The Complexity of Evolution: History as a Post-Newtonian Social Science*

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ABSTRACT

The sciences of the 20th century largely inverted the understanding of the world fostered by Newtonian science. In recent years, that changed worldview has increasingly manifested itself in the social sciences. This paper examines the Post-Newtonian worldview and the conception of Social Sciences that has emerged. Drawing particularly on Complexity Studies, the author suggests that Post-Newtonian History can picture the course of human cultural evolution as 'punctuated equilibria', a series of stable states interrupted by phase transitions so that Modernity can be interpreted as such a phase transition, a Second Axial Age.

> [W]hat happens among human beings and what happens among the stars looks to be part of a grand evolving story featuring spontaneous emergence of complexity that generates new sorts of behavior at every level of organization from the minutest quarks and leptons to the galaxies, from long carbon chains to living organisms and the biosphere, and from the biosphere to the symbolic universes of meaning within which human beings live and labor, singly and in concert, trying always to get more of what we want and need from the world around us.
>
> McNeill 1998

The implications of Quantum Mechanics were so violently shocking to its pioneers that for Werner Heisenberg 'the foundations

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of physics have started moving'; for Albert Einstein there was 'no firm foundation to be seen anywhere'; and for Niels Bohr this new science had 'shaken the foundation on which the customary interpretation of observation was based' (as quoted in Capra 1983: 53–54). Post-Newtonian science had begun turning the Western worldview on its head, a process that other 20th-century sciences, most notably research in Neurobiology and Complexity Studies, would underscore. However, it is only in the last decade or so that a similar shock has begun to spill over the Social Sciences. The seeds for this emerging Post-Newtonian approach were planted with Foucault's Social Archaeology in the mid-1960s, the Family Therapy of Boszormenyi-Nagy in the early 1970s, and the Economic History of Mensch in the mid-1970s. Today, thinkers in many fields are developing this un-Newtonian approach to Social Science, from Christian's Big History (Christian 2004) to Barad's philosophy of Agential Realism (Barad 2007), from Latour's Agent-Network-Theory sociology (Latour 2005) to Boje's Organizational Dynamics (Boje 2008).

In this essay, I want to explore some of the implications of a Post-Newtonian approach to History. Most particularly, I shall focus on the contribution of Complexity Studies. (I use this term rather than 'Complexity Theory' because it offers no coherent theory, functioning as a meta-science that is as much a worldview as a specific scientific discipline.) One of the problems of applying its principles to social phenomena is that, as a relatively new field of study, no one is quite sure how to define it. I stopped counting definitions of Complexity Studies at about thirty. For my purposes, I offer this definition: *Complexity Studies examines the patterns that emerge as complex, multi-scaled phenomena evolve*. To illustrate how complexity principles are vital to Post-Newtonian History, I shall examine one critical pattern in human history – the evolution of social structure as society's networks have become more populous, our technologies, more sophisticated, and our cultures, more globally interdependent. In doing so, I shall examine four major topics:

• how the 20th-century science turned the Newtonian worldview upside down;

• how a Post-Newtonian worldview has begun manifesting itself in the social sciences;

• how the dynamics demonstrated in Complexity Studies is central to this new conception of the Social Sciences;

• how those dynamics illuminate Post-Newtonian History.

I turn first to the science at the heart of both the Newtonian and Post-Newtonian worldviews, and how Newtonian science turned its worldview upside down.

NEWTON TURNED ON HIS HEAD

The Newtonian worldview, what Morin (2008: 3) calls the 'master paradigm of Western civilization', began to emerge in the mid-17th century with the philosophy of Descartes and the experimental science of pioneers such as Boyle (Shapin and Schaffer 1985), and was most completely represented in the physics of Isaac Newton's *Principia Mathematica* (1687). The world depicted here was 'a perfect machine' (Morin 2008: 6), composed of a collection of metaphysically distinct entities, interacting like the molecules in a container of gas, in a deterministic, predictable manner, according to the laws of nature. Matter was dead and mindless, except for life, especially human beings, whose rational nature sets our species apart. Reality and its truths are ultimately knowable. 'I believe that the truth is out there but that it is rarely obvious and almost never foolproof', as Michael Shermer (2011: 2) states this assumption. The scientist *as a distinct entity* could, therefore, wrestle with Nature, read it *objectively* as a 'book', forcing it to reveal its mysteries, and, thus, as Descartes noted, 'make ourselves masters and possessors of nature' (*Discourse on Method* 6: 40). In doing so, scientists would discover the true essence of reality and answer such thorny questions as whether light was made of particles or waves.

By the end of the 19th century, this worldview had proven wildly successful, from the electric lights on the streets of London, Paris and New York to the political ascent of Western powers. Then, the unthinkable happened: physicists, practicing the techniques of Newtonian science, discovered that the world was not what the Newtonian worldview had taught them. Einstein's Theory of Special Relativity demonstrated that, far from being 'dead', matter was a form of energy, in constant motion. By the early 1930s, researchers in Quantum Mechanics found that nature, far from being an open book, was a mystery. The distinct 'things' of Newtonian physics were actually *entangled* structures of '*coherent* energy storage' (Ho 2008: 81; author's italics) in a field of interacting phenomena. For physicist Richard Feynman, 'It is all quite mysterious. And the more you look at it the more mysterious it seems' (as quoted in Barad 2007: 254). As Bohr would argue, and Heisenberg eventually agree, raw reality, as it exists *prior to human perception*, was not ultimately knowable, as Newtonian science assumed. What one experiences as distinct 'things' or 'events' are actually interconnected 'phenomena' defined by the filter with which one engages 'the open process' of unmediated reality (Barad 2007: 140). Light could be perceived *either* as a particle or as a wave *depending on the apparatus through which the scientist viewed it*. The unmediated reality, an unending dance of energy storage networks, however, was not directly knowable.

Neurobiology would further emphasize the limitations of the Newtonian worldview, as it demonstrated the extent to which our perceptions are the constructions of the brain. These perceptual constructions are most dependent on input *stored in the brain* (Cohen and Stewart 1994: 349), refreshed with information from immediate sense experience mostly as the world around us changes. Ultimately, the resulting 'consciousness does not constitute a single, generalized process', but, rather, 'a multitude of widely distributed specialized systems and disunited processes', integrated by a brain module that Michael Gazzaniga calls the 'interpreter', the brain's storyteller (Gazzaniga 2011: 102). Moreover, this process creates a prejudice for *coherent* stories. As neuroscientist V. S. Ramachadran explains, 'the brain abhors discrepancies of any kind' (Ramachadran 2011: 70), to the point that, in a process referred to as 'confabulation', the brain can fabricate 'information to preserve its harmony and overall view of itself' (*Ibid.*: 267). In this process, human perception reduces the world to an image that a person constructs, largely shaped through the apparatus or discourse with which he or she engages it, in order to survive.

Complexity Studies would further reinforce all this. As scientists in fields ranging from Fluid Dynamics to Economics and Ecosystem Study began modeling their subjects with non-linear mathematics, they discovered a world of highly interconnected, networked phenomena, continually adapting to each other on many scales – atoms, molecules, cells, organisms, ecosystems, *etc*. (For a history of these developments, see Pagels 1988.) While Quantum Mechanics focused on describing behavior at the subatomic scale, Complexity Studies examined the patterns that emerge as complex, many-scaled phenomena co-evolve. Its most un-Newtonian world is composed of intricately interconnected networks on many scales, whose behavior is characterized by systemic causality, and, above all, unpredictability, with unexpected developments frequently emerging. (Cohen and Stewart 1994, offer a first-rate summary of complexity principles and the world they suggest.) In such a world, living things face the challenge of surviving in a continually changing world they cannot directly perceive.

The essential differences between these worldviews can be summarized in the following way.

Table 1

Newtonian *vs*. Post-Newtonian Worldview

	Newtonian	Post-Newtonian
Matter	Stable, metaphysically individual, passive things	Entangled, interacting energy storage phenomena in ongoing transformation
Behavior	Determined/controlled	Adaptive
Structure	Stable containers	Dynamic networks
Causality	Linear cause-and-effect	Systemic co-evolution
Evolution	Gradual/stable	Dynamic emergence
Natural Law	Universal	Emergent at different scales
Scientist's Role	Objective observer	Entangled participant

Note: see Boje and Baskin 2010: 24.

This Post-Newtonian worldview, which physicist Robert Laughlin (2005) characterizes as 'the Age of Emergence', as opposed to 'the Age of Reduction', is only now beginning to enter wider social consciousness, just as it took about a century for the ideas in Newton's *Principia Mathematica* (1687) to be expressed in, for example, Adam Smith's *Wealth of Nations* (1776). Since roughly the beginning of the 21st Century, a body of thought has started to emerge in the Social Sciences. Let us turn now to that conception of Social Science.

TOWARD A DYNAMIC CONCEPTION OF SOCIAL SCIENCE

With its emphasis on a rational, predictable universe, Newtonian Social Science became a celebration of the triumphs of rational man and his ability to overcome the destructiveness of irrationality. This conception of the social, what Latour calls our 'default position' (Latour 2005: 4), views society as a collection of individuals, contained in stable institutions, not unlike Russian nesting dolls, in which, as Latour observes, the 'social "context" [is] a specific domain of reality' that 'ordinary agents are always "inside"' (Latour 2005: 3–4). Those individuals' behavior, in addition, must be controlled, that is, ensured of their rationality, by the rules and hierarchies of those institutions – the Newtonian 'systems', as opposed to Barad's (2007) post-Newtonian 'phenomena', at the micro-level of families or work groups, the meso-level of organizations or professions, and the macro-level of governments, religions or markets. And the social scientist who studies them must stand outside and objectively observe the cause-and-effect relationships within them in order to understand those laws. Moreover, because meaning is inherent and directly accessible in the reality around us, the job of such a scientist is to determine the truth of any event or phenomenon by considering the abstract categories in which that truth resides, as opposed to mere contextual specifics. Thus, Newtonian Social Science is represented in the Sociology of Auguste Compte, Durkheim or Weber, the History of Marx, or the Psychology of Freud.

The emerging Social Science grounded in Post-Newtonian thought is, in contrast, the study of the evolution of dynamic, nested social networks. If the world around us is not a collection of distinct objects bumping into each other, but, rather, an open process, a dance, if you will, of energy storage phenomena in ongoing transformation; social structures are not containers, but networks, continually forming, being maintained and falling apart, as Latour (2005) notes in Actor-Network-Theory (ANT). In this way, Social Science studies nested networks of both human and non-human participants – think, for instance, of the agential function of automobiles in driving 20th-century human behavior or of computers currently – in continual transformation, a process as open as Barad's quantum reality, a world of constant change and almost-overwhelming abundance. As Latour (2005: 166, author's italics) notes, every 'interaction seems to *overflow* with elements which are already in the situation coming from some other *time*, some other *place*, and generated by some other *agency*'. Moreover, rather than being 'inside' a series of institutions at several *levels* of scale, the actor/agents of ANT are continually associating, maintaining those associations, and falling apart, a 'circulating fluid' (Latour 2005: 13), where agents are continually appearing, combining, and disappearing. Rather than viewing society as a Russian doll of structural levels stuffed into progressively larger structures, Latour examines society as a flat 'topology' (Latour 2005: 165–172), a series of networks that are related to and entangled with other networks so that, ultimately, they form a network of all networks, very much like the Chinese conception of the Tao. This image is not so much the 'overarching framework' of the Newtonian discourse, but 'panoramas', approximations whose 'excess of coherence' makes them 'misleading if taken as a description of what is the common world' (Latour 2005: 157–159).

A significant amount of work has already been done viewing social structures as the dynamic networks examined in ANT. In psychology, for example, Family Therapy has viewed human behavior as a reflection of the dynamic, multi-generational social networks to which people belong and have belonged and the forces that enable these networks to cohere, as in the theory of multi-generational family loyalties and obligations put forward by Boszormenyi-Nagy and Spark (1973) or the theory of attachment (see Cassidy and Shaver 2010). In Organizational Dynamics, David Boje's (2001, 2008) theories about dynamic organizational storytelling examine how participants in social networks at many scales go about creating meaning from moment to moment and how that can affect behavior throughout organizations. In History, Michael Mann (1986: 1, author's italics) explores societies as the interaction of '*multiple overlapping and intersecting sociospatial networks of power*', and Giovanni Arrighi (2010 [1994]) examines the ongoing evolution of economic and political networks in Western Capitalism.

The post-Newtonian study of these networks, however, is no longer about finding 'the' truth out there. As Quantum Mechanics makes clear, the scientist can no longer observe Newton's the 'book of Nature' objectively; rather, *what scientists see is the world in which they are entangled, shaped by the apparatus through which they look*. View light through one apparatus and it appears to be particles, while another will make it appear to be waves. View particles through one apparatus and you can measure their momentum; view them through another and you can measure their position. The meaning that one experiences is not merely in the things-in-themselves, but *an interpretation that can vary depending on the filters with which scientists engage a reality of which they are part and can never know directly.* This radically different perception of meaning creation is critical for Barad's Agential Realism (2007), a philosophy grounded in Bohr's Quantum Mechanics.

For Barad, and for the post-Newtonian worldview in general, raw reality is an open process of ongoing energy transformations – Jullien (2011) calls them 'silent transformations' such as the cellular processes that create aging – which the human mind can only know through an intellectual filter, an apparatus or discourse, that gives shape to the raw transformational process. In observing human phenomena, the discourse – one's explanatory 'story' – that the observer filters the world through shapes the boundaries, the interactions, and the meaning that he or she perceives. Such a discourse determines 'what counts as meaningful statements', statements which emerge from a much more inclusive 'field of possibilities' (Barad 2007: 819). The power of one's discourse to shape perception is obvious in a quick scan of Frank's 'Introduction' to *ReORIENT: Global Economy in the Asian Age* (1998: especially 12–34), where he chronicles the various explanations of the 'rise of the West' – from Weber's emphasis on the Protestant Ethic and European rationality to Marx's contrast of Capitalistic *vs.* Asiatic modes of production, from

Polanyi's insistence that market relations did not exist before the 19th-century to Braudel's conclusion that China's 'economy was not yet mature', from McNeill's recognition that in *The Rise of the West* he ignored Europe's debt to the rest of the world to Jones' admission that in *The European Miracle* he focused too strongly on 'special positive features'. The recantations by McNeill and Jones are especially telling when one remembers that the brain's interpreter module moves toward coherence so strongly that it will distort or ignore conflicting data. The issue here is not who is 'right' or 'wrong', but which discourses offer the most fruitful images of history for exploration. For Barad, these differences in meaning reflect variations in the way different discourses create our perceptual reality – 'discursive practices are specific material configurings of the world through which determinations of boundaries, properties, and meanings are differently enacted' (Barad 2007: 335). A 'different material-discursive apparatus of bodily production materializes a different configuration of the world...' (*Ibid.*: 390). As opposed to the Newtonian view, there are *many* truths out there, depending on the discourses with which one engages the world, so that the ideal way to understand the meaning of almost any phenomenon is to examine it through several discourses at once.

All of which leads me to the question of Post-Newtonian Social Dynamics and the role of Complexity Theory in this emerging approach.

THE COMPLEX DYNAMICS OF SOCIAL NETWORKS

With a Newtonian worldview, social dynamics are largely those of the machine, so that people act according to universal laws, parts of social machines at a variety of levels of scale (see, *e.g.*, Baskin 1998). Thus, as Dorothy Smith suggests, traditional Newtonian medical psychiatry provides the equivalent of a social machine shop, through which 'people in positions of power' can remove and try to fix defective human parts when they threaten the 'local order' of the social machines, without addressing the 'messy' underlying issues (Smith 1990: 133–138). This is a critically important issue, because, as post-Newtonian science demonstrates, life is inherently messy. As a result, the central defect of Newtonian Social Science is its refusal to confront life's messiness by dismissing the irrational as non-essential. The medical system does so by treating emotionally disturbed people as representing abstract categories of psychological dysfunction, analyzed according to Newtonian universal psychological laws of cause-and-effect, rather than as responses that reflect long-term silent transformations. Legal institutions serve an equivalent function, *although*, for Foucault (1995), *they actually help create much of the dysfunction its court and prison machine shops exist to fix*. For the Newtonian, rationality can triumph over irrationality through the machinations of such systems.

From the Post-Newtonian perspective, however, the dynamics that drive life's messiness in actor networks are unavoidable, and their dynamics are the subject of Complexity Studies. Many of its principles take a central role in the writings of pioneers in Post-Newtonian Social Science, sometimes before those principles were formulated. Positive feedback loops with their self-reinforcing cycles (Arthur 1994: 1–12), for example, have a prominent place in a variety of fields. Foucault's sociological conception of the 'dangerous individual', first published in 1978, as a person so dangerous that he or she must be imprisoned as 'a mechanism for the defense of society' (2000: 193), creates the fear that makes severe punishment appear reasonable. Other complexity principles that are widely employed include self-organization (Kauffman 1995: 14–15), as in Boje's 'antenarrative' (2001: 1–3), the process by which people spontaneously build the narratives by which they live, or co-evolution (Kauffman 1995: 221–224), as in Frank Wilson's (1998) discussion of how the hand, brain, language and human culture evolved in tandem. From another perspective, Christian defines Big History in terms that sound very much like a description of Complexity Studies itself, quoting William McNeill's comment quoted in this paper's epigraph (Christian 2004: 4). Emergence – the way local interactions at one scale can produce unexpected macrobehaviors at another scale (Johnson 2001: 18–19) – is another critical element in Post-Newtonian Social Science.

The most powerful methodological tool that I have derived from Complexity Studies is what I call the Life Cycle of the Attractor.

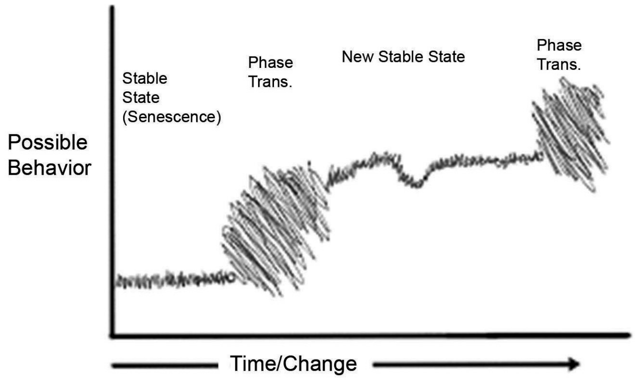

Fig. 1. Life Cycle of an Attractor

An attractor describes the patterns of behavior that characterize any phenomenon under specific conditions (Cohen and Stewart 1994: 204–207). Put a chunk of ice in a pot on the stove and turn up the heat. It will remain solid until it hits its melting point, becomes turbulent, and transforms into liquid. It will then remain liquid until it hits its boiling point, becomes turbulent, and transforms into gas. According to this pattern, phenomena are born in turbulent phase transitions, in which their component phenomena seek the behaviors that enable them to survive current conditions. Once they discover those behaviors, they practice them, creating their characteristic attractors. As the component phenomena build relationships based on their characteristic behaviors, a 'stable' state emerges, in which behaviors and the relationships they require, become relatively predictable. At some point, the component phenomena become so dependent on their relationships that they can no longer adapt, entering 'senescence' (Salthe 1993) where they force the changes around them to serve their characteristic interactions. The strategies that had enabled the phenomenon's components to survive now make that survival more difficult. At this point, the phenomenon must either disintegrate or re-enter phase transition.

The Life Cycle of an Attractor reflects work done in Post-Newtonian thought that began emerging in the 1970s. For example, Eldrege and Gould's 'punctuated equilibria', first described in 1972, explains the pattern of global ecosystem evolution as a matter of stable periods interrupted by the phase transitions following mass extinctions (Gould 2002: 745–820). Foucault's cycles of continuity and discontinuity in the evolution of Western *episteme* (Foucault 1994) also suggests such a pattern. Arrighi (2010[1994]) constructs a similar image to describe the four cycles of Western Capitalism over the last 600 years, just as Mensch's 'wave model' (1979: 73) explains the cycles of technological innovation and economic boom since the Industrial Revolution. Others have used a similar pattern to describe phenomena ranging from the life cycle of organizations (Adizes 1988) to human personality development (Baskin 2010).

Before turning to a post-Newtonian panorama of human history, it is important to note, as Bondarenko (2007) does, that, for History and Anthropology, the word 'complexity' can mean different things than it does in Complexity Studies. As a result, in the following analysis, I will use the terms 'complexity principle' and 'complexity dynamics' to refer to applications in Complexity Studies, while I use 'social/cultural complexity' or 'governmental/religious complexity' to describe historical or anthropological applications.

AN APPROACH TO HUMAN HISTORY

To illustrate this Post-Newtonian approach to Social Sciences, I want to elaborate on work I am currently developing with Moscow anthropologist Dmitri Bondarenko (Baskin and Bondarenko 2011), as we examine the full scope of human history. From this point of view, human beings are an extremely innovative species that, in interaction with other agents in their networks, from climate to the other life forms, from technology to our symbolic world, have created increasingly complex social worlds – that is, their social networks have come to include an increasing diversity of actors whose interactions have driven an accelerating emergence of socio-cultural adaptations. For us, this story is very much a panorama in Latour's sense of the word. Although overly simple and coherent, *as any panorama must be*, our analysis focuses on the essential dynamic of this saga: in each stable state, over centuries, largely unnoticed silent transformations, especially in human demographics and technological innovation, create dramatic changes in their actor networks.

At some point, these significant changes render the society's basic survival strategies archaic, driving them into phase transitions where they negotiate new styles for maintaining their actor networks. This is *not* a story of inexorable progress, as, for example, Marx's historical determinism or Service's (1962) evolution of the state, suggests. There have been movements toward less socially complex forms; perhaps, the best example is the movement of much of Islam, a highly sophisticated Post-Axial state for a millennium, developed into much more tribal conditions, especially following World War I. The point that Bondarenko and I emphasize is that, while the *general* movement of human history has been toward more socially and culturally complex forms, in each time and place that movement has reflected the responses of social network agents to specific conditions, ranging from climate change to technological advance and changes in religious or governmental conditions. Such a panorama of human history can be visualized in the following way:

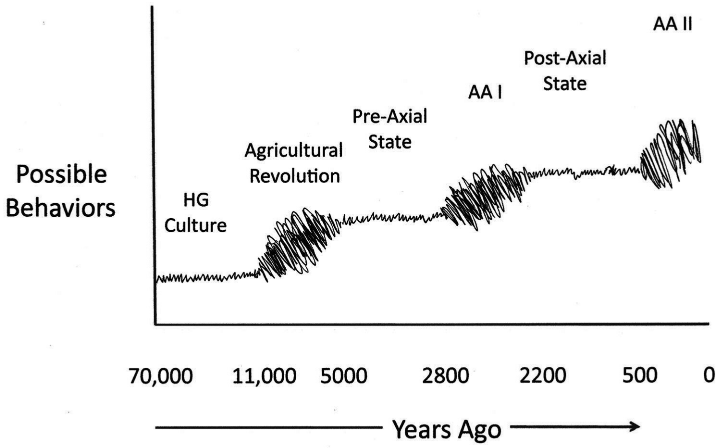

Fig. 2. Human history as punctuated equilibria

Such a figure cannot but seem overly linear. It is not. For one thing, the dates are approximate. For example, the beginning of the Pre-Axial State is generally dated c. 3100 BCE in Sumer and Egypt, but not until 2200 BCE in China, a distinction not reflected in the figure. In addition, Jullien's concept of silent transformation adds a powerful element of non-linearity. That is, the effects of many changes proceed relatively quietly, until they allow powerful and shocking emergent behaviors. Think, for example, about the movement from the Agricultural Revolution to the Pre-Axial State. A variety of innovations appear from approximately 4000–2500 BCE. Writing first appears in Sumer in 3700 BCE (Fischer 2001: 31); horses were first ridden by 3500 BCE in Kazakhstan (Anthony 2007: 220); bronze was introduced in the Middle East c. 3300 BCE; spoked wheels have been identified as early as 2700 BCE east of the Ural Mountains (*Ibid.*: 374). All of these, alone and in combination with the others, had significant effects on the development and, eventually, the breakdown of Pre-Axial State networks. Even the most squiggly of lines in Fig. 2 cannot convey that non-linearity.

Given that caveat, let us examine the story Fig. 2 suggests: Our hominid ancestors lived in networks defined as *Hunter-Gatherer Bands* for more than one million years. When they became fully modern *Homo sapiens*, Fagan (2010) suggests it was between 50,000 and 70,000 years ago, the key difference from their predecessors appears to be that they could use language as we do today and began to live in a symbolic world that reflected what they believed they needed to do to survive (see Donald 1991 or Mithen 1996). The resulting symbolic cultural discourse, reflected in the cave paintings of sites such as Lascaux, depicts a network of humans, their weapons, and the animal prey on which their survival depended (Fagan 2010: 209–213). These hunter-gatherers appear to have lived in nomadic bands of about 30 people, rarely exceeding 50, connected into larger networks, mega-bands, that may have been as large as 150 or 200 (Dunbar 1996: 70). This number is significant because, as Gazzaniga (2011: 150) notes, '150–200 people are the number of people that can be controlled without an organizational hierarchy'. As a result, hunter-gatherer society could be governed by personal influence in extended family groups where everyone *could* know everyone else. During this stable state of cultural evolution, modern *Homo sapiens* spread across the globe, replacing earlier hominids, including Neanderthals in Europe and *Homo erectus* in much of Asia (*e.g.* see Tattersall 2012).

Then, starting about 14,000 years ago, the Ice Age ended, and a series of climate changes led to increasingly sedentary populations. By 12,000 years ago, Abu Hureyra in present-day Syria had a population of 300–400 (Fagan 2004: 238), and by 7800 years ago, Catalhoyuk in Turkey had a population of about 5,000 (Modelski 2000: 3). In addition, *the Agriculture Revolution* (11,000 to 5,000 years ago) developed to feed these larger populations drove such communities into a phase transition, in which this jump in the complexity of social life pushed people to experiment with new, more appropriate ways of living. The larger the populations, the more intensive the agricultural efforts, and the larger the surpluses became, leading to increased wealth, trade, craft specialization and innovation. One set of such innovations would have been a new symbolic world, dominated by the forces of nature, developing the beginnings of myths that we know through the more sophisticated versions of Greek or Egyptian myth, reflecting their dependence on agriculture. The technological innovations noted above – writing, horse riding and bronze metallurgy – all emerged toward the end of this phase transition. Another set of innovations arose with the need to govern communities of hundreds and then thousands. These experiments are reflected in Service's (1962) band-tribe-chiefdom-state schemata, although, as more recent scholarship emphasizes (see, *e.g.*, Mann 1986 or Bogucki 1999), these developments appear to have been more like a long-term process of silent transformations that spurred many different experiments until the Pre-Axial State emerged as a successful way to survive (an attractor) in more complex, more populous, more technologically advanced societies. With a symbolic world grounded in an agriculturally oriented *mythos*, focusing on the actor network of humans, the land, and the forces of nature on which agriculture depended, emerging leaders would claim special access to those powers. As a result, in chiefdoms, Earle (1997: 149) writes, 'Chiefly leaders were often viewed as ruling because of a sacred charter that recognized them as divine or with structured differential access to divine power'. By 5,000 years ago, that phase transition was drawing to an end.

The great *Pre-Axial States* (c. 3100 BCE to 800 BCE) first emerged in river valleys – the Tigris and Euphrates in Mesopotamia (c. 3100 BCE), the Nile in Egypt (c. 3000 BCE), the Indus in India (c. 3300 BCE) and the Yellow River in China (c. 2200 BCE). These were becoming increasingly complex social networks, especially with the growth of cities: as early as 3300 BCE Uruk in Mesopotamia had 40,000 inhabitants, a number that would grow to 80,000 in 500 years (Modelski 2000: 22, 28). The leaders of these civilizations maintained order in these increasingly complex communities, as their chiefly predecessors had, through cultivating their relationship with the powers that fostered the agriculture that enabled them to feed larger communities, whether such leaders were thought to be literally the sons of the gods, as in Egypt, or were responsible for maintaining the required rituals as in China. Priests in these societies were often responsible for maintaining the agriculture surpluses – gifts from their gods – in their temples, which were used for storage as well as worship (Service 1975: 206). As these societies' wealth grew, people were increasingly able to specialize, not just as rulers or priests, but also as craftspeople, merchants, soldiers and traders. All these developments were reinforced by acceleration in technology, as writing became increasingly important, bronze was used for tools and weapons, and horses and chariots became essential to warfare. Toward the end of this period, iron, more plentiful and cheaper than bronze, was introduced as weapons. The continuing increase in the complexity of these networks may be most forcefully documented in the growth in urban population, where, by 1000 BCE, four cities exceeded 100,000 inhabitants (Modelski 2000: 42–55).

By that time, most of the Pre-Axial States were being overwhelmed by the ongoing increase in complexity. In the West, the mysterious 'Sea People' (see, *e.g.*, Armstrong 2006: 42) destroyed both the Hittite and Mycenaean civilizations and drained the power of Egypt during the middle of the 12th century BCE. In China, the Zhou Dynasty began losing control of its territories by the middle of the 10th century BCE, eventually deteriorating into 170 competing kingdoms. This disintegration drove the phase transition that Jaspers (1953) described as *the Axial Age* (800–200 BCE), because it marked a turning point in human history. In the four cultures where it occurred, Greece, Israel, India and China, writing would become integrated into daily life, changing the way people understood their worlds (see Ong 1982), and iron weapons, domesticated horses, and significantly larger populations, made war intensely destructive

(Bellah 2011: 270) – the Peloponnesian Wars in Greece, for instance, or the Warring States Period in China. To survive in these increasingly complex social networks – the number of cities with populations of 100,000 or more increased from two to seven in the Eastern Mediterranean and from one to eleven in China (Modelski 2000: 49, 42) – the period witnessed three key types of social innovation to manage the chaos that had caused breakdown of the old ways: warfare became more intense, culminating in the empires of Alexander in the Mediterranean and the Qin dynasty in China. New forms of government arose, most notably the *poleis* in Greece and bureaucratic kingdoms in China. New cosmic discourses, universalistic ethical belief systems (see, especially, Bellah 2011) emerged – rational philosophy in Greece, monotheism in Israel, Hinduism and Buddhism in India, and Confucianism and Taoism in China – all expressed in written form, thus moving their social consciousness from the group-based consciousness necessary in an oral culture to a more individual one that reading makes necessary. While much of the mainstream discussion of the Axial Age have focused on these cosmic discourses (see, *e.g.*, Jaspers 1953; Bellah 1976 or Armstrong 2006), a Post-Newtonian approach makes it clear that this period's ethical belief systems are more accurately viewed as part of a response that occurred in all parts of Axial Age societies. By the end of the period, empire had emerged as the preferred form of government, as China was united initially in 221 BCE and Alexander's empire (336–323 BCE) set the example for the Roman Empire.

Empire would continue to be the preferred form of government for these increasingly complex societies, throughout the stable state of *Post-Axial States* (200 BCE – 1500 CE), including, most notably, those of Rome and Byzantium, of the Mongol Empire and other Chinese dynasties of the period, and of the series of Islamic empires. Each was grounded in a cosmic discourse by which literacy refined older religious traditions. Christianity in Rome and Byzantium, Hinduism in India, Confucianism in China, and Islam – all created the shared experience and social control that enabled their states to extend their power, almost as if a desire for world hegemony became the antidote for the axial-generated fears of chaos. With these expansions economic activity and culture exchange increased, resulting in the 'world system' of the late 13th and early 14th centuries, which would fuel the rise of European power (see, *e.g.*, Chase-Dunn and Hall 1997). Social complexity continued to increase, and, between 1200 and 1500, five cities would exceed a million inhabitants (Modelski 2000: 63). Increasing rates of literacy also accelerated technological development: in China that would include the invention of printing (the 9th century), gunpowder (between the 9th and 11th centuries), firearms (the 12th century), and a wide variety of machines for manufacture, inventions that appear to have made their way to West Asia and Europe (see Temple 2007). In the beginning of the 15th century, the Ming Dynasty, the wealthiest state in the world, launched an armada, unmatched in size and number until the 20th century, to trade with and receive tribute from the rest of the world. At the end of this period, the Ottoman Empire and the Ming Dynasty largely dominated world politics; yet, as Goldstone demonstrates, they would prove unable to adapt to the shifts driven by population growth – more than 50 per cent increase between 1520 and 1580 in Asia Minor and from 200 to 300 million in China between 1500 and 1600 (Goldstone 1991: 356, 358). These states entered their senescence.

As a result, from a post-Newtonian viewpoint, the 'Rise of the West' (McNeill 1991) seems less a 'European miracle' (Jones 2003) than a *Second Axial Age* (1500–2100? CE), another phase transition in human history. Like AAI, AAII emerged in response to the decline of the dominant form of socio-political organization (European feudalism allied with the Catholic Church), explosive growth in trade and wealth, and the inability of a too-long-established religion, grounded in an antiquated cosmic discourse, to explain events. And like AAI, these events were complicated by technological innovations – the increasing availability of printed books and widespread use of machines. Where printing and machines had been an accomplishment of the late stable state in China, they were incorporated into the fabric of Western culture, products of the late Middle Ages. When the Protestant Reformation became as political as it was religious, a century of war, based on ideology available for anyone to read and using a still-more-advanced type of weapon, culminated in the Thirty Years' War (1618–1648) on the Continent and the English Civil War (1642–1651) (see Shapin and Schaffer 1985). As with AAI, the devastation of these wars would lead to a new cosmic discourse, evolving as much to control the violent impulses that generated this devastation as to explain a more complex world. That discourse was Newtonian science, grounded in Descartes' philosophy and Newton's physics. Its amplification of Greek Rationalism would be most strongly articulated in the Enlightenment; it would also dismiss traditional religion, displacing the passionate belief of religion into Nationalism and Capitalism, the great social experiments of AAII. By the 20th century, Western Europeans had spread their discourses throughout the world, *and* the limitations of those discourses had become evident, first, in the new sciences, and, second, in two world wars. The current period of intense globalization probably marks the beginning of the latter stage of AAII. Today, new discourses are emerging to adapt to these challenges.

One quality that makes the Life Cycle of an Attractor so valuable is its fractality. That is, one can use it to examine self-similar patterns at various scales – not merely the full panorama of human history, but also the evolution of Chinese dynasties as stable states, with interregnum periods, such as the Warring States Period or the period after the fall of the Han Dynasty in 220 CE as phase transitions. For the purposes of this paper, it may be most fruitful to look at AAII in such terms. Already, a great deal of work has been published on the economic/political cycles that have dominated the last 500 years. Arrighi's (2010 [1994]) examination of the four cycles of Capitalist development – Italian, Dutch, British, and American – and the possibility of another emerging has a striking resonance with Goldstone's (1991) cycles of population growth leading to state breakdowns. Those resonances are particularly worth exploring from a Post-Newtonian perspective, as systemic adaptations of social networks, exploring the possibilities in a phase transition in world history. Unfortunately, it is only possible to point to some of the possibilities that such a fractal approach to the life cycle of attractors suggests, but I hope the reader can understand why I find it so provocative.

This essay is only a beginning, with an outline of world history that is obviously oversimplified. However, it does suggest how a Post-Newtonian discourse differs from other approaches. By integrating the principles of complexity with such other Post-Newtonian methodologies as Latour's ANT and Barad's Agential Realism, it provides what for me is the most accurate model for understanding human behavior. Moreover, because it can be applied to Social Sciences ranging from Psychology and Sociology to History and Anthropology, from Law to Economics to Organizational Dynamics, it offers the intriguing possibility of developing one methodological toolbox available to all these. At the very least, it is well worth pursuing such an approach.

NOTE

* Much of this paper grows from the work I have been doing with Dmitri Bondarenko on a Post-Newtonian conception of history. See, for example, Baskin and Bondarenko 2011. A first version of this paper was presented at INSC 2012 in Barcelona (Baskin 2012).

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