# The role of complexity studies in the emerging "processual" worldview

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> *The computer as a research instrument provides us with a new way of seeing reality, and the architectonic of the sciences must change accordingly.*
>
> — Heinz Pagels, The Dreams of Reason

## Introduction

In February of 2007, the coauthors of this essay met at a workshop on Complexity and Philosophy, sponsored by the Institute for the Study of Coherence and Emergence, in Stellenbosch, South Africa. During the workshop, we both made presentations that applied the principles of complexity thinking to human history[1,2] and started talking about some of the implications of this approach. When we met again in 2009, we realized that we were both interested in similarities between the Axial Age (c. 800-200 BCE) and Modernity (c. 1500-the present). Both periods were times of political fragmentation, rapid technological innovation, experiments in government, reinterpretation of religion, and devastating warfare. What insights might emerge, we wondered, if we treated these two periods as what Complexity Theory calls "phase transitions," transformational periods, in the evolution of human culture?

For the next five years, we worked together to answer that question and published the preliminary product of our work, *The Axial Ages of World History*, in 2014. In the process, we stumbled across of a variety of provocative insights, which we are continuing to explore, many as a result of using the intellectual toolbox provided by complexity thinking. Perhaps the most important of these insights concerns the nature of the emerging worldview, grounded in a "second scientific revolution." This emerging worldview has received much attention in recent years.[3,4,5,6,7] This worldview was also reflected in some social sciences, especially anthropology and archaeology: the "dual-processual theory" elaborated by Richard Blanton and some other scholars in the mid-1990s, radically shifts emphasis from static and discrete societal types to processes by positing that political leaders employ one of two basic processes to build and maintain power — a "network" strategy or a "corporate" strategy.[8] At the heart of the shift to this new worldview "struggling to be born," to use Pagels' words,[3] lies the transformation from the linear, mechanical model of the older "Newtonian" world to the non-linear, "processual" model of the emerging world.

In this essay, we use the word "processual," the adjectival form of "process," to mean "relating to or involving the study of processes rather than discrete events".[9] Understanding this processual model is critical for readers of this journal because, in many ways, Complexity Theory *studies the patterns that emerge as phenomena evolve in a processual world*. And, so, in this essay, we want to examine how using the tools of complexity thinking enabled us to recognize how fundamental a processual model is to understanding the globalized world culture now developing. To do so, we shall, first, explain the emerging processual worldview and contrast it to the older mechanical view, then discuss how we used complexity tools to recognize this worldview, and conclude with some comments on the insights that emerged from viewing the world this way.

## Process vs. mechanism

The Newtonian worldview, the "master paradigm of Western civilization"[10], and the emerging processual worldview both reflect the human need to *model the world in a symbolically coherent way*.[11,12,13] Such a model provides order and meaning in societies by answering a series of critical questions: What is the origin of the world? What are our responsibilities to what Hayden calls the "powerful forces that permeate things but cannot ordinarily be seen"[14] — those that cause birth and death, abundance and disaster? How should we determine the meaning of events and behaviors? How should people interpret and respond to the behavior of others both in the group and outside it? In Western Europe, the Newtonian model replaced the Christian model of the Middle Ages. The older model viewed the world as illogical and unknowable, created and existing not in accordance with any regular laws but solely on God's arbitrariness; as a result, people had to rely on the authority of the Church and State. The new model replaced it with a knowable world, which people could understand with Science, a world where self-organization makes sense.

In a way that would shape the Newtonian worldview, mathematics, the most exact of sciences, was the gateway by which

Western thought moved from a Christian model to one that was scientific. Many of those who elaborated the Newtonian model — Kepler and Galileo, Descartes, Newton, Spinoza, and Leibnitz — were both scientists and philosophers who became fascinated with the power of mathematics to explain the natural world. Galileo, for example, described Nature as “a book written in mathematical characters”,[15] as valuable to understand God as the Bible. And God, Himself, had used mathematics to design the world as a machine. As Kepler put it, the “universe is not similar to a divine animated being, but similar to a clock”.[16] Both Christian and early Newtonian models viewed God as the source of all being. By making Him a mathematician, however, the Newtonian model made His world available to human understanding, because its creation realized God’s logical plan, not the arbitrary manifestation of His will.

The resulting Newtonian world was, like a mechanical clock, composed of distinct, reified “things” that may be contained in other things (*e.g.*, atoms in molecules or people in organizations). Mathematics was critical because human perception was a distortion of the actual world, about which mathematics could deliver the undeniable truth. And because these “things” interacted according to Universal Laws of Nature in linear, predictable ways, the future, like the past, was spread out in a deterministic dance. As Descartes explained, matter (*res extensa*) was mechanical and “dead,” and only the human mind (*res cognitans*) was alive. By learning the Laws of Nature, the scientist would be able to control Nature and bend it to the will of humanity.[17]

In pursuing this notion of science, its proponents would launch the Industrial Revolution, scientific medicine, and electricity, enabling the nations of Western Europe to colonize much of the Americas, Africa, Asia, as well as Australia and the Insular Pacific. Cities grew, trade increased, and, by the early 20th century, living standards and life expectancy were beginning to increase in this dominant culture.

As Stewart[18] notes, Newtonian science succeeded *in spite of a major limitation*. Until the development of the computer, scientists had to model their subjects with linear equations. The difference between linear and non-linear equations, as most readers of this essay know, is that linear equations can only model systems where large causes create large effects, and small causes, small effects. Non-linear equations were simply too complex and time-consuming to be widely used before computers. In using only linear equations, the world Newtonian scientists “discovered” in their models would be linear.

Ironically, but as one would expect from the law of dialectics, the success of linear Newtonian science would demonstrate its inadequacies. By the beginning of the 20th century, the advances in Newtonian science began to bring its basic assumptions into question.[4,5] Relativity and quantum physics challenged some of the Newtonian model’s most basic assumptions.[19] By 1929, philosophers such as Whitehead in *Process and Reality* were beginning to reconceptualize the world more as complex process than as machine. Currently, even the largely linear, highly successful Neo-Darwinian conception of evolution is being replaced by Evolutionary and Developmental Biology, a.k.a. EvoDevo.[20]

With widespread availability of desktop computers in the late 1970s, the final piece of the puzzle was now available to create an alternative to Newtonian science. Suddenly, scientists in fields ranging from fluid dynamics to economics and artificial intelligence were able to model their subjects with non-linear equations. These scientists quickly discovered that their subjects could be modeled much more accurately with non-linear math. As they began to discuss these findings across disciplines, Complexity Theory emerged,[3] enabling its practitioners to discover patterns that appeared across their disciplines and among many levels of scale. We suspect it will be recognized as the study of the dynamics of non-linear, processual systems, much as Newtonian physics filled the same function for linear, mechanical systems.

By the beginning of the 21st century, many of the major elements of a processual worldview were becoming clearer:

1. Einstein's equation $E=mc^2$ demonstrates that matter isn't “dead” as Descartes insisted; it's a form of energy, a “domain of *coherent* energy storage”.[21]

2. Matter exists as a nested network of such energy storage phenomena on many levels of scale. At each level, a phenomena/network is composed of agents, each of which is itself a network — atoms in molecules, organisms in ecosystems, solar systems in galaxies. Because of this networked structure, almost every phenomenon in the Universe connects through a variety of scales to almost every other.

3. These phenomena are dynamic. Everything throughout the Universe is in constant motion and has been since the Big Bang.

4. Because these networks are dynamic and intricately interconnected, causality is systemic and non-linear, rather than a matter of linear cause-and-effect, as in the Newtonian worldview. The world is “processual” — a “thick” interpenetration of many flows on many levels of scale,[22,23] rather than a simple reified collection of things.

5. With constant change at every level of scale, agents throughout these networks must continually adapt. As agents continue to adapt, unexpected events emerge because conditions continue to change. To meet these emergent surprises, phenomena in both organic and cultural networks must have ways of recognizing change and evolving new behaviors to adapt to conditions they've never known. In this way, our world becomes an evolving processual network of networks.

6. Neurobiologists have discovered that our brains construct models of the actual world that we can never directly perceive.[12,24] As a result, the job of the scientist is to create and test the best available models of that actual world so that humans can navigate a world that is beyond their ability to control.

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This table summarizes the difference between these two ways of understanding the world:

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Table 1.

Two Worldviews

| | Mechanical | Processual |
|---|---|---|
| Metaphor | Clock | Ecosystem |
| Matter | Dead “stuff” | Domains of coherent energy structures |
| Composition | Distinct reified “things” contained in larger things | A multi-scaled network of nested networks |
| Causality | Linear chain of cause and effect | Systemic process that can produce cascades of effect |
| Change | Deterministic | Adaptive and emergent |
| Perception | Distorted reflection of a directly knowable world | Brain’s construction that models a directly unknowable world |
| Science | Search for undeniable truth (immutable objective “laws of Nature”) to control the world | Building models that better enable navigation of the world, but do not claim to reflect the absolute truth |

With this new understanding, the world is no longer a collection of reified things, discrete and isolated from each other. Rather it is a very-nearly-alive universal process composed of innumerable interconnected non-linear processes, which interpenetrate each other at many scales. Whitehead describes it as a flowing “unity of becoming”.[22] Some might find it curious that this non-linear worldview should arise just at the point when the challenges created by the linear worldview are becoming critical. In fact, one might argue that many of these challenges have resulted from people continuing to experience the world through a linear model when the best way to address those challenges is non-linear.

For example, the linear *manufacturing* model is a series of actions cut off from the rest of the world, in which 1) inputs 2) are processed to create products that are 3) sold, 4) yielding either profits or losses. Because this worldview focuses almost entirely on the manufacturing as a machine, the person who “operates” it must find a place to dispose of wastes. The*effects* of that waste are *not* significant. They are not part of the model. The Capitalist operator of a corporate machine is only responsible for producing profits, as illustrated in Milton Friedman’s[25] comment that a corporation’s *sole social responsibility* is to maximize profits within the scope of the law. Such waste issues would only become visible in the mid-20th century.[26] Linear Capitalism was so deeply embedded in people’s minds that even a half-century later, people all over the world are still struggling, not very successfully, to address unavoidable problems such as ecological damage and global warming.

Similarly, a linear *healthcare* model most often depicts the patient as a “broken machine” that doctors must repair.[27,28] With contagious diseases, this model enabled researchers and physicians to see 1) an infectious agent, such as bacteria, 2) attacking a living thing 3) whose symptomatic “brokenness” could be “fixed” with a drug or surgery. While this model made it possible to perfect surgery and largely wipe out contagious diseases, such as polio or whooping cough, it also complicated care of autoimmune diseases, such as cancer or heart disease. The “cure” for such diseases today is often believed to be a fixative agent, usually a drug, even for mental illness. Yet, cancer, heart disease, and mental illness are all processual illnesses, the non-linear result of the organism working to survive in a difficult environment. There are no causative agents for these diseases, only non-linear conditions that must change.[29]

We do not mean to “blame” the world’s problems on the Newtonian linear model. In both manufacturing and healthcare, that model advanced knowledge and practice that increased living standards and life expectancy; in fact, it gave birth to modern economic and medical sciences. But it also created challenges that can best be addressed with a non-linear worldview. For any history student, this emerging view requires a very different way of thinking about the world. Complexity Theory may offer the most useful intellectual toolbox for exploring such a processual world.

## Writing The Axial Ages of World History

From the time when we started working together, our grounding in complexity thinking enabled us to put many pieces of this processual worldview in place. However, using these principles to re-examine human cultural history as a complex phenomenon enabled us to understand the emerging model more deeply and fully.

We began with this back-of-the-cocktail-napkin figure that was first published in *E:CO* nearly a decade ago[30]:

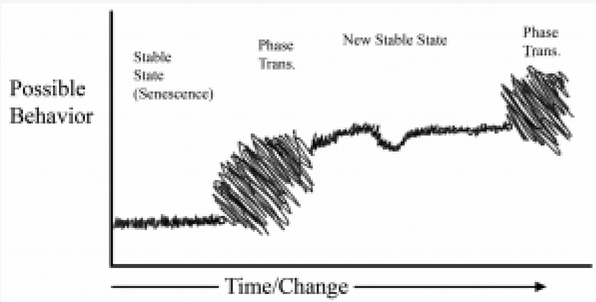


**Fig. 1: Life cycle of an attractor**

The pattern is familiar: Throw a chunk of ice in a pot on a stove and turn up the heat. It will remain ice until it approaches the melting point and, then, go into a turbulent phase transition, after which it will become water. It will then remain water until it approaches the boiling point, go into a turbulent phase transition, and become water vapor. Water can be in any of these three phases, but it can only be in one at any moment, depending on the conditions of its environment. Or watch the smoke ascend from a cigarette, alternating between a stable column and shorter swirly, turbulent patterns, until the smoke dissipates.

This pattern applies to almost any complex process that evolves over time. Some readers will recognize Punctuated Equilibrium, the pattern of ecosystem evolution defined by Niles Eldredge and Stephen Jay Gould more than 40 years ago.[31] It can also represent social processes ranging from Michel Foucault's theory of the evolution of Western culture[32] to Giovanni Arrighi's examination of Western Capitalism,[33] Miroslav Bárta's[34] analysis of Ancient Egyptian history as punctuated equilibrium to Gerhard Mensch's analysis of the cycle of economic depressions and booms.[35]

A similar pattern emerges in all these social processes: When a stable state ends, the network of living agents, ideologies and technological artifacts[36] within that phenomenon falls apart, and its agents begin to explore their current environment in a transformational phase transition. Those agents continue in that highly innovative period until they find patterns of behavior that enable them to survive. Over time, those patterns become attractors, the habits that define the narrow range of all possible behaviors characteristic of a phenomenon. Capitalism in 21st century America, Christianity in 12th century Europe, Neo-Confucianism in 15th century China — each of these terms describes the complex of ideas, stories, technologies and behaviors that characterized their societies.

As the environment of any phenomenon changes over time, it continues in its stable state and adapts to those changes. The longer those habits are successful, the deeper the relationships based on them become. If those habits continue to be successful long enough, people come to depend on the habits to support their sense of identify, their financial security, and the esteem of others. As a result, when the changes in the environment become so great that the old habits make it difficult, or impossible, to adapt, people find themselves locked in old behaviors because they fear what they may lose. The process then enters "senescence",[37] in which its agents try to force the old habits to deal with new challenges, creating a sense of crisis. Finally, these agents are no longer able to cope, the overall network falls apart, and its components re-enter phase transition (or dissipate).

When we started discussing the similarities between the Axial Age (c. 800-200 BCE) and Modernity (c. 1500 CE-the present), we noted that both were times of

- Rapid population growth — Axial Age population in the largest cities grew from about a hundred thousand to about half a million, and Modern cities from about half a million to tens of millions[38]
- Accelerated technological innovation — what the development of iron and writing did for the Axial Age, machine and printing did for Modernity
- Increased socio-cultural innovation — axial experiments in politics included the *polis* in Greece and 140 monarchies in China, while in Modernity the national state emerged
- Devastating warfare — the Warring States Period in axial China and the Peloponnesian Wars in axial Greece, or the Religious Wars of the 16th-17th centuries and the World Wars of the 20th in Western culture.

As we discussed how to examine these similarities, we wondered whether we could treat these periods as phase transitions in the evolution of human culture.

As a result, to represent the evolution of human culture over the last 50,000 years, we created a similarly informal drawing[6]:

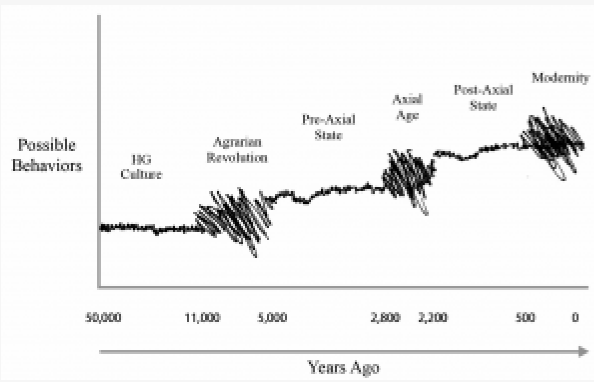


**Fig. 2: Human cultural history as "punctuated equilibrium"**

Here, rather than expressing the time axis as rising heat, as in the example of water (Fig. 1), we expressed it as increasing social complexity. In anthropology, "social complexity" is usually defined structurally, reflecting role diversity and the number of levels of socio-economic integration.[39] Where hunter-gatherer bands were largely egalitarian, often without a designated leader, by the pre-axial state, societies would include a royal court, priests, military, artisans, and a farming class.

Taking this complexity-oriented approach, we realized that social complexity grew in a self-reinforcing cycle of increased population, advances in technology, growing trade and wealth, and more involved social structures. Larger communities needed better technology to feed their members; more people interacted, exchanging ideas that created technological advances; with those advances, they made new artifacts that enriched their lives; as they created new artifacts, trade, and therefore wealth, also increased, making it possible to support larger populations. And the cycle continues today.

Until the end of the Ice Age c. 11,000 years ago, human communities were almost entirely small, nomadic, bands of hunter-gatherers. But with warmer temperatures human culture entered a phase transition, the Agrarian Revolution, as community populations increased until, by 5,000 years ago, cities such as Uruk began reaching 40,000.[38] With more experience in agriculture and new technologies to exploit it, a part of the population was freed to engage in crafts full time, and with the consequent trade, early efforts in writing and recording emerged in Sumeria and Egypt. During the Agrarian Revolution, these societies also experimented in new ways to govern larger populations, described, for example, in the well-known band-tribe-chiefdom-state schema.[40]

By 3000 BCE, a new stable state had emerged in the cultures of the pre-axial states in Mesopotamia and Egypt, and then, later, in India, China, continental and insular Greece. Across Eurasia, very different societies were organized remarkably similarly. Here, government, economics, and religion were integrated around a formal version of each society's initially oral mythology. In each state, a king with special connection to the world of the gods would be responsible for working with the gods to maintain order. The king governed through the loyalty of his inner circle. Population continued to grow, with cities reaching 150,000 by 1200 BCE.[38] Technology also advanced, with writing becoming the key to effective government. Starting about 1500 BCE, inter-society trade increased rapidly and, with it, the amounts of wealth available to people outside the royal family.[41] Then, by 1200 BCE, iron metallurgy would become increasingly widespread, and domesticated horses and use of the wheel contributed to make war increasingly devastating.[42]

By 1000 BCE, two thousand years of increased complexity was beginning to overwhelm many of these pre-axial states. The resulting social breakdown would lead to the Axial Age (c. 800-200 BCE), as the societies in Greece, Israel, India and China reinvented themselves in another phase transition. In Greece (hundreds of *poleis*) and China (140 kingdoms), for instance, these societies became politically fragmented, and people became increasingly innovative and competitive with those in other fragments. Warfare also became increasingly devastating. Partly as a result, religious thought flourished — philosophy in Greece, the monotheism in Israel, Buddhism and Hinduism in India, and Confucianism and Daoism in China — as people worked to understand how to thrive in their new conditions.

Toward the end of this period (roughly 400-200 BCE), people learned the lessons of their axial experiences. In Greece, the limitations of the *polis* non-bureaucratic political model and rationalism were becoming clear as early as the writings of Plato, in the early 4th century BCE. By the late decades of the 4th century BCE, the rise of Macedonian power signaled the form government would take in the West — bureaucratic empire. Similarly, in China, the shortcomings of multiple kingdoms became increasingly clear, and a quest for supremacy arose during the Warring States Period (403-221 BCE). At the end of that period, the Qin Dynasty established the first Chinese Empire.

This new social organization was the post-axial state (c. 200 BCE-1500 CE), as it emerged in the Roman and Byzantine Empires, several Islamic empires, and a string of Chinese dynasties. Here, the king maintained loyalty through the bureaucracy that reported to him. Religions of the Book, which had emerged during the Axial Age, became integral to the governing structure. Across these societies, writing became increasingly important. During this period, population again expanded, growing from about 250 million worldwide at the beginning of the Common Era to nearly 600 million by 1600 CE.[43] Technology also advanced, especially in China, which would introduce paper, printing and the printed press; gunpowder, guns, and rockets; clocks, machines for manufacture, and the compass.[44] Finally, trade continued to grow until, in the 13th century, the Mongol invasion spread the first Eurasian economic world-system from Bejing to Brussels.[45] By 1500 CE, this increase in social complexity was once again beginning to overwhelm the ability of post-axial states to manage their societies. The result was another phase transition, Modernity.

Modernity (1500 CE-the present) began in Western Europe, which was as politically fragmented as the early Axial Age societies, with its many kingdoms and continental empires, city-states, "free communes", principalities, and incipient nation-states. After a thousand years of political turmoil — from the fall of Rome to the Germanic invasions, the Norse and Islamic invasions, and the Black Death — people in this society began developing a cultural attractor for the modern phase transition. Politically, its innovation would move toward the nation-state. Technologically, it incorporated many of the innovations from China, as well as science from India and Islam. From firearms to the printing press to commercial machines, people in the West introduced significant improvements, both in the technology and the way they were employed.[46]

As a result, population skyrocketed, reaching one billion at the end of the 19th century and seven billion in 2011. This modern phase transition also transformed religious institutions and practices, as people adapted to increasing social complexity. By the beginning of the period, the combination of trade from the Eurasian world-system had combined with increasing use of machines to create a growing commercial class. While the old landed aristocracy was aligned with the Catholic Church, the rising commercial class would align with the Protestant movement. After a century and a half of religious wars, religion would become a matter of personal choice, rather than a vehicle for social cohesion.[47]

What seemed incredible and impossible in the Middle Ages — recognition of claims of different religious communities within one and the same society for being "true believers" and for social and political rights as equally legitimate — was compellingly set as a compromise final of the religious wars; and this was the prologue to contemporary tolerance as an important Western value.[48] Science and Capitalism then emerged to take the place of religion as the way modern society understands the cosmos and organizes itself. Politically, Nationalism would produce the group identity and excite the fervor that religion had in the medieval period. In many ways, the experiments of this phase transition were enormously successful. However, in the last 50 years, their shortcomings have also become evident, and it seems that people around the world are now in the process of learning the lessons of our phase transition, as the Greeks and Chinese, Israelis and Indians did more than 2,000 years ago.

What we want to emphasize is that the tools of complexity theory opened our study of cultural evolution up, leading us to a variety of provocative conclusions. In the rest of this paper, we want to touch on two of them — the power of cultural stories in any society's development and the richness of treating history processually.

## Our complexity-inspired insights

By applying complexity tools to the unfolding of human history, we began to understand cultural evolution as a multi-faceted and multi-directional process with identifiable patterns. At first, the clearest pattern was the alternation between social stable states and phase transitions (see fig. 2). But as we began digging into the transformations of the Axial Age and Modernity, we were surprised to realize the power of culturally shared stories in this process.

That realization began to emerge when we came across Jan Assmann's *Cultural Memory and Early Civilization*.[49] In that book, he notes how, in Greece and Israel, the axial experience begins with the transition from oral to written storytelling. As a result, both societies had a body of "foundational texts" that largely recorded a version of stories of a past heroic era — Homer's epics, for example, or the story of the Exodus. People in these societies used these stories as a sort of "cultural DNA," and experienced the results of using them as models for social behavior. Over time, they developed "canonical texts," which became the official statement, as in the accepted version of the Bible. Finally, as people in both societies moved away from the time of these canonical texts and experienced further changes, these texts became the object of commentary that enabled people to keep their canonical texts applicable to current conditions.

Assmann's schema, we soon recognized, also described the axial experiences of India and China. Even Modernity seemed to fit this pattern.

In addition, we learned that current work in neuroscience validates this analysis. Gazzaniga,[24] for example, discusses the human brain as a sort of organic storytelling machine that makes sense of what William James[50] had called a buzzing mass of formless signals. Neuroscientists have found that the brain mixes sense perception and memory, passes it through the existing models with which people interpret all those formless signals, creates a series of possible stories to explain what they are experiencing, and then chooses the story that fits best. Through explanatory stories of this sort, people map the signals of the world-as-it-is, in order to survive. Then they test their stories in action, and if the actions reflect their desires, they know those explanations are "true."

The foundational stories of the axial societies became the shared model of reality by which people in their societies lived together. The pattern of development in all the axial societies reflected the need to continue shifting in a processual world where rapid changes in population and technology, trade and wealth led to experiments in social institutions. Eventually, all these phase transition experiments created social attractor that worked in this new world — the union of bureaucratic empire and Religion of the Book.

What most surprised us, however, was the power of foundational stories to shape each society's history. In axial Greece, for example, the *Iliad*, which took its final form some time around 800 BCE, depicts a collection of independent states acting like fractious brothers until their honor is attacked by and enemy in the East (Troy). They come together to defeat the enemy and then return to acting like brothers.

And that's largely what happened. In 500 BCE, Greece was a collection of hundreds of politically independent societies (*poleis*) that fought like fractious brothers, with Athens and Sparta as leaders. In 490 and 480 BCE, the enemy from the East, Persia, invaded. In both cases, the *poleis* came together and defeated Persia. Then, safe from that threat, they continued acting like fractious brothers, and nearly destroyed their city-state experiments in the Peloponnesian War (431-404 BCE).

Suggestive as the Greek example is, it pales next to what happened with Modernity. As David Noble[51] points out, one of the foundational stories of Modernity is that of the Apocalypse, which became extremely popular around 1200 CE. According to that story, the end of the world will come through a series of events:

- Armageddon will be the final battle between good and evil;
- The elect will ascend to Heaven;
- Humankind will be perfected under the rule of Christ; and, finally,
- The blessed will have eternal life.

Nobel then points out the striking way in which this story was expressed in four important technologies in the 20th century:

- Atomic power is Armageddon;
- Space travel is the ascend of the elect;
- Genetic engineering is the perfection of Man; and
- Artificial Intelligence can provide eternal life.

In a linear, mechanical world, it seems absurd to suggest that the stories people told in the 12th Century could help create technologies in the 20th. How are we to interpret these parallels? We won't suggest that the stories were directly translated into these technologies. But in a processual world, composed of interpenetrating networks, where people model their behavior on their shared cultural stories, a relationship between stories in the 12th Century and technologies in the 20th makes a lot more sense.

Another example is Modernity's so-called "civil religions" — totalitarian ideologies (for example, Communism and Fascism). Like axial religions, they postulate the possibility of achieving an ideally perfect world, but contrary to axial religions, in this life, not the afterlife. These ideologies offer their own, atheistic, substitutions to the core ideas and principles of axial religions, justifying the power of their leaders with the canonic writings of Hitler, Marx-Lenin, or Mao, rather than sacred books.

Just as provocative was the power of a processual reading to explain key developments in any society's evolution. Consider the Religious Wars of the 16th and 17th centuries. It's easy to view this conflict, estimated to have killed about eight million people, as primarily issues of "religion" or "politics".[52] But our analysis revealed a fully processual flow that didn't add up unless we included economic and technological processes that flowed back centuries.

We were especially surprised at how strongly historical processes in China shaped our new understanding of the Religious Wars. The most important technological development making the war possible was the introduction of Guttenberg's printing press with movable type around 1450.[53] The printing press made Protestantism possible because, now, anyone with a reasonable amount of money could have a Bible. It was no longer necessary to trust the Church to communicate and interpret the Word of God. Books and pamphlets also became much more widely available so that it was far easier for people to get political thoughts to a broader audience. In this way, between 1517 and 1520 Luther's publications sold about 300,000 copies.[54] It was with the Reformation that the politics of opinion emerged. Almost anyone could now circulate a new point of view.

Of course, the printing press was not a European invention. The Chinese had invented block printing in the 8th century CE and, then, movable type in 1045.[44] They had also started making paper as early as the 2nd century BCE. So the printed material that made the Religious Wars, and Protestantism itself, possible were apparently the result of a processual flow that began during periods of intense innovation within the Chinese post-axial state.

And that's not all. One economic process that figured vitally in the Religious Wars was the rise of a wealthy commercial class across Europe, whose members would become predominantly Protestant. Two of the major processes driving the rise of that class also seem to have Chinese roots. First, the introduction of manufacturing machines, mostly using waterpower, created a first "industrial revolution" between the 10th and 13th centuries.[46] The Chinese, however, had been using water-powered machines since the 1st century CE; they had also developed a wide range of other machines, including clocks by the 8th century CE.[44] So the flow of Chinese technology westward almost certainly made an enormous contribution to the rise of the European manufacturing and commercial class.

This, of course, brings up a much-discussed question: Why weren't the Chinese able to build the modern world-system, even though they invented so many of technologies which the West would use to create Industrial Capitalism?[55,56,57] In the first half of the 15th Century, the Chinese even build the biggest, most powerful navy the world would see until the 20th Century. There is some evidence that they may even have visited and mapped the Americas.[58] Yet, they never considered conquering the world, as Europeans did, and destroyed their fleet for reasons that seem to be mostly cultural. In *The Axial Ages of World History*, we speculate that the Chinese were limited by a very old, very successful post-axial cultural attractor that limited their ability to apply those technologies to their world. At the same time, Western Europe was able to incorporate the technologies into a cultural attractor that was still in phase transition. Without the habits of thought that limited the Chinese, the people of Western Europe were able to experiment and apply them innovatively before they had become ingrained in old cultural habits.

Equally important was the trans-Eurasian trading system created by the Mongol invasions of the 13th century.[45] On one hand, this system created extensive opportunities for Europeans to participate in the trade routes that had already existed from China through Islam. On the other, it enabled the Chinese to have more direct contact and to more intensely affect Western technology. The increasing wealth that resulted from this spill-over of Chinese processual developments would help cause the Reformation. One of Luther's major targets in his efforts at reformation was the corruption of the Church, especially with the Indulgences by which the wealthy could buy papal forgiveness of their sins. As the commercial class grew in the centuries after the Mongol invasions of Eastern Europe, this corruption became more and more intense. In this way, Chinese processes affected and helped drive the events that would lead to the Religious Wars.

## Conclusion

What this sort of processual analysis suggests is that history evolves very much like the way EvoDevo suggests natural ecosystems do. In one sense, such evolution can't be understood if one focuses too strongly on any one element. Adaptive change and communication about its effects are happening throughout both biological and social phenomena. Evolution is both individual and systemic, and everything between. In both cases, it is an extremely "thick" process.

The implications here will come as no surprise to students of Complexity Theory. The need to tear down disciplinary silos, the importance of staying aware of many levels of scale, the power of feedback loops and self-reinforcing cycles — all these are likely to become increasingly important in the study, not only of history, but of all social sciences. Especially as they are approached more and more processually.

We want to close this brief discussion by emphasizing how surprised we were at much of what we realized. Complexity Theory offers a set of extremely powerful tools whose value has increased because it has emerged at a time when our basic way of thinking about the world is shifting. What we are certain of is that Complexity Theory has enabled us to understand the work we have been doing in a different and provocative way. We have even wondered whether the dynamics of complexity thinking might not replace those of Newtonian physics as central to that shifting paradigm. With that, we offer these thoughts to the reader for his or her own reconsideration.


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