Neurobiology, Stratified Texts, and the Evolution of Thought: From Myths to Religions and Philosophies

Steve Farmer, Ph.D., www.safarmer.com

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Abstract

This paper describes a general model of the origins of primitive magical and religious world-views and their transformations over thousands of years in stratified religious, philosophical, and cosmological traditions. The model draws on traditional textual research, neurobiological data, and studies of complex systems. The paper takes a genetic approach to the model, describing how fields as diverse as philology, neurobiology, and research on complex systems have been fused over two decades in a single cross-cultural theory. The paper begins by discussing collaborative studies of parallel developments in European, Chinese, Near Eastern, South Asian, and Mesoamerican traditions that first suggested the need for such a model. It continues with a look at the neurobiological origins of so-called correlative thought, which it links to the roots of magic and ritual, primitive anthropomorphic deities, and cross-cultural exegetical processes that helped drive those parallel developments. It finally describes how models of complex systems suggest designs for computer simulations of how those parallels evolved in stratified textual traditions. The paper concludes by discussing ongoing mergers of neurobiological and cultural research, contemporary issues tied to the neurobiological roots of religion, and empirical tests of the model. The latter include early challenges raised by the model to claims that the ancient Indus Valley or Harappan civilization was literate (Farmer, Sproat, and Witzel 2004) and new predictions involving recent Chinese tomb-text finds, which are rapidly overturning traditional views of the formation of ancient texts.

1. Introduction

This paper describes a general model of the evolution of premodern religious, philosophical, and cosmological systems.[1] The model covers the period from the earliest myths to the collapse of premodern world-views that began shortly before the scientific revolution. Insofar as those views affect modern thought, the range of the model can be said to extend to the present.

Parts of the model depend on two fields that have not figured significantly in previous studies of premodern religions and philosophies. The first is neurobiology, which the model draws on to explain the origins of so-called correlative thinking, which is linked in turn to the origins of magic and the anthropomorphism underlying myth and primitive concepts of deity. Neurobiology is also used to model cross-cultural sides of exegetical (or commentarial) processes involved in the parallel growth of later religious and

[1] The model is described more fully in Farmer, *Brains, Gods, and History: Neurobiology and the Evolution of Thought* (forthcoming). For earlier discussions, see Farmer 1998: esp. 91-6; Farmer, Henderson, and Witzel 2002; Farmer, Henderson, Witzel, and Robinson 2002.

philosophical traditions. The second field concerns studies of complex systems, which suggest designs for computer simulations of the emergence of key theological and philosophical ideas in textual traditions. A short list includes abstract cosmological principles and monotheistic deities, multi-layered hierarchical and emanational systems, cyclical and linear models of time, and dozens of related ideas referred to in shorthand below as "high-correlative" or simply "scholastic" structures. One design for computer simulations capable of growing structures like these is described near the end.

The model evolved over two decades from work with collaborators from a number of fields. Key coworkers include the Sinologist John Henderson, of Louisiana State University, and the Indologist Michael Witzel, of Harvard. The computational linguist Richard Sproat, of the University of Illinois, helped verify one early prediction of the model, which challenged standard claims that India's first urban society was literate. I will talk briefly at the end about how that prediction arose and how the fall of the Indus-script thesis is affecting views of literacy in ancient Eurasia in general. I will also describe a new prediction involving recent Chinese tomb-text finds, which are radically transforming older views of the formation of ancient sources.

Rather than discussing the model abstractly, I will attempt below to describe how the model evolved, which may help demystify a bit how fields as apparently unrelated as studies of premodern thought, neurobiology, and models of complex systems came to be merged in a single predictive and hence testable model. Parts of the paper may also be useful to other premodernists interested in what parts of the brain sciences and simulations of the rise and fall of complex systems might be relevant to their work.

2. Origins of the model: parallels in Chinese and Western traditions

The initial finds that gave rise to the model date back over two decades, when not long after graduate school John Henderson and I occupied adjacent offices at Louisiana State University. John at the time was finishing his classic study of 2000 years of "correlative" systems, as Sinologists have referred to traditional Chinese cosmologies since the 1930s (Granet 1934; Henderson 1984; Farmer, Henderson, and Witzel 2002). Next door, at first unaware of John's work, I was studying the same types of cosmologies in premodern Europe, although no one in the field yet referred to these as "correlative" systems. When John and I finally compared notes, we realized that our findings were far too similar to be coincidental. Levels of direct contact between China and Europe in most periods we were studying were extremely low. But despite this, we could identify dozens of similar cosmological structures rising and falling in both regions nearly synchronically over several thousand years. This finding pushed the work of both of us in comparative directions, since we recognized that we could not hope to understand the phenomena we were studying in one region while ignoring their parallels elsewhere.

Some of those parallels had been noted before. The most famous involved near synchronicities in the emergence of abstract religious and philosophical ideas throughout Eurasia in the second half of the first millennium BCE. These parallels had been highlighted in the 1940s by the German theologian Karl Jaspers, who placed them in his so-called axial age, in and around the middle of the first millennium. George Sarton pointed to further parallels extending far into medieval times in his massive *Introduction* *to the History of Science*, which appeared between 1927-53. But neither Jaspers nor Sarton (nor later Asian comparativists like Hajime Nakamura) offered any dynamic explanations for these parallels, which left their origins rather a mystery. In Jaspers' case, what little explanation was offered had mystical overtones that can be pictured as a survival of the same correlative ideas we were studying in premodern traditions. The same can be said for Jung's "archetypes," which had also been evoked from time to time to explain such parallels. This part of Jung's work is still occasionally cited, most often through Joseph Campbell's popularizations of Jung's views of myth.

Our rejection of these ideas not only involved their religious overtones, which were alien to our scientific instincts, but simpler reasons as well: the ideas we were studying were not static but evolving. High-correlative systems do not show up in early layers of Platonic or Vedic or Confucian traditions, etc. But they are found pervasively in later layers, typically in more complex forms the further you go. In the language of complex systems, these are "emergent" and not archetypal structures that just keep reappearing under different "masks," as Campbell had it. Dynamic explanations are needed to explain their growth, and none had ever been suggested that dealt with them with anything approaching the level of detail with which we were studying them (**Table 1** gives a short list drawn from a far larger set of such structures).

Table 1
A Short List of Emergent Correlative Structures

- **Primitive pantheons and early emanational cosmogonies**
- **Abstract cosmological principles and early monotheistic deities**
- **Abstract orders of elements, dualistic principles, concepts of "phases," etc.**
- **Paradoxically immanent and transcendent gods**
- **Dualistic One/many frameworks, Platonic-like participation models**
- **Abstract emanational systems with a single or periodic reabsorption into the One**
- **The transformation of real or mythical tradition founders into cosmic beings**
- **Trinitarian concepts in Buddhism, Christianity, and Hinduism, etc.**
- **Concepts of *avatars*, multiple images of Buddha, Mani, Laozi, Zeus (in Neo-Platonism), etc.**
- **Nested hierarchies in scholastic systems in general**
- **Stratified models of time (distinctions between time, eternity, aeviturnity, etc.)**
- **Cyclical cosmologies with increasingly elaborate correlative structures (cycles within cycles, kalpas and yugas, cosmologized concepts of "phases," etc.)**
- **"Typology" in linear/scaling models of time (e.g., in Judeo-Christian and Islamic thought)**
- **Emergent correlative structures of canons and texts**
- **Increasingly comprehensive mystical-magical and astrological systems**
- **Abstract hierarchies of angels, souls, bodhisattvas, demons, aeons, virtues, vices, etc.**
- **Increasingly multi-leveled visions of heaven and hell in which all levels reflect all others**
- **Elaborate formal charts of correspondences, mandalas, cosmological drawings**
- **"Double truths" in Hindu, Buddhist, Islamic, Neo-Confucian, and Christian scholasticism**
- **Increasingly complex numerological-cosmic systems (seen in Buddhist scholastics, Shao Yong, Joachim of Fiore, etc.)**
- **Exaggerated correlative systems in which everything reflects everything else ("Indra's net," Dante's multileveled picture of the cosmos, etc.)**

In any case, when we began our work, near the end of the Cold War, historical research was in a new parochial stage, and little serious comparative work was underway. In my original field, late-medieval and Renaissance studies, even passing reference to non-Western parallels was viewed as heretical; that is the dominant view in that field even today. What led me to ignore the taboos lay in the fact that one of Henderson's conclusions about the decline of high-correlative systems in China matched one of mine about their fall in Europe. One reason for that fall, which started well before competing scientific models appeared, involved radical shifts in views of books and authority, coupled with massive increases in available sources due to printing. Interestingly, similar forces were at work in late sixteenth-century China, where a second Asian printing revolution (the first took place in the eleventh century), accompanied by similar shifts in attitudes towards texts, was also occurring (Henderson 1984; Elman 1984).

These findings suggested that study of changing views of texts might shed light on the cross-cultural patterns we were studying in the evolution of religious and philosophical ideas. One obvious hypothesis worth testing had it that those patterns were correlated with shifts in information flows tied to developments in literate technologies, which were being intensely studied in the 1980s by other researchers. A second thesis had it that mythology figured somewhere in the story, as suggested by the many fragments of heavily reworked myth that show up in even the most advanced high-correlative systems.[2] The latter finding caused me to expand my studies from the latest to the earliest stages of premodern thought, including research on comparative mythology.

3. Studies of premodern cosmologies outside China and Europe

From the mid 80s to mid 90s, working at the time independently, Henderson and I began searching elsewhere for high-correlative systems like those we had found in premodern China and Europe. Our studies in this period verified that such systems evolved in all literate premodern civilizations, including those located in the New World no less than in Eurasia. Evidence in Mesoamerican traditions can be traced in the remains of pre-colonial Maya, Aztec, and Mixtec codices; in early Spanish reports of lost Maya commentarial traditions; in the *Popul Vuh*, books of *Chilam Balam*, and other colonial documents based partly on pre-Columbian sources; as well as in newly deciphered Maya inscriptions.[3] Mesoamerican traditions play a crucial role in our work due to their geographical isolation, which helps eliminate the possibility that pan-Eurasian parallels we were studying involved direct transmissions.

Parallel developments we explored in this period included the elaborate cycles-within-cycles associated with mature models of time in Chinese, South Asian, and Mesoamerican traditions; neatly scaling (or "typological") linear models of time that emerged in late-ancient and medieval Jewish, Christian, and Islamic traditions; and the

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[2] For extreme examples in Western traditions, see Farmer 1998: e.g., 314 ff. and *passim*.

[3] For an overview of recent decipherments, see among other studies Coe 1999; for colonial sources, see the succinct summary with illustrative texts in the classic study by León-Portilla 1968; cf. also the discussions of Spanish-Maya syncretism in Farriss 1984.

complexly nested hierarchies associated with scholasticism in general. One of our later conclusions, developed with the Indologist Michael Witzel, suggested that it made no obvious difference whether the traditions out of which these systems emerged were literate or orally "fixed" using the extreme mnemonics typical of early South Asian traditions. More recent evidence from excavated manuscripts suggests something similar about pre-imperial Chinese sources (for discussion, see the papers in Kern, ed. 2005, and **Section 10.3.2** below). In one joint paper we explored the hypothesis that the most elaborate of Indian mnemonic techniques may have arisen as a kind of counter-literacy when esoteric Vedic traditions were first challenged by writing in the Persian era in Gandhara (NW historical India) (Farmer, Henderson, and Witzel 2002: n. 55; a future paper expanding on this thesis is planned with M. Witzel).

Two major conclusions emerged at this time that were critical to the later development of our model. The first was the idea that attitudes towards authoritative texts were remarkably similar in different civilizations. John Henderson explored this theme in two major studies in the 90s that focused on similarities in canon formation, commentary traditions, and the twin births of "orthodoxy" and "heterodoxy" in premodern Chinese, Jewish, Christian, and Islamic traditions (Henderson 1991, 1998).

The second conclusion involved exegetical transformations of ideas that occurred in textual traditions over long periods, which eventually provided the dynamic engine for our model. This conclusion emerged out of my studies of extreme syncretic traditions, which are discussed in **Section 8** below. Exegetical methods once again unexpectedly turned out to be similar in all premodern civilizations. For reasons discussed later, use of these methods over long periods was key to the elevation of the abstract idea of correlation into a central principle in premodern cosmologies, which occurred frequently in late-ancient and medieval scholastic traditions (Farmer 1998: esp. 91-96; Farmer, Henderson, and Witzel 2002).

By the early middle ages the claim was nearly universal in Eurasian traditions that the cosmos consisted of many "levels" that somehow mirrored all others; as one striking Greek, Hebrew, Arabic, and Latin formula had it: "All things exist in all things in their own mode." Poetic metaphors expressing the same idea included visions of the cosmos as a hall of mirrors or string of jewels endlessly reflecting a single image.[4] One variant in Buddhist and Confucian traditions had it that the cosmos was like the myriad images of the moon reflected in a lake or stream. Many similar metaphors can be identified in late-medieval European, Near Eastern, Indian, Central and South Asian, and Far East Asian traditions, and in somewhat less well-developed forms in Mesoamerican sources as well. These cosmological models were often coupled with elaborate numerological concepts and cosmic notions of musical proportion whose detailed differences again suggest their mostly independent but parallel development. By late-traditional times these ideas were often embedded in neatly scaling scholastic systems and cosmological charts structured a bit like modern chemical periodic tables, to which they interestingly enough do have historical links (for an extreme example, see Farmer, Henderson, and Witzel 2002: 52,

[4] Some of the most extreme of these metaphors, involving, e.g., the jeweled "net of Indra," show up in the Sanskrit *Avatamsaka Sutra* (Flower Garland Sutra) or Chinese *Huayan* (trans. Cleary 1993), which was closely associated with medieval Huayan Buddhism.

Fig. 1, which can be viewed online). Primitive charts of this type can be traced back to the fourth and third centuries BCE in Eurasia, and many intermediate forms exist as well, which suggests that these too were emergent structures with a long history.

Structural anthropologists including Levi-Strauss and Griaule long ago argued that correlative systems a bit like these, especially those involving binary oppositions, can be identified in the earliest myths. One critique of such claims (e.g., in Goody 1977) is that claims of such structures in preliterate traditions are artifacts of the literate methods of the structuralists rather than reflections of primitive thought. But the same criticism cannot be leveled at the high-correlative systems we were studying, whose creators quite often consciously elevated the idea of correlation to the center of their systems. In any event, elaborate high-correlative systems can be identified in all mature premodern civilizations, and any evolutionary model of human thought must account for their origins.

4. Initial studies of neurobiology and the history of thought

In the early 1980s, I began exploring neurobiology for clues to those origins, working on the hypothesis that universal processing of some sort had to be involved in the parallel growth of these systems. In this period I held a series of post-docs, first from the National Endowment for the Humanities and then Harvard University, to study extreme syncretic systems, whose role in this story I discuss later. This also gave me three years to explore the technical literature in neurobiology, which I have tried to track ever since.

My timing was lucky, since in the 1980s the revolution in the neurosciences that now generates tens of thousands of papers yearly was just beginning, and it was still possible to follow key developments in the works of a few major figures. Building on earlier seminal studies by Mountcastle and by Hubel and Wiesel, researchers by the mid 1980s including Edelman, Merzenich, Hopfield, Llínas and Pellionisz, McClelland and Rumelhart, Sejnowski, Changeux, and Goldman-Rakic — there were others, but these (with a few earlier figures including Luria, N. Bernstein, Penfield, and J.Z. Young) were the ones who most grabbed my attention — were building the first global models of how brains map reality, backed at times by early simulations of neural networks. By luck, my introduction to the field came in a pair of now-classic papers by Edelman and Mountcastle (1978) that highlighted brain symmetries that were oddly reminiscent of the correlative structures that Henderson and I were studying in the historical realm.

Neurobiology currently factors in our work in three primary ways. The first provides a model for what might be characterized as the "default conditions" behind primitive correlative thought — the grounds of imitative magic, linguistic realism (the belief that words are tied to reality, which also has a magical component) and related concepts that eventually factored in the growth of high-correlative systems. The second is pertinent to the origins of man's god- and myth-making tendencies, which (see **Sections 6** and **10.2** below) can also be tied directly to correlative thought. The third involves cross-cultural ways in which premodern commentators and other exegetes worked up stratified traditions over thousands of years, which is critical to dynamic sides of our model.

Other parts of our work draw on neurobiology in ways I can only mention here in passing. One involves neural and behavioral mechanisms involved in cultivating vivid dreams and waking visions, which played a major role in textual exegesis as well as in the genesis of early religious and philosophical traditions (for cross-cultural examples, see Bulkeley, ed., 2001). Another involves the heightened role that memorization played in traditional thought, which can be coupled through neurobiological theory to the origins of the extreme views of textual authority associated with premodern traditions. These issues are discussed in a book-in-progress that expands on the topics sketched in this talk.

Below, I focus on the three main topics noted above, starting with the neurobiological origins of correlative thought, which provides the foundations of our model.

5. Brain symmetries, 'topographic maps,' and correlative thinking

Symmetries in brain structure that can be linked to correlative thought have been studied by neuroanatomists since the late nineteenth century. Microscopic studies relevant to the issue began in 1887, when the great Spanish anatomist Santiago Ramón y Cajal first applied Golgi's staining methods to the cerebral cortex (or neocortex) — the thin outer sheet of brain tissue, 2-4 mm thick in primates, critical to higher brain processing. Cajal's exquisite drawings in *Textura del sistema nervioso del hombre y los vertebrados* (1899-1904) highlighted vertical symmetries in neural organization that extended throughout the cortex. By the mid 1920s, the German anatomist Constantine von Economo had applied the label "columns" to these vertical assemblies; the suggestion that these were basic functional units in higher brain processing was made in the late 30s and 40s by Cajal's student, Rafael Lorente de Nó, based on the latter's studies of synaptic links within individual columns. We know today that long-range links also bind cortical columns to others in distant cortical regions and subcortical centers (Economo 1925; Lorente de Nó 1938; Mountcastle 1957, 1978, 1998). In 2004, the first attempt was announced by IBM and an international research consortium, headed by Henry Markram of the École Polytechnique Fédéral de Lausanne, to use supercomputers to simulate data processing in these nearly crystalline neural input-output units (**Fig. 1**).

The fact that different cortical regions process different types of data has been known again since the nineteenth century, based on studies of brain-damaged patients and microscopic studies of cell types in different cortical regions. By the early twentieth century enough data were available from the latter studies to create detailed maps of the cortex. Despite major advances in the last century, most cortical areas are still best-known by the numbers Brodmann assigned to them in 1909 based on such data (**Fig. 2**).

Information on how data processing occurs at the neural level in single columns had to await the appearance in the late 1950s and early 60s of single-neuron recording methods, which provided the key trigger of the current revolution in the brain sciences. Single-neuron recordings of the first area of the somatic sensory cortex (Brodmann area 1) of cats by Mountcastle (1957), followed by studies in the 60s by Hubel and Wiesel of the cat's primary visual cortex (Brodmann area 17), suggested that specific columns were dedicated to highly specialized computations — starting with primitive "feature detection" in these primary perceptual areas, located in the back half of the cortex. Mountcastle, for example, showed that columns in the somatic sensory cortex are tuned to specific types of tactile data. Hubel and Wiesel later identified similar detectors in primary visual cortex; these include columns that preferentially detect lines oriented in one direction or another in narrow regions of the right or left visual field; other columns

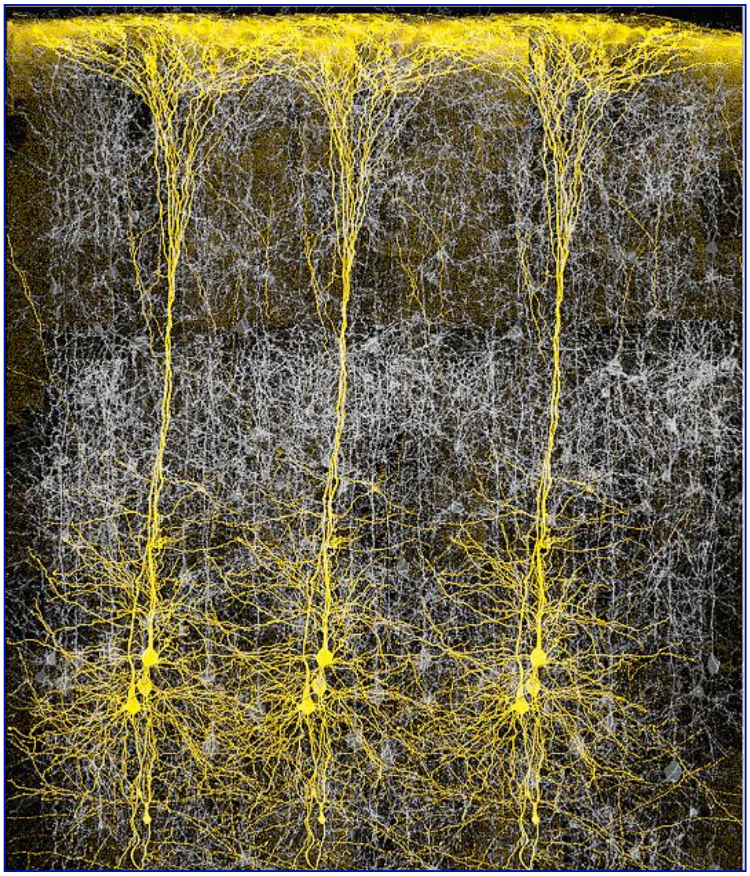
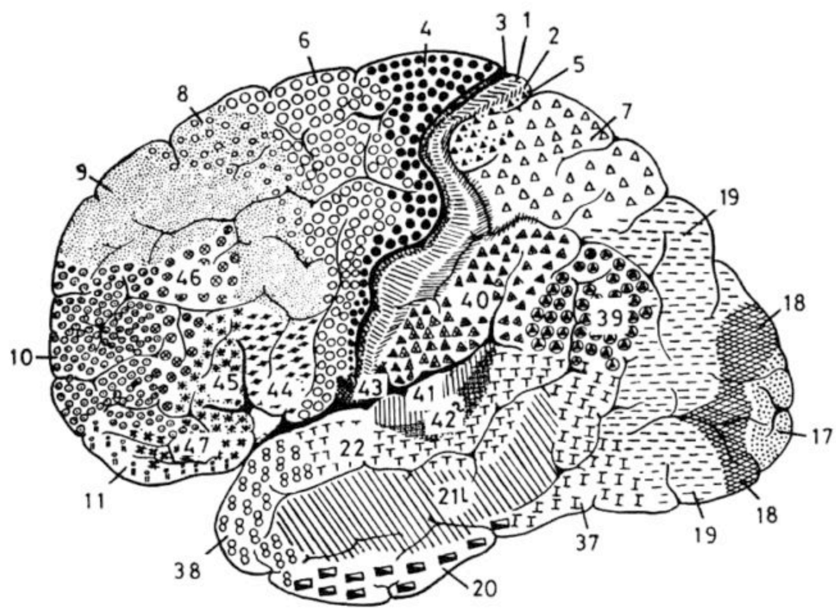


Fig. 1. Illustration of some of the vertical symmetries in cortical columns, the central processing units in the cerebral cortex. (Equally dramatic symmetries exist in the horizontal direction.) Image adapted from "The Bluebrain Project," École Polytechnique Fédéral de Lausanne, which highlights large pyramid output neurons located in layer 5 (out of 6) in the columns. Other neurons involved in columnar circuits are shown in the background.

Fig. 2. Brodmann's designations of cortical areas, based on anatomical divisions and differences in neural cell types. Brodmann's numbers are still often used alongside more recent labeling conventions derived from functional and not anatomical criteria. Posterior regions of the cortex are primarily devoted to sensory processing (e.g., areas 17-19 refer to visual cortex and areas 1-5 to somatic sensory cortex) while the most anterior regions in the prefrontal cortex (including here Brodmann areas 8, 9, 10, 11, 44, 45, 46, and 47) are responsible for higher cognitive functions. After Korbinian Brodmann, *Vergleichende Lokalisationslehre der Grosshirnrinde* (Leibzig, 1909)



are sensitive to lines oriented in the same direction but only in the opposite field; and so on for other primitive visual features (for reviews, see Hubel and Wiesel 1968, 1977). Later workers used similar methods to identify feature detectors in the primary auditory cortex (Brodmann areas 41 and 42), including those tuned to specific frequencies in left and right auditory fields.

As recording methods improved, in the 80s and 90s, researchers began using multiple-neuron recordings to study how processing occurs in columns further forward in the cortex, which are known from studies of brain-damaged patients to be associated with advanced perceptual and cognitive processing. These include regions in which the sensory features studied by Mountcastle and Hubel and Wiesel are recombined in monosensory and then multisensory integration centers to create coherent topographic (or in our terms, correlative) maps of the world. It is in these topographic maps that we locate the neural grounds of correlative thought in the historical domain.[5] Key experiments in this period by Goldman-Rakic and her coworkers (cf. Nauta and Feirtag 1986: 303, 307) suggested that topographic processing in columns extends all the way into the prefrontal cortex (Brodmann areas 8-11 and 44-47), which can be crudely pictured as containing the most abstract "maps of maps." Different areas of the prefrontal cortex, which is densely connected to every other brain region, are critical to the regulation of emotion, to simulations of the future, to the operation of working memory, and to the generation of abstract models of the social and exterior worlds (cf. Fuster 1997; Grafman et al. 1995). It is for this reason that a long line of neurobiologists including Luria have referred to the prefrontal cortex as the "organ of civilization" (cf. esp. Goldberg 2001).

As recording methods improved, researchers began to develop abstract models that picture the cortex as a hierarchical stack of topographic maps in which sensory data are processed in posterior and cognitive data in anterior regions. More sophisticated models stressed the distributed nature of neural processing, in which perception and cognition arise out of synchronic firings of widely distributed neural assemblies, coordinated by re-entrant (looplike) feedback and/or feedforward links (for early models of this class, see Mountcastle and Edelman 1978; Rumelhardt and McClelland 1986; Edelman 1987; for recent experimental evidence that confirms and extends these ideas, see Sporns and Honey 2006; Bassett et al. 2006). Leaving aside the issue of distributed processing, it remains useful in a first approximation to model the cortex as a stack of topographic maps in which "the frontal hierarchy is the mirror image of the posterior hierarchy," as Fuster (1997: 212) suggestively puts it, or in which the prefrontal cortex is pictured as a "map of the whole cortex" (Goldberg 2001: 36). The parallels with the correlative structures we were studying when these ideas first began to appear were striking, although it took us nearly a decade to link the neurobiological and historical data.

Definitive arguments for why neural maps are organized topographically were lacking until the early 1990s, when animal experiments demonstrated that symmetry in brain maps is a requirement at a minimum for the orderly merging of sensory data (Stein

[5] The phrase "topographic map" refers to the fact that spatial relations between cortical columns are preserved in synaptic projections to other cortical and subcortical processing centers. On the origins of these correlative maps, see below and the following note.

and Meredith 1993) (**Fig. 3)**.[6] The symmetries in cortical structure that facilitate these mergers are rooted so deeply in the brain that experimental rewiring of subcortical visual regions to auditory cortex result in primitive visual responses, as Sharma et al. (2000) have shown in a remarkable series of animal studies. The dependence on cortical symmetries in sensory integration has now been demonstrated as well in humans using non-invasive imaging methods (Teder-Salejarvi et al. 2005). When damage occurs in regions critical to sensory integration, perception of the world may be deeply fragmented, as illustrated dramatically in a famous case study of Luria's (Eng. trans. 1987).

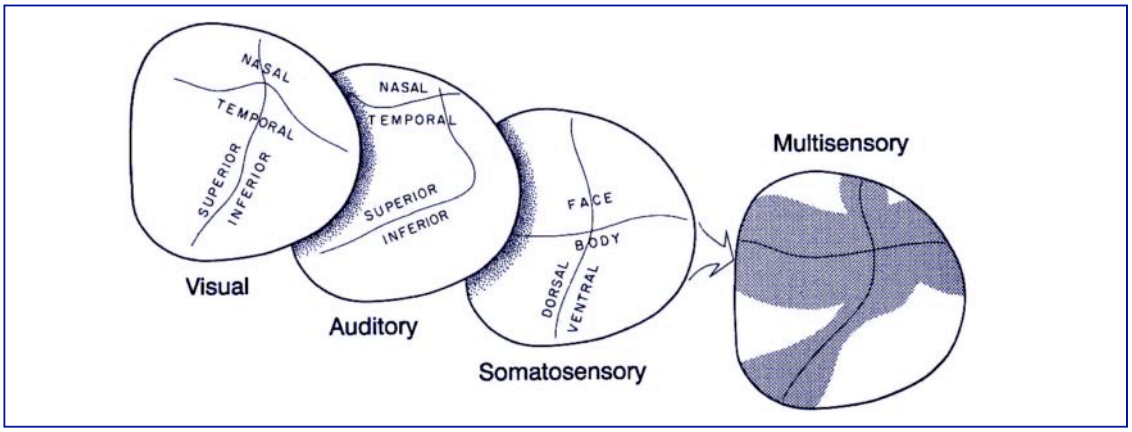


Figure 3. An abstract representation of the integration of topographic (or correlative) maps involving vision, hearing, and touch in multisensory integration centers, in this case in a subcortical region (the superior colliculus). Both animal and human studies suggest that the step-like integration of perceptual and cognitive maps generated in different regions of the cortex requires that data in those regions be organized in structurally topographic fashions. In the absence of such symmetries, reality is perceived in a fragmented fashion. Diagram adapted from Stein and Meredith (1993).

Conversely, individuals with the odd condition known as synesthesia experience exaggerated correlations of sensory data, in some cases "tasting" words, or "seeing" colors, etc. This makes synesthetes ideal models for studies of correlative thinking and closely related phenomena including imitative magic; the condition at present is being intensely studied for the light it throws on cortical integration in general.[7] Recent work suggests that synesthesia may have several causes, as Hubbard and Ramachandran (2005) stress in a recent review. But a growing consensus exists that at least one version of synesthesia consists in nothing but a heightened consciousness of normal sensory

[6] It has also been shown that multilayered topographic (or correlative) maps are self-organizing features in computational models of brain development, which suggests that such maps may maximize the efficiency of data processing in distributed systems (Obermayer and Sejnowski 2001; Bednar, Kelkar, and Miikkulainen 2004; Sullivan and de Sa 2006). For recent neurobiological studies supporting this view, see Bassett et al. 2006. For discussion of these findings in a cultural context, see Farmer (forthcoming).

[7] Synesthesia, which since the late nineteenth century was largely viewed as a neurobiological curiosity, is currently witnessing an explosion of interest due to the light it throws on this issue. Remarkably, one-third of the roughly 125 papers on synesthesia (or synaesthesia) listed in the National Library of Medicine's PubMed data base by the end of 2006 were published that year.

integration going on constantly in all of us (Ward, Huckstep, and Tsakanikos 2006; Mulvenna and Walsh 2006), which again suggests the deep neurobiological origins of correlative thinking. This view finds further support in the fact that synesthetic experiences can be readily induced in normal subjects by use of hallucinogenic drugs, which were widely employed in ancient religious-magical traditions. Further evidence pointing in the same direction shows up in research on cross-modal sensory effects, including shifts in vision that can be induced in normal subjects by altering auditory input (Dijklerman and de Haan, in press).

Strong arguments exist that the effects of art depend in part on synesthetic responses. This is illustrated most dramatically in music, whose emotional effects appear to rely on topographic links between the cortical and subcortical systems that process motor, auditory, and emotional data. Suggestions of the cultural significance of these links show up in the discussions of ethical and ritual-magical effects of music in ancient exegeses on the Vedic *Samaveda*, Confucian *Liji* (Classic of Rites), Platonic *Republic* and similar works, whose views were expanded in later high-correlative systems. The idea was common in any event throughout the premodern world that individuals, societies, and the cosmos as a whole could be "tuned" by use of music, especially in ritual settings.

It should be noted finally that correlative brain maps are not static but highly plastic structures: crude maps are laid out genetically and in fetal development, but final response patterns are fixed by experience, which in humans involves massive cultural input. The mechanisms involved in map formation include over-production of cortical circuits followed by cultural and experiential "pruning" of unused circuits that involve selective processes similar to those in evolutionary and immunological theories (Edelman 1978, 1987; Changieux 1985; Le Bé and Markram, 2006). Of special significance to brain-culture interactions is the fact that this pruning occurs in a series of critical periods or "maturational windows" stretching from childhood to early adulthood, resulting in long-term adjustments to brain structure in which cultural input is crucial (cf. Julesz and Kovács 1994; Goldberg 2001; Wexler 2006).

Recognition of the role that culture plays in shaping the brain forces a major revision of the standard view that human brains have not changed significantly for 40-50,000, or on some models hundreds of thousands, of years.[8] While in a phylogenetic sense human brains may have evolved little over tens of millennia, in an ontogenetic sense they are restructured in each generation, with the most far-reaching changes occurring in these maturational windows. One implication of this finding is that it is not possible to neatly separate biological and cultural factors in brain development; this suggests in turn that existing divisions between neurobiological and cultural studies must be bridged before either field can fully mature (see further **Section 10**, below).[9] A second implication is that brains shaped in different historical environments can be expected to process data in significantly different ways; moreover, due to variations in personal experience, major

[8] For overviews of competing models, see Henshilwood and Marean 2003; Wong 2005.

[9] Cf. Goldberg 2001; Wexler 2006. Similar arguments apply to the co-evolution of brain and culture in a phylogenetic sense; for one influential model, see Deacon 1997. In a sense, the increased availability of unallocated cortical space that emerged with the mature brain 50,000 to 200,000 years ago made further genetic evolution of the brain unnecessary. In one obvious example, cortical plasticity allowed the brain to adapt to writing in historical times without apparent genetic change.

differences at a detailed level can be expected as well in the specific perceptual, cognitive, motor, and emotional correlations made by individuals. The latter finding undercuts socially deterministic models of the origins of early cosmologies of the type Durkheim popularized in the early twentieth century, as demonstrated in a dramatic series of New Guinea field studies by Barth (1987).[10]

Advances in studies of neural plasticity in the 80s have deep implications for brain-culture interactions that are still being worked out two decades later. In one famous set of experiments, Michael Merzenich and his colleagues at the University of California at San Francisco demonstrated that surgical alteration of the hands of macaque monkeys resulted in correlative shifts in the cortical maps of the hand in the somatic sensory cortex (Merzenich et al. 1984). At the time of these studies, restructuring of brain maps was thought to take weeks or longer, but recent work suggests that cortical rewiring is continuous, with major shifts in early development especially occurring on a time-scale of minutes or hours (cf., e.g., Le Bé and Markram 2006).

Studies of neural plasticity provide support for hierarchical models of the nervous system as a whole as a multi-layered structure in which changes on any one level affect all others in correlative ways. One result is that activation of cortical or subcortical maps encoding one type of sensual, emotional, or cognitive data can be expected to trigger analogical responses in distant maps that are similarly structured. Correlative processes of this sort are presumably tied to the root metaphors that George Lakoff and his coworkers locate at the deepest semantic levels in language, in which emotional, perceptual, and cognitive reactions appear to be similar though not identical in different linguistic milieus (cf. Johnson and Lakoff 1980; Feldman 2006). Shifting from the linguistic to historical realm, we find that similar dynamic processes were associated worldwide with high-correlative systems, in which changes on any level of reality were typically said to affect all others. Numerous examples of this principle show up in magical traditions, astrological systems, theories of omens, and political-cosmological theories in every mature premodern civilization known (**Fig. 4**; see also *infra*).

Recognition that the correlative systems that Henderson and I were studying mirrored correlative structures in the brain did not explain how those systems evolved. If brain symmetries were all that were required, you would expect to find high-correlative systems in the oldest layers of textual traditions, and that demonstrably is not the case. To understand the emergent sides of these systems, we first had to investigate how primitive correlative ideas were amplified and systematized over millennia in literate traditions. But suggestions that the roots of correlative thought lay in neurobiological principles did solve one part of our puzzle — by demonstrating that the brains that generated this type of thought were themselves correlative devices, through and through.[11]

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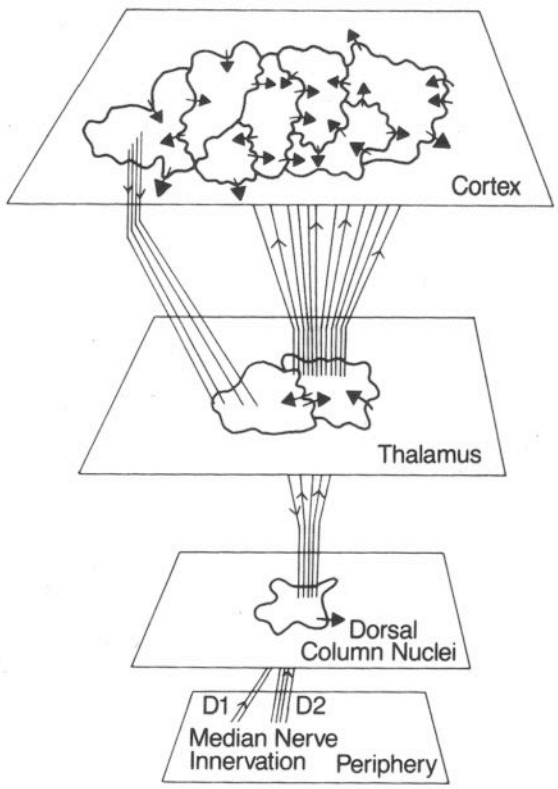
[10] The issue of how specific correlations become more-or-less fixed in later literate traditions involves the generation of the kinds of "path dependencies" discussed in **Section 9**. See further on this topic Farmer, Henderson, and Witzel 2002.

[11] Other sides of topographic (or correlative) processes in neurobiology and inter-brain communications are discussed in Farmer (forthcoming). Key to these processes is the general concept of phase locking, which ties together a variety of phenomena including the synchronization of heart beats, of movements of fishes in schools or birds in flocks, of menstrual cycles in cohabiting women, and of fireflies firing in sync. For an engaging non-technical discussion, see Brown 1991.



Schematic diagram of dynamic vertical and horizontal reentrant connectivity across a linked system of laminae and nuclei. Changes in any one level must result in readjustment of all "linked" levels.

Figure 4. Diagram of dynamic principles in the nervous system, adapted from Gerald Edelman's classic study of selection principles in neurobiology, *Neural Darwinism* (1987). This part of Edelman's work drew in part on experimental studies earlier in the 80s by Merzenich and his coworkers, which provided dramatic proof that changes in major brain systems affect linked systems in topographic or correlative ways.

Edelman's original caption could be applied without change to the dynamics of virtually any premodern correlative system: "Changes in any one level must result in readjustment of all 'linked' levels."

6. Anthropomorphism: correlative brains as myth- and god-generators

The second contribution of neurobiology to the model involves testable theories it proposes for the origins of early man's myth- and god-making or anthropomorphizing tendencies. The model pictures these tendencies as joint products of two forces: heavy social biases in cortical processing and the systematic ways in which early developing cortical maps guide the structural growth of later ones.

Social or anthropomorphic biases in cortical processing are a major element in social models of the origins of intelligence, which have become increasingly influential since they were first introduced four decades ago (Jolly 1966; Humphrey 1988; Barrett and Henzi 2005). In brief, these models hold that the enlarged primate cortex, and in humans particularly the prefrontal cortex, evolved to enhance survival in complex social environments, and not to facilitate more abstract types of calculations. Social deception provides one element driving cortical expansion in these models: hence the term "Machiavellian intelligence," which was applied in the 1980s to the best-known version of these models (Byrne and Whiten, eds. 1988). Many variations of these models now exist, and recent studies suggest that tool use and benign social adaptations probably exerted selective pressures in cortical expansion no less critical than social deception (Reader and Laland 2002; Cheyney and Seyfarth 2002). But the whole class of models does parsimoniously explain well-known imbalances in the allocation of cortical space: by far the largest part of human cortex is dedicated to processing data involving faces, gestures, language, sexual cues, and social signals, etc., and not socially neutral data. Moreover, deception clearly does play major roles in the primate world, as shown in a variety of well-designed field studies (Cheyney and Seyfarth 1999). In humans, the enlarged cortex among much else allows us to invent stories and tell lies, whose uses in social conditions in which survival and reproductive success may be enhanced by manipulating others can hardly be discounted. One recent paper by Byrne and Corp (2004) argues that primate "deception rates" are directly proportional to cortical size.

Social biases in cortical processing can be coupled with early man's god-making and myth-making tendencies when we consider those biases in relation to known principles of cortical development. Recent non-invasive imaging studies, including functional magnetic resonance imaging (fMRI), have confirmed earlier suggestions that the cortex develops in highly programmatic ways, with primary perceptual areas maturing first and the prefrontal regions most involved in model generation last; complete anatomical maturation of prefrontal regions does not occur until late teens (Gogtay et al. 2004; for discussion of the cultural implications of this pattern, see Wexler 2006). Moving from the anatomical to the functional level, research in the last decade suggests that the generation of cortical maps follows the identical pattern, with early maturing maps guiding the formation of later ones. One reason for this pattern is presumably to preserve the symmetries required for the orderly integration of sensory and cognitive data; this thesis is supported by the fact that aberrant map formation in perceptual regions is typically coupled with major deficits in cognitive regions that mature later. Studies begun in the early 1990s, led by Merzenich and his coworkers, have explored this issue in respect to dyslexia and closely related learning disorders, whose origins on their model can be traced to early distortions of maps in perceptual areas. Remediation in this case focuses on exploiting latent plasticity in those areas with intense perceptual retraining, with the goal of restructuring cortical maps from the bottom up (Tallal, Merzenich, et al. 1998; Temple et al. 2003).

Studies of the topographic ways in which cortical maps are shaped can be used to explain why young children systematically overextend social concepts in their earliest models of the world, as first emphasized in the 1920s and 30s by early students of cognitive development including Piaget, Vygotsky, and Luria (for religious sides of this issue, see also Guthrie 1993, 2002). Familiar expressions of these tendencies show up in the human features (especially faces) that normal children inject into drawings of the sun, clouds, and even houses; and in the talking animals in human social settings that are universally prominent in children's stories. When social biases in early map formation are absent or attenuated, as we find in the case of children with autism and related disorders, the consequences in later cognitive development are typically catastrophic.

The suggestion of these findings is that the social and anthropomorphic features of myth and primitive concepts of deity can be modeled in a straightforward way as joint products of heavy social biases in early cortical processing and the topographic ways in which cortical maps are formed. Given how deeply these tendencies are rooted in cortical development, it is easier to explain why humans build anthropomorphic models of the world than it is to imagine how such tendencies can be overcome. This problem can be tied to the persistence of primitive religious ideas even in technologically advanced societies, which remains a global problem hundreds of years after the Enlightenment.

I return to further sides of this issue, including specific ways to test this part of our model, in **Section 10.2**, below.

7. Neurobiology and exegetical 'engines': the rise of high-correlative systems

Neurobiology's third contribution relates to the dynamics of our model, which pictures key structural developments in religious and philosophical traditions as byproducts of exegetical processes operating in those traditions over long periods. Our studies in the 1990s unexpectedly suggested that exegetical methods were similar worldwide; the most common amplified the correlative features of the texts or traditions to which they were applied. Neurobiology helps explain the cross-cultural similarities in these methods, which involve a limited range of allegorical and scholastic techniques, each possessing well-defined systematic effects.[12]

Premodernists increasingly recognize that much of what is traditionally represented as speculative thought emerged from exegetical attempts to harmonize and systematize earlier traditions. The origins of dozens of key religious and philosophical ideas can be traced to exegetical processes, whose operations can be studied in glosses, scholia, commentaries, and many different types of scholastic texts. Even the earliest Eurasian textual canons, which began to form in the middle of the first millennium BCE, were heavily stratified works, reflecting their origins in complex mixtures of oral and written sources. Early attempts to harmonize these sources promoted the rapid growth of the abstract religious and philosophical systems that suddenly emerged from Greece and the Middle East to India and China in the last half of the millennium, some still surviving at the foundations of modern religious traditions. One key to the emergence of these canons lay in the expanded use throughout Eurasia in this era of lightweight writing materials, which facilitated the rapid collection and syntheses of older traditions. One key force in the pan-Eurasian spread of this technology was apparently the Persian Empire, which by 500 BCE had promoted the use of simplified scripts and light-weight writing materials from Egypt to NW India and Central Asia — right up to China's doorstep.[13]

Ironically, authorship of these stratified canons was typically assigned to divine forces or to fictional or semi-fictional wisemen — "Moses" or "Vyasa" or "Laozi," etc.[14] — creating obvious problems for exegetes who pictured these texts as unerring holy

[12] Farmer 1998; Farmer, Henderson, and Witzel 2002. For a summary chart of a dozen or so exegetical methods and their systematic effects, see the Appendix in the latter study. A reprint can be downloaded from http://www.safarmer.com/neuro-correlative.pdf.

[13] For earlier discussion of these issues, see Farmer 1998: 78-9 and n. 52; Farmer, Henderson, and Witzel 2002. The issue of the relationship between oral and literate traditions in India is discussed briefly in the latter paper; see esp. n. 55. On the interesting mix of oral and literate traditions in China in the last three centuries of the pre-common era, see the important studies in Kern, ed. 2005.

[14] The fictional or semi-fictional nature of many of these figures is often suggested even in their names. Thus Vyasa = "The Compiler" and Laozi = "Old Master," etc. Traditional views of Plato and Aristotle and Confucius and the "historical" Buddha have more similarities to these figures than is commonly admitted. Recent evidence on the latter point is reviewed at length in Farmer (forthcoming).

scripture. Inconsistencies continued to pile up as glosses, scholia, and later interpolations found their way into these texts, as traditions were updated to reflect changing doctrinal or political needs, and as local and foreign traditions syncretically merged. In periodic classicist or religious revivals, most associated with eras of rapid textual growth, a few outer scholastic layers might be shed;[15] but older strata normally remained untouched, and the usual pattern in textual traditions until early modern times involved increasing and not decreasing levels of textual layering. Anti-text movements, again associated most often with periods of textual growth, frequently ended in the establishment of their own textual canons; evidence of anti-text formulas being memorized or even chanted to preserve the exact words of founders of anti-text schools provides a poignant reminder of the strength of traditional views of textual authority.[16]

From case studies of a wide range of commentary traditions, by the 1990s Henderson and I had identified similarities in the exegetical strategies (Henderson 1992, 1998) and specific exegetical techniques (Farmer 1998; Farmer, Henderson, and Witzel 2002) of commentators and exegetes in every global region. Eventually we were able to link these similarities to the limited ways the brain has available to harmonize discordant data in general, most of which involve correlative processes. We also showed that repetitive use of those methods could efficiently explain the parallel developments we had earlier identified in the evolution of high-correlative systems; and this in turn allowed the design of computer simulations capable of mimicking those long-range patterns of growth.

To summarize this part of our model quickly: There are only so many ways to reconcile discordant texts; the result is that reciters, scribes, and exegetes in every civilization were forced to draw repeatedly on the same basic sets of exegetical techniques, resulting over long periods in the convergence of the abstract structures of the systems they created. Which methods they used out of the dozen or so basic types available can often be predicted by applying best-fit rules that match these methods to specific types of texts or exegetical tasks. Random elements in those choices prevent the resultant systems from being deterministic in traditional senses of that term; but once a basic exegetical pattern was established in a tradition, the same methods tended to be applied repeatedly in later strata of that tradition, as early commentators who used those methods gained authority and exegetical reshapings of the tradition increased the fit between those methods and later exegetical tasks;[17] the result was a relatively high degree of predictability in respect to the long-range structural growth if not to the specific contents of single traditions. Local cross-breedings of traditions tended to give systems in given geographical regions strong family resemblances that helped distinguish them from those in distant regions; but so long as textual layering piled up at more-or-less similar

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[15] The canonical examples involve the classicist and Protestant revivals of fifteenth and sixteenth century Europe. On parallel movements in China in the later Ming dynasty, see Henderson 1984; Elman 1984.

[16] The first major development of these movements shows up from Greece to India and China in the fourth and third centuries BCE in Pyrrhonian skepticism, in later Vedic traditions (seen, e.g., in the account of Kautsa in *Nirukta* 1.15), in early Buddhism, and in certain sides of Daoism. For discussion, see Farmer, Henderson, and Witzel 2002: 69 ff. On ways in which neurobiological changes involved in extensive memorization enhanced concepts of textual authority, see Farmer (forthcoming).

[17] This is an example of so-called historical lock-in and path dependencies in evolving complex systems; for discussion, see below, **Section 9**.

rates in distant traditions, the levels of complexity of the systems that emerged out of those traditions remained similar as well, no matter what their differences in detail. Throughout mature Old World civilizations, rough synchronization of those rates was facilitated by pan-Eurasian demographic trends and fairly rapid dispersals in literate technologies; this resulted in similar patterns of growth in religious and philosophical traditions that were independent of direct transmissions of ideas.[18] This helps explain the large-scale parallels Henderson and I had found in Eurasia from the mid-first millennium BCE to late-traditional times, even when levels of cultural contact were low (see **Fig. 5**).

The thesis that exegetical processes operating over long periods could explain major developments in religious and philosophical traditions clashes with thousands of years of assumptions that those traditions were products of human genius or even divine inspiration. It is not easy to challenge assumptions like these, and partly because of this, it took us nearly a decade to work out the final details in our model and to test its empirical predictions, some of which are reviewed in later sections.

8. On reconciling the irreconcilable: syncretic 'laboratories' in history

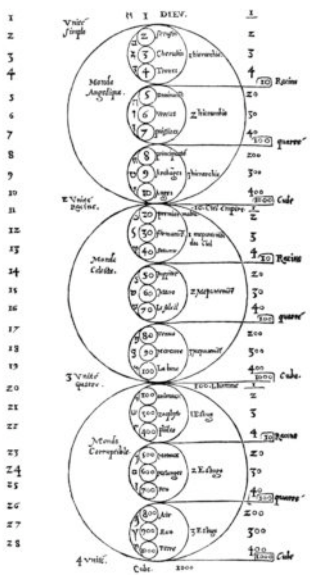
One reason why exegetical processes are not recognized more widely as engines of cultural change lies in the slowness of those processes. It is often possible to work through hundreds of pages of exegetical sources, each packed with obscure technical terms specific to one tradition, before encountering a single novel idea. The snail pace of such developments often renders major innovations nearly invisible even to the few researchers who specialize in commentary traditions. A bit as in evolutionary theory, mutations of ideas in such traditions only become obvious when large numbers pile up over long periods; moreover, most intermediate forms are lost, typically making it impossible to identify the first appearance of even key religious and philosophical ideas.

One class of texts is an exception to this rule: extreme syncretic works that merged traditions with abandon. Such works appeared in every premodern era in which information flows rapidly increased. Some of those increases followed innovations in literate technologies; others political expansions that brought foreign traditions into closer contact; others demographic expansions or growths in trade that had similar effects. Regions located at major cross-roads, like Gandhara in NW India (modern Pakistan), or Alexandria in Hellenistic Egypt, served as syncretic nodes over long periods in which traditions merged at accelerated rates, highlighting the links between exegetical processes and developments in ideas. Expanding our biological metaphor: these regions serve roles in the history of thought similar to those played in biology by periods of punctuated equilibrium, in which evolutionary processes suddenly speed up.

The usefulness to our model of research on syncretism emerged from my textual studies of one of the most extreme syncretists ever, the Italian philosopher Giovanni Pico della Mirandola (Johannes Picus Mirandulanus, 1463-94). Pico lived at the end of four centuries of textual revivals and the start of the printing revolution, which brought to a

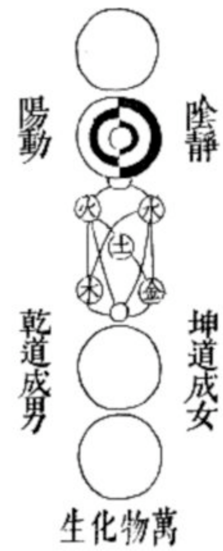
[18] Obviously long-range transmissions did occur, e.g., in the spread of Buddhist traditions from India to the East, or in Arabic transmissions to the West in the later Middle Ages. But on our model such transmissions were not needed to keep rates of structural growth in Eurasian traditions more-or-less in sync.

Fig. 5

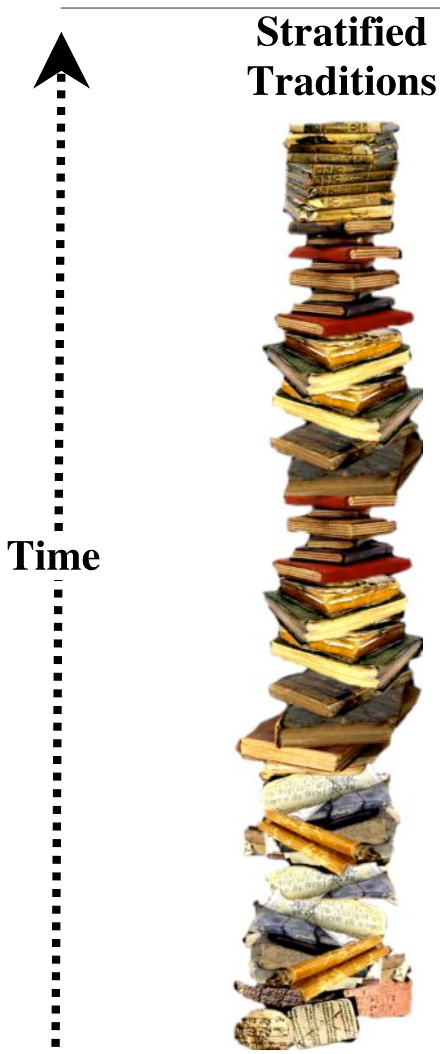


5a

5b



5c



Scribes, reciters, and commentators in Eurasia from the mid-first millennium BCE (earlier in special cases, e.g. in respect to Egyptian funereal texts) until just before the scientific revolution tended to apply similar exegetical strategies to successive layers of stratified textual traditions. The result is that the high-correlative systems (in both verbal and iconographical forms) that grew out of those traditions evolved in similar ways over long periods.

So long as the strata in those traditions piled up at similar rates, the complexities of those systems emerged at similar rates as well. Another way of putting this: The complexities of premodern systems remained proportional to the temporal depth of the traditions out of which they evolved, so long as rates of information flows remained constant. This relationship helps explain otherwise puzzling parallels in the growth of distant and unrelated traditions.

Pictures above: 5a (left): Italian cosmological diagram from late-traditional Europe, meant to represent Pico's exaggerated correlative cosmology (Farmer 1998: 195; British Library 692.f.17, e6v). 5b (middle): Eleven-headed and multi-armed Avalokiteshvara, unknown late-traditional Sino-Tibetan provenance, expanding on Indian traditions. 5c (right): Diagram of the Neo-Confucian "Great Ultimate" (*Taiji tu*), Song Dynasty.

close some two thousand years of Western manuscript traditions. Increases in rates of information flows in Pico's period can be compared without hyperbole to those witnessed in our times due to personal computers and internet. Pico was rich and came from a well-connected aristocratic family (with links for starters to the Pope, Emperor, King of France, and the Medici); assembled the most diverse library of his period; employed a staff of translators and informants with ties to every major Greek, Latin, Hebrew, and Arabic tradition then known; and was viewed by many of his contemporaries as the most daring philologist of his times, attempting to deal with Latin, Greek, Arabic, Hebrew, and Aramaic sources. By his early 20s Pico had studied in the major universities and academies of Bologna, Padua, Pavia, Florence, and Paris.

Drawing on these resources, in 1486 Pico composed 900 theses meant to represent "all the most ambiguous and controversial questions" known in his period. The text includes materials from twenty-eight traditions or subtraditions drawn from Latin, Arabic, Greek, Egyptian, "Chaldaen" (Aramaic), and Hebrew sources. The plan was to debate and harmonize these insofar as was possible[19] in a giant dispute held in the Vatican before the College of Cardinals, with Pope Innocent VIII as judge. The location of the debate at the center of Western Christianity was not accidental: Pico's letters suggest that the dispute was a prelude to the cosmic debate Christ would hold at the end of time, resulting in a final reconciliation of all "nations" (*gentes*) or "sects." Underlining the scale of his project, one of Pico's 900 theses promises to reconcile all of Plato and Aristotle; a long series promises to reveal his rediscovery of secrets revealed by God to Moses that would lead to the final conversion of the Jews — a traditional sign in Christian mythology of the end of the world. The *editio princeps* of the 900 theses includes Pico's offer to pay the traveling expenses of any theologian or philosopher coming to Rome to debate him (for text, translation, and commentary, see Farmer 1998).

Neither the debate nor end of the world occurred: Pope Innocent VIII, best-known for commissioning the *Malleus Maleficarum* (The Hammer of Witches), the standard Inquisitor's manual, tossed Pico in a dungeon instead; and the text of the 900 theses became the first printed book banned universally by the Church. But a few copies survived, preserving a "laboratory" of sorts for studying the links between exegesis and the evolution of religious and philosophical ideas. Given the gigantic scale of his project, Pico was forced to call on every major exegetical strategy used in the West; when these were applied to traditions already worked up in correlative directions over two millennia, the result was a high-correlative system in which everything predictably reflected everything else; cosmological charts in Pico's own commentators exhibit perfect mathematical symmetries (cf. **Fig. 5a**; for a larger reproduction, see Farmer 1998: 194-5; Farmer, Henderson, and Witzel 2002: 73).

It is not possible here to discuss Pico's methods or those of his non-Western analogues in depth. A chart in the Appendix to Farmer, Henderson, and Witzel 2002, which is available online, summarizes the effects of a dozen or so methods used in every region and period in premodern history. One of the most common involved simply adding new "levels" to reality as needed in which every conflict in an authoritative text

[19] What Pico thought could or could not be harmonized was tied to a common premodern view of history that envisioned a slow degradation in traditions over time. For discussion, see Farmer 1998.

could be said to have its own validity. The repetitive use of such methods resulted in steady increases over time in the structural complexities of correlative systems.

This strategy was used by Neo-Platonists like Proclus (fifth century CE) to harmonize conflicts over Zeus and other divinities in the Platonic corpus, which was accepted by neo-Platonists as holy scripture. The conflicts were settled by multiplying "Zeuses" and allegorically transforming them into cosmic principles that ruled over different levels of reality (Farmer 1998: 87-9; cf. Dodds 1963: 259-60). In Manichaean traditions in Central Asia in exactly the same era — the temporal overlaps are striking — conflicts over Jesus, Mani, and other divinized figures were settled in the same way (for illustrative texts, see Klimkeit 1993). In Buddhism, again in the same period, conflicting stories over the "historical" Buddha were harmonized by multiplying Buddhas and assigning them to different directions or cosmological eras; similar transformations involving multiplications of a deified Laozi were occurring in Neo-Daoism at exactly the same time (see, e.g., Bokenkamp 1997: 208 ff.); still further examples involving multiple *avatars* of Indic deities can be cited from the same period.

In the later middle ages, simpler concepts of heaven and hell inherited from ancient traditions evolved in similar ways in Dante's *Commedia* and its non-Western analogues; striking examples show up in the increasingly complex multi-layered visions of heaven and hell of late-traditional Buddhist and Mesoamerican traditions. Similar processes were central to the generation of the complexly nested hierarchies typical of ancient and medieval scholasticism universally.

Much closer relations existed in premodern than modern times between textual traditions and art, with the result that similar trends can be traced in iconographical traditions. One dramatic example involves the genesis of the unique many-headed and many-armed gods, whose appendages were typically said to symbolize diverse powers, that originated in late-ancient India and later spread to Central Asia, Tibet, and the Far East. As Doris Srinivasan (1997) notes in her study of early stages of this movement, the multiplication of appendages occurred in such predictable ways that you can roughly date these images simply by counting their heads or arms! (Cf. **Fig. 5b**.) Skilling (1997, cited in Kingsbury 2002) notes similar ways in which increasing numbers of past and future Buddhas can be traced in Theravadin Buddhism from the pre-common to late-medieval era. Interestingly, none of these studies ties these developments closely to exegetical issues, where they typically originated, or notes the many parallels outside South Asia.

In summary, cross-cultural studies suggest that the exegetical strategies of reciters, scribes, and commentators were remarkably similar whether those strategies were applied to Vedic, Confucian, Platonic, Daoist, Aristotelian, Jewish, Christian, Platonic, or Mesoamerican sources, or to complex syncretic mixes of these and other traditions. The similarities in exegetical methods can be traced to neurobiological constraints; most involved correlative principles, as illustrated in the examples above. Broad structural convergences in religious, philosophical, and cosmological systems everywhere can be efficiently modeled as products of the repetitive use of these strategies in stratified traditions over long periods; so long as strata piled up in those traditions at similar rates, the complexities of those systems tended to increase in similar ways as well.

As suggested earlier, part of our work also involves study of political, demographic, and technological developments that helped keep those rates roughly in harmony in different eras. We also take into account selectionist pressures, especially involving social-political forces, that favored the survival of certain types of correlative systems over others. But while it is important to note these issues in passing, it is not possible to discuss them in detail in this review.

It should be mentioned finally that despite the role that exegetical processes played in generating high-correlative systems, in mature literate societies the belief that everything in the cosmos mirrored everything else eventually became a commonplace, with the result that countless examples show up in non-exegetical contexts. Pico's modeling of his Vatican debate on Christian myths involving the dispute Christ would hold at the end of time is one instance of such views. Even Pico's title (the "Count of Concord," referring to a small principality close to Mirandola) was cited by Pico's supporters as a correlative symbol that the role he assigned himself as a cosmic harmonizer was divinely sanctioned. Similar ideas were common in other cultures, including the cosmic role assigned to the Son of Heaven in premodern China. The latter idea showed up in fully systematic form by the late third century BCE, when high-correlative Chinese thought first emerged out of the grand syntheses of the early imperial period (cf., e.g., Knoblock and Riegel 2000).

But commonplaces aside, the most extreme cases of such ideas first show up in exegetical contexts, coupled most typically with attempts to harmonize discordant texts. One of the oddest results of our research has been the realization that the magnificent cross-cultural parallels in world traditions whose study first triggered our work can be largely traced to something as trivial as attempts to reconcile irreconcilable texts. The one consolation is that this extended lesson in human folly has a certain lawfulness to it.

9. Computer models of the evolution of religious and philosophical traditions

I want finally to quickly discuss the simulation designs I mentioned in the beginning. In the late 1980s and early 90s, just as we were first tying neurobiology to our work, studies of complex systems began to appear whose dynamic features closely matched those of our model. The mathematical methods used to model complex systems are at heart extremely simple. One of their attractive features is that by repeatedly applying simple transformations to an evolving system, correlative structures begin to emerge in that system that in the right conditions become increasingly articulated and more complex over time. This was precisely the pattern we found in premodern traditions, which suggested the usefulness to us of simulations based on these ideas.

What we label "correlative systems," and neurobiologists call "topographic maps," mathematicians refer to in general as "self-similar" or "self-affine" structures — better known as "fractals." [20] Fractals at their simplest are simply multileveled structures that are scale-invariant, or structurally similar at every size. Benoit Mandelbrot's introduction of fractals in the late 70s and early 80s included scores of examples of how such correlative structures evolve in a wide range of physical, biological, and social systems (Mandelbrot 1983). Many standard models of fractal growth exist today that can be

[20] The difference between self-similar and self-affine systems pertains to whether the structures of those systems are identical at all scales or whether shifts in scale result in systematic distortions in one or more dimension; in the latter case, the system is said to be self-affine. Often the term "self-similarity" is applied informally to both self-similar and self-affine systems, which is the practice I adopt below.

readily adapted to simulating the growth of correlative systems in the historical realm.

Interestingly, in *The Fractal Geometry of Nature*, Mandelbrot argues that the earliest mathematical work on scaling structures, found in writers like Cantor and Koch in the late nineteenth century, was in part inspired by contemplation of self-similar (or correlative) systems in history — expressed, e.g., in Leibniz's monadology and the Western great chain of being (Mandelbrot 1983: 405ff., 419). This leads to the amusingly self-referential result, a bit in the spirit of an Escher or Borges, that mathematical methods inspired in part by studies of high-correlative systems can now be used to model the evolution of those same systems (cf. Farmer 1998: 94-5, n. 91)!

One elegant model of fractal growth involves what are sometimes referred to as nonlinear "dissipative" or "leaky" systems. In simple versions of these models, fractal or correlative structures evolve in emergent fashions when evolving systems are transformed in a loop-like or iterative way by two opposing forces: the first pumps information (or energy of some sort) repetitively into the system; the second simultaneously leaks or dissipates some of that information out of it. So long as rates of information flows remain within a given range, systems driven by these forces will become increasingly complex and self-similar over time. Above that range, those systems will enter phase transitions in which their behavior changes in less predictable or non-linear ways: pumping more information into the system above that point will cause that system to partly or wholly collapse. Rates of information flows in this case serve as "tuning parameters" that regulate the system's linear and nonlinear patterns of growth.

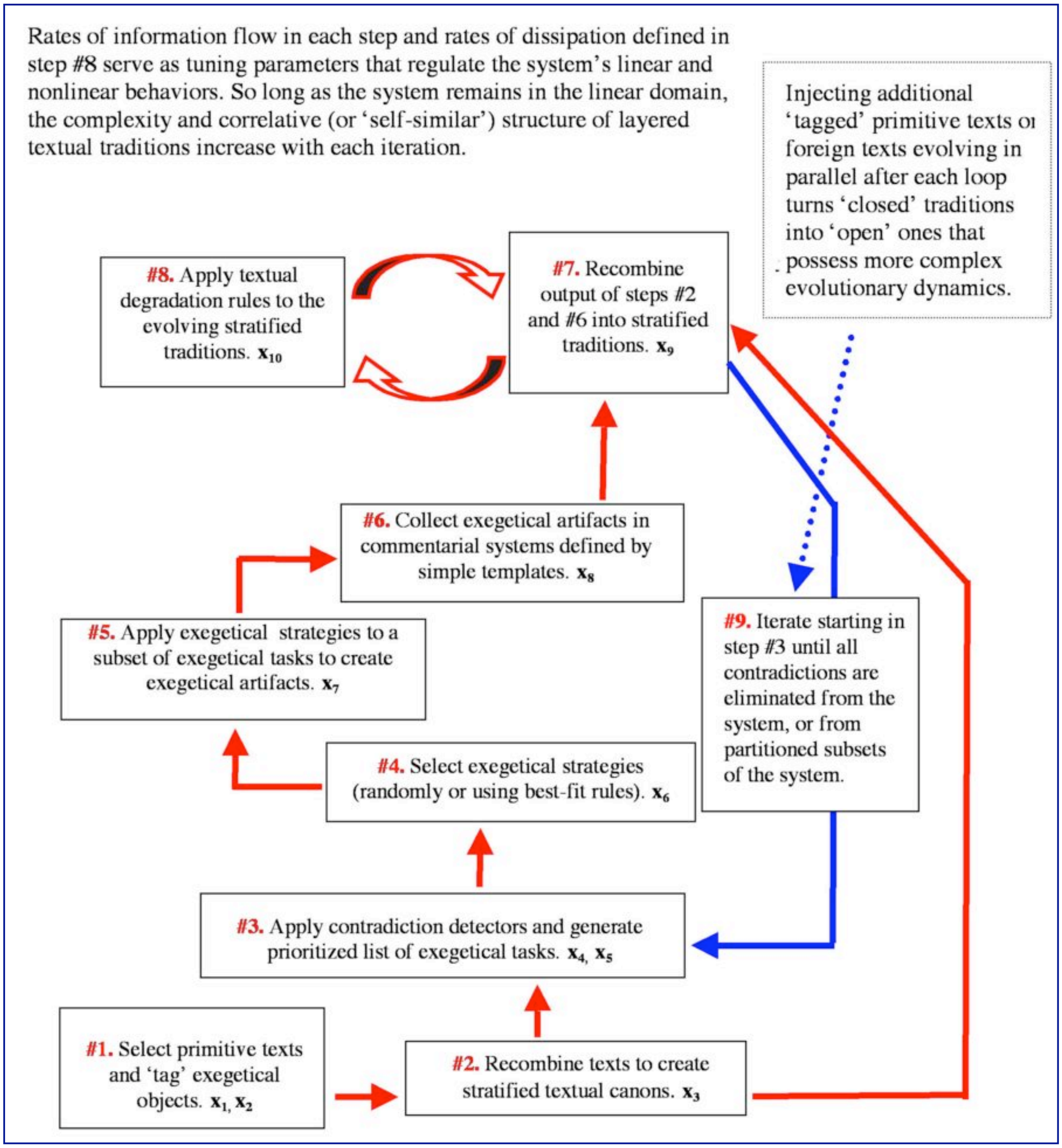
Models applying simple concepts like this allow the simulation of real-world systems of extraordinary complexity. Models based on these ideas are currently being used to simulate the evolutionary behavior of complex systems in physics, astrophysics, geology, ecology, economics, neurobiology, and many other fields (for two of many good reviews, see Flake 1999; Boccara 2004).

In our adaptation of these ideas, each iteration of the system can be pictured as creating a new layer in a textual tradition. The information "pump" required by the model consists of repetitive transformations of concepts by any of the exegetical methods identified in our textual studies; as suggested earlier, many but not all of these have reconciliative functions. The required "leaks" in the model correspond to textual losses, scribal errors, linguistic drift, and other entropic forces that in real-world conditions steadily drain textual traditions of part of their original sense. When rates of information flows in the model remain in linear ranges, correlative or fractal structures will form in those traditions in emergent ways; as those rates pass into nonlinear domains, those traditions reach maximal levels of complexity and partly or wholly collapse.

In the late 90s, we began to use these ideas to design simulations of "toy" textual traditions. A flow chart and algorithm for one simulation are shown in **Figure 6**. The principles behind the simulations are extremely simple; in the classroom we have had much success showing how they function using nothing but primitive marked-up texts and a list of rules for handling common exegetical tasks.

Moving through the flow chart (see Farmer, Henderson, Witzel, and Robinson 2002 for details): The simulations begin (step **#1**, at the bottom) with a more-or-less arbitrary selection of base texts; these might consist of snippets of holy hymns, love poems, myths,

Fig. 6. A Flow Chart and Algorithm for a Simple Simulation



Algorithm exegesis-process (prepared_sources)
primitive_texts = *select_subset_from* (prepared_sources)
tagged_primitive_texts = *tag_concepts* (primitive_texts)
stratified_textual_canons = *randomly sort and recombine_subsets_* (tagged_primitive_texts)
loop until no contradictions
contradictions = *detect_contradictions* (stratified_textual_canons)
exegetical_tasks = *prioritize_contradictions* (contradictions)
exegetical_strategies = *select_exegetical_strategies* (exegetical_tasks)
exegetical_artifacts = *apply* (exegetical_strategies, exegetical_tasks)
commentarial_systems = *match_templates_to_artifacts* (exegetical_artifacts)
tradition = *combine* (commentarial_system, textual_canons)
dtraditions/dt = *apply_degradation_rules* (tradition)
tradition = dtraditions/dt + tradition
end loop
end algorithm

or chronicles, etc.: just as in real-world traditions, any genre of text will do.[21] The texts are next mixed up in realistic fashions (**#2**) to simulate the formation of stratified canons. Contradiction detectors (to simplify programming, this part of the simulation can also be done by hand) are then applied (**#3**) to identify and prioritize conflicts in the simulated textual corpus. Exegetical strategies (of any of the types identified in our textual studies) are then selected randomly or assigned to exegetical tasks according to best-fit rules that match the strategy to the task (**#4**). The strategies are then applied to a subset of those conflicts to create "exegetical artifacts" (**#5**), which are collected (**#6**) in "commentarial systems" whose structures are defined by simple templates. These systems are then combined with the earlier canon (from step #2) to create a simulated stratified tradition (**#7**). Textual degradation rules of one or more type are applied to the tradition (**#8**) to simulate scribal errors, textual losses, and similar entropic forces required by the model. Finally, the cycle is repeated to simulate layered growths in the tradition (**#9**). More sophisticated designs can periodically inject new materials into the system, including those representing foreign traditions evolving in parallel, to turn "closed" into "open" traditions, or to model syncretic fusions of multiple traditions.

Basic output in the design (in **#5** or **#6**) involves simple verbal statements of types commonly seen in scholastic traditions — which even in their original forms often amusingly resemble something a bit like computer-generated prose.[22] It is possible in principle to add verbal-graphic translators to turn collections of these expressions into the kinds of correlative charts and diagrams often found in premodern commentaries.

By playing with rates of data flows (e.g., by adjusting parameters in steps **#5** and **#8**) you can control how rapidly correlative structures form or collapse in the simulations. This side of the model can in principle be used to test hypotheses about how political or demographic changes, innovations in literate technologies, or shifts in levels of cultural contact impacted historical information flows and hence the rise or fall of correlative systems. Our current model hypothesizes that several of these forces were involved in the rapid expansion of systematic thought that took place throughout Eurasia in the last half of the first millennium BCE, which accompanied the first large-scale Old-World formation of textual canons. Similar forces can be tied to the further expansion of correlative systems in ancient and medieval scholastic eras and to declines in those systems seen both in periods of massively reduced or increased information flows.[23]

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[21] Hence in antiquity materials as unlikely as the chronicles found in the *Spring and Autumn Annals* in early Chinese traditions and erotic Hebrew poetry like the *Song of Solomon* found their way into canonical traditions. What was critical was not the form of the original texts but the ways in which these texts were exegetically worked up by later commentators.

[22] Particularly striking examples show up in the hyperscholastic forms of Pico's 900 theses. Cf., e.g., thesis 5>26, where we find a multileveled progression meant to harmonize conflicts over beauty in different Platonic texts: "Beauty exists in God as its cause, in the total intellect truly essentially totally, in the particular intellect truly partially essentially, in the rational soul truly participationally, in the visible accidents of the heavens imagerially essentially totally, in subcelestial visible qualities imagerially partially essentially, in quantites imagerially participationally" (!) (Trans. Farmer 1998: 447).

[23] The fact that such systems may collapse both following massive reductions or increases in information flows follows from the nonlinear behavior of those systems; for details, see Farmer, Henderson, and Witzel 2002: 67-70; and Farmer, Henderson, Witzel, and Robinson 2002.

Simulations based on these ideas are capable in principle of growing in familiar sequences a wide range of structures closely resembling traditional religious and philosophical ideas — primitive dualistic concepts, complex pantheons, monotheistic gods or abstract cosmological principles, paradoxically immanent and transcendent deities, abstract sets of elements or "phases," mystical trinities, cyclical and linear models of time, multilayered images of heaven and hell, complex systems of *avatars* — and so on down a long list. The structures that emerge on any iteration depend on the genres of texts at the tradition's base, on the number of iterations that have already occurred, and on the exegetical strategies applied to the traditions on each iteration. As noted earlier, initial choices of those strategies may begin randomly, but as the system matures those methods tend to be reinforced as the fit between methods and the forms they impose on systems improves over time. This is an illustration of what economists refer to as "historical lock-in" or "path dependencies" in complex systems — concepts that have many obvious applications in history.[24] The result is that more-or-less arbitrary differences in strategies applied in early layers of a tradition may affect the trajectories traced out by those traditions over millennia. It is a melancholic fact that ancient "frozen accidents" or "founder effects" in traditions, to adopt Gell-Mann's terms (e.g., 1994: 23), continue to affect the lives of billions of people in the contemporary world.

You can increase the sophistication of these designs by allowing multiple solutions to exegetical problems (simulating one cause of schisms in historical traditions; see Henderson 1998 and Farmer 1998 for examples) and by adding fitness rules that affect the survival of one or another type of correlative system in different social or political conditions. Such simulations can also be used in principle to test models of the collapse of high-correlative systems. As briefly suggested earlier, as nonlinear dissipative systems approach maximum levels of complexity, they enter phase transitions in which even minor perturbations can cause them to partially or fully collapse. The study of such events is the center of one branch of studies of complex systems known as self-organized criticality or SOC (Bak 1991, 1994). The behavior of systems in these phase transitions matches conditions we have studied in historical contexts in late-traditional times, which frequently witnessed both vast expansions and collapses of high-correlative traditions. Preliminary discussions of this issue are found in Farmer 1998: 133-7; Farmer and Henderson 1997, 2001; and Farmer, Henderson, and Witzel 2002.[25]

It would take a lot of dedicated programming (and funding) to move beyond studies of toy traditions to those involving genuine historical texts. But we know enough about the linear and nonlinear behavior of complex systems to be confident that such simulations can be written. The capability of creating such tools provides further support for the principle announced three decades ago by the mathematical biologist Robert May (1976) — that simple iterative models can simulate the dynamics of extremely complex

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[24] Cf. Farmer, Henderson, and Witzel 2002: 50, n. 7. The concept is most fully developed in the works of W. Brian Arthur, currently at the Santa Fe Institute. See Arthur 1989, 1999. These papers are available at Arthur's website, http://www.santafe.edu/~wbarthur/Papers/Papers.html.

[25] Further extensions of the model deal with issues on the "further side" of these transitions, when due to printing and related factors historical traditions became less dependent on memory and authority, and correlative thought gradually transformed into heuristic scientific models. These issues are discussed in Farmer (forthcoming).

systems. The systems historians study are certainly no more complex than those faced by biologists, and there is every reason to believe that the revolution in complex studies that May helped realize applies no less to historical studies than to biological fields.

10. Uses and tests of the model

Just as in any other branch of science, models in history should be viewed as purely heuristic devices: in exchange for simplifying reality, they must do something to justify their existence. The question of "what is all this good for?" could be expanded into a long talk. Here I will limit myself to discussing three uses of our model:

10.1. By combining textual research on myth, religion, and philosophy with studies of neurobiology and complex systems, the model bridges artificial divisions between the biological and cultural sciences.

More sophisticated models of the class described above can be expected to appear in the next two decades, following trends already underway in anthropology, archaeology, and related fields. Especially promising are network approaches capable of being extended to studying brain-culture interactions, pictured in a sense as neural networks "writ large."[26] One natural use of such models is to study how neural systems embedded in cultures are affected by shifts in information technologies, including but not limited to the literate (and mnemonic) technologies that are the focus of our current work.

Cultural topics are increasingly central to neurobiologists, following the findings concerning neural plasticity reviewed earlier. Revived interest in brain-culture links returns the field in a sense to directions pioneered by Vygotsky, Luria, and their colleagues in the late 1920s and early 30s,[27] which were largely abandoned as interest shifted to single-neuron recordings in the 1950s. Revivals of these views are evident in recent interest in co-evolutionary models of brain and culture, which recognize that neurobiology cannot be separated from studies of the cultural forces that help shape the brain. Most models of this type to date have focused on phylogenetic issues, including the co-evolution of brain and language (e.g., Deacon 1997). A few others have addressed the general problem of how culture affects brain development, with the brains of one generation in a sense programming the next (Goldberg 2001; Wexler 2006). But only recently have studies appeared that take the co-evolution of neurobiology and "higher" human traditions seriously, despite interests along these lines expressed by early pioneers in the neurobiological revolution (cf. Changeux 1985: 273 ff.; Edelman 1987: 311).

The main reason for these delays involves problems in history and not neurobiological research. It is ironically far easier to pick up the neurobiological data

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[26] One attractive approach using network models is discussed in Rundle et. al. 2002. Other methods useful for historical modeling of the type discussed above include diffusion limited aggregation (DLA) models, cellular automata, spin-glass models, genetic algorithms, and nonlinear dissipative models of the types briefly described earlier. For general overviews of some of these approaches, see Flake 1999; Boccara 2004. Further on modeling of complex systems in biology, see Kauffman 1993. Tools useful for the construction of simulations of the needed type are available in so-called unit process tools often used in modeling chemical and environmental systems; thanks to Peter Robinson for pointing me to the latter tools.

[27] For translations of some of these early studies, see Vygotsky 1978; Luria 1976.

needed for brain-culture studies than the historical data, which often comes overlaid with traditional assumptions about ancient sources that have only recently been challenged by new discoveries (on this see further, **Section 10.3.2**). This problem is compounded by the fact that many historians remain hostile to the introduction of modeling techniques in humanistic studies, where major achievements are often ascribed to individual creativity or genius. Even when such attitudes are absent, few historians at present have the training to recognize what parts of neurobiology are relevant to their work. Traditional views that history is largely a descriptive endeavor finds further support in the continued attribution of key developments to outsized tradition founders, despite much evidence that most texts ascribed to such figures are heavily stratified works that emerged over many centuries. Resistance to such evidence is reinforced by the fact that many specialists in ancient traditions are drawn from the shrinking pools of modern intellectuals whose own beliefs are tied to those traditions. These problems are heightened when religious identity or a sense of "national pride" affect research, which is an especially serious problem in studies of ancient India (Witzel and Farmer 2000). As a result, nearly a half century after C.P. Snow's famous essay on the war of science and the humanities (*The Two Cultures*, 1959), it is not uncommon to hear historians claim that building models and testing predictions do not apply to history, as they do to every other scientific field.[28]

These views are changing as online access to sources and increased global contact highlight parallel developments in premodern traditions, which point to the need for cross-cultural models of the evolution of thought. The idea that shifts in information flows were critical to such developments is also becoming obvious in light of the rapid changes modern cultures are experiencing due to such shifts. Finally, studies of cultural factors in genetics as well as neurobiology signal a future in which "a biologist will need to be more of a social scientist, and a social scientist will need to be more of a biologist," as Jablonka and Lamb (2006) suggest in a far-reaching review of new genetic models.

The neurosciences currently model brains as highly plastic structures that co-evolve with culture in ontogenetic no less than in phylogenetic terms. Coming to terms with this view is one of the biggest challenges currently faced by historians of ideas. The next decade promises to deepen our view of these co-evolutionary processes and to provide further tools useful for modeling them; and these developments can be expected in put to an end traditional views that divided studies of human traditions from the rest of science.

10.2. The model provides testable theories of the origins of early man's god- and myth-making tendencies, and of step-like transformations of myth and early religion in later textual traditions.

The thesis that religion originated in anthropomorphic modeling of the world has a long history.[29] Hume, Feuerbach, and Tylor developed early versions of that thesis in the

[28] The origins of many of these attitudes can be traced to Dilthey (1883), who insisted on a sharp division between the so-called *Naturwissenschaften* and *Geisteswissenschaften* — the latter, as even the name suggests, tied to prescientific views of human nature. Few historians today would quote Dilthey to justify their views, but much of their hostility to science lay in paths he established a century and a quarter ago.

[29] A useful bibliography of modern articles related to anthropomorphic modeling is maintained at Carnegie Mellon University at http://www.anthropomorphism.org/bibliography.html.

eighteenth and nineteenth centuries; Durkheim and Malinowski added social twists to it in the early twentieth. Discussions of anthropomorphism and the related concept of animism are key as well to cognitive approaches to the origins of religion, e.g. in studies by Guthrie (1993, 2002) and others (see the papers in Pyysiäinen and Veikko 2002).

In the third century CE, Clement of Alexandria ascribed a primitive version of this thesis to Xenophanes, who according to tradition lived in the late sixth century BCE:

> The Ethiopians have gods that are black and flat-nosed; the Thracians gods that are red-haired and blue-eyed.
>
> If oxen and lions had hands or could draw and create works like those of men, and if animals were to draw pictures of gods, horses would draw pictures of gods like horses, and oxen like oxen, and each would make their bodies like their own.[30]

One problem with earlier models of this type was their lack of any neurobiological explanation for these tendencies (recent cognitive models of religion do invoke biological models of other types). As noted earlier (**Section 6**), our model traces these tendencies to heavy social biases in cortical processing coupled with the topographic ways in which early developing cortical maps guide the formation of later ones. The result is a testable theory for why normal children overextend human physical, mental, and social concepts into the exterior world; our model relates this overextension to man's god- and myth-making tendencies. Potential tests of the model lie in comparing normal children's models of the world with those of children with specific developmental disorders, including autism and Asperger syndrome, known to adversely affect cortical and subcortical circuits that process social data (cf., e.g., Castelli et al. 2002; Klin and Jones 2006). Comparisons of subjects with Williams syndrome, which is tied to hyper- and not hypo-social behavior, and appears to differentially affect the same circuits (see, e.g., Reiss et al. 2004), can serve as controls in such studies (for earlier contrasts between autism and Williams syndrome in brain-culture studies, see Deacon 1997).[31]

A deeper problem in earlier models lay in their lack of dynamic explanations for later transformations in religious and philosophical traditions. In the absence of such explanations, even recent cognitive approaches to religion (e.g., those in the papers in Pyysiäinen and Veikko 2002) lack any historical dimension. As suggested earlier, our model pictures those transformations as byproducts of exegetical forces operating in textual traditions over long periods. One result of repeated syntheses of texts was a gradual decrease in the overt anthropomorphism seen in primitive myths and religions; but even by late-traditional times anthropomorphism flourished in more abstract forms;

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[30] Diels-Kranz, *Fragmente der Vorsokratiker*, frag. 16, 15; drawn from Clement of Alexandria, *Stromata* VII, iv, 22.1; V, xiv, 109.1-3. How much of this is Xenophanes and how much is Clement is an open question, due to the fact that many pre-Socratic fragments were heavily reworked by later writers.

[31] One approach to such tests lies in studies of drawings by autistic children, in most of whom, unlike children with Williams syndrome, normal anthropomorphizing tendencies are absent. For one relevant study, see Cox and Eames 1999. The fact that avoidance of human subject matter is not present in the drawings of some autistic subjects reflects current views of the condition (of which Asperger syndrome is a high-functioning subtype) as a spectrum or heterogeneous disorder. A second approach lies in comparison of autistic subjects and those with Williams syndrome using standard psychometric measures including the so-called Magical Ideation Scale and Duke Religion Index.

classic examples show up in the man-the-microcosm motif and related systems of cosmic magic that show up globally well into early modern times. By the time those systems collapsed, thousands of years of textual syntheses resulted in what might be pictured as the ultimate human solipsism — expressed in exaggerated correlative cosmologies whose abstract structures closely mirror those found in topographic brain models (cf. Farmer 1998: 95-6.)

One disquieting consequence of our model involves the neurobiological origins it assigns to primitive magical and anthropomorphic beliefs. Modern resurgences of religious fundamentalism even in technologically advanced countries suggest that Enlightenment assumptions that such beliefs would disappear on their own with the advance of science were naive. One danger in those beliefs lies in their links to parochial ethnic identities; that danger is vastly amplified as those beliefs are scaled up in half-anthropomorphic concepts of nation-states. Demographic research suggests that such beliefs do decline with higher education, and especially advanced work in science; but experience in the West suggests that the required levels of education may not be easily achievable on a mass scale. Attempts to challenge such beliefs in lower-level education can be expected to be opposed by elite groups that benefit from those beliefs; the failure to root them out even using unacceptably coercive methods in the former Soviet Union and China suggests in any case that simple indoctrination is not likely to succeed.

Evidence that primitive religious ideas and magical beliefs are rooted in neurobiological development suggests that even in ideal conditions struggles against their excesses must be faced anew in every generation. One working thesis behind our research is that the best way to combat those excesses lies in highlighting their biological origins and in further developing testable models of the co-evolution of brain and “higher” traditions, whose long-term patterns of growth follow largely predictable paths.

10.3. The model has uses as a dating tool and has the ability to make testable predictions about premodern civilizations.

One final use of the model lies in the help it can give in dating problematic texts and in illuminating unknown sides of premodern history. The simulation design sketched earlier focuses on long-term patterns in the growth of religious and philosophical traditions, but more narrowly focused models — of even simpler numerical as well as symbolic types — can be designed to explore the micro-behavior of single traditions or periods. One obvious use of such simulations lies in studying the shifts in information flows linked to the explosive growth of abstract religious and philosophical ideas throughout Eurasia in the last half of the first millennium BCE. Another is in studying periods in which scholastic-syncretic systems evolved at accelerated or dampened rates or began their final collapse. Evidence suggests that shifts in rates of information flows were related to all these events; finding innovative ways of estimating those flows is a requirement for the development of more sophisticated future models.

In the last decade, we have explored ways in which the model might help date individual strata in heavily layered texts and traditions. Besides using formal stylometric tools, philologists often “intuitively” date such strata by sorting them according to the levels of formality, abstractness, or complexity associated with abstract concepts embedded in those strata. Our model provides dynamic explanations for why these methods work and suggests ways in which they might be standardized using simple computational tools (for an example of the use of one such tool, see below, **Section 10.3.2**) In some cases, absolute dates can be estimated when exegetical developments in a text are compared with those in closely related texts for which we have reliable dates.

In general, from study of how concepts were reshaped over long periods in stratified traditions, it is possible to fill in chronological gaps in the records of one tradition by extrapolating from the records of others. We expect future uses of such models in helping to date problematic layers in texts, like those typical of ancient India, and in modeling literate conditions in cultures from which only fragments of textual traditions survive, as is the case in pre-Columbian Mesoamerica.

I will end by discussing several tests of the model. A number of those tests pertain to the predictable time course of the types of parallels in religious, philosophical, and cosmological traditions whose study began our cross-cultural research; these tests are discussed in detail in Farmer (forthcoming). I will focus below instead on two predictions of a different sort that illustrate the model's ability to open new ground in historical studies. The first, involving the Indus Valley civilization, has been widely publicized and has reasonable claims at this point of having been confirmed. The other, pertinent to recent Chinese tomb-text discoveries, is a new prediction that can be tested against finds in the most important archaeological field currently linked to textual studies.

10.3.1. Predictions and tests involving the Indus Valley symbol system

One of our model's subsidiary features is that it can help distinguish manuscript cultures from non-literate societies. This follows from the fact that extensive manuscript production leaves markers in the archaeological record, even when no manuscripts survive. Some of those markers include direct evidence of such production, including pictures of scribes or writing instruments, archaeological remains of such artifacts, and long inscriptions on durable materials (for details, see Farmer, Sproat, and Witzel 2004). More indirect markers include evidence in iconography of high-correlative structures, which on our model are expected products of extensive literate production.

In 2000, while testing our model in South Asian traditions, I was struck by the absence of all such markers in the excavation reports of the Indus Valley or Harappan civilization, India's first urban society. This finding clashed with standard claims that the Indus civilization was literate for six or seven hundred years or more. Those claims were based on finds of thousands of Indus artifacts carrying short strings of symbols — averaging less than five symbols per object — that have survived on a dozen or so different types of durable materials. This evidence had been regarded since the first example turned up in the 1870s (in that case on a seal) as evidence of a full writing system. Since the late 1920s, the fact that no Indus "text" longer than seventeen symbols has ever been found — and that is a highly anomalous piece — has been claimed as evidence that the Harappans wrote long texts exclusively on perishable materials, all traces of which have disappeared. Based on this assumption, many studies have since implied that the level of literate sophistication in the Indus Valley was equal to that of contemporary Egyptian and Mesopotamian civilizations, and many papers have speculated about lost archives and manuscript traditions.

By the time I began exploring this issue, well over a hundred claimed decipherments had been announced of the supposed script. Many of the supposed decipherments were tied to political arguments between competing Indian ethnic groups over India's supposed first inhabitants; all were tied to wild speculation about the supposed language or languages encoded in the inscriptions. What made these debates so peculiar was the fact that Harappan archaeological remains lack every known marker of manuscript production — and this in turn suggests that the short strings of symbols found on durable materials did not encode language but belonged to a different class of symbols. This hypothesis, which can be backed today by evidence from many directions, was the first major challenge since the 1870s to the famous Indus-script thesis.

The claim that the Indus system was not a script in any standard sense of that term, which I first made in a talk in 2001 at Harvard, was initially received almost universally with skepticism. But in the last half decade, following extensive reviews of the evidence, the thesis that Indus symbols were non-linguistic has been accepted by a large number of script experts, South Asian linguists, and Indus researchers. Studies elsewhere of nonlinguistic symbol systems, which come in a surprisingly wide range of forms, have also suggested alternatives to the script model that closely match the empirical evidence.

The case against the Indus-script thesis was summarized in a paper that Richard Sproat, Michael Witzel, and I published in December 2004; the controversy triggered by our paper was the subject of a feature story in *Science* the same week (Farmer, Sproat, and Witzel 2004; cf. Sproat and Farmer 2005; Farmer, Henderson, and Witzel 2002; *Science* 306: 2026-9). Indian nationalists and Western researchers whose entire careers have been tied to the Indus-script thesis have predictably reacted negatively to our paper. But the arguments against the Indus-script thesis are powerful, and it is safe to claim that the thesis in its traditional form is dead among most serious researchers. Among the evidence that undercuts the thesis is the extreme brevity of the inscriptions, major statistical anomalies in sign-repetition rates, and the existence of large numbers of Indus symbols that show up only once or a few times at best in tens of thousands of symbol cases. Most importantly, the claim that the Harappans wrote long texts on perishable materials, which has provided the backbone of the script thesis since the 1920s, conflicts with the fact that every premodern civilization known to have written on such materials also left large numbers of long texts behind on durable materials.[32] One of the most interesting of our findings is statistical evidence that suggests that Indus symbols were not even evolving into a speech-encoding system after a minimum of 600 years of use, despite the fact that the Harappans were in trade contact throughout that time with literate Mesopotamian societies (Farmer, Sproat, and Witzel 2004: 33). Going beyond the Indus Valley, suggestions have since emerged that what M. Witzel and I have labeled a vast "No Script Zone" may have existed from the Iranian plateau to Central Asia and India from at least the end of the third millennium well into the first millennium BCE — in NW India only ending with the arrival of the Persians shortly before 500 BCE. Interestingly, a study by C.C. Lamberg-Karlovsky (2003) that independently appeared around the time of our proposal has suggested that the coexistence of scripted and

[32]This finding by itself can be claimed as enough to kill off the traditional script thesis. For full discussion, see Farmer, Sproat and Witzel 2004; a reprint can be downloaded from http://www.safarmer.com/fsw2.pdf. Evidence of the absence of long "texts" in the Indus Valley is so compelling that my collaborators and I have offered a $10,000 prize for any provenanced find that carries as little as 50 or more symbols.

scriptless societies may in fact have been common in ancient Eurasia, which conflicts with many studies which have viewed writing as a requirement of urban civilization.

What has not been much noticed to date amidst all the controversy over the so-called script is that the first suggestion that Indus society was not literate did not derive from new empirical finds, but from a totally unexpected prediction of a theoretical model. Empirical tests of that prediction only came later, which is a common pattern elsewhere in science, if not in historical studies. If nothing else, the Indus-symbol story suggests that models like this can push historical research in new directions, and it is reasonable to expect that such models will play a larger role in future premodern studies.

10.3.2. Predictions concerning the Guodian *Laozi* and future tomb-text finds

I will close by discussing a new prediction (and hence test) of the model, pertinent to the most important controversy involving recent Chinese tomb-text finds. The reliability of the "received texts" from early China has largely been taken for granted since the Han dynasty, but that view is now being challenged by these finds, which often differ widely from the received texts. (The best English discussion so far is found in articles by Boltz and Kern in Kern, ed. 2005; cf. also Shaughnessy 2006). When combined with more fragmentary discoveries of ancient Greek and biblical papyry (both reviewed in Van Seters 2006), these finds have the potential to overturn traditional views of the formation throughout Eurasia of classical sources, not excluding the partly oral "texts" of early India. The Chinese evidence provides our best data on this issue since it allows us to study the formation of ancient sources in detail — not based on speculative reconstructions using received texts, most of which come to us via medieval sources, but from study of genuinely ancient materials preserved in tombs.

I will not try here to review all these developments, which are as complex as they are far-reaching, but will focus instead on the most famous problem involving these sources, which is tied to further tests of our model.

The best-known Chinese finds involve over a dozen texts on bamboo slips found in Guodian Tomb 1 (typically dated c. 300 BCE) that were published in 1998. The importance of these finds is illustrated by the fact that by 2005 these texts had already been discussed in over 3,000 publications (Kern 2005: xxxvi, n. 6). The most famous of the tomb's contents are three bundles of bamboo slips that contain roughly two-fifths of the materials in the received text of the *Daodejing* or *Laozi*, the most famous Daoist work and one of the most commented upon texts in the world. (On the Guodian *Laozi*, see the papers in Allan and Williams 2000, from a conference held when the texts were first published). Composition of the *Daodejing* is traditionally ascribed to "Laozi" (literally the "Old Master"), but since Lau's work in the 1960s that view has largely died out among most Western (and the most advanced Chinese) Sinologists. Today, most philologists take it for granted that the *Laozi*, like all or most pre-imperial era works, is a stratified or composite text that evolved over an extended period, not reaching its final form until the late third century BCE or even later (cf. Boltz 2005). The importance of the three Guodian *Laozi* bundles lies in the evidence they contain on how the *Laozi* evolved, and by extension on how other ancient texts were formed. Some of that evidence includes differences in the order of materials in the bundles when compared with the order in the received text. Even more important are the textual "omissions" when compared with the received text and two later excavated versions of the *Laozi* discovered in 1973 in Mawangdui Tomb 3, which was sealed in 168 BCE.[33] Interpreting these data has led to alternative models of the Guodian *Laozi* that have broad implications for views of the formation of the *Laozi* and by extension ancient texts in general; for details on these models, see the discussions in Allan and Williams (2000).

The most conservative of those models picture the contents of the Guodian bundles as extracts of an earlier complete (or in one variation, nearly complete) version of the work that corresponds more or less to the received text; these models do not require major revisions of earlier views of the work. A more radical (and much more interesting) class of models pictures the bundles as containing sources of a type that in the next century or so (i.e., after c. 300 BCE), a period of known literate expansion, were merged with other oral or written materials to form something close to the received text.

By 2006, some version of the source model appears to be favored by most (not all) specialists on the *Laozi*, due to the character of other tomb-text finds analyzed by Boltz, Kern, and others. But no plausible way has been proposed to test alternative models other than to wait until other early versions of the *Laozi*, or further sources that later found their way into the received text, show up in future excavations. It is certainly reasonable to expect such finds, since we know of huge numbers of pre-Qin dynasty tombs: Zin Zuxin, in Allan and Williams (2000: 23), reports that 20 cemeteries exist with thousands of unexcavated tombs in the Jishan tomb complex alone, of which the Guodian cemetery is just one part; and this is only one of huge numbers of unexcavated tomb sites dating from pre-imperial China.[34] But due partly to political reasons, excavation work has been slow, and no one knows when the next relevant finds will show up. The situation is frustrating, since reasons exist for viewing these texts as philological time bombs that in the end are likely to force a major upheaval in how we view classical sources, and not just in China.

Interestingly, exegetical sides of our work suggest a detailed thesis concerning the apparent omissions in the Guodian *Laozi*, and this in turn leads to a testable prediction about future tomb-text finds. The model not only suggests that the source models of the formation of the *Laozi* are correct, but goes much further, by suggesting that most of the missing sections of the *Laozi* were not composed until *after* the texts in the Guodian bundles. And this in turn results in the prediction that no tomb-text versions of the *Laozi* older than or contemporary to the Guodian bundles will ever show up that contain these sections. Given the fact that this includes nearly three-fifths of the received text (see n. 42 for possible exceptions), the prediction is obviously a bold one.

The grounds of that prediction can be sketched quickly based on what was said earlier about exegetical sides of our model; further details are given in Farmer (forthcoming).

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[33]The two Mawandui versions of the *Laozi*, which are written on silk and not bamboo, are often said to be close in wording to the received text, although on our model the minor differences throw significant light on the evolution of the text. The normal order of the two *Dao* and *De* sections of the text, as noted below, are also reversed in the Mawangdui versions, but this issue is not pertinent to the following discussion.

[34]For 158 excavated sites from the pre-imperial era through the Han dynasty that have already yielded manuscripts, see Enno Giele's "Database of Early Chinese Manuscripts," available online at http://www.lib.uchicago.edu/earlychina/res/databases/decm/. The database at present is only updated to September 2000; see the introduction to Kern, ed. 2005 and Shaughnessy 2006 for further data. M. Nylan in Kern, ed. 2005: 37, n. 37 cites an article by Liu Qing that speaks of "30,000 Han excavated tombs."

Our model posits that reciters, scribes, redactors, editors, commentators, scholiasts, etc., tended to work up early strata in layered texts in predictable ways as they faced exegetical problems in those strata. And this implies that it should be possible to draw up fairly objective criteria, based on what we know of exegetical processes in general, that allow even "blind scorers" (and in principle computer programs) to assign an "exegetical index" to passages in a stratified text or tradition; higher indices on the model tend to be associated with materials of later exegetical age.[35]

When we compare materials in the Guodian *Laozi* bundles with those in the Mawangdui and received texts, we find that chapters, verses, and lines that show up exclusively in the latter works have much higher exegetical indices both on the average and in the aggregate than anything seen in the Guodian texts. And on our model, that constitutes *prima facie* evidence of the later dates of the supposedly omitted materials.

Interestingly, those materials include many of the most famous passages in the received text. The missing parts include both opening chapters of the two broad divisions of the received and Mawangdui texts (the *Dao* and *De* sections), which do not show up in the organization of the Guodian bundles. (On the source models, these two divisions were added at a later date.) The opening chapters of these sections contain the most striking paradoxical expressions in the *Laozi*, of a type that in other ancient traditions can be quickly shown to fulfill reconciliative functions; on our model, these chapters can hence be assigned a late exegetical age. The location of the chapters at the start of the two main divisions of the work also finds parallels in the positioning of similar texts in other stratified works, which were often located at the start or end of those works to emphasize the supposed harmony of the materials following or preceding it. One of many examples of this type is found in the concluding "Hymn to Unity" in the *Rgveda* (RV 10.191).[36]

The Guodian *Laozi* is filled with conflicts that would draw the attention of any ancient exegete, for whom the smallest nuances in sources were typically viewed as having deep significance (for cross-cultural discussion, see Henderson 1991). One of the most obvious conflicts of this sort involves the Dao or "Way." Just as in later versions of the *Laozi*, in the Guodian text we are often told that the Dao is "nameless" or "constantly nameless," only to find this idea at least implicitly contradicted in other nearby passages. In Guodian Bundle A, for example, opposing views on this issue show up in two contiguous chapters (A:10 and A:11, Henricks 2000: 53-5, corresponding to chapters 32 and 25 in the received text).[37]

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[35] In brief, the blind-scoring method uses a checklist to assign numbers to passages based on how many structures typically associated with exegetical transformations show up in those passages. The numerical total assigned to a given passage determines its exegetical index, which on the model is tied to its apparent age. The data used to draw up the checklists include the types of information summarized in Appendix A of Farmer, Henderson, and Witzel 2002, http://www.safarmer.com/neuro-correlative.pdf.

[36] Short passages of younger age were often injected into older texts in ancient stratified works due to interpolations that found their way into those works over long periods. But it is equally common to find larger pieces of younger texts placed at the front and/or back of those works, with the oldest portions eventually pushed into a central core. On this pattern in the *Rgveda*, which has been recognized since the work of Bergaigne and Oldenberg in the nineteenth century, see the discussion in Witzel 1997: 261 ff. Similar examples show up in biblical sources and many other texts, including heavily layered Mesoamerican sources like the *Popul Vuh* and books of *Chilam Balam*.

[37] Below, I follow the standard practice of referring to *Laozi* chapters by the received-text numbers.

The first of these, following Henricks' intentionally close translation, begins:

> The Way is constantly nameless.

But on the following slip that view appears to be contradicted in the following lines:

> Not yet knowing its name,
> We refer to it as the Dao.
> Where I forced to give it a name, I'd call it the Great.

And this in turn seems to contradict yet another passage, partly reconstructed (due to a break in the slip) using later texts (B:5, chapt. 9 in the received text; Henricks 2000: 98):

> The Way is great yet has no name.

In further passages in the Guodian bundles we find references to the "Bright Way," "Level Way," and "Great Way,"[38] which in the mind of any ancient exegete would, at a minimum, further confuse the issue of whether the Way was nameless or had a name.

There are many conflicts like this in the *Laozi* involving a wide range of concepts besides the Dao. One common method of handling these conflicts was simply to announce the occult or paradoxical identity of the opposed concepts, turning what might otherwise be construed as pure "Word Salad" into a high mystery. Classic cross-cultural examples lie in the identification of Atman and Brahman in later strata of Vedic traditions and, even more famously, in the manifold paradoxes of Christian trinitarianism. Many other examples of the same type can be cited, including well-known examples in Mesoamerican sources.

Evidence of the use of this method is clear in the Mawangdui and received versions of the *Laozi*; nothing quite comparable shows up in the Guodian bundles.[39] The best-known example is found in the final lines of the opening chapter of the *Dao* section of the text. I follow here Henricks' translation of the Mawangdui *Laozi* (1989: 188), adding a single exclamation point to emphasize the central paradox:

> These two together emerge;
> They have different names yet they're called the same!
> That which is even more profound than the profound —
> The gateway of all subtleties.

As is often the case in the *Laozi*, the exact referents in this passage remain ambiguous, due to the oddly modular ways in which the *Laozi* and many other early Chinese texts were composed. [40] As a result, we cannot assume that the referents are

[38] Henricks 2000: 98, B:5, chapt. 41 in received text; Henricks 2000: 112, C:1, chapt. 18 in received text.

[39] Other types of paradoxical expressions do show up in the Guodian texts, but these are neither as well-developed as these nor do they appear to involve reconciliative issues; for discussion, see Farmer (forthcoming).

[40] As D.C. Lau suggested decades ago, individual chapters in the *Laozi* often contain conceptually unrelated verses that appear to have been linked only because they shared a single word (Lau 1963). This led to a conceptual disconnect between verses in those chapters and to the kinds of ambiguities that made the *Laozi* the subject of thousands of years of commentarial debate. This point has recently been generalized by Boltz, who refers to features like this in early Chinese texts as "movable textual building blocks" (Boltz 2005). Interestingly, the conjunction of unrelated snippets of decontextualized texts was also a feature of

necessarily located in the immediately preceding verses. But this issue aside, the exegetical functions of passages like this are known from later chapters of the *Laozi* as well as from numerous other Chinese and non-Chinese sources, and it is safe to assume that attempts to resolve conflicts like those noted above figured in these verses.

Other putatively missing chapters, verses, or lines in the Guodian bundles are similarly tied to exegetical structures commonly found only in later and not earlier strata of ancient texts. These missing elements include every high-paradoxical expression of the type illustrated above, including those in the first chapter of the *De* section of the work (chapt. 38 in the received text). Given the fact that the opening chapters of the two divisions of the work include the most famous verses in the *Laozi*, it is difficult to imagine cogent reasons why any Guodian anthologist would omit them — if indeed they existed before the closure of the Guodian tomb and were found in his putative sources.

Other missing sections, including again many of the most striking passages in the work, can be assigned to a later age on similar grounds. Thus Henricks, whose views of the Guodian *Laozi* are otherewise fairly conservative, notes that none of the chapters except one in the Mawangdui and received texts of the *Laozi* that expound on the nature of the Dao (chapters 1, 4, 6, 14, 25, 34, 51, and 52, on Henricks' view) shows up in the Guodian bundles (Henricks 2000: 18). Studies of stratified texts in other civilizations suggest that discussions of the same types seen in these chapters again typically are found only in later and not early strata of ancient works, providing internal commentary on problematic terms in earlier strata. Interestingly, the only chapter of this type included in the Guodian bundles is A:11 (chapt. 25 in the received text), which contains the rather anomalous claims about the name of the *Dao* cited earlier. And again one asks: if the Guodian bundles were part of an anthology of a supposedly complete (or nearly complete) *Laozi* chosen partly for thematic consistency, why would the anthologist have retained this text and so many others in direct conflict — including the passage in the preceding slip that declares that the Dao is "constantly nameless" — while stripping away every section of the work that provides a means to harmonize those conflicts?

Other important materials not found in the Guodian texts that have exceptionally high exegetical indices, suggesting their later age, include every passage that links the One (a relatively late exegetical creation in every known world tradition in which it appears) and the Dao (chapters 10, 14, 22, 39, and 42). Parallels here again show up cross-culturally in later but not earlier layers of stratified texts, including syncretic identifications of the One and older ideas in later Vedic texts and Western Neo-Platonic sources.

For a list of other missing materials in the Guodian texts, many but not all in the same class, see Henricks 2000: 17-19.[41] A number of other putative omissions that can be

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post-Rgvedic Vedic and Hebrew, Christian, and Islamic exegetical traditions, in what can be pictured at times as a kind of bibliomancy (for extreme Western examples, see Farmer 1998: 67-8; for further cross-cultural examples, see Henderson 1991). Also apparently related is the way in which omen verses in the *Yijing* could be conjoined when making prognostications (cf. Shaughnessy 1996: esp. 7 ff.).

[41]Interestingly, anticipations of some of these missing materials are found elsewhere in Guodian Bundle C, in materials that the modern Guodian editors have assigned the title "Taiyi shengshui" (The Great One Generates Water). See Henricks 2000: 123-129 for the text, which develops a primitive emanational cosmogony. As Henricks points out in an earlier passage (p. 18), while the received *Laozi* makes much of water as a symbol (e.g., in chapters 8, 34, 43, and 78), none of these passages show up in the Guodian *Laozi*, while water symbolism is prominent in the "Taiyi shengshui," as the title implies. This raises the

assigned late dates on exegetical grounds are discussed in Farmer (forthcoming).

This sketch is only intended to suggest the general lines of this argument. Any fuller discussion must address the issue of how to assign exegetical indices to individual *Laozi* passages. It should also ideally address potential counter-arguments to some of the arguments sketched above. But even this brief sketch suggests that strong *prima facie* evidence exists for claiming that most of the missing parts of the Guodian *Laozi* were late compositions, many providing internal exegesis of a sort on earlier strata of the text. And this provides a further empirical test of our model, by suggesting that no *Laozi* tomb-text finds as old or older than the Guodian bundles will ever show up that include these materials, which includes some three-fifths of the known *Laozi* text.[42]

11. Conclusions

This paper has described a general model of the evolution of premodern religious, philosophical, and cosmological systems. The model provides a dynamic theory of the growth of those systems that combines textual research with data from neurobiology and studies of complex systems. One novel feature of the model lies in the neurobiological roots it assigns to correlative thought, which can be linked to the origins of magic, myth and ritual, anthropomorphic deities, and related concepts that provided the foundations for the growth of high-correlative systems in stratified textual traditions. Neurobiological data are also used to explain cultural invariances in exegetical processes that helped drive those developments. The paper suggests how computer simulations based on the model can assist in many tasks, including helping date problematic texts and modeling parallels in the evolution of premodern traditions worldwide. Tests of the model include predictions it provides concerning the time-course of such parallels and evidence it has raised concerning the non-literate nature of Indus civilization. The paper ends by proposing a new test of the model involving the most important controversy that exists over the recently discovered Guodian tomb-texts of the *Laozi*.

The paper argues that predictive models of this type have the capability of revolutionizing studies of premodern traditions and of promoting future expansions of co-evolutionary models of the brain and human thought.

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possibility, not explicitly noted by Henricks, that the concept may have migrated into later versions of the *Laozi* via this text. Boltz 2005: 76, n. 23 does not discuss the conceptual overlaps in these sources, but raises the even more interesting possibility that the conjunction of the Guodian *Laozi* and "Taiyi shengshui" in Guodian Bundle C may imply that they were viewed by the original compiler as a single edited text. On this thesis, the only reason the modern Guodian editors separate the works follows from the fact that the materials in the "Taiyi shengshui" were previously unknown. Combining both possibilities — that the water symbol may have migrated into later *Laozi* versions via the "Taiyi shengshui," and that the two texts may once have been viewed as one — suggests that the Guodian materials may throw far more light on the early formation of the *Laozi* than normally assumed.

[42] It is important in closing to note that our model remains neutral on the age of the minority of missing sections of the Guodian *Laozi* that cannot be distinguished on exegetical grounds from materials included in the work. But given the evidence that the most important missing materials were late, it is a reasonable working hypothesis to assume that these were later compositions as well.

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