies. Rather, the organization is an individual with its own distinctive traits which are passed from one generation to the next through learning. This sort of individual influences the behavior of its members concerning rank, attachments, friendly relations, role divisions, and profiles. (Khalil, 1995, p.410)

An important glue of these social entities is what Tuomela (2007, p.338) calls "we-mode thinking and acting": the members think and act for the group's use and benefit. This makes it difficult to deny them status as "social agents in a genuine sense" (Niiniluoto, 2007, p.419), even with rather restrictive definitions of agenthood (e.g. Sibeon, 2004). These entities cannot only be regarded as "social", "organizational" or "collective" actors (Mouzelis, 1991; Sibeon, 2004), but should also be seen as being endowed with agential causal powers (Pettit, 2009). That emergent structures in these systems should hence be considered real, is what results in the particular relationship between part and whole that is characteristic of open systems in general, and wicked systems in particular (see Goldspink and Kay, 2007). This relationship is in practice a dialectical one, as Levins and Lewontin (1985) put it:

> "Part" and "whole" have a special relationship to each other, in that one cannot exist without the other, any more than "up" can exist without "down." What constitutes the parts is defined by the whole that is being considered. Moreover, parts acquire properties by virtue of being parts of a particular whole, properties they do not have in

[5] Khalil instead refers to the broader group of "mammals" here, however, this is no longer believed to be the case – see Read (2012).

> isolation or as parts of another whole. It is not that the whole is more than the sum of its parts, but that the parts acquire new properties. But as the parts acquire properties by being together, they impart to the whole new properties, which are reflected in changes in the parts, and so on. Parts and whole evolve in consequence of their relationship, and the relationship itself evolves. These are the properties of things that we call dialectical: that one thing cannot exist without the other, that one acquires its properties from its relation to the other, that the properties of both evolve as a consequence of their interpenetration. (Levins and Lewontin, 1985, p.3)

As Fuchs (2007, p.18) argues, this interpretation of emergence amounts to "a reformulation of dialectical philosophy," despite the lack of explicit acknowledgement of the "dialectical tradition and heritage of the philosophy of nature in the line of Friedrich Engels" and Hegel (Fuchs, 2003, p.74) (one exception to this is Carneiro's (2000) wonderful study of the transformation of quantity into quality, providing a complexity-perspective on the law stipulated by Hegel (Bukharin, 1925) and studied by Marx and Engels in *Anti-Dühring* and *Dialektik der Natur*.)

The capacity for the component to adapt to the whole means that events and acts play out on multiple levels, and that the boundaries dividing different levels are quasi-porous: there is, for example, no biological phenomenon whose causes and consequences play out in only one context. Hendrichs (1983) provides an example of this multi-levelness:

> When performing their defecation ceremony at a specific place on the boundary of its territory, dik diks do at least five things at once: they excrete urine and dung; they mark their territorial boundary with optical and olfactory signals; they claim their territorial ownership up to that point; they strengthen their attachment to that place; they strengthen the integration of their group. (Hendrichs, 1983, p.741)

This interconnection between levels is also expressed in that sub-wicked systems have two types of emergence, while complex systems display only one. Complex systems display what Gilbert (2002) calls "first order emergence"; in which interactions among individual components result in a whole. Subwicked systems also display what Gilbert (2002) calls "second order emergence" and what Goldspink and Kay (2007) call "reflexive emergence", where the components are able to recognize and adapt to the emergent products of their own interaction, resulting in "the amazing variety and mutability of social [and societal] systems" (Bunge, 1998, p.8). This implies that we may also consider some emergent structures as having capacity for agency, again illustrating the reality and capacity for agency of structures in such systems.

"Wicked systems*[6]*" is a reference to Rittel and Webber's (1973) term "wicked problems", which describes a class of problems that are characterized by a set of epistemological griefs; e.g. that they lack definitive formulations, that it is unclear when and if we are finished solving them, that they are caused by – and are the causes of – many other similar problems, and that they require uniquely tailored solutions. The reference implies that this is in fact not only a description of isolated problems as such, but that it captures something fundamental about the nature of the systems that generate such problems.

Wicked systems are arenas of and for innovation, with their constituents constantly trying to outsmart one-another, reaping their own benefits, reacting to threats from other constituents, as exemplified by large human societies and ecosystems over evolutionary time. This produces a situation where complicated organization and complex dynamics are in a constant state of re-negotiation, constantly challenging any settlement of the system into a level hierarchy, constantly facing the system with qualitative novelty that other components have to react to. This has two immediate results. First, the dynamics of wicked systems cannot be understood in terms of functions, but rather as emergent externalities from underlying component interaction. Secondly, qualitative change, i.e. change in kind,

[6]The question may here arise whether wicked systems are in fact "systems" at all, if they fulfill no functionalities and have unclear boundaries. *Cambridge Dictionary* defines "system" as "a set of connected things or devices that operate together". Oxford English Dictionary defines it as: "1. An organized or connected group of things. 2. The whole scheme of created things, the universe. 3a. A group or set of related or associated things perceived or thought of as a unity or complex whole. 3b. A set of persons working together as parts of an interconnecting network." etc. These definitions clearly cover wicked systems as well, as they are often "perceived or thought of as a unity of complex whole" and they do consist of "connected things or devices that operate together" (at least in the broader sense of "together".) This seems to imply that wicked systems indeed fulfill the dictionary definition of the term (one might object that the often ill-defined boundaries of their components challenge – or at least make problematically recursive – definition 1, but in any case it is clear that they are commonly "perceived or thought of as a unity or complex whole".) So far so good. However, there is a second line of criticism against the term, basically arguing that the concept "system" itself is associated to what we call "complicatedness"; as Jenkins (2010, p.142) argues, "notions of system may encourage us to tell the wrong story about humans". Bunge (1999, p.5) responds to this with that: "trying to avoid the word 'system' just because of its association with Parsons or Luhmann is like boycotting the word 'nation' only it is abused by nationalists." While I remain unconvinced about the ultimate usefulness of nations, I do find that using "system" is both legitimate and indispensable. That being said, it should also be noted that what I mean by "system" in this context also resonates strongly with Delanda's (2006) notion of "assemblage".

related to what Archer (e.g. 2013a,b) calls *morphogenesis*, is the *modus operandi* of wicked systems, and to disregard it in their study "signifies nothing less than the wilful obliteration of [the] very subject matter" (Arendt, 1958, p.57).

It is the innovation of underlying actors that upsets any level hierarchical organization, thereby ruining prospects for near-decomposability, by constantly rewriting the "rules of the game". As Wicked systems are non-decomposable, short runs (see section 1.1) are not just hard to find, there is no guarantee that there even exists a meaningful short run – wicked systems may in fact be seen as systems that largely lack relevant short runs and thereby also opportunities for powerful formal modeling. Levels of organization have been described as "stable foci of regularity and predictability", and as such, the existence of levels of organization in itself must be expected to act as attractors to adaptive processes: they should self-reinforce and self-stabilize over time (Wimsatt, 1994) since adapting systems evolve in such a way as to minimize uncertainty in their environment (Levins, 1968). However, as Wimsatt (1994) points out, this is only half the story. In a competitive situation, i.e. a situation with what Khalil (1995) calls individuality, entities under competition (be they organisms, organizations or humans) will themselves seek to be as unpredictable as possible to their competitors, which would make it adaptive to also break up level hierarchies.

Wimsatt (1975, p.181–185) furthermore argues that Simon's principles take only ease of design and assembly into account, not optimality of function. Optimality of function, of course, may be under strong selection pressure, and when it is we should expect this to cause breakdowns in level-hierarchical organization. The reason is that there is no convincing argument for why a style of organization that simplifies assembly and design would also make for optimal function. Intuitively this expectation seems to be carried out in reality. Technological artifacts that are mass-produced (strong pressure for adaptability, cheap assembly and easy maintenance) contain more standard components, and are simpler in their architecture, than ones that are highly specialized and produced only in very few numbers.

The wickedness of human communities developed from an initial sub-wicked organization of great ape foraging groups and communities (Grove et al., 2012). Through the development of increasingly tight and multifaceted cooperation (Tomasello et al., 2012), early hominin (after the concestor[7]) communities may have begun to accumulate the physiological and cultural affordances necessary

[7]The concestor refers to the last common ancestor of humans and chimpanzees (Dawkins and Wong, 2005). The nature of the concestor can be inferred from strong similarity in lifestyle and morphology between fossil great apes (Wrangham and Pilbeam, 2002) from the relevant time space 5-7 million years ago (Kumar et al., 2005).

to transition from social/sub-wicked to societal/wicked, through the "seamless" (Hughes, 1986) integration between the social and technical, transforming, eventually, the emerging human community into a larger interconnected sociotechnical system (Geels, 2004). Technology here functioned simultaneously as powerful *modes of interaction* between actors, while also themselves being *interactors* (Hull, 1988). Due to the complicated and near-decomposable structure of technology, technological artifacts can maintain vast and heterogeneous arrays of interaction and thereby integrate cultural systems by tying its various domains together. Hence, through such socio-technological structures, human culture became capable of maintaining interaction systems where every node is densely connected to just about all domains of the web. The seamless web – which is barely but importantly discernible in chimpanzees technology-assisted extractive foraging (e.g. Biro et al., 2003) and "politics" (Van der Waal, 1982) – was thereby simultaneously *integrated* through weakly constrained interaction, and *separated*, through specialization. This is a procedural recipe for full-scale wickedness.

Interactions in these seamless webs have a strong enveloping competitive component but display also the whole spectrum of ecological interactions (competition, symbiosis, neutralism, parasitism, commensalism and amensalism; see Sandén and Hillman 2011, p.407). Symbiotic interactions may give rise to self-organized systems toward the trans-complicated and trans-complex regimes; e.g. bundles of value chains as described by Sandén and Hillman (2011, p.404-406). Parts and levels may over time co-adapt to become increasingly co-dependent; compare with examples of symbiotic origins of complicated systems (see Leigh, 2010; Roze and Michod, 2001). The boundary between wickedness and trans-qualities is thereby porous.

Components act and react within neighborhoods in the seamless web, and, since each is part of many neighborhoods, change is liable to propagate across the system. Dynamically and macroscopically, this leads to two dialectical dynamical regimes: transition and lock-in. Transitions are self-propagating waves of qualitative "reconfigurations" of and by components, traveling across neighborhoods in the seamless web (Geels, 2002; Lane and Maxfield, 1997). These may form potentially system-wide cascades of change (Geels, 2011; Lane, 2011a; Lane et al., 2009b; Schiffer, 2005). However, if locally beneficial reconfigurations cannot be made, change will be resisted, and if such criteria, posed by large numbers of strongly interconnected components, are combined, the range of actually viable innovations will be strongly constrained and channeled. The result is a lock-in, such as by a dominant design (Utterback and Abernathy, 1975) or a sociotechnical regime (Geels, 2002; Rip and Kemp, 1998). The combined effects of cascades and entrenchment of effects is a potentially unlimited horizon in time and scope for consequences of actions.

Due to the strong and heterogeneous connections that crisscross wicked systems, it is impossible to divide such systems them into realistic pictures: only the full system is enough to represent the system, and that will never be theoretically achievable (see also Cilliers, 1998, 2002). Any “picture” captured will necessarily be from a perspective, and rarely subject to universal agreement. Even if we could obtain a “realistic picture”, this would frequently not help much since the system changes unpredictably over time – including as a direct result of us interacting with it.

Since there is no axis of reduction, there is no native method fit to fully cover wicked systems, and hence, as Paper I discusses, the attempts to formally deal with wicked systems have generally focused on treating them either as complex or complicated systems – “the reductionist and the functionalist approaches extend the tool found successful in one domain to decipher the other” (Khalil, 1995, p.414-415) – neither of which matches their ontological nature and neither of which can be said to have been very successful. They are, in Archer’s (1996) terminology, *conflating* the systems either downward or upward.

In the context of social theory, the former – ontologically individualist reductionism – relates to what Gilje and Grimen (1992) call the *action paradigm*, in which actors are viewed as free agents whose interaction leads to varying types of phenomena. In this view, structures and systems are merely relatively stable patterns, either emerging from or simply constituted by aggregated individual action. In relation to social meta-theories, this implies treating society as ontologically flat, as – to a certain extent – in *assemblage theory* and *analytical sociology* (DeLanda, 2006; Hedström, 2005) (see chapter 3).

	Action paradigm	**Fact paradigm**
Primacy:	Bottom-up	Top-down
Complexity:	Dynamical (complex)	Structured (complicated)
Ontology:	Individualism	Holism

The latter – ontologically holistic reductionism – relates to functionalism, and more broadly to what Gilje and Grimen (1992) call the *fact paradigm*, i.e. in which social facts are the primary object of study: institutions, social structures, organizations etc. The term “social structure” is used in a strong way, while “agency” is used weakly, i.e. as simply ways in which structures are reproduced. This encapsulates methodologically holistic (e.g. social fabric matrix, see

Hayden 1982, and institutional dynamics, see Radzicki 1988), functionalist and system-focused approaches, as well as Luhmann's (1986; 1995) system theory (as Wan (2011) convincingly argues), and is traditionally understood (e.g. by Danermark et al. 1997) to have Èmile Durkheim[8] as its early proponent. (It can also be seen rather explicitly represented in Mumford's (1966) concept "mega-machine", in which society is seen as an "archetypal machine composed of human parts".)

Hence, from a social theory standpoint, the combination between complexity and complicatedness is linked to the meeting between the *fact paradigm* and the *action paradigm*, between agency and structure, a meeting whose resulting ontology is either "dualist" (as Giddens, 1984) or a "dualism" (as Archer, 2000). (The resulting implications of wicked systems on the view of social structures will be discussed in Chapter 3.) The intuitive, but non-formalized, alternative to these two directions, is to cast wicked systems into the realm of subwickedness by using narratives as the methodology. This is an attractive option since it matches the ontology of wicked systems (as we will see in Chapter 2). That narratives are compatible with the combination of complicatedness and complexity does, however, not mean that they are very capable of dealing with either – indeed, this is why such systems are perceived as overwhelming to begin with.

1.2 Uncertainty in Wicked Systems

As we have seen, complicated systems permit exact prediction, while complex systems are more uncertain: due to nonlinearity, one may only predict their general dynamics, rather than specific states. Wicked systems are defined by an even deeper level of uncertainty, which lies at the core of what dealing with wickedness is about: both prediction of future states, and of future dynamics rely on the possibility of decoupling "the game" from "the rules of the game". But in wicked systems, the game and its rules frequently change dynamically on similar time scales: qualitative – and, from the perspective of decomposition, *ontological* – change is occurring on the same time-scales as quantitative change.

This means that wicked systems are less like a game in which defined entities play according to set rules, and more like a boiling pot of change where each discernible shape and structure, resulting from the interplay of a variety of counteracting forces, may very well dissolve as quickly as they evolve. Yet, entity

[8]Boudon (1981, p.155) however refers to this view as a result of a "superficial reading of Durkheim", that has given rise to "the myth of Durkheimian holism" (Cherkaoui et al., 2008, p.18). Durkheim's empirical analyses are in fact "much richer, subtler and promising" than this would suggest (Cherkaoui et al., 2008, p.39).

interaction, game-play and gradual quantitative change are ubiquitous, as many stuctures display surprising persistence, but this may just as soon be replaced by rapid fundamental transitions and rapid qualitative change, as quantitative change becomes qualitative (Carneiro, 2000).

This perspective on level of near-decomposability of different system domains gives a new perspective on the separation between *static ontologies*, characterized by the belief that "change is only a momentary departure from equilibrium or harmony, which would be the ideal state of affairs" (Bunge, 2011, p.20), and *dynamic ontology*, in which the central thesis is that "statis is a particular and ephemeral case of process: that every state of a thing is either the initial, intermediary or final phase of a process" (Bunge, 2011, p.20). The latter is exemplified by Emirbayer's (1997) relational sociology:

> Sociologists today are faced with a fundamental dilemma: whether to conceive of the social world as consisting primarily in substances or in processes, in static 'things' or in dynamic, unfolding relations. Large segments of the sociological community continue implicitly or explicitly to prefer the former point of view. Rational-actor and norm-based models, diverse holisms and structuralisms, and statistical 'variable' analyses – all of the beholden to the idea that it is entities that come first and relations among them only subsequently – hold sway throughout much of the discipline. But increasingly, researchers are searching for viable analytic alternatives, approaches that reverse these basic assumptions and depict social reality instead in dynamic, continuous, and processual terms. (Emirbayer, 1997, p.281)

This separation is not as much a binary dichotomy as a gradual scale; Bunge (2001, p.32-33) distinguishes (in a somewhat biased terminology) between "radical" and "moderate" dynamicism, where the former invokes the full *phanta rhei* of Heraclitus, and sees the world as constituted by processes or events rather than entities, while the latter admits that "some traits remain invariant throughout certain changes" (Bunge, 1977c, p.279) and that change is sometimes enabled exactly by this permanence.

The position on this scale is not only defined by the system category, but can also vary over time. For example, the ontological stability of society is rooted primarily in the stability of material culture, and ontological change is driven primarily by innovation and changes in the material base (see e.g Archer, 2014; Bauman, 2013; Danermark et al., 1997; Elder-Vass, 2017). Hence, as the power relation between these two factors change, as material culture becomes more liquid, not least due to digitalization, human society becomes more prone to qualitative change – in other words moving toward a more dynamic ontology (see Törnberg, 2016a).

Dynamics of qualitative change is exceptionally difficult to study, even compared to complex and chaotic systems. For example, the stock-market, while infamous for its unpredictability, is only *quantitatively* chaotic: on the relevant time-scale, it is ontologically fixed, and hence, it is only chaotic in relation to its state, not its kind (Byrne and Callaghan, 2013). The unpredictability of the stock-market is an example of what we can call "second order chaos", in reference to Gilbert's (2002) "second order emergence": if predictable patterns emerge, they will be discovered and undermined by constituent agents. Conversely, in wicked systems, the capacity of agents to detect emergent structures allows such second-order chaos to take a qualitative form (what could be rightly described as "ontological chaos".)

Because of this, consequences of action in wicked systems is shrouded in deep uncertainty, described by Lane and Maxfield (2005) as an "ontological uncertainty": not about the truth of well-defined propositions ("truth uncertainty"), nor about the meaning of a given statement ("semantic uncertainty"), but about what entities that inhabit the world, how they may interact, and how interactions and entities change through interaction (Bonifati, 2010). Uncertainty keeps us from aligning action to respond to future ill effects (game theory; e.g. Gintis 2000; Ostrom 1990), but it also prevents us from designing effective interventions without high likelihoods of causing unexpected troubles in other domains.

Clearly, however, there are many important cases where we can surely make assumptions of near-decomposability also in wicked systems, and where we thus are able to bring powerful scientific approaches to bear. For the purposes of complexity science, it would seem reasonable that certain subsystems - such as crowd behavior, protein-folding, or the *ceteris paribus* fate of a new trait in a population - can be argued to fit this description. The dynamics of cars and people play themselves out over much shorter time scales than that on which urban systems, roads, traffic regulation and so on, change. Such phenomena are also often ephemeral, which bounds the problem even further. For example, at night the traffic jam dissipates and leaves no traces that affect tomorrow's traffic.

But what about evolutionary societal and ecological phenomena more in general? For example, what about sociotechnical transitions, evolutionary radiation events, or other wicked problems? Wicked systems in general are open systems, in which many and far-flung types of processes co-exist, co-evolve and have an impact on each other on overlapping timescales and levels of organization. They involve discontinuous, qualitative change as well as cascade effects (Lane, 2011a) whereby change strongly and rapidly feeds back into the conditions for further change. Such systems are, to say the least, hard to contain in a Simonean compartment with a "short run" over which, for example, transitions can be studied against the background of an unchanging external environment.

Put in another way, the type of hierarchy that micro-emergence assumes does matter in wicked systems, as Bickhard (2000, p.326) argues, "emergence presupposes a notion of levels", but neither causality nor structure is restricted to the hierarchies: we have interpenetration and overlaps, as well as multi-directional causality. It is not only that "an *n*:th level system is composed of things on level *n-1*" (Bunge, 2004b, p.133), but it may also include elements from any other levels. Simon (1991) was of course aware of the existence of such interpenetrations, but nevertheless, assumed that there was enough hierarchical structure to make modeling possible, and thus emphasized that which falls within the hierarchies, proposing that hierarchical models provide an adequate approximation (in line with the spirit of the time). In complex and complicated systems, such interpenetrations are indeed exceptions, but in wicked systems they are instead the norm. More figuratively speaking, if complicated and complex systems are like onions, where you can neatly peel each layer from the next with only some thin slimy strings connecting the two, wicked systems are more like a mango: any attempt at separating them into levels, or in fact even trying to peel them, will most likely result in a gooey – but delicious – mess.

1.3 Boundaries of Wicked Systems

Due to the high level of interconnection and dynamic complexity in wicked systems, it tends to be difficult to define system boundaries. Decomposable systems generally have clear defined boundaries, and in turn consist of distinguishable entities. For example, the birds in a flock might interact in complex ways leading to unpredictable emergent dynamics, but at least the birds themselves can be distinguished as clearly defined, separate entities that are unlikely to evolve during the time-scale of the flock. This is often not the case in wicked systems. As Cilliers (2001) puts it, what we call wicked systems

> have structure, embodied in the patterns of interactions between the components. Some of these structures can be stable and long lived [...], whilst others can be volatile and ephemeral. These structures

> are also intertwined in a complex way. We find structure on all scales. [...] [N]on-contiguous sub-systems could be part of many different systems simultaneously. This would mean that different systems interpenetrate each other, that they share internal organs. How does one talk of the boundary of the system under these conditions? (Cilliers, 2001, p.4-6)

Furthermore, since ideas of spatial continuity do not apply to these systems, one of the foundations on which we traditionally base the notion of boundaries is turned on its head. As Cilliers (2001) puts it:

> We often fall into the trap of thinking of a boundary as something that separates one thing from another. We should rather think of a boundary as something that constitutes that which is bounded. This shift will help us to see the boundary as something enabling, rather than as confining. [...] [An] implication of letting go of a spatial understanding of boundaries would be that in a critically organised system we are never far away from the boundary. If the components of the system are richly interconnected, there will always be a short route from any component to the "outside" of the system. There is thus no safe "inside" of the system, the boundary is folded in, or perhaps, the system consists of boundaries only. Everything is always interacting and interfacing with others and with the environment; the notions of "inside" and "outside" are never simple or uncontested.[9] (Cilliers, 2001, p.5)

So not only are wicked systems under constant ongoing ontological change, but their boundaries are far from as clear as positivist science tends to imagine them. In wicked systems, entity interaction – on and between all levels – is ubiquitous and central to the dynamics of the system. But since there are also relations with the surrounding environment, it is generally not obvious where the boundaries are to be drawn. It is more of a question of framing: we frame the system by describing it, but reality constrains where the frame can be drawn (Cilliers, 1998, 2001). The boundary is neither only a construction nor only a natural thing – it is a mix and an ongoing interaction between these (Richardson and Lissack, 2001).

[9]It is interesting to note that the dominance of boundaries can in fact be said to be a general fact of high-dimensional systems. To see this, consider the ratio between surface area S_n and volume V_n for a n-dimensional hypercube: $\frac{S_n}{V_n} = \frac{2nr^{n-1}}{r^n} = \frac{2n}{r}$, now clearly as $lim_{n\to\infty} \frac{S_n}{V_n} = \infty$.

This clearly has implications for how to approach wicked systems scientifically. While complex systems require radically new scientific methodologies to deal with the intricacies of relational reduction, the poor decomposability of wicked systems calls for something far more radical still (Castellani and Hafferty, 2009). The constant ontological transformation clearly implies a weaker type of knowledge claims, and Cilliers (1998; 2001) accordingly suggests a significantly less universal conception of scientific knowledge: as contextual, local and specific in time and space. This may sound postmodernist in a negative sense, but there is a significant difference between this and full-blown relativism. That the possibilities for prediction and description are limited does not mean that *anything goes*, as the most radical postmodernist theorists could lead us to believe; the world can be known, even if that knowledge is contextual and time limited. While this has implications for positivism, it in no way downplays the importance of scientific work. Quite the opposite: that our knowledge of a system is only local and temporary emphasizes the importance of knowing how to learn about a system (Byrne and Callaghan, 2013). It however affects how to scientifically relate to the systems under study, as Actor-Network theorist Law (2004, p.7) puts it: "... in this way of thinking the world is not a structure, something that we can map with our social science charts. We might think of it, instead, as a maelstrom or a tide rip. Imagine that it is filled with currents, eddies, flows, vortices, unpredictable changes, storms, and with moments of lull and calm".

But our scientific knowledge will not only be contextual and time-limited: because of the constant ontological transformation we have no stable ground to stand on required for a reduction of the system; if we are to be sure that the dynamics of the system is the same, we cannot represent a complex system with anything less complicated than itself (Cilliers, 2001). Since simplifications are of course necessary for any meaningful scientific work, this basically means that any representation will necessarily be flawed, and we cannot even know in which way it is flawed.

In wicked systems involving humans, the question of framing and system boundaries is decidedly at its hardest. In such systems, the choice of framing will not only be a scientific question, but an *ethical* question, as the choice will necessarily affect the reality of the system (Byrne and Callaghan, 2013; Cilliers, 2000): constructing a boundary for a system can mean that this boundary becomes more present in the system; temporary structures may gain longevity by being described. This is part of what Bhaskar (1979) calls the *relational condition* of the social sciences, which is one of the ways that wickedness specifically plays out in societal systems, which will be the focus of the next chapter.

Chapter 2

Relational Limits

- Wickedness in Human Society

So far, the separation has dealt with different factors connecting to openness and closure, and the nature of social structures, and we have seen that the separation does not cut cleanly between social and natural systems, but that it is rather, as Khalil (1995, 1999) argues, a question of system organization. The contribution thus far can be seen as a continuation of Khalil's work. However, Khalil focuses only on what Bhaskar (1978) refers to as the ontological (i.e. the activity-, concept-, and space-time-dependence of social structures) and epistemological (i.e. the openness of social systems) limits of naturalism, and neglects what Bhaskar calls the *relational conditions* of social science. Our description of society cannot completely suffice with these naturalistic notions about openness/closure and complexity, as these miss "that the self-organization of society is not something that happens only blindly and unconsciously but depends on conscious, knowledgeable agents and creative social relationships" (Fuchs, 2007, p.27). Human agents – the components of the social realm – are entities with unique causal powers – a fact that we cannot overlook when formulating our ontology of these systems. In Bunge's (1998, p.122) words: "Human beings are the creators, reformers, and destroyers of all human social systems, and social laws and rules are nothing but the patterns of being and becoming of such systems".

The next section approaches this condition, but from a rather different viewpoint: we will look at how the relationship between structure and emergence evolves and plays out in social systems, and from that review the implications of the relational condition (relating to Paper III and Törnberg and Andersson 2016). We begin our exploration of human social systems just across the boundary into the realm of natural systems.

2.1 Narratives before Society

Our chimpanzee cousins (*Pan troglodytes*, *Pan paniscus*) illustrate a picture that most probably represents the natural origins of wickedness and human societies. Hominins (*Homo* and extinct relatives) diverged from Pan 5-7 million years ago, and fossil remains suggest that Pan has remained similar ever since. Apart from their only very slightly complicated tools, they have no higher level of organization than the community, which is organized through friendships and maintained by intimate daily contact. Like human hunter-gatherers still, and many other species (e.g. wolves), they have a fission-fusion organization where smaller foraging groups continually form and dissolve within the community. This permits the community to grow relatively large and cohesive while not putting too much pressure on the land and its resources. Large fraction of their time is spent in the upkeep of their relations, through touching, grooming and exchanging favors, building a mutual trust between each member of the community that allows them not only to (locally) hunt together, but also to lend assistance in fights between communities and in internal conflicts and so on. This way of maintaining a group imposes clear limits on the size of the group: two chimpanzees who have not previously met cannot know whether to trust one another, and because of this, when chimpanzee groups grow too large, they tend to destabilize and rupture into two separate groups (Moffett, 2013, p240-241). Furthermore, since intimate trust is the only form of collaboration, communities never cooperate, but compete fiercely for territory and food (de Waal 2005; bonobo communities mostly mingle amicably but remain separate and compete for both territories and females; see Kano and Ono-Vineberg 1992).

Human groups attained the capacity to expand this limitation by letting communication – gossiping and story-telling – supplement direct intimate interaction (Dunbar, 2004). Gossiping let humans know about the trustworthiness of other humans in the group, without requiring direct interaction, thereby allowing human troops to build trust through reputation-driven indirect reciprocity (Nowak, 2006): more tightly and across significantly larger groups than other apes. This however put great pressure on cognitive capacity, as navigating such groups demands the ability to deal with constant social innovation: intrigues, new constellations, secrets, lies, and the relations between others and between others and oneself (Read, 2012). According to the "Machiavellian intelligence" (e.g. Byrne and Whiten, 1988) and "cultural intelligence" (van Schaik and Burkart, 2011) hypotheses, these requirements were key drivers of the evolution of human intelligence and large costly brains (Aiello and Wheeler, 1995).

Regardless of the validity of these hypotheses, which are currently under strong development, it is clear that gossiping and narratives are deeply ingrained in human cognition: Michotte's (1963) experiments in attribution of causality provides clues on just how deep. In these experiments, observers were shown two or more small, colored rectangles in motion on a screen, and when asked to describe what they saw, they intuitively imposed elaborate cause-and-effect stories in which the moving rectangles were assigned intentionality and meaning through intricate plots, exemplified by descriptions such as "the red ball hit the blue ball" or "the red ball is chasing the blue ball" (see also the Thematic Apperception Test, Murray 1938). Narrative structuring assigns intentions and cause-and-effects to sequence of experienced events by drawing them into unified plots, through which they take on significance and meaning (Ricoeur, 1980). There is certainly some flexibility in this description, but the narrative has to represent events in a way that is perceived as coherent, i.e. that fulfills implicit assumptions about human behavior and cause-and-effects. The structuring process that configures events into such plots is interactive or dialectical, moving between a temporal meaning that might explain or show a connection among the events and the events' resistance to fitting the construction (Polkinghorne, 1991).

While narrative competence emerges at an early age and is culturally universal (Mancuso, 1986), its specific coherence relies on a culturally specific understanding of human characteristics, which are at the same time constructed by the narrative; "the narrative constructs the identity of the character, what can be called his or her narrative identity, in constructing that of the story told. It is the identity of the story that makes the identity of the character" (Ricoeur, 1992, p.147-148). Narrative structuring shares some similarities to the visual configuration described by Gestalt psychology, in which, for example, three dots can be seen as the angle points in a triangular figure (Gurwitsch, 1964). In the same way, narrative structuring has a part-whole or Gestalt organization: just as spatial organization (e.g. of a kitchen) consists of topological relations (up, down, left, right, next to, inside, etc.), temporal organization (e.g. a trip to the store) consists of causal and enabling relations. In this way, narrative structure is used to make meaningful the actions of actors, public individuals and groups, and governments and institutions, based on implicit behavioral assumptions. This capacity, according to Lakoff's (1987) theory, moves us to recognize the patterned bodily experience of going from an initial state, through a sequence of events, to a final state. This source-path-goal schematic pattern serves as the metaphoric origin for the type of temporal organization that makes the elements of episodes and stories understandable as parts of a temporal whole (Polkinghorne, 1991).

Narratives are not only used for the understanding of external actors; they are also widely believed to be the way we understand ourselves (Polkinghorne, 1988). When people we meet tell us the story of their lives, we are not surprised that they have one – in fact, we would be surprised (or even worried) if, in trying to get to know someone, all he or she had to share were a series of unconnected events (see Lacan's notion of a psychotic structuring Lacan 1960. Stories are important for having a vision of the self and to understanding and connect to others. The reconstruction of a coherent self-narrative has been held as a therapeutic goal since Freud's inauguration of psychoanalysis, which Spence (1982) describes as the art of turning disordered pieces of information from patients into coherent stories. This view conceptualizes anxiety as an evolved imperative to narratively relate ourselves to the larger community, and shows clearly how narratives may have evolved to align strongly individualist members to form a functional group in early communities.

2.2 Narratives in Society

However, while gossiping and story-telling allowed *Homo sapiens* to form larger and more stable bands, even gossip has its limits: the maximum "natural" size of a group bonded by gossip is about 150 individuals (Dunbar, 1992, 1995; Dunbar and Shultz, 2007). As we pass this threshold, informal organization starts breaking down, and there starts to be the need for things like formal ranks, titles and rules to keep the group together. Clearly, while gossiping allowed a powerful extension of group size for early humans, it was not a foundation which could hold together cities and empires with thousands, and eventually hundreds of millions of inhabitants.

The way that this transition occurred holds central significance for the relationship between individuals and structures in society, and for how we can understand societal systems. Passing this threshold occurred through an *exaptation* (Bonifati, 2010) of narratives, in which the use of narratives and story-telling no longer only included individuals as actors, but also collective actors and social structures. In other words, the cognitive tools that we developed to deal with sub-wicked systems, story-telling and gossiping, were applied to deal also with emergent social structures: the groups and social structures became actors in narratives (Henshilwood and d'Errico, 2011).

This most likely first played out in the form of sizable – in recent egalitarian hunter-gatherers sometimes 2,000 strong – communities composed of several bands whose members were distinguished on the basis of multiple society-specific, and socially acquired, labels (Moffett, 2013). These features made it easy for humans, unlike wolves and chimps, to recognize members of other groups at a glance (Diamond, 1992, p.220). Through such labeling, they accomplished what Moffett (2013) calls “Anonymous Society”, where one no longer need to personally know another member to know how to relate.

This allows large groups to cooperate, as strangers can cooperate successfully by identifying one another through symbols and belief in common myths. Through this common ground, social entities such as organizations and communities, attain “the causal power to influence the behaviour of human individuals” (Elder-Vass, 2007d, p.465). Instead of organizing through the interaction between every single individual, they organized toward a mythical idea of a collective, rooted in common stories and labels (e.g. Johnson and Krüger, 2015). Large-scale human cooperation – whether a modern state, a medieval church, an ancient city or an archaic tribe – is ultimately rooted in common narratives which enable mutual trust: two tribesmen who have never previously met can cooperate on the basis of their common membership in a thought in-group, defined by a complex web of shared belief in stories about the world. Similarly, today, two persons who have never met can cooperate and exchange goods through their common belief in ideas such as trade, capitalism, and the value of money.

In small, traditional societies, common stories of ghosts, gods and spirits may have functioned to cement the social order, and today, our modern institutions function on the same basis (Harari, 2014). Just as rumors and stories function in small groups to assign characteristics to the actors involved, we today assign human characteristics, agency, and even emotional states to imagined emergent actors. This can be observed in brands being seen as *trustworthy* or *manly*, or in the depiction of “the market” as *worried* or *stressed.* Such characteristics hardly make sense as descriptions of imagined collectives, but to an extent, the stories become self-fulfilling prophecies (if you own stocks, and you understand the market as a “worried” actor, this is likely to affect your trading decisions so as to induce volatility.)

In this way, narratives are used not only to understand the inter-human world, but also the roles and behavior of institutions and social structures: humans not only adapt to emergent structures, but they do so by assigning meaning and roles to them. They shape our behavior and organize our society, yet they – strictly speaking – do not exist outside of our collective stories. Over the years, there has developed an incredibly complex network of such stories. Within this network, ideas such as “the market” can accumulate immense power. We navigate this symbolic network, using stories as building blocks to construct new stories.

This symbolic network has increasingly come to dominate how we understand the world and ourselves, in what Baudrillard (1994) calls the "precession of simulacra". As this operates in the same symbolic landscape in which we understand ourselves, this is also the lens through which we see ourselves: we relate ourselves to the categories and groups to which we see ourselves as being part. The dual reality of humanity is hence mirrored in our individual selves: Lacan (1960) described this fundamental split as *the mirror stage* – in which the Symbolic, and Imaginary is formed, separated from the Real – the relation between which determines our very structuring: our narratives can never fully capture reality, which is reflected in cracks and tears in our selves. In other words, just as the defecation ceremony of *dik diks* is multi-dimensional, so does human symbolism and narratives cut across levels – but in an immensely more flexible and powerful way.

Let us, briefly, connect this historical exposition of the nature on narrative and the evolution of societal systems to contemporary social theory on the agency-structure relationship. As we have seen, wickedness is defined by the feedback interaction between complexity and complicatedness – the dialectics between agency and structure: just as in complex systems, patterns emerge from the interaction between constituents, in wicked systems, however, this emergence is *reflexive* (Goldspink and Kay, 2007): the patterns are observed, and met by adaptation from the individuals in the system. The narrative nature of human wicked systems means that in societal systems, this interaction between social structure and emergence takes a particular form: narrative, meaning, intentionality, and so on, are the building blocks of social and societal systems. This does not mean to argue that individuals should be treated as only products of narratives. As Kaidesoja (2007, p.82) points out: "it is surely one thing to say that the conversations, in which biological individuals engage in their lives, in many ways shape and modify their powers, and another to claim that people are nothing but conversational constructs."

As we have furthermore seen, social actors, unlike the components of systems in the natural world, are capable of collective intentionality (Searle, 2010, 1995, 2006), sophisticated communication and creative collaboration, including what Sawyer (2003) calls "improvised dialogues" that make "distributed creativity" possible. This capacity to evaluate the social world is not limited to the external, but just as important is the capacity of self-awareness and reflexivity: human beings, as Sayer (2005) points out, are "evaluative beings", continually monitoring and assessing their own behavior and that of others, in a narrative form. Evaluative beings tend to engage in what Archer (2003) calls "internal conversation", that is, processes of continuous "internal deliberation", which is "self-reflexive because it is a self-critical exercise" (Archer, 2003, p.105-106). The importance of these dialogue has been stressed in different contexts by a number of leading social theorists, such as Giddens (e.g. 1992), Archer (e.g. 2000), Sayer (2005), Elder-Vass (2007c, 2010), and Mouzelis (2007). Fleetwood (2008) has even gone as far as arguing that that reflexive deliberation via internal conversation is *the* "process that links social structure and agency" (Fleetwood, 2008, p.260). This, however, seems to underestimate other factors, such as more deep-lying social instincts, including emotions (Elster, 1999; Emirbayer, 1996), as well as what Bourdieu (2005) terms "habitus".

This idea of self-evaluation also resonates with Taylor's (1989) discussion of "strong evaluation", that is, human beings' capacity to evaluate their own preferences and beliefs, and thus to form "second-order desires" (see e.g. Callinicos, 2004). This is essentially what allows humans to change the games that they are playing, as they are playing them, since the notion of internal conversations emphasize that "our relationship to the world is not simply one of accommodation or becoming skilled in its games, but, at least in some ways, one of wanting to be different and wanting the world and its games to be different" (Sayer, 2005, p.35). This brings us into the importance of meaning and value in the context of human social structures in general, and in their qualitative change in particular.

2.3 Narratives and Social Structures

The exposition about narratives in human communities in this chapter has served to show how "agents are constrained and enabled by ideas, rules, norms and discourses" (Kurki, 2008, p.228), and that "'meanings' or 'ways of conceiving' that are dominant come to inform the intentions and the actions of agents" (ibid, p.224). As we have seen, both ideational and material aspects have to be brought in to adequately provide a view on the causal roles of social structures (Elder-Vass, 2017). Hence, when causation in social systems occurs through symbols and meaning, analysis becomes *interpretation*, or Weber's *Verstehen*. This is part of what Bhaskar (1979) calls the *relational condition* of social science, in that it implies that social researchers are equipped with unique tools to understand the dynamic in such systems, since they are themselves part of their own research subject. This gives them access to the actors' points of view, through the understanding of meaning. Such a research method implies entering into the shoes of the other, and treating the actor as a subject, rather than an object of our observations (Morehouse, 1994; Spradley, 2016). It also implies that unlike objects in the natural world, human actors are not simply the product of the pulls and pushes of external forces: individuals are seen to create the world by organizing their own understanding of it and giving it meaning.

Mechanisms in natural systems exist regardless of their meaning, while social structures are what they are through their meaning for the underlying individuals (Geertz, 1994). For example, if money had no meaning for individuals, it could not function as an explanatory mechanism: it would not be able to affect behavior. In other words, it is the interpretation of social structures by the underlying actors that grants them causative abilities; value and meaning *are* the stuff of the social realm, and so research is inherently about meaning. Because social structures exist only in virtue of the activity they govern, they do not exist independently of the conception that the agents possess of what they are doing in their activity; i.e. some theory of these activities. Since social structures are themselves social products, social activity must be given a social explanation, and cannot be explained solely by reference to non-social parameters (Bhaskar, 1979, 2010).

Because of this, *hermeneutics* is often seen as replacements to causal explanations of events within social science (Ricoeur and Thompson, 1983), but, as Archer et al. (2013) argue, this is taking it too far. Without hermeneutics, we cannot understand the meaning of an action, but identifying the meaning is not enough to explain what brought about the act: there are also beliefs, intentions, motivations, etc., at play (Bhaskar, 2010). There is hence a double hermeneutics in play in social systems, as "meaning has to be understood, it cannot be measured or counted, and hence there is always an interpretive or hermeneutic element in social science" (Sayer, 2000, p.17). In natural systems, the scientist attempts to interpret and create meaning in the object, but in social systems, the object has already been interpreted by the objects of study, an interpretation which is even part of its causal capacity. The formation of concepts is not only a part of the scientific work, as in the natural sciences, but also part of the scientific object. This is the "hermeneutic premises" (Collier, 1994) of the social sciences. Because of this, our view of societal systems is necessarily historical, value-laden and "situated": there is no view from nowhere, so while our perspectives and knowledge is necessarily partial and relative, it is the best we can hope for: without somewhere to stand, no knowledge is possible (Nagel, 1989).

In short, since value and meaning are the stuff of the social realm, and what grants social facts their explanatory power, there will necessarily be an interpretive or hermeneutic element in the social sciences. In fact, the "mechanism" metaphor should be used with care, as it implies a problematic Humean notion of causality (e.g. Harré, 1985): social mechanisms are not mechanical, and the adoption of such a conception of causality "makes it very difficult ... even to suggest a plausible theory of human agency" (Ellis, 2002, p.197). We can talk about generative mechanisms of social structures because they do make something happen, but while doing so, we must not forget that the effects of structures are mediated by agency: in social life, nothing happens without the activation of the causal powers of people (Carter and New, 2005). Hence, values and meaning are deeply connected to qualitative change, since humans are capable of navigating and transforming them through social action. For example, when studying how changing pay structures affect employee behavior in companies (e.g. Lazear, 2000), it is easily forgotten that the desires and values underlying these behaviors had to be taught, as workers would otherwise work no longer than necessary to meet their traditional needs. Or put in another way: sociotechnical change is to a large extent about change in values and meaning – and hence contains hermeneutic elements – showing how qualitative change is inextricably entangled with meaning (Geels, 2005; Geels and Schot, 2007). The nature and effects of such change in wicked systems will be the topic of the next section.

2.4 Innovation in Society

We have so far looked at how the relationship between structural and dynamic complexity plays out in social systems, and we will now turn toward a second central feature of wicked systems: the way that innovation drives constant qualitative change and the increase of these two complexities.

As has already been noted, wicked systems are deeply connected to innovation: on the micro-level, they are arenas of and for innovation, in which their competing constituents try to outsmart one-another; on the macro-level, they are characterized by a combination of self-propelling cascades of transformation, and periods of stasis and locks-ins. These cascades are self-propagating waves of qualitative "reconfigurations" of and by components, unfolding distributedly and locally in "the adjacent possible" (Kauffman, 1996, 2000) and propagating across neighborhoods in the seamless web, potentially with system-wide implications (Geels, 2002, 2011; Lane and Maxfield, 1997; Lane, 2011b, 2016; Schiffer, 2005). In other words, qualitative change in wicked systems is driven by positive feedback, change driving change, making both constant innovation and deep uncertainty hallmark properties of wicked systems.

Wicked systems both *enable* open-ended innovation, and are themselves *produced* by it. They enable innovation since the complicatedness (afforded by the technical) and the complexity (afforded by the social) are both necessary components of open-ended innovation. Without the structural complexity, it is impossible to construct sophisticated and specialized systems; unstructured system interactions would make for unmanageably design spaces, in practice impossible to explore through creative processes (Stankiewicz, 2000). Without the dynamical complexity, it is hard to imagine any efficacious adaptation process, as these rely on exploration of design spaces through e.g. parallelisms, feedback, and mass-interaction. They are *produced* by innovation, since the innovations themselves are structurally complex, and become part of a dynamically complex, seamless web. This positive-feedback dynamic is not a functionality of the system: their lack of what Khalil (1995) calls artificiality means that their macro-level is not aimed at fulfilling any functions, but that it is merely the emergent and aggregated sum of externalities of the underlying innovation processes.

These features of wicked systems also play out in a particular way in human society. This relates to what e.g. Lane (2011a); Lane et al. (2009b); Lane (2016); Lane et al. (2011) call the "Innovation Society": a society where innovation is no longer just a means of solving problems, but where innovation is ideologically sublimated and has become entrenched at the very heart of how society functions – where innovation is important in itself quite regardless of what gets innovated. *The Innovation Society is a society organized around the dynamics of its own wicked nature.*

The development of such a society was crucially enabled by the capacity of social structures to affect their own constituents, which has allowed the innovation feedback cycle of wicked system to become reified into a goal in its own right, elevating it from emergent dynamics to a social goal. This has led to a situation where constant innovation has become *entrenched* in society (Wimsatt, 1986), and thereby necessary for its functioning and stability. This dependency suggests a rather paradoxical stability: we have become locked into a state of constant explosive change (*plus ça change, plus c'est la même chose*, indeed!) Through this process an inherent property of wicked systems has become a core value in society, expressed culturally as an ideology that permeates it (Lane et al., 2011)

That innovation has become a project for innovation itself is, as a natural phenomenon, an entirely new thing – unique to human culture. But it is not an essential feature of human culture, and it has not always been that way. The idea that we can improve society and our own quality of life by innovation is characteristic of the Enlightenment and signifies a drastic shift in ideology: from the view that we ought to preserve a God-given social order to the view that that we ought to use science (in a broad sense) to understand the world and master it so as to increase our wellbeing. There are of course several sub-ideologies that propose different ways of organizing innovation to achieve such improvements in well-being – most importantly based on either bottom-up self-organization or top-down management – neither of which has proven itself to be potent as solutions to the sustainability problems that we face today.

Lane et al. (2011) summarize the Innovation Society and its ideology as follows:

> Our society's dependence on innovation cascades is expressed in, and sustained by, an increasingly widespread way of thinking, which we will term the Innovation Society ideology. This ideology underlies almost all current discourse about business strategy and governmental policy. The following four propositions form its central core: (1) the principal aim of policy is sustained economic growth, interpreted as a steady increase in GDP; (2) the engine of this growth is innovation, interpreted as the creation of new kinds of artifacts; (3) Which new kinds of artifacts have value is decided by the market; (4) the price to pay for not innovating, or for subordinating innovation to other values, like cultural enrichment or social justice is prohibitively high: competition, at the level of firms and of national economies, dooms dawdlers to failure, which translates into economic decline and social chaos.

The capacity of societal systems to relate to their own emergent phenomena was also key to permitting the expansion of the human sociotechnical system: it allowed it to be subjected to itself – its process and conditions – permitted it to improve its own function, and through this, increase the speed and magnitude its cycle of innovation. The "Great Acceleration" (Moore, 2014; Steffen et al., 2015a; Waters et al., 2016) may be understood as the quantitative signature of this qualitative explosion in diversity. But the development can also be seen directly in a veritable explosion in types of artifacts: if 3 million years ago, our ancestors had essentially one kind of artifact, and 50 000 years ago, maybe a few hundred, today's inhabitant of New York City can choose among over 10^{10} different barcoded items (Lane, 2016).

The introduction of new artifacts necessarily involves changes in new patterns of interaction among people, not only through the use of the artifacts, but also through, for example, their production, marketing and maintenance. There is an inextricable linkage between the introduction of new artifacts into a society and transformations in the social relations and organization of that society. As people's living conditions and social relations transform around the presence of the artifact, they may become incompatible with the institutional and organizational structures of the old; structures that used to facilitate now become deadweight. This is a point of conflict, where new organization may replace the old, where agency can play an important role, as the developing structures have not yet become entrenched. A society's institutions emerge in interaction with the artifacts and the technology of that society, through highly unpredictable feedback processes: on the small scale, a new office computer system may result in new company work processes; on a large scale, the hand-mill co-evolved into a society with feudal lords, and the steam mill into a society with industrial capitalists. The institutions that form around technologies need to be in a sense compatible with the technology with which they interact: when institutions become misaligned with the artifacts underlying them, instabilities occur, creating the opportunity for social and technological change. As the rapid progress of artifact innovation continues, such societal instabilities are continually sparked on all levels of society. Societal structures effective in harnessing the possibilities of available artifacts gradually turn into shackles as the artifacts continue to evolve. The breakdown of structure leads to an "era of ferment", where a set of alternatives are competing openly for the development of new structures co-evolving with the development of new technology (Geels, 2006; Grübler, 2003).

Such feedback process of co-evolution results in unpredictable social and technological transformation, making it highly difficult to achieve intended social effects through technological development. But such technological change is in any case the exception: artifacts are generally not evaluated on the basis of the transformative effects they will have on societal structure, but only evaluated locally. It is this type of atomistic evaluation processes that decides the value of new artifacts: it is the what we refer to when we say "the market". Atomistic rationality has taken over a larger and larger part of what used to be part of the realm of political decisions, while politics is increasingly left to priming the pump of innovation. Progress is seen as inevitable, whatever it may entail (see also Ellul, 1967).

The stability of this system is based on competition on all levels, which, through the interlinkage of markets associated to neoliberalism, has now become global (e.g. Harvey, 2007). This competition out-crowds everything but more innovation. Any attempts to subordinate innovation to other values, like cultural enrichment or social justice, are made impossible by competition at the level of individuals, firms and national economies. Competition dooms any potential Samaritans to failure, which at the national level – which ostensibly has some level of political play – would translate into economic decline and social chaos.

This in practice undermines any attempt at going against the stream, except on the global level – where necessary structures to scaffold agency are largely lacking[1] (Dunford, 2000).

2.5 Innovation meets Uncertainty

The production and use of innovation will naturally result in some environmental and social externalities: changes that cannot be predicted (Sveiby et al., 2009). As society becomes more entangled and wicked, it is becoming increasingly difficult to respond to these externalities, as the dynamical consequences of action in such a web is shrouded in ontological uncertainty (Lane and Maxfield, 2005). This uncertainty not only prevents us from designing effective interventions, without high likelihoods of causing unexpected troubles in other domains, but it also keeps us from aligning and organizing action in the first place (e.g. Gardner et al., 1990; Gintis, 2000). This is indeed illustrated by the enormous difficulties in organizing an adequate response to climate change. That it, indeed, is even harder can be seen by comparison with similar global challenges just a few decades ago (Gareau, 2013; Laube et al., 2014).

If these externalities of innovations are left without response, they accumulate until they pass certain thresholds and develop in to full-scale crises (e.g. Rockström et al., 2009). In the case of biological innovation, such crises seem to become increasingly rare as the structural complexity of the system increases. With more species, ecosystems become more stable, and the size of the available design space increases, both resulting in increased capacity to respond to externalities (Allesina and Tang, 2012; Stankiewicz, 2000). In society, however, innovation seems to have the opposite effect. As we have seen, more innovation makes our society more and more wicked and uncertain, and hence makes its problems harder and harder to anticipate and respond to. Hence, society will produce more crises, they will be harder to solve, and the system will develop toward increasing instability (see also Ponting, 2007; Tainter, 1990).

Uncertainty forces us to be shortsighted by preventing us from building sufficient certainty for large-scale alignment and action. A shorter and shorter foresight horizon, combined with a virtually un-bounded horizon for consequences of actions, makes wicked systems susceptible to self-undermining: what we typically refer to as unsustainability. Societal evolution is thereby prone to spontaneously and collectively embark on pathways leading to new dynamical regimes

[1] There have certainly been an increase of multi-national political organizations, in part in an attempt to meet this development, but the balance of power has clearly shifted.

that may be arbitrarily disadvantageous (e.g. the Anthropocene; Steffen et al. 2015a). Control demands a global overview, but growth and change is local and demands no such overview, so wicked systems may outgrow any capacity for governing them.

As organized efforts to respond strategically become more difficult, as the anticipation of the effects of actions becomes clouded in ontological uncertainty, they are met instead by responses whose consequences are never even taken into account: innovation responds only to the myopic opportunities that crises provide. In other words, like the alcoholic curing a hangover, society tries to solve its problems by applying more of what caused them. This is a condition that Beck (1992) calls "reflexive moderniy", in which modernity "becomes its own theme", as the focus of innovation increasingly becomes to alleviate the negative effects of previous innovation. But every such 'solution' is not only unlikely to solve the highly entangled problem (in part as it would imply undermining their own *raison d'être*) but also has the potential to produce new problems.

As Lane (2016) observes, the result is a cycle of *problem-solution-problem* with potentially disastrous effects. Lane exemplifies this with the obesity epidemic, initiated by a large surplus in cheap available calories, brought about by innovation cascades in agriculture. This resulted in innovations in food processing to provide higher returns to producers and distributers from the cheap calorie surplus. This, in turn, resulted in changing patterns of consumption, followed by a rapid increase in obesity rates. The market responded to this problem with waves of innovation in the diet and pharmaceutical industries, with huge market successes, but no discernible effect in decreasing the obesity epidemic. The social results of these dynamics have been catastrophic: the obesity epidemic is today seen by many in the public health community as the principal public health challenge of the twenty-first century.

Through the lens of the innovation ideology, the wicked problems we are facing tend to start to look like engineering problems, i.e. solvable through more innovation. As Kingsnorth (2011, p.x) points out, even the green movement have fallen into this perspective, seeing unsustainability "as an engineering challenge which must be overcome with technological solutions guided by the neutral gaze of Science, [which] has forced it into a ghetto from which it may never escape". Through this lens, the reinvigoration of naturalism, following from society's increasing impact on environmental systems, seems less a result of an increased understanding of the complexity of societal systems, and more a sign of a pervasive innovation ideology.

Chapter 3

From Naturalism to Realism

As we have seen, while it is increasingly uncontroversial to claim that society is complex, complexity seems to represent a rather large number of system properties. In approaching society, the assumption of mainstream complexity science has been that societal complexity is essentially similar to the complexity of the kind of systems with which it has shown great success, such as bird flocks or fish schools (Mitchell, 2009). The undeniable structural complexity of society has been seen as merely a complicating factor: the only thing missing in the attempts to understand society is more time, effort and funding. This has not only been the foundation for the way that society has been approached methodologically, but also scientifically, as it has been seen as a green light for the same type of positivist application of formal methods that have proven successful in their application to complex and complicated system.

The above systemic examination of ontological categories implies that this assumption has been erroneous. Most importantly, it seems that the complexity of most natural systems is in fact rather different from that of society: the former is "complex" and the latter is "wicked". This separation can indeed be seen in how the "mainstream" understanding of complexity, associated e.g. to the Santa Fe Institute, differs from the understanding of many social scientists of what has been understood to be the same system category. This division is reflected in e.g. Morin's (2008) separation between "restricted complexity" and "general complexity", as well as in Byrne's (2005) "simple" and "complex" complexity. In the terminology of this essay, the former describes complexity, and the latter wickedness.

Wicked systems are certainly complex, in the sense that they display dynamical complexity, but they are not *only* complex. They are heterogeneous, interconnected, nonlinear, far-from-equilibria, emergent and adaptive, as suggested by Complexity Science, but also open and contingent, with any patterns only local in time and space, and subject to ubiquitous qualitative change. This is furthermore related to the way that emergence plays out, with restricted complexity approaches focusing on the emergence of the whole from the parts, thereby neglecting, or even rejecting, the role of top-down causation, while generalized complexity approaches instead emphasize feedback between structure and emergence (Elder-Vass, 2010).

This calls for a science of wickedness that, in the words of Reed and Harvey (1992, p.359), "treats nature and society as if they were ontologically open and historically constituted; hierarchically structured, yet interactively complex; non-reductive and indeterminate, yet amenable to rational explanation". Since wicked systems are not closed, we cannot approach them only through formal models, and hence, as Cilliers (2002, p.X) puts it, the study of what we call wickedness "is not going to introduce us to a brave new world in which we will be able to control our destiny; it confronts us with the limits of human understanding." Our understanding of complex systems has implied a way to untangle their intricate webs of causation, but a deeper understanding of wicked systems instead seems to imply learning about the boundaries of knowledge and just how "how little we can know about the world" (Koppl, 2010).

This does not have postmodernist implications for *whether* we should do science, but it does carry significant implications for *how* we should do science. While different framings of the same system are possible, reality does have a say in how they are made. Wickedness suggests a perspective which accepts neither positivism nor relativism: it recognizes that our scientific descriptions of reality are social constructs, but also that "they are constructs made by reality and therefore shaped by reality" (Byrne and Callaghan, 2013, p.33). In other words, this complexity speaks to *realist* (rather than postmodernist) social theories (Walby, 2007).

This connection to realist theory can also be seen in the way emergence needs to be understood in wicked systems. This term has generally, implicitly or explicitly, been understood as epistemological concept: "'emergent' was construed as 'unexplained' by means of contemporary theories" (Bunge, 2003, p.13). This view was first represented by British emergentists in the late-19th early 20th centuries, but can now be identified in a range of work on complexity, including that of Ernst Mayr[1], Tony Lawson[2], Keith Sawyer[3], Peter Hedström[4], and Niklas Luhmann (see Wan, 2011, p.67). A central part of wicked systems, however, is what Kaidesoja (2009) calls an "ontological concept of emergence", which is real and unaffected by our knowledge of its processes: "Emergence is often intriguing but not mysterious: explained emergence is still emergence" (Bunge, 2003, p.21). Emergence is an aspect of dynamical complexity, implying relationally distributed mechanisms, not a function of our knowledge. The wicked systems perspective hence follows the ontological understanding of emergence of e.g. Archer, Bhaskar, Gell-Mann, Searle and Elder-Vass: "Emergence is the idea that a whole can have properties (or powers) that are not possessed by its parts-or, to put it more rigorously, properties that would not be possessed by its parts if they were not organised as a group into the form of this particular kind of whole" (Elder-Vass, 2007a, p.28).

The view, and the wicked systems perspective in general, has much in common with Mario Bunge's "emergentist-systemist" philosophy (e.g. Bunge, 1979a, 2000a,b), and with the related (see Danermark et al., 1997, p.4) critical realism of e.g. Archer et al. (2013), and Bhaskar (2013), in particular Reed and Harvey's (1996; 1992) "complex realism", further developed by e.g. Harvey (2009), Byrne (2002, 2004, 2005, 1998), Byrne and Ragin (2009), and Byrne and Callaghan (2013). This section will serve to see how these ideas connect and relate to wickedness, to see how Complexity Science can learn from social theory regarding how to approach wicked systems in general, and society in particular. We begin by looking at the mainstream complex systems ontology and its development.

3.1 Society in Mainstream Complexity Science

Complexity Science developed through and around new computational methods, and at the heart of this methodology lies computer simulation, which crucially

[1] E.g. "the characteristics of the whole cannot (not even in theory) be deduced from the most complete knowledge of the components" (Mayr, 1982, p.63)

[2] E.g. something is "*emergent* if there is a sense in which it has arisen out of some 'lower' level, being conditioned by and dependent upon, but not but not predictable from, the properties found at the lower level." (Lawson, 2006a, p.176)

[3] E.g. "at the global system level are patterns, structures, or properties that are difficult to explain in terms of system's components and their interactions" (Sawyer, 2005, p.4)

[4] E.g. "social emergence refers to social properties that cannot, in practice, be predicted by knowing everything there is to know about the pre-emergent properties of the parts" (Hedström, 2005, p.74)

brings the capability to describe the entities and interaction rules of dynamical systems so as to put it all "into motion" (Fontana, 2006). The typical model in this tradition has a microlevel of interacting nodes existing in a pre-defined environment. Having set up the rules and the environment, the system is allowed to play out, and the results and patterns that emerge from the often long causal chains of interaction are studied. This is a highly flexible methodology that made it possible to study and visualize dynamics that are inaccessible both to analytical mathematics and to unaided human cognition. This can be viewed as an extension of the study of the micro aggregation from additive cases, as in classical linear and mathematical methods, to situations where "the whole is more than the sum of its parts".

As so far described, complexity science could be seen just as a methodological toolkit allowing the study of a broader range of phenomena than previous tools – which would be all well and good. But the "social life" of these methods (Law et al., 2011) has increasingly led to the development of a corresponding social ontology: the labeling of society as a "complex system" clearly goes beyond a methodological claim, and into the realm of ontology (Fontana, 2010). As Perona (2007) argues, Complexity Science is guilty of a "fallacy of misplaced concreteness": in Lawson's (2005) terminology, the "ontic" (description of reality) is not separated from the "theoretic" (descriptions of the models), meaning that reality becomes seen as artificial and closed.

This is playing out much in the same way as the development of neoclassical economics, which is widely understood to have grown its ontological perspectives on the economy on the basis of its methods, as Debreu (1986, p. 1265) puts it: "as a formal model of an economy acquires a mathematical life of its own, it becomes the object of an inexorable process in which rigor, generality, and simplicity are relentlessly pursued". Through this process, an equilibrium-based ontology developed within economics, as the assumptions required for the application of the mathematical methods increasingly turned into theory about the nature of the world, and factors that could not readily be brought into the mathematical machinery were simply disregarded. Models were no longer separate from theory, as methodology transformed into epistemology, in turn – over time – transforming into ontology (Fontana, 2010) – or, put more simply: economists found a hammer, and everything started to look like nails.

In Complexity Science, that hammer is primarily simulation. This has led to an understanding of society that emphasizes micro-level interaction, which can be seen in definitions of complexity. Johnson (2009, p.1) defines complexity as "the study of the phenomena which emerge from a collection of interacting objects". Similarly, Mitchell (2009, p.13) describes a complex system as "a system in which large networks of components with no central control and simple rules of operation give rise to complex collective behavior, sophisticated information processing, and adaptation via learning and evolution". Holland (2006, p.1) agrees, but is almost even more restrictive by stating that complex systems "are systems that have a large numbers of components, often called agents, that interact and adapt or learn." This is very much in line with Joshua Epstein's understanding of society as a complex system growing from the bottom up (Epstein, 1996).

All of these fit in well as descriptions of the ontology of most simulation models, but as descriptions of society they seem overly focused on the individual agent level. As Lane (1993, p.194) puts it, these models "offer only very limited scope to the emergence of new structures–and, so far, none at all to the emergence of higher-level entities." Social structures are seen as merely patterns emerging from the behavior of underlying agents, or as Jarvie puts it (cited in Bhaskar 2010, p.55), in these perspectives "army is just the plural of soldier". Despite Complexity Science being associated to a criticism of reductionism, it seems to fit neatly into the realm of ontological individualism. As Epstein (2006, p.37) readily admits, "classical emergentism holds that the parts (the microspecification) cannot explain the whole (the macrostructure), while to the agent-based modeler, it is precisely the generative sufficiency of the parts (the microspecification) that constitutes the whole's explanation! In this particular sense, agent-based modeling is reductionist."

While such assumptions may be appropriate in complex systems, where only first order emergence applies (Gilbert, 2002), the "reflexive" (Goldspink and Kay, 2007) second order emergence of wicked systems is completely at odds with such an understanding, as it emphasizes the reality and causal capacities of emergent structures. These are essentially what enables the structural complexity of such systems. Hence, while the methods of mainstream complexity may provide helpful aid in the first half of our science of wickedness, i.e. casting light on the heterogeneous, interconnected, nonlinear, far-from-equilibria, emergent, and adaptive nature of society, its methodology is based on an ontological perspective that does not allows us to approach other aspects of wickedness – i.e. that it is also open and contingent, with patterns only local in time and space, and ubiquitous qualitative change – let alone the value-laden and meaningful nature of society in particular. Let us therefore look at alternative ways of looking at the complexity of society, which takes into account both structure and emergence, by leaning on ideas developed in critical realism and in Mario Bunge's emergentist-systemism.

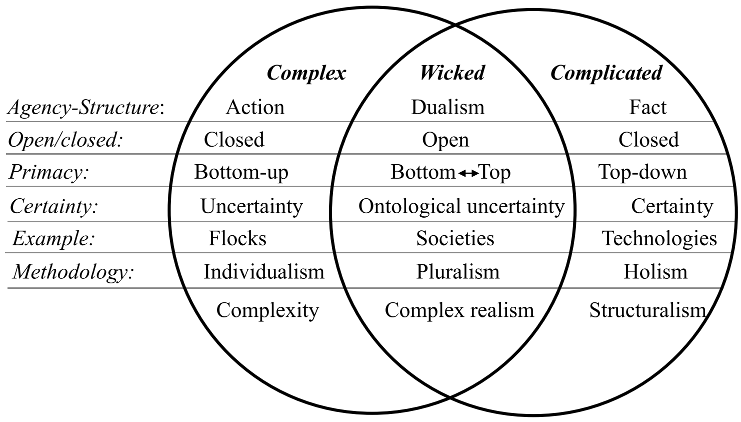

Figure 3.1: *Wicked systems shows how the meeting between structure and agency, emergence and hierarchy, complexity and complicatedness, and so on, results in a qualitatively different ontological system category.*

3.2 Fact and Action in Wicked Society

As we have seen, the wickedness perspective argues for the causal capacities and reality not only of the components, but of the structures that emerge from their interaction. As we have also seen, this meeting between structure and dynamics mirrors a metatheoretical meeting between the "fact" and "action" paradigms in sociology (Gilje and Grimen, 1992), and indeed between structure and agency – one of the most central questions of sociology.

In this tension between what basically amounts to whether to treat society as a complicated or complex system – both of which are subsets of reductionism – the wicked system perspective clearly points toward a third option, where we instead attempt to take both agency and structure into account, and where reality is seen as a dialectic between them (e.g. Wight, 2006). Such a theoretical perspective has been developed by theorists such as Archer, Layder, Pawson and Sayer – an "analytical dualism" (e.g. Archer, 1982, 1996; Bhaskar, 2008; Layder, 1985) that starts from the ontological claim, following from the "ontological concept of emergence", that structures and agents each possess distinct properties and powers in their own right, referred to as *sui generis*, and that they are very different type of entities, rather than as two parts of the same process (as in Anthony Gidden's (1984) "structuration theory"). This has multiple implications, such as that the goal of social analysis is to keep structure and agency apart, to study the link and interaction between them, not to reduce one to the other (Danermark et al., 1997).

While social structures are not "powerful particulars" like individuals, in the sense that they can produce "observable effect in certain conditions and in a relatively autonomous way" (Kaidesoja, 2007, p.81), they *are* endowed with *sui generis* properties and powers. As we have seen, they are characterized by anteriority: they precede agency, not in the sense that they could exist without human action, but in the sense that humans only reproduce or transform social structures, they do not create them. Property relations, linguistic systems and legal systems are existing features of the world into which we are born, they are not things that we create at birth. Their anteriority points to another important property: they are relatively enduring. They are granted this longevity through the material expressions that are always part of social practices, in a mutual dependence between material practices and the formation of meaning (Danermark et al., 1997; Törnberg, 2016a). Social structures also have powers: they are capable of "motivating or discouraging, constraining and enabling certain sorts of human action" (Carter and New, 2005, p.10), for example: unequal wealth distributions will tend to constrain the poor and enable the rich. Hodgson's (2009) concept of "reconstitutive downward causation" is also useful here, capturing the elusive notion that "the whole, to some extent, reconstitutes the parts" (Hodgson, 2009, p.168).

Individuals are similarly equipped with *sui generis* properties and powers: they are self-conscious, reflexive, emotional, intentional, cognitive, and so on. Their reflexivity and symbolic abilities endow them with the powers to formulate plans, organize project, pursue interests, etc.: it is people who make history; they inhabit the social world, and are able to reflect upon, seek to change, or even overthrow the social structures, according to their own interests and views.

The understanding of emergence of structure from agents emphasizes that there is no singular "humanity", but only plural and heterogeneous mortals, giving their politics its organic, interconnected and contingent nature (Arendt, 1958). Hence, social structures are not planned, but often unexpected: people do not marry to reproduce the nuclear family, nor do they work to reproduce the capitalist economy, but these are nevertheless the unintended consequences of their activity (Bhaskar, 2010). Social structures are both the cause for and caused by action: we tend to behave according to the wage-labor relations, which in turn reproduces the structure of wage labor, in turn generating new action, and so on. This interplay between social structure and agency occurs over time, meaning that their emergence takes the form of a continual process. "Causality, in virtue of its transitivity, gives aid and comfort neither to the holist nor to the individualist. The causal chain just keeps rolling along." (Sober, 1980, p.95).

Individuals, and the emergent structures following from their relations, contingently combine to produce second and third-order emergent structures. This means that the world is not only differentiated, but stratified: it has different levels characterized by different properties. This is similar to the idea of emergent multi-level systems in complexity science (e.g. Beurier et al., 2002): but with the difference that it is not excluded to micro to macro emergence, where macro-patterns emerge from a set of interacting micro-objects. Instead, the capacity of humans to relate and act upon emergent structures results in that emergence tends to go in more than one direction: interaction is not limited to a single stratum; emergence can occur from interaction between social structures and the actors that underlie them. This idea of emergence as going in all directions rather than only "upward", is a central difference between natural and social systems. One way to describe this is as going from a Darwinian "population thinking" to an "organization thinking", in which no relevant population can be discerned, and variation/selection are inadequate to describe change, which is rather based on a modality of "organizational self-transformation" (Lane et al., 2009a). While the natural world is often seen as hierarchical, the social world is better described as consisting of sets of nested structures, and its effect on actors as "a plurality of interpenetrating constraints deriving from many recognisable 'levels' looping back and around each other" (Dyke, 1988, p.64). In fact, as we have seen, this hierarchical perspective likely does not even apply to many of the systems in the natural world, but is rather a feature of the models that have been applied in this context (see e.g. Hendrichs, 1983; Khalil, 1995).

This takes us away from an understanding of "explanation" that is in line with crude naturalism's tendency of reducing phenomena to underlying levels, exemplified by analytic sociology's idea of "carefully dissecting" social processes into their underlying component parts and their actions (Hedström, 2005, p.73). Instead of, as suggested by analytical sociologists and complexity theorists alike, asserting the individual level as a *conditio sine qua non* for social scientific explanations, we should aim for a "multiscaled social reality" (DeLanda, 2006, p.34-40) – because regardless of how "complex" the individualism of these approaches, it is still individualism (Wan, 2011). The multiscaled perspective suggests a social explanation that makes structure part of the process, having a methodology and ontology that allows for nested but interpenetrating systems with causal powers running in all directions.

This emphasizes tracing the interaction within and between *strata*, as emergence is not seen as a macro appearing from the dynamics of the micro, but as a continual process between levels. Emergence can be explained – at least in principle – in terms of elements and interactions, as suggested by Bunge's (1979b) "rational emergentism". This implies a rejection both of individualism and holism in favor of an approach that, while explaining phenomena in terms of generative mechanisms in deeper strata of existence, does not see the higher properties and powers as "explained away" by such an explanation (Danermark et al., 1997; Elder-Vass, 2010), since "explained novelty is no less novel than unexplained novelty" (Mahner and Bunge, 1997, p.29). We can, at least in certain cases, trace relational emergence of phenomena to underlying constituents and their relations, which "allows higher level properties to be explained scientifically," (Elder-Vass, 2007b, p.415) but due to *equifinality* and *multifinality*, we cannot directly link a macro to a micro, meaning that such explanation "does not allow them to be replaced with properties of the parts in causal explanations because it is only when the parts are organized into this particular type of higher level system that the causal power exists" (Elder-Vass, 2007b, p.415).

While reductionism is deeply problematic as a research strategy, amounting to "the methodological principle according to which (micro)reduction is in all cases necessary and sufficient to account for wholes and their properties" (Bunge, 2012, p.178), *reduction* is often desirable and fruitful, such as when part of a productive research strategy in wicked systems, "reduction does not imply leveling: it relates levels instead of denying that they exist" (Bunge, 1977a, p.79). Reduction is important, as emergence should be explained rather than dodged, while ontological novelty at every level should at the same time be acknowledged. Both the phenomenon and its underlying mechanisms remain as real and with their separate powers and properties: social explanation always involves a meeting between structure and agency, and is played out as a co-acting between people and the cultural and social structures they encounter, use and embody; "structures which position them, motivate them, circumscribe their options and their capacity to respond" (Carter and New, 2005).

3.3 Explanation in Wicked Systems

This also has implications for the type of explanation employed. Abbott (2001b, p.164) separates between two such approaches in sociology: the *variable-based approach*, which focuses on stochastic realizations and uses correlations between variables to try to find causal links, and the *narrative-based* approach, which instead focuses on identifying mechanisms and categories by looking at patterns in data (Abbott, 2001b; Abell, 2004; Calhoun, 1998; Griffin, 1993).

The *variable-based explanation*, related with a *regularity* or *succession* theory of causality associated with empiricism, implies treating wicked systems as complicated, through the formulation of thought-up entities – "variables" – that are purported to interact through causes and effects. Causality is here understood as the relationship between these entities, which also requires that they are fixed over time, and that they exhibit fixed set of attributes. This is hardly the general case in wicked systems, although, of course, such assumptions may be more legit and useful in some cases than in other. Variable-based analysis usually also assumes that causes are independent, in the sense that there is no interaction between causal factors. This is also hardly the case in wicked systems (Marini and Singer, 1988). However, there is also a more fundamental problem to the approach: variables do not exist in the real world (Byrne, 2002). Bunge (1985, p.138) puts this succinctly: "in science we handle changing things, not changeless ones, let alone thingless changes". Variable-based approaches have a tendency of losing sight of these rather important facts, and that it is "individuals whose lives provide the data for the models. Although variables rather than individual people may become the subjects of the statistician's narrative, it is individuals rather than variables who have the capacity to act and reflect on society" (Elliott, 1999, p.101-102). This implies a Hempelian banner of causality, in which "causes" tends to essentially mean "causal variables" (Abbott, 2001b; Skocpol, 1984), hence describing causality between entities existing in the model, not in reality. Even a model that successfully accounts, in a statistical sense, for the variation in some phenomenon, can still tell "us rather little about just what is going on at the level of social processes and action that underlie [...] the interplay of the variables that have been distinguished" (Goldthorpe, 1997, p.9). Hence, this seems to be yet another example of the social life of methods, as the variable-based approach implies an understanding of the system as artificial and complicated.

Narrative-based explanation essentially relies on treating wicked systems as subwicked, on being compatible with how actors of these systems understand their environment, and on fundamental human cognitive capacities in relation to such systems. Such an approach has the benefit of matching the ontology of the system[5], suggesting the possibility of "narratives as a fundamental foundation of

[5]It should be noted that our language itself brings with it pieces of implicit ontology, that are brought into our narratives, mathematical models, and everything in between. Such a conception of the role of language is of course part and parcel of e.g. discourse analysis, but has has also been the subject of some interesting formal study, in particular in the context of probability theory. An example of this is Goodman's *new riddle of induction*, which shows how Bayesian induction is based on the assumption of our language's concepts matching natural kinds (Godfrey-Smith, 2009). This illustrates how ontological assumptions are part of language, how formal models are

complexity research" (Byrne and Callaghan, 2013, p.202). This match can be seen in the affordances in narratives when it comes to complex causality, time, and multi-level explanation. As Abbott (2001a, p.101) puts it: "reality occurs not as time-bounded snapshots within which "causes" affect one another ... but as stories, cascades of events. And events, in this sense, are not single properties, or simple things, but complex conjunctures in which complex actors encounter complex structures." Temporal sequence is crucial in these stories, and a different order of events may produce different outcome (Griffin, 1993), as well as for allowing for both multiple temporal levels and the real complexities of causality (Ricoeur, 1980).

In narrative theory, the focus is on events rather than variables, and the entities involved are not ontologically fixed as the story plays out – entities participate in events and change over time. This takes us from a "push-type causality" to one which requires tracing of events, and one which allows patterns on different time-scales and structural level to interact and play out a common story (Poole et al., 2000). An event and process focused approach does however not imply advocating a process ontology, in the sense of seeing entities not as "the fundamental categories of being" but as "derivative of or based in process" (Sawyer, 2005, p.134); as Sawyer continues, "an empirical focus on practice does not require a process ontology. One could accept the traditional 'entity' view that individuals and groups both exist and nonetheless argue that it is methodologically necessary to study situated practices" (Sawyer, 2005, p.134).

Narrative-based explanation focuses on identifying mechanisms through pattern, which signifies a move from aggregation and variance, to categorization and pattern-finding, and using comparison between cases to find relevant mechanisms (Byrne, 2005; Byrne and Ragin, 2009). The two research strategies proposed by critical realists are highly relevant here, as they allow connecting events and phenomena to mechanism-based explanations: *retroduction* and *retrodiction*. Retroduction is to identify the causal powers that act upon events, the entities that possess these properties and powers, and the underlying mechanisms (Sayer, 2010), while retrodiction aims to explain how these can combine to produce the events in question (Danermark et al., 1997). This view and approach to explanation speaks especially to a current development within Complexity Science, with a move from simulation models based on *ad hoc* assumptions, towards research on digital trace data, for example in the emerging discipline of computational social science (see e.g. Conte et al., 2012; Jungherr, 2015). This development has

often built on less rigid foundations than one may conclude, and constitutes a more formal way to shed light on the depth of the problem of dealing with change of kind.

clear potential for supporting a more ontologically plausible approach to wicked systems.

3.4 Data Mining and Categorization in Wicked Systems

As we have seen, dynamical complexity implies that mechanisms can be distributed within a system, rather than located in any specific component, implying that "cause is a property of complex and contingent mechanisms in reality" (Byrne and Ragin 2009, p.515, see also Coverdill et al. 1994). The contextual nature of wicked systems implies that cause is not universal or permanent, but rather local and temporary. Such a perspective has traditionally been understood through qualitative rather than quantitative reasoning, in part since "quantitative" tends to mean "variable-based". In other words, a narrative and complex causation perspective has tended to imply that we rarely use formal tools when approaching data. This is problematic, as complexity is a real and important part of these systems and, as we have seen, high structural and dynamic complexity limits how far we can go without the aid of formal tools. In other words, neither the traditional quantitative or qualitative approaches are adequate in approaching wicked systems.

The increasing proliferation of digital trace data and sophisticated analytic methods, implying a convergence of qualitative and quantitative approaches, has important potential here. These seem to be capable of supporting a narrative-based reasoning while at the same time being capable of increasing the capacity to deal with high structural and dynamic complexity. This potential is however not without possible issues: many argue that the digital humanities and computational social science are fostering weak, surface analysis, rather than deep, penetrating insights, much due to the exclusive focus on computational models (e.g. Kitchin and Lauriault, 2014). The fields are argued to be reductionist and crude in their application and interpretation of the techniques – sacrificing context, clarity, and critique for the automatic identification of large-scale patterns, predicated in the notion that breadth could replace depth and context as basis for interpretation. This seems to in turn be based in the confusion of the mere identification of pattern with the explanation of human behavior; as Kitchin (2014) succinctly points out: "It is one thing to identify patterns; it is another to explain them". Even if, as Anderson (2008) argues, such methods are commercially valuable due to their predictive capacities, this does not necessarily make them useful for scientific inquiry: "It is possible to predict well without explaining anything about what is going on" (Hedström, 2005, p.107). As Kurki (2008, p.166) puts it, "what is important in tracking causal connection is not identification of law-like regularities or empirical observerables, but, rather, the description of the real properties, structures and generative mechanisms that underlie the actualization of events and their empirical observations".

This tendency of pattern-finding in digital trace data research may furthermore be linked to a tendency of thinking that interpretation can be altogether removed from the equation, and that content analysis should be analytic, quantitative, and what is understood as "objective" (Anderson, 2008; boyd and Crawford, 2012). This ambition is deeply flawed. Whether one admits it or not, the construction of the corpus, tool, and statistical results are all types of interpretation – it does not become less, but more, interpretative, with more steps between corpus and conclusion (Byrne, 2002; Kritzer, 1996). This only leads to the reification of what basically amounts to a form of glorified variables, whose subjective nature is merely hidden under a thin veneer. Through formal models, one may conceal subjectivity behind computational or mathematical forms of representation, hiding the normative decisions of framing by enciphering the assumptions and normative choices in technical code (Feenberg, 1991).

There are however directions of digital analysis that are built on more theoretically sound foundations. These methods tend to build on using comparison and categorization, which in turn build on similarity/difference rather than variance analysis, with the aim of finding patterns that give leads on the underlying mechanisms which shape phenomena in the observed processes (Skocpol, 1984). The idea of using comparison and categorization is a hopeful one, as it steps away from the complicated system idea of seeing causes as single factors whose presence inevitably generates an effect and whose absence means that the effect does not occur, toward a conception of causality more compatible with wicked systems . The typical example of such a research approach is Darwin's *Origin of Species*, where a large number of case studies were combined to find a powerful emergent generative mechanism (Byrne and Callaghan, 2013).

Two examples of such systematic comparison techniques are Qualitative Comparative Analysis and cluster analysis (Cooper et al., 2012). These, in particular QCA, come out of the realist tradition's focus on case study based research, in which case studies has been regarded as the primary research design (Easton, 1998), due to their potential to, in the case of single-case studies, reveal the generative mechanisms in specific contexts, and in the case of multi-case comparisons, identifying situations or contexts in which similar mechanisms operate (Ackroyd, 2009). This way of combining narrative explanation within cases, and systematic comparison across, suggests a middle path between quantitative and qualitative social research (Cooper et al., 2012), since, in contrast to variable-based methods or controlled experiment which deals in single causes, such methods are capable of including more than one cause. Causation is in these methods understood in terms of a combination of factors in interaction, and there is explicit recognition of "causal complexity" (Coverdill et al., 1994, p.57). Furthermore, these methods are capable of dealing with contingency and contextual dependency of social causality, as they are capable of investigating situations where equifinality and multifinality apply.

These techniques are also useful as a starting-point to think of other developing analytic techniques, that go outside the quantitative-qualitative divide in similar ways. For example, Paper IV shows how it is possible to approach certain text analytic techniques through a similar theoretical lens, by using Topic Modeling (Blei, 2012) in combination with close-reading to explore large quantities of textual data. Topic models cluster textual data, and is commonly used to give an overview over large data quantities. However, while informative, such analysis runs the risk of reifying resulting "topics", in the same way as variables are reified within variance analysis: we end up essentially telling a story of the rise and fall of something that does not actually exist, and to add insult to injury, the complexity of the algorithms turns it into even more of a black-box than most traditional variance studies.

We instead suggest an alternative approach, using topics not as reified entities, but as a basis of a type of explorative sampling, and a way to provide a map through which the material may be explored in various levels of detail. This exploration was performed using a custom-developed text analysis platform, designed for this type of computationally-assisted exploration, which treats computational methods not as a replacement, but as aids to human intuition and interpretation, and an extension of human cognitive capacities. In this integrated interpretation environment, automatic analysis provides a discursive landscape that the researcher can "zoom" into, and combine various types of analysis to find traces of the underlying meaning. The framework does permit the use of some variance-analysis as well, but in a way in which these are explicitly designed to function as variance traces, rather than as reifications.

The notion underlying this platform is essentially that methods will *always* have a social life (Law et al., 2011), meaning that they will always tend to drive ontology: human cognition has an inherent tendency to reify and create stories around whatever measures we devise[6]. Hence, it becomes necessary to design

[6]This is part of a wider argument regarding the relationship between the technological and the social, or base and superstructures, if you will, that was hinted at in chapter 2.

methods in such a way that they afford a methodology that is in line with a reasonable ontological understanding of the system under study.

The approach to data that is supported by this platform is not a matter of testing pre-established hypotheses, but rather of a *quantitative* (Martindale and West, 2002) or *computational hermeneutics* (Mohr et al., 2015): continuing re-engagement with the data that mixes levels of interpretation and analysis, predicated on the idea that "[e]xploration is the real and serious game" (Byrne, 2002).

3.5 Facing Emergence in Wicked Systems

Categorization and comparison can indeed be highly useful for finding macro-patterns in data and to use as basis for the identification of generative mechanisms. However, it will not necessarily take us all the way to identifying the underlying mechanisms at play. Dynamical complexity may often lead to phenomena resulting from unintuitive combinations of factors, which we can do no better than black-boxing under the label of "emergence". Just as we cannot approach digital trace data without algorithmic aid, we cannot unpack such black-boxes, or, in Wan's (2011) terminology, solve the "problem of transformation". We may ponder potential generative mechanisms, but without aid, we have no way of determining whether those in fact even have the potential of generating the identified causal patterns.

This is where simulation models come in. Simulation permits quantitative studies of mass-interaction and a de-mystification of emergence (an idea that has in a more mysterious and metaphysical form been around since Aristotle's Metaphysics: "the totality is not, as it were, a mere heap, but the whole is something besides the parts", cited in Cohen 2010):

> Simulations are partly responsible for the restoration of the legitimacy of the concept of emergence because they can stage interactions between virtual entities from which properties, tendencies, and capacities actually emerge. Since this emergence is reproducible in many computers it can be probed and studied by different scientists as if it were a laboratory phenomenon. (DeLanda, 2011, p.6)

By translating narrative descriptions into a simulation model, we can see whether they produce the hypothesized emergent result (McGlade, 2014). However, due to equifinality and multifinality, doing so will not tell us as much as one might think: if they do produce the emergent phenomenon, we cannot know for sure that they are indeed the generative mechanisms at play in the real system, and if they do not, we cannot even know that they are *not* the generating mechanisms. This does however not mean that such models are useless: what we do get is a link between a micro-level mechanism and a macro-level phenomenon in a complex system, which may or may not "shine through" in the actual system, as there is not a single mechanism at play but rather multitudes of interacting mechanisms. This is the reason why we should not think of open systems in terms of *laws*, and why it is instead more useful to talk about *tendencies*, "which may be possessed unexercised and exercised unrealized, just as they may of course be realized unperceived (or undetected) by anyone" (Bhaskar, 2010, p.13); a system may have a tendency for certain phenomena, but it might not be realized in the empirical system if it is inhibited by other mechanisms. In wicked systems, causes are not as single factors whose presence inevitably generates an effect and whose absence means that the effect does not occur, rather, cause is a property of a combination of a range of local, temporary and contingent mechanisms.

This means that one should approach empirical regularities with some caution, as they will be local in space and time. Phenomena are complex entangled effects from the influence of multiple interacting mechanisms, reinforcing or cancelling each other out, and so objects should be seen as having forces whether these forces are displayed or not. Conversely, the question of the most important mechanism for a specific phenomenon can only be decided on a case-to-case basis based on specific empirical investigations.

Due to this complex causation, many wicked problems are so unique and contingent that modeling makes no sense. In some cases, however, certain mechanisms do tend to "crowd out" others, and shine through into the macro-level system despite of the multitude of other interacting factors, possibly generating regularities: "Over restricted regions of time-space certain mechanisms may ... be reproduced continuously and come to be (occasionally) apparent in their effects at the level of actual phenomena, giving rise to rough and ready generalities or partial regularities, holding to such a degree that prima facie an explanation is called for" (Lawson, 1995, p.26). This is related to the concept of "control parameters" (e.g. Scheffer and Carpenter, 2003) in complexity science: at given points of time, certain mechanisms tend to dominate the system dynamics, and tuning certain parameters may disproportional affect the system. Using simulations, we can go some way in determining the relative importance of a given mechanism for the system dynamics: simulation conclusions are usually only tested for stability in the parameter space, but it is also possible – although only rather arduously – to explore their stability in the *algorithmic* space, i.e. in the space of interaction with other mechanisms. This can be informative with regard to whether an emergent effect will be likely dominate a system despite embedment in the richness of real open systems. For example, congestion emerges quite robustly in systems of interacting cars in traffic (e.g. Bando et al., 1995): we have found that entire classrooms of students independently developing models – according to whatever assumptions and methods of implementation they find reasonable – will almost in every case produce models exhibiting the same phenomenon, implying an algorithmically highly stable phenomenon.

This furthermore illustrates an alternative way of thinking of models than what is represented by e.g. Hedström (2005), who departs from an analytical sociology perspective. Hedström refers to models that do not engage with data as "fictions", arguing that they have no connection to reality from which their "isomorphism" and "validity" can be assessed – they are "no mode of calibration" (Hedström and Åberg, 2005). This idea of validation and isomorphism has exactly the platonic flavor to it which Hayles (1999) picks up on in her critique: it presupposes an idea that models are useful to the extent that they match an imagined ideal form of system – a form that is just perpetually out of our reach. The result of trying to reach for that platonic world is models that become increasingly complicated and specific, in the attempt to reach that ever-evasive "realism". Since they cannot intermix with the viewpoints, knowledge and experiences of the participants, this causes them to lose their real source of usefulness (e.g. Klosterman, 2012). They will not only fail the goal of being "realistic" representations of reality, but also their goal of functioning as useful metaphors and pedagogical tools helping us building a better intuition for complex dynamics. As Macy and Willer (2002, p.147) put it: "making these models more realistic inevitably adds complexity that undermines their usefulness as tools for theoretical research if we can no longer figure out how the model produces a given result." Good simulations can function as computationally-assisted thought-experiments, contributing ideas about how emergence can play out in closed systems, and we can use them as crutches for our flawed intuition for complex dynamics when describing and thinking about wicked systems.

At their best, models allow us to develop concepts about emergence like "threshold", "tipping-point", "feedback", or "cascade", that have been immensely useful in elucidating emergent dynamics in wicked systems. Such concepts do not in themselves constitute claims: "it is undisputed today that concepts can neither be true nor correct, but that they are only instruments, which prove to be more or less suitable when it comes to the correct ascertainment of truths and/or untruths"[7] (Luhmann 1992, p.390 cited in and translated by Wan 2011, p.36). In

[7] In the German original: "Unbestritten ist heute, dass Begriffe weder wahr noch richtig sein

Bunge's words, concepts cannot be "tested, because they neither assert nor deny anything. Hence there are no true or false concepts: concepts can only be exact or fuzzy, applicable or inapplicable, fruitful or barren" (Bunge, 1996, p.49). These concepts, if proved the former rather than the latter, can then be used in statements and theories the world, and it is the world that determines the truthfulness of these statements and theories (Christis, 2001). This view of simulation, as a way to develop powerful metaphors (Thrift, 1999), as well as concepts for complex dynamics that may then be used to formulate claims about wicked systems, represents a radically different view on the use and understanding of modeling compared both to analytical sociology and mainstream Complexity Science. The reductionist perspective often uses 'merely metaphorical' as a form of critique, but in a wicked world, metaphors are what we live by (Byrne and Callaghan, 2013, p.6)

The main limitations of the use of simulation models in wicked systems is hence not, as Hedström and Åberg (2005) might suggest, the necessity to make assumptions about underlying mechanisms, but rather that they are limited to first order emergence. This is not a problem for the results of simulation as such, since first-order emergence is important in a large range of systems. It does, however, constrain what can be studied with their aid. Remember that wickedness means that the rules of the game change on the same timescale as the game is played, and in interaction with the gameplay. Simulation models in comparison, operate by fixed rules, which have pre-assigned meaning[8]: "[e]very interaction is a product of rules because the agents are only autonomous in terms of the implementation of their rules" (Byrne, 2002, p.136). Taking real social action – the way individuals actively interact with social structures – into account requires an understanding of how humans understand emergence. This, as we have seen, implies theories of meaning, value, and narratives. Because of this, it is hard to imagine modeling that would support the general study of second-order emergence (Gilbert, 2002), as they would need to share the wickedness of the system under study.

There is, however, an underused potential in including institutions and social structures as real and active actors in the simulations. For example, I have supervised a student project looking at the conflict between opinion dynamics on the micro- (e.g. relative agreement) and macro-level (e.g. spatial voting). Con-

können, sondern dass sie nur Instrumente sind, die sich als mehr oder weniger geeignet erweisen, wenn es um die richtige Feststellung von Wahrheiten bzw. Unwahrheiten geht." (Luhmann, 1992, p.390)

[8]Genetic programming is an exception to this that proves the point: the results of such systems tend to be as flexible as they are hard interpret.

tradictory results are often found on these two levels (e.g. Deffuant et al., 2002; Downs, 1957), and the aim was to see which effect that would dominate a system in which both played out. Such simulations, which grants causal status to social entities, may allow us to better understand emergence "that runs in every direction" (Byrne and Callaghan, 2013), and not only micro-to-macro, even if they cannot fully take social action into account and do not bring us into the realm of second order emergence.

Again, the almost singular focus on micro-emergence does not need to be a deal-breaker if we are operating from the perspective of the complexity-toolkit-as-computational-hermeneutics. The purpose is not to completely explain or capture the system, but rather to contribute yet another heuristic tool to a toolkit, bringing a host of qualitative and quantitative techniques, to be brought into an integrative and iterative engagement for the understanding of social systems. Such an approach is exemplified by Paper V, which suggests that part of the observed importance of free social spaces for radical social mobilization is emergent and based in network structural effects, in the form of interaction between network clusters and political deviance. Rather than singularly focusing on the model in itself, as a reified entity, the paper attempts to integrate these ideas into a larger narrative grounded in the literature. This is not an easy task, considering the tension between "the gang [who] can count but don't know what they are counting" (Byrne, 2002, p.15) and the gang who "can't count, won't count, and assert that counting is a vile and perverse activity which ought not to be allowed" (Byrne, 2002, p.15) running high, but it is a necessary one if simulation is to become a constructive part of social scientific work.

3.6 Integrated Pluralism - Tying Together Traces

Simulation models are not unique in their assumptions of closure, as "all theorising in science [...] involve some partial or temporary closure" (Hodgson, 2006, p.3). As we have seen, openness means that there are no universal methods that can be used to study all aspects of reality. The bad news is that this, in practice, lays waste to any project aiming at "realistic" rather than "unrealistic" models and assumptions: all theories are abstractions, partial, and unrealistic (Mäki, 1992).

The good news is that this does not mean that modeling is meaningless, but rather that it speaks to the increasingly influential philosophy of pragmatism (Baert, 2005); "All models are wrong, but some are useful" (Box et al., 1987), or put inversely: "Everything is lawful, but not everything is beneficial" (1 Corinthians 10:23). This proposes seeing models as tools, rather than descriptions of reality: “a theory is not really to be believed to give us a truthful picture of what the world is like, it is rather to be used as a useful tool for whatever purposes there may be” (Mäki, 2001, p.10). But it does not necessarily lead to a complete instrumentalism, as there is, at least to some extent, a “difference between descriptively false and descriptively incomplete statements” (Hedström, 2005, p.20), and the usefulness of a model is “a product of the fact that [it] contains a good deal of truth” (Wimsatt, 2007, p.392).

While wicked systems cannot be reduced to any single model, different models are capable of casting light at different aspects of them – giving us what (Byrne, 1998) calls “traces of reality”. This can be illustrated with economic theory, in which, undeniably, neoclassical, complexity and heterodox economics all have contributed many useful models and studies. This is despite their fundamentally contradictory – and, I would argue in the case of neoclassical economics, blatantly erroneous – understanding of the ontological nature of economic reality (for a complex realist perspective on economic theory, see see Törnberg 2016b). As this example shows, even mathematics need not be employed as a map of reality or for prediction, but can also be approached as explanatory heuristics (Hodgson, 2013; Sugden, 2000). The key point is to not confuse the “ontic” and the “theoretic” (Lawson, 2005) in either direction, i.e. not to reject methods due to issues with their ontology, nor to reject the reality due to issues with one’s method.

This integrative approach of letting an “ontology that proclaims both the diversity and the unity of the world” (Bunge, 1973, p.162) guide the methodology, which Danermark et al. (1997) call “critical method pluralism”, Bunge (1973, p.162) calls “integrated pluralism” and Mitchell (2002) calls “integrative pluralism”, has been systematized in various ways (e.g. *method triangulation*, *combined operations* and *mixed strategies*; e.g. Thurmond 2001) and is gaining significant traction in sociology (Danermark et al., 1997). This view suggests that social science should be question-driven, allowing the nature of their inquiry to guide their methods, rather than the other way around, while avoiding “the confusion between a factual item such as a mechanism, and any of its models” (Bunge, 2004a, p.375). This in turn requires the formulation of an ontology of the system under study; a fixed-point from which to pose the questions, or, as Lawson (2006b, p.47) puts it, “to focus competently on specific aspects requires an understanding of the totality”.

Binding together the various traces of reality, acquired through a multitude of methods, into a coherent whole requires narratives: the narrative has strong aligning and integrating functions and can form the “glue” in iterative cycles of sub-wicked approaches. The ontological flexibility of the narrative allows it to bind together and interpret results from multiple sources for traces of reality, while sketching out their limitations in scope, hence functioning as descriptions of the trajectories of wicked systems. There will clearly come multiple stories from such scientific work – all potentially compatible with the available data – and it should be noted that the integrative approach aims at bringing together not only different models, but also stories: there is usually more value viewing them as perspectives that cast light from different direction on the same issue, rather than as competing truths; we should hence "try to integrate all the fields of knowledge that study the same objects" (Wan, 2011, p.53).

Such an integrative approach also implies a clear step away from the notion of science as ideally objective and external, admitting instead for the relational condition of social science: that the scientist is an inseparable part of the subject of study, hence inevitably affecting reality through its study (Bhaskar, 1979). This can be illustrated by the development of the postmodernist theory itself, as the postmodernist crisis in knowledge was not caused by theory alone, but is a response to real changes in society. Again, reality has a voice in the formation of theory; it is the complexity of postmodern society that has generated the crisis of knowledge – but these changes in theory have also had important implications for that same reality: again, the two interact and co-evolve.

Since reality cannot be captured in its entirety, but only from a frame of reference, and we will impact the system by deciding on a perspective, theorizing becomes a type of practice. Furthermore, reality speaks to us through how our theories affect it: if theory is practice and prediction is impossible, the only way to evaluate our work is the change that our practice makes. Hence, while in closed systems, objective study may be possible, and the point can be to predict, for societal systems, *the point is to change it*. This is not to say that theorists should become activist – it is to claim that they already are.

The real question is whether we should be activists for the hegemony and the *status quo*, or for societal change. Formal models are no less activist because they conceal normative decisions of framing by enciphering them in technical code (Feenberg, 1991). But, as Byrne and Callaghan (2013) note, there is a clear tendency for such ostensible neutrality of scientific work to serve what Gramsci called the hegemony. The reason for this tendency is the social life of the necessary assumption of fixed ontologies that makes the world seem like it is playing out from a set of fixed rules, with the resulting emergent effects seeming natural and inevitable. Mainstream Complexity Science has often been guilty of this, as exemplified by the description of Pareto wealth distributions as a "natural" result of interaction dynamics, implying a certain inevitability by neglecting the possibility for qualitative change of underlying rules (perhaps to a system in which poverty is not "natural"). Again, such limitations are fine when they are merely methodological – it is with their transformation into a tacit and unexamined ontology/ideology that they become problematic.

An alternative to being affected by the social life of one's methods in this way, is to take a more explicit and active engagement with the system under study. Indeed, Cilliers (1998) focused strongly on the ethical implications of Complexity Science, and based on this he argued that it was even unethical to attempt to engage with societal systems from the outside. He is not alone in these considerations. Gerrits (2012) argues in the context of policy interventions that it is necessary for "the complexity researcher to be engaged with her subjects, both for deeper scientic understanding and better policy information" (Gerrits, 2012, p.181); we need to engage with the actors who are part of the situation, and to take account of their respective narratives, if we are to fully understand their meaning. As Byrne and Callaghan (2013, p.208) argue: "good social knowledge of complex social systems is based on co-production between social scientists and the human agents in the field of investigation". This notion of co-production takes us beyond dialogue and into the realm of action[9].

3.7 To Change it

As we have seen, social and environmental unsustainability is strongly linked to the emergent properties of wicked systems: these systems are arenas for competition fought out through innovation, and this constant innovation has in human society been reified into a goal in its own right. This innovation is resulting in an increasingly global society, leveraged by increasingly diverse and versatile technologies and strategies (e.g. Beinhocker, 2006, p.6), and fueled by accelerating resource use (Steffen et al., 2015a), which has transformed human society into a major driver of planetary systems (e.g. Biermann, 2014; Steffen et al., 2015b; Zalasiewicz et al., 2011). At the same time, increasing sociotechnical interconnectedness, fueled by strongly innovation-oriented economic and ideological systems, has made this society more prone to uncontrollable cascade effects, with lower resilience to stress and an amplification of problems from local to more global scales (e.g. Folke et al., 2010; Helbing, 2013; Lane, 2011a). This development has brought about increasingly severe and interconnected crises; e.g. the

[9]Thereby also connecting with the rather large strand of literature associated to action research, e.g. Argyris et al. 1985; Byrne 2011; Reason and Bradbury 2001; Whyte 1991

climate crisis, biodiversity crisis, refugee crisis, financial crisis, and so on. The political reponse to this "crisis of crises" (e.g. Beddoe et al., 2009; Lane et al., 2011) – which tend to emphasize prediction, planning and control – has been inadequate both in its ability to align around a common direction and in levelling action (e.g. Castree et al., 2014; Haasnoot et al., 2013; Leach et al., 2010; Loorbach, 2010). Instead, the political has largely been reduced to priming the pump of innovation, in an attempt to innovate out of a hole that was created by innovation – disregarding overview and direction for the benefit of locally driven change. This is resulting in cycles of problem-solution-problem, in the end producing merely profit and new problems (Lane, 2016).

This points to a confounding assymmetry in the human condition – between our ability to transform the world and our profound lack of understanding of the very world which our own strength has established; our power over the world seems to be increasing at the same rate as our ability to control this power is diminishing. This assymmetry is rooted in a fundamental aspect of the seamless webs of wicked systems, in which understanding and controlling demands a global overview, but growth and change requires only local and myopic action. The former entails untangling a socio-eco-technical web of feedback and threshold effects, intertwined drivers and deep uncertainty; the latter, in comparison, merely entails the innovation of artifacts that thrives locally in the societal system over the short term. Hence, our world is pushed forward in its track not by rational decision-making based on in-depth understanding of the problems at hand, but rather through the invention and marketing of products; cascades of myopic innovation launching us in directions that we cannot predict or control (see Lane, 2011a). More succintly put, promethean powers are being exercised in a society of beings too absorbed in consumption to take any responsibility for the world (Arendt, 1958, p.XV).

This fundamental unsustainability harks back to the development of a sociotechnical system – the interweaving of social life with threads of materiality – that enabled the dynamics of self-driving innovation. This afforded an emergent feedback process of constant acceleration, putting mankind at the mercy of the thoughtless invention of every artifact which is technically possible, no matter how destructive. The unsustainability of these artifacts is only a competitive disadvantage in so far as it becomes a problem before the civilization has had time to eliminate its competition, which in practice means that there is little selection pressure for long-term sustainability. In other words, while the current crisis of crises is neither an historical coincidence, nor a biological exigence, it is a strong historical attractor following from the development of a sociotechnical innovation system.

Our unsustainability is deeply linked to a defining aspect of wicked systems – the fact that humanity as a whole does not fulfill any functionality; our collective behavior is merely the accumulation of externalities of underlying processes that are never evaluated on the systemic level. Humans are all "the helpless victims of a mechanism which is nothing but the cumulative effect of their own strategies, engendered and amplified by the logic of competition of everyone against everyone." (Bourdieu, 1998, p.27). In other words, there is no collective "us" that has taken us to where we are – "at no moment did the species vote for it either with feet or ballots" (Malm and Hornborg, 2014, p.64). But neither is there a "humanity" that could take charge of events, and consciously make its own future: human beings are plural and mortal, and it is these features of the human condition that give politics both its openness and its desperate contingency: no snowflake in an avalanche ever feels responsible.

This does not mean that this condition cannot be changed, or that we cannot construct governance structures that can lever our collectivity into new "societal actors" (Knight, 2015) capable of instilling our processes of innovation with a necessary level of collective agency. Negotiation and narratives have the power to form local alignment in seamless webs, allowing us to steer the direction of innovation, and thereby of wicked systems. In Hannah Arendt's words: "when plural persons come together to bind themselves for the future, the covenants they create among themselves can throw 'islands of predictability' into the 'ocean of uncertainty"' (Arendt, 1958, p.xix). Technological change has enabled new forms of collaboration and new ways to come together, which is simultaneously enabling alternative economic organizations, and clashing with important tenets of the old systems (Castells, 2002, 2011; Mason, 2016).

Innovation is by definition needed to solve the meta-crisis, but at the same time, it is also what caused the crisis – innovation as constituted by our current processes of innovation. Since the necessary social transformations is unlikely to be generated by the same structures and processes that caused it, what is needed is meta-innovation: an alternative sociotechnical regime for innovation. But as we have seen, there appears to be no off-the-shelf approaches for organizing innovation in ways that lead to a sustainable path into the future. The meta-perspective of viewing the structures and processes of innovation as regimes (Geels, 2005; Grübler, 2003) – constructing niches and themselves becoming entrenched – was useful to understanding the problems we face, and can be similarly useful in finding a solution: new forms of innovation and production, unattached to the structures of the current regime of innovation and instead belonging to a new cluster of societal organization, can contribute to the formation of scaffolding structures facilitating the development of new forms of organization for harnessing innovation.

Harnessing innovation implies developing scaffolding structures capable of directing and supporting iterative processes of innovation. Through such structures, collective agency can be instilled into the economic sector, as exemplified by social movements experiments in organizing democratic alternatives to the atomistic *market*, for evaluating innovations (see e.g. Fenton-Smith, 2015). This literally brings in collective agency into the innovation process, and suggests a way in which scaffolding structures for supporting social innovation can emerge within civil society (Lane et al., 2011). Underlying this is an alternative view of socio-eco-technological systems, characterized by multidimensionality, path-dependency and unpredictability (e.g. Bai et al., 2015; Beddoe et al., 2009; Berkhout, 2002; Folke et al., 2002, 2010; Rip and Kemp, 1998). These qualities – all related to ideas about complexity – are seen as irreducible root causes of the crises that we face and of our inability to predict, prevent and deal with them. The main lesson is that we must harness and embrace these troublesome qualities rather than vainly attempt to plan and control them away.

Chapter 4

Conclusion

This essay has aimed to cast light on the borderlands between the natural and social sciences with the purpose of developing a complexity-informed understanding of the ontological distinctiveness of social systems. It was noted that, while complexity has been asociated to an influx of naturalism, the ontological conception of emergence in fact provides a solid foundation for a critique against crude naturalism, as it suggests the existence of exclusively social entities, requiring their own methodological approaches. This was investigated by attempting "to analyze and to systematize the ontological categories" (Bunge, 1977b, p.12) by looking at the interaction between binaries like individuality/artificiality, emergence/hierarchy, agency/structure, and complexity/complicatedness (Khalil, 1995). This categorization has served as a foundation of a naturalistic perspective on naturalism, with the conclusion that society, as well as some natural systems, are fundamentally different in type from the systems among which they are typically being placed, and that they need to be approached in another way.

We have furthermore noted two ironies in that the reinvigoration of crude naturalism is driven by, on the one hand, increasing impact of social systems on the natural world, and, on the other, the development of digital data and computational methods:

For the former, it seems obvious, as Malm and Hornborg (2014) point out, that the increasing acknowledgement of society's impact on nature should logically imply a more profound engagement with social and cultural theory, not in coaching society in terms of natural science. That humans alter geological layers *does* make social science more relevant for geologists, but it does *not* make geologists more equipped to study societal processes: as is becoming painfully clear, society mostly drives climate change, not the other way around.

The latter is exemplified by Manovich (2016): "Digital is what gave culture the scale of physics, chemistry or neuroscience. Now we have enough data and fast enough computers to actually study the 'physics' of culture". The irony here is that digitalization is part of a development toward technology becoming increasingly liquid (e.g. Archer, 2014; Bauman, 2013), thereby undermining the ontological stability of culture (e.g. Elder-Vass, 2017). This means that formal methods are in fact becoming less capable of dealing with society, as their necessary assumption of fixed ontology are becoming increasingly problematic, and their "short runs" increasingly short (Simon, 1991). In other words, approaching society as a closed system – as physics, if you will – has in fact never been less appropriate.

The underlying naturalistic idea that drives both of these developments – that formal methods constitute a development toward increased predictability, and toward making social science "scientific" – is fundamentally misconceived. As we have seen, the lack of precision is not a problem of the methods, but part of the ontological nature of the system: if your prediction is *exact* in an uncertain system, it is certainly *exactly wrong*. Car repair doesn't become a social science just because you start interviewing carburetors – it just makes you a terrible mechanic.

The category of systems to which society belongs – whose components display both individuality and artificality (Khalil, 1995) – are non-decomposable (Simon, 1991), which in turn means that their mode of change is, to important extent, of *kind*, not of *degree*. To understand such change, methods based on fixed ontologies – including quantification and measurement on a ratio scale – will not be adequate: change of kind implies a change of the very meaning of what is measured. Instead, cause-and-effects in such systems can be accessed through the comparison of categories of effects, and from there deducing the causes – according to the idea that "where there is difference in the effect, there is a difference in the cause" (MacIver 1942, p.26, cited in Byrne and Callaghan 2013). However, *nota bene* that this in no way contradict a computational approach, but simply implies that the nomothetic program may not be an appropriate foundation for such a pursuit. Computational tools may be highly beneficial for aiding a program of systematic comparison, as illustrated by the computationally relatively simple tools associated to Qualitative Comparative Analysis (e.g. Rihoux and Ragin, 2009).

As we have seen, the claims that emergentism and Complexity Science are anti-reductionist seem to be in practice misleading: complex individualism is still individualism. The difference between the Platonic backhand and forehand

(Hayles, 1999) is not between *reductionism* and *emergence*, but between *component* and *relation* reductionism. Since these abstractions are rendered as real, the corresponding ontologies follow from a lack of distinction between the real and the artificial. What we need is not to go from "factors to actors" (Macy and Willer, 2002), but from artificiality to reality (Khalil, 1995).

Instead of approaching naturalism by continuing to "extend the tool found successful in one domain to decipher the other" (Khalil, 1995, p.414-415), this essay has suggested taking a turn to ontology in the complexity scientific approach to societal systems. A set of compatible ideas were found primarily in critical realism of e.g. Archer et al. (2013), and Bhaskar (2013), and in particular Reed and Harvey's (1996; 1992) "complex realism", further developed by e.g. Harvey (2009), Byrne (2002, 2004, 2005, 1998), Byrne and Ragin (2009), and Byrne and Callaghan (2013), as well as in Mario Bunge's related "emergentist-systemism" (e.g. Bunge, 1979a, 2000a,b).

Based on a review of these ideas connected to the ontological categorization of Wicked Systems, this resulted in an approach to societal complexity that:

(i) steps away from the ontological individualism and reductionist explanation of mainstream Complexity Science, to one that views emergence not as something that necessarily develops bottom-up, but that can run between levels and in any and all directions. This furthermore suggests a type of explanation that does not merely describe underlying elements, but traces processes through the structures and elements involved.

(ii) focuses on qualitative change – changes in kind rather than only in degree – suggesting a step away from approaching data through variable-based methods, to one that instead emphasizes categorization and pattern-finding, accepts that wicked systems cannot be fully represented in closed models, and therefore calls for an approach that sees the scientific practice as interpretation rather than as analysis, and aims for exploration rather than complete explanation or "realistic" representation.

(iii) sees to *complex* rather than simple causation, and *tendencies* rather than laws. This reframes models from attempts to match or access a platonic ideal form of the system – inevitably resulting in their reification – to indicators giving us traces of reality (Byrne, 1998). This changes our understanding of the toolkit of complexity from realistic representations of reality, to parts of a set of "computational hermeneutics"; crutches that can help our intuition navigate cognitively difficult terrain, but that should never be expected to walk on their own.

(iv) takes an integrative and methodologically pluralist approach, allowing ontology to guide methodology and focusing on the specific with an understanding of the totality, tying together a range of traces to a coherent narrative.

(v) steps away from notions of science as objective and external, admitting that the social scientist is an inseparable part of the subject of study, meaning that theory becomes a form of practice: we change the world by understanding it, and we understand it by changing it (Byrne, 2002). Since description becomes a form of criticism in an unequal and unsustainable world, this in turn implies active engagement.

To conclude, it should be noted that this does not only bear relevance within the confines of scientific research; we are ravaging our world with a "perfect storm" (Pievani, 2014) of interrelated crises of increasing scale and magnitude, driven, ultimately, by our confounding lack of understanding of the very world which our own strength has established. It is increasingly understood that this "crisis of crises" (Beddoe et al., 2009) calls for a fundamental transformation in how we organize our society – what some call a Great Transition (Raskin et al., 2002). But at the same time as the capacity to understand large-scale change is starting to seem increasingly essential for our survival as a species, scientific research risks withdrawing – driven by scientism and empiricism – to a focus on small, empirically verifiable study, with any theory left implicit and tacit. But to see the human impact on the Earth system, and allow us to gaze toward a more just, equal, and sustainable future, a bigger picture is needed, capable of evoking the experience of seeing the first photographs of Earth from space: showing our precious sphere floating in infinite black emptiness; reminding us that we live on a precarious razor-thin interface between rock and emptiness, between a vast past and an unknown future, in a moment that is not only remarkable in beauty but perhaps also in brevity. We need a science capable of seeing not only the frailty of that reality, but also that another world is possible.

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