The neurobiological origins of primitive religion: Implications for comparative mythology

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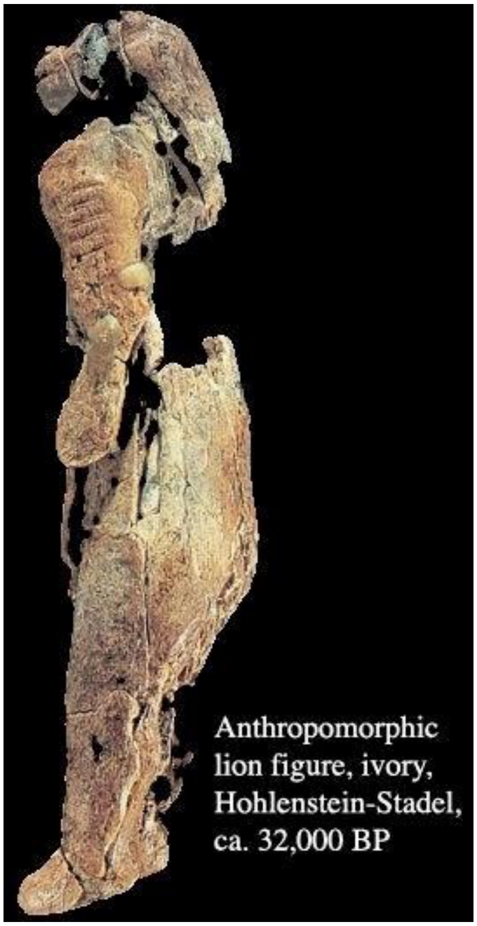
Anthropomorphic lion figure, ivory, Hohlenstein-Stadel, ca. 32,000 BP

Revised version of a paper prepared for the Second Annual Conference of the International Association for Comparative Mythology, Ravenstein, the Netherlands, 19-21 August 2008. The paper was published in conference volume in 2010.

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Abstract

This paper describes a testable neurobiological model of the origins of primitive religion and myth. The paper is divided into four parts. Reflecting the aims of this conference, part one discusses the need for such a model in comparative mythology. Topics covered include the help such a model can give in distinguishing similarities in myths arising from shared ancestry or cultural transmission from those due to parallel invention; in establishing the maximum time depth possible in reconstructing ancient myths; in dating the oldest mythic thinking, which neurobiological data suggest predated anatomically modern man (placing the earliest myths long before ca. 200,000 years BP, and undermining claims they were "inventions" of some later period); in picturing how myths were transformed in the last 5,000 years of literate religious, philosophical, and cosmological traditions; and in explaining the remarkable persistence of myth in modern political and religious thought.

Sections two and three review earlier naturalistic models of religion and myth and introduce the first testable model of the origins of these phenomena. The model builds on recent neurodevelopmental findings that picture models of the world as high-dimensional elaborations of lower-level perceptual maps heavily biased to process social information; in humans, the emergence of these models can be traced from infancy through adulthood as they unfold in the cortical and subcortical systems of the so-called social brain. The paper provides evidence that the anthropomorphism underlying primitive religion and myth was a "spandrel" or non-adaptive side-effect of the development of these systems, which are critical to human survival.

Section four discusses empirical tests of the model involving neuropathologies that affect the social brain. Data here are drawn from research on one remarkable form of synesthesia linked to exaggerated anthropomorphizing tendencies and on autistic disorders in which such tendencies are missing or badly attenuated. The importance of testing the model is critical: the view that religion is a byproduct of some sort of the so-called social brain is suggested in a number of recent naturalistic models developed by Guthrie, Boyer, Atran, Harris, Dennett, Dawkins, and others, and can presently claim to be the consensual view; but in the absence of rigorous ways to test these models, that view cannot claim scientific status or provide a solid foundation for future research in comparative mythology or religion.

The ideas presented in this paper are part of a broader model developed elsewhere (Farmer, Henderson, and Witzel 2002; Farmer 2008; Farmer forthcoming) that combines neurobiological, philological, and historical evidence with computer simulations to explain important global parallels in the evolution of traditional religious, philosophical, and cosmological systems. The general aim of the paper is to suggest that by combining work in these fields we can build testable models of the evolution of human thought of the same general class that have long been indispensable in the physical and biological sciences.

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> We are in the midst of a historical moment reminiscent of the one in which biology found itself before the last World War, when vitalist doctrines predominated, even among scientists. Molecular biology has destroyed them. We must assume that the same will happen to spiritualistic theses. – Jean-Pierre Changeux, *Neuronal man*, 1985.

> If oxen and horses 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 similar in shape to their own (ascribed to Xenophanes, early 6th to early 5th centuries BCE; first cited in Clement of Alexandria, *Stromata,* 3rd cent. CE.).

0.1 Introduction: neurobiology, myth, and religion

This paper describes a neurobiological model of the origins of primitive religion and myth and anthropomorphism in general. Reflecting the aims of this conference, the paper pays special attention to the model's implications for comparative mythology. The paper draws in part from a book-in-progress (*Brains and history*) that combines neurobiological, philological, historical, and computational research to generate a general model of the evolution of major world traditions. Due to limitations of space, I will largely confine myself in this talk to discussing the links between primitive religion and myth, having in mind by the latter (following the definition in the *OED)* a "narrative usually involving supernatural persons, actions, or events, and embodying stories of natural or historical phenomena." Other sides of primitive religion illuminated by brain-culture studies — involving visions, ritualistic magic, mechanisms of social bonding, communication with gods and ancestors, concepts of life after death, etc. — are dealt with elsewhere in my book and will be noted here only in passing. Also left aside in this paper is discussion of key transformations that occurred in myth and religion in literate traditions over the past 5,000 years; discussion of the stereotypical changes that occurred in this period play a key role in the book noted above, which describes computer models capable of simulating those transformations in detail. For now on this, see Farmer 1998, 2008; Farmer, Henderson, and Witzel 2002; and Farmer, Henderson, Witzel, and Robinson 2002; parts of the underlying simulation engine used in these models are described in a working paper by Farmer, Zaumen, Sproat, and Witzel 2009).

The questions this paper addresses are simple but have broad implications. Why did early humans everywhere tend to model reality — or at least the most emotionally salient parts of reality — as the result of the acts of supernatural beings?

Why did they endow those beings with human mental and social qualities, and often with human physical traits as well? Can we build *testable* models of how anthropomorphic views are generated, creating a foundation for scientific approaches to comparative religion and mythology? Testing is essential, since while in the last decade numerous studies have approached religion and myth from naturalistic viewpoints, due to a lack of tests no model can currently claim scientific status.

Most of my talk focuses on oral rather than literate traditions, but in passing I will suggest ways in which joint neurobiological and philological studies can illuminate step-like developments in traditional philosophical, religious, and cosmological systems emerging cross-culturally over the last 5,000 years. I will also suggest why modern models of the world have lost most of their anthropomorphic qualities, although it is still possible to detect survivals of these in simple psychological tests; one of the most dramatic of these tests is illustrated near the end of my talk. The general aim of my paper is to suggest that it is possible to build models of the evolution of myth and religion that are no less rigorous than models in the biological and physical sciences — and that can be verified not only in textual data but in useful heuristic computer simulations as well.

1.1 Why is a neurobiological model of myth needed?

Let's start with the most basic question. Why do we need a neurobiological model of myth? Below I suggest four answers to that question. I will spend the most time on the first of these, since it reflects on the most important theoretical work currently going on in the field, much of it first discussed in this series of annual conferences, which (unofficially) began in 2004.

1. **A neurobiological model is needed to help sort out similarities in myths due to common descent, transmission, and parallel invention — and to help estimate the maximum time-depth possible in reconstructing ancestral myths.**

Some of the most important recent work in the field involves attempts to reconstruct prehistoric myths using methods loosely based on those used in comparative linguistics and population genetics (Witzel, *Origins of the world's mythologies*, in press). The aim is to reconstruct prehistoric myths and if possible to infer something about ancient migrations by comparing myths in the oldest available texts. Given the massive corruption found in what currently passes for our earliest ancient texts, such reconstructions can only claim approximate validity, and the time depth of reconstruction is open to debate (Farmer 2007 and below; Witzel *Origins*, in press). But if used cautiously such reconstructions can be useful heuristic tools in modeling prehistory, especially when their results heavily overlap with (similarly approximate) linguistic and genetic reconstructions.

One obvious limitation to this approach arises from differences in the ways that myths as opposed to genes or languages change over time. Old myths not only drifted in sense or merged with or were replaced by foreign myths, paralleling similar behavior in historical linguistics or population genetics, but were also at times abandoned or invented anew as ecological or cultural conditions changed. Classic examples include the rapid appearance of horses in the mythologies of North American Plains Indians after the first European contact; the equally rapid development of Melanesian cargo cults due to similar influences; and the wholesale invention by Mormons of an entire mythology for New World Indians in the 1820s and 30s. Nor are major ecological or cultural changes necessary to generate new myths. In his classic study of cosmologies among the Mountain Ok in Inner New Guinea, Fredrik Barth (1987) not only records major differences in myths in nearby Ok villages, but the birth of new myths too due simply to the private visions or ambitions or memory failures of single ritual specialists.[1]

One reason why more attention is currently paid to the transmission rather than generation of myths lies in the fact that research in comparative mythology necessarily depends on data "fixed" in texts. This gives even ancient myths a misleading aura of semi-permanence that is often projected into preliterate contexts.[2] The most extreme case lies in attempts to reconstruct myths antedating the apparent African diaspora. Even in ideal circumstances the texts in this case are a minimum of 50,000 years younger than the attempted reconstructions; sometimes, quite ludicrously, the claimed evidence includes missionary reports a few centuries old at best. The impossibility of useful reconstruction in this case is obvious when we consider not only the instability of myths and the corruption of sources but as well the massive ecological upheavals that followed the apparent African exodus 50-70,000 years ago. While traveling to their later homelands, the earliest humans in the Middle East, South or Central Asia, Europe, the Far East, and Oceania lived through the worst of the last glacial period — including the ascent to the glacial maximum ca. 18-20,000 years ago and descent to its minimum ca. 10-12,000 years BP; wild climate changes between or after those periods, including the sudden "Great Freeze" of the Younger Dryas event, ca, 13000 years BP, and the sea rises that accompanied the collapse of the Laurentide ice sheet ca. 8400 years ago; habitation at different times of savannas, jungles, deserts, river basins, coastal areas, mountains, and high plateaus, each obviously with different mythic demands; correlated changes including major extinctions of animal and plant life on which human survival depended, each again surely deeply impacting myths; population bottlenecks precipitated not only by migrations but by disease and famines, with

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[1] Abandonment of old myths and inventions of new ones of course tend to occur most quickly in cases in which old gods (or saints or spirits or divinized ancestors) fail in their assigned functions. Hence the origins of Western medieval rituals known as the "humiliation of the saint" or medieval Chinese demotions of bureaucratic gods who failed during famines or other local disasters. Abandonment of myths (often accompanied by the demonization of failed deities) is in any event common and has to be taken into account in any theoretical model of comparative mythology.

[2] Clearly some types of oral transmission are capable of relatively high-fidelity; the classical case lies in some types of Vedic traditions. But this is an extreme case and may itself have originally emerged as a kind of "counter-literacy" under pressures from literate technologies imported from the Persian Empire. On this, see Farmer, Henderson, and Witzel 2002, n. 55; and in detail, Farmer, forthcoming.

similar results; and the first large-scale diversification of human economies starting after the last glacial minimum, resulting in radically altered hunting and gathering environments and the first pastoral and farming and urban trading societies; the fact that the latter changes directly impacted myth formation can be unambiguously validated in our earliest texts. Myths are acutely sensitive to ecological change, and sorting out the effects of such change again requires a model of myth generation — and that requires an understanding of the evolutionary and neurobiological origins of the anthropomorphic tendencies that lie at the base of primitive religion and myth.

There is still another way that myth transmission differs from that of languages and genes that again suggests the need for such a model. Not only can we expect ecological upheavals to encourage inventions of new myths, but we can also predict that new myths generated in similar environments often have similar features. Just as in biology, comparative mythology is full of examples of how similar ecologies encourage the emergence of similar forms; given sufficient data, we should be able to develop usable estimates of the frequency of independent invention based on mass comparison of cognate and non-cognate myth complexes (Farmer 2007). It would be a strange farming society indeed that lacked cyclical planting and harvesting myths and at some point dead-and-resurrected gods; anomalous river dwellers who lacked flood myths; and rare religions of the oppressed that at some point did not invent (or adopt from other cultures) cosmic saviors. Due to limits in our textual sources, our detailed understanding of similarities in myths is often too imprecise to confirm whether those similarities derive from common descent, transmission, or parallel invention; at times all may play partial roles. Uncertainties are greatest in the case of similar myths known only in fragmentary form from widely separated eras, which is often the only evidence available; this is a particularly serious problem in comparative studies of Indo-European myths. What is clear is that a generative model of myths is required before we can expect to sort out all these issues in a systematic fashion.

Possessing such a model will not give us every answer; a neurobiological model cannot yet give us reliable estimates of the maximum time depth of reconstructions of ancestral myths, which can be expected to depend on the stability of conditions between the oldest versions of those myths and those used in their reconstruction; such estimates require a detailed understanding of prehistoric ecological changes that current eludes us. But such a model can help us develop such estimates when conjoined with improved data that should become available in the next few decades. Bill Zaumen, Richard Sproat, Michael Witzel, and I have developed cultural simulation software that should prove useful in analyzing data of these types; that software will be released *via* Internet for customized use by non-programmers in 2010 (cf. Farmer, Zaumen, Sproat, and Witzel 2009).

2. A neurobiological model can help us decide between models that picture primitive myth and religion as cultural ‘inventions’ and those that view them as (adaptive or non-adaptive) byproducts of brain processes; it can also help us estimate the dates of the earliest myths.

There are three approaches to dating the earliest myths. The first is based on the assumption that myth is an "invention" that appeared at a given point in prehistory. One common period suggested for the earliest myths is the time of the so-called symbolic explosion, sometime shortly after 40,000 years BP, when iconographical evidence of anthropomorphism first appeared. [3] Other variants assume that myth originated before modern man's African exodus but leave the dates open. If we accepted either alternative and (quite dubiously) assumed as well that that oral myths were capable of remaining relatively stable through multiple population bottlenecks and ecological upheavals, we could make a case that someday we might reconstruct man's "first" myths.

The second and third views assume that myth-making is a byproduct (either selected for or a non-adaptive side-effect or "spandrel"[4]) of neurobiological processes. On either of these evolution models, the question of when the "first" myth appeared is meaningless. The anthropomorphic modeling associated with myth in both cases reaches back minimally to the first modern humans, ca. 200,000 years BP; depending on which sides of brain processes that we associate with myth generation those dates can be pushed back much further — an issue that is addressed later in this paper.

The idea that the anthropomorphism underlying primitive religion and myth is in fact a side-effect of brain development is supported by a great deal of testable evidence reviewed at length in this paper. That evidence suggests that religion and myth are non-adaptive (and in evolutionary terms, quite expensive) byproducts of the ways in which the so-called social brain — distributed brain systems involved in face-recognition, the reading of emotions and sexual signals, modeling of the cognitive states of others (in so-called theories of mind), etc. — developed early in evolution (see Sections 3.1 ff.). On this evidence, crude animistic modeling of some sort can be expected in all higher social animals, not just in man — amusingly, in a sense vindicating the words ascribed to Xenophanes, found in the epigraph of this paper. In this case, the elaboration of such models in myths can be traced back as far as we are comfortable placing human language. Much evidence suggests that language too emerged over a vast period, with the result (as discussed below) that something corresponding to myth can be claimed to be much older than the first anatomically modern men.

3. A neural model is needed to explain cross-cultural similarities in the ways myths were transformed in literate traditions, helping generate the partly deanthropomorphized deities and cosmic principles of later world traditions.

One perennial problem in mythological research is that preliterate and literate myths are often naively confused (Farmer 2007). One reason is presumably because even ethnographic reports of myths eventually reach us *via* texts, which often misleading conflate a plethora of myth variants in single fixed forms. Moreover, once prehistoric myths found their way into texts, they tended to get "worked up" abstractly

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[3] E.g. in the ivory anthropomorphic lion from Hahlenstein-Stadel, ca. 32,000 years BP. shown on the cover of this paper.

[4] A term for a non-adaptive side-effect, introduced into evolutionary biology by Gould and Lewontin 1979.

by scribes and commentators operating over long periods in stratified textual traditions, helping transform myths into the abstract religious, philosophical, and cosmological forms typical of mature premodern civilizations (Farmer 1998; Farmer, Henderson, and Witzel 2002; Gonzalez-Reimann 2002; Farmer 2008; Farmer forthcoming). [5] Cross-cultural data summarized in these studies suggest that the exegetical methods used to integrate myths in manuscripts were similar crossculturally, due again to neurobiological influences. The implication is that a neurobiological model is needed not only of myth generation but of myth transformation in literate traditions as well.

4. **A neurobiological model is needed to explain the unreasonable perseverance of primitive mythic tendencies in modern traditions.**

Myths in the forms studied in comparative mythology arise from what can be pictured as "default conditions" in the human brain expressed in some way in all periods of history (*infra* and Farmer forthcoming). In later cultures, those default conditions may be partly overwritten by literate traditions in which anthropomorphic tendencies become worked up abstractly in predictable directions (Farmer 1998; Farmer, Henderson, and Witzel 2002; Farmer 2008; Farmer forthcoming). This notwithstanding, it can be shown from simple experiments (cf. Section 4.3 below) that myth-making tendencies can be identified in all normal subjects just below the surface; study of neuropathologies in which those tendencies are amplified or attenuated provides useful ways to uncover which sides of neural processing are involved in myth generation. The fact that even modern societies have not succeeded in eliminating these tendencies entirely helps explain why after at least 250 years of scientific discussion primitive thought forms including myth continue to be major political, religious, and cultural influences even in technologically advanced societies.

In order to explain the perseverance of myth in modern cultures, we need a testable model of its origins. The confident prediction made in the early 1980s by Jean-Pierre Changeux — a leading neurobiological theorist and early advocate of brain-culture studies — of the coming demise of "spiritualistic theses" may be true in the scientific world; recent studies show that an insignificant percentage of top scientific researchers identify themselves as being religious in any form (for summaries of the data, see Dawkins 2006: 97-103). But the deep neurobiological roots of anthropomorphism discussed later suggest that we cannot expect that the same will be true for global populations — at least until some future time when more of the world's population is exposed to serious scientific education.

2.1 The universality of early anthropomorphism, and its role in early religion

But were in fact primitive religion and myth really universal in premodern times? Before developing a testable model to explain their origins, we need to discuss claims

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[5] It is the predictability of these processes that allows us to model long-range patterns of growth in those traditions in computer simulations. See Farmer, Henderson, and Witzel 2002; Farmer, Henderson, Witzel, and Robinson 2002; Farmer 2008; and Farmer forthcoming.

involving preliterate tribes who were innocent of religion, or at least who supposedly told no myths about gods or spirits. If such tribes have ever existed, any model that claims that primitive religion and myth arose from neurobiological "default states" would hardly be credible.

Claims of the existence of such tribes have been made repeatedly since antiquity. The most recent involve the Pirahã of the Amazon, whose reportedly simple culture and primitive linguistic traits — at least as pictured by the linguist (and former Christian missionary) Daniel Everett — have made a sensation in the global press. But a closer look at the evidence suggests a more complex and quite melancholic story: among the few artifacts noted in Everett's works are Pirahã necklaces made "from seeds, homespun cotton string, teeth, feathers, beads, beer-can pull-tabs, and/or other objects," whose functions "are decorative only secondarily, their primary purpose being to ward off the evil spirits that they see almost daily" (Everett 2005). As this passage suggests, the claimed reluctance of the Pirahã to tell myths may itself testify to the fearful hold gods and spirits have over their daily life. The inclusion among Pirahã spirit-deflectors of "beer-can pull-tabs" also hints that the impoverishment of this rapidly dying culture may involve recent disruptions to old ways of life. The result as one severe Everett critic notes may be a "creolized, stripped-down remnant" of older values tied to the Pirahã's earlier links to tribes known to have once possessed a rich mythology (Levinson 2005).

Everett's testimony in asides also suggests that the Pirahã are much more prone to myth telling than he tells the press. Thus despite his public claims that none of the Pirahã is bilingual, in his technical papers he speaks repeatedly of tribesmen freely relating stories in Portuguese as well as their native language (e.g., Everett 2005). Much comparative evidence demonstrates that myth telling is not as common in some premodern societies as others, but — and here the Pirahã must stand for the rest — no one has ever turned up evidence of a single early society that failed to picture major segments of reality in anthropomorphic terms.

The fact that anthropomorphism was pervasive in early cultures does not mean that religion consists only of stories about gods and spirits. Any comprehensive model of myth and religion must account as well for the means of communicating with gods, spirits, and ancestors; for concepts of souls and life after death; for shifts from blood sacrifices to anthropomorphic gods to "spiritual" sacrifices to transcendent deities; for the related shift in literate times from tribal to universal ethical ideas; for the magical union of worshippers with redemptive deities; for the (fairly late) development of meditative practices aimed at mystical union; and so on down a long list (Farmer 2008; Farmer, Henderson, and Witzel 2002; Farmer forthcoming). Tied to many of these developments is the fact that cruder anthropomorphism tended to diminish in literate traditions, eventually giving birth to monotheistic gods and abstract cosmic principles often not only said to be distant from human form but to transcend human understanding as well.

Despite these complexities, anthropomorphism remains our best entry point to studying primitive religion and myth scientifically. There was a popular saying in the nineteenth century inspired by the work of the French physiologist Jean Pierre Cabanis; the most famous version shows up in William James, a staunch "spiritualist," who cited it critically in *Principles of psychology* (1890): "The brain secretes thought as the kidneys secrete urine, or the liver secretes bile." Darwin (1838) earlier proposed a version less apt to shock the pious, but still prudently confined to a private notebook: "Why is thought being a secretion of brain, more wonderful than gravity a property of matter?"

Darwin could have added: And why does thought so often express itself in anthropomorphic forms? Why do children draw faces on the sun, or turn house doors into mouths and windows into eyes? Why are children's stories populated worldwide by talking animals inhabiting human social settings? Why did early cultures link gods with stars or constellations linked with social myths? Why do human languages assign gender to inanimate parts of nature? And if overextensions of human traits to the exterior world are rooted in neurobiology, how have human cultures managed to transcend anthropomorphic tendencies? Why do we tend to associate myth more with earlier than with later cultures?

The aim of the model discussed below (starting with Section 3.1) is to demonstrate that primitive anthropomorphism is a predictable side-effect of neural development — originating in social biases in brain programs running continuously in all of us. While these biases may be partially overwritten in literate traditions, in times of historical stress they tend to return to full strength.

The brain not only naturally secretes thought but gods and myths as well — a finding that could bode ill for man's long-term survival, given his growing technological power. Before sketching out the grounds of the model, it will be useful to look at earlier attempts to link anthropomorphism to primitive myth and religion and the brain to religious experiences of other types.

2.2. Earlier naturalistic models of myth and religion

The idea that the gods inhabiting myth originated in overextensions of human qualities to the exterior world can be traced to antiquity. The most famous expression of that idea came in the words found at the head of this paper traditionally ascribed to Xenophanes, who lived in the early 6th to early 5th centuries BCE. Similar ideas show up in Hebrew scriptures compiled in the same period, an era in which the expanded use of lightweight writing materials was radically transforming mythic traditions throughout Eurasia (Farmer 1998; Farmer, Henderson, and Witzel 2002; Farmer forthcoming).

In the middle of the eighteenth century, Hume placed anthropomorphism at the center of his *Natural history of religion* (1757) and *Dialogues concerning natural religion* (first published 1779), which continue to have a deep impact on naturalistic models of religion and myth (see below, Section 2.6):

> There is a universal tendency among mankind to conceive all beings like themselves, and to transfer to every object, those qualities, with which they are

> familiarly acquainted, and of which they are intimately conscious. We find human faces in the moon, armies in the clouds; and by a natural propensity, if not corrected by experience and reflection, ascribe malice or good-will to every thing, that hurts or pleases us (Hume 1757).

In the nineteenth century, these ideas turned up in dozens of variants as evolutionary models grew in popularity in all fields from biology to cultural history. In 1841 Feuerbach argued in *Das Wesen des Christentums* that even late theological concepts in Christianity consisted in the projection of man's nature into ideas of god. Feurerbach did not suggest a clear evolutionary path from primitive anthropomorphism to the Christian ideas discussed in his work; his model derived from critiques of Hegel and not what anyone today would view as scientific or historical data. But his approach had a major impact on naturalistic studies of religion, which began to appear in large numbers after Darwin published *Origin of species* in 1859.

The most influential of these came in E.B. Tylor's *Researches into the early history of mankind* (1865) and *Primitive culture* (1871). Tylor argued that the origins of religion lay in primitive "animism," which can be roughly viewed as an extension of concepts of life or soul (*anima* in Latin) to the non-human world. Similar views were advanced in the early years of evolutionary theory by others, many of them closely aligned with Darwin. These included (besides Herbert Spencer) Darwin's neighbor John Lubbock, in *Pre-historic times* (1865) and *Origins of civilization* (1870), and the ethnologist John Ferguson McLennan.

In *Descent of man* (1871), Darwin summed up views of anthropomorphism that were widespread at that time by quoting McLennan's "The worship of plants and animals" (1869), which placed the origins of religion in the "simplest and earliest hypothesis" to occur about the world — "that natural phenomena are ascribable to the presence in animals, plants, and things, and in the forces of nature, of such spirits prompting to action as men are conscious they themselves possess." Transmitted largely through Tylor's concept of animism, this view has impacted a long list of writers — stretching from Piaget in the 1920s to recent writers including Boyer, Atran, Harris, Dennett, and Dawkins. The most detailed model of the origins of anthropomorphism so far is found in the work of the anthropologist Stewart Guthrie, to whom we will return shortly.

At the end of the nineteenth century William James took a radically different approach to religion in *Varieties of religious experience*, which was originally written for his Gifford lectures in Edinburgh in 1901-2. Unlike these earlier figures, James had little if any interest in gods, formal theology, religious institutions, or historical transformations in religion. As his title implies, his interest lay in religious experience — existential anxiety, ecstasy, possession, hallucination, prophecy, spiritual healing, conversion, mystical rapture, and so on. James acknowledged that much of this experience could be viewed as abnormal from a psychological standpoint. But in his eyes that did not undermine its spiritual validity, which in the light of his "pragmatism" could only be measured by its psychological effects. James' beliefs here were intensely personal: he claimed his lifelong depressions only lifted once he embraced his wife's spiritualism, which expanded in old age when much of his time was taken up in seances and conversations with the dead. One of James' last publications, in 1909, notoriously recorded his conversations with his dead friend Roger Hodgson. (James' *New York Times* obituary the next year carried the wonderful subtitle "Exponent of pragmatism and dabbled in spooks.")

The influence of James' work in studies of the origins of primitive religion has in many ways been unfortunate due to his shift of emphasis from primitive anthropomorphism to subjective religious experience, all of it approached ahistorically. In the 1970s, working in the tradition of James, Norman Geschwind, one of the twentieth century's great neurologists, took this trend further in reexamining what has been claimed since antiquity to be the heightened religious experiences of epileptics. What followed were a series of still controversial studies that attempt to link a set of behaviors including intensified religiosity and hypergraphia to the period between seizures in temporal lobe epileptics (Waxman and Geschwind 1974, 1975; cf. Trimble and Freeman 2006). In the following decades, a large literature has developed supporting or attacking Geschwind's attempts to localize extreme forms of religious experience in specific regions of the brain. Recent claims have even been made that intimations of "God" can be induced artificially in the temporal lobe (the region most associated with epileptic seizures) by the application of technologies including transcranial magnetic stimulation (TMS) (St.-Pierre and Persinger 2006).[6]

Many recent studies in the tradition of James have been sensationalized in the press and have been credulously hailed by New Age spiritualists, including at times researchers involved in the studies. The most famous are associated with Andrew Newberg and his coworkers at the University of Pennsylvania (cf., e.g. Newberg *et al.* 2001, 2003; Khalsa *et al.* 2009). Using non-invasive imaging techniques, Newberg's group has studied changes in regional blood flow patterns in the brains of meditating Buddhist monks and Catholic nuns while they used various visualization or chanting methods. What all this has to do with religion is questionable: from a neurobiological angle, one could predict similar blood-flow patterns would show up from studies of atheists changing nonsense words and perhaps pornographic rhyme.

Many similar studies have recently been undertaken elsewhere; perhaps the most notorious — much ridiculed in the field — is a study by a University of Montreal group that reports results of functional magnetic resonance imaging (fMRI) studies of blood-flow patterns in Carmelite nuns recorded "while they were subjectively in a state of union with God." The authors claim (without a hint of skepticism) that the experiences of their subjects may also include

> …the sense of having touched the ultimate ground of reality, the experience of timelessness and spacelessness, the sense of union with humankind and the universe, as well as feelings of positive affect, peace, joy, and unconditional love (Beauregard and Paquette 2006).

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[6] For an amusing story on this method and its failure when tested on the evolutionary biologist (and atheist) Richard Dawkins, see in the UK Telegraph from 2003: "Holy Visions Elude Scientists," http://tinyurl.com/5t9oav. More on Persinger's claimed "God helmet" can be found on the Web.

It is impossible to imagine what light if any fMRI studies of modern meditating monks and nuns could throw on primitive religion — which highlights one problem introduced in naturalistic approaches to religion and myth since James altered the direction of research in the early twentieth century. From an historical standpoint, meditation of the types described in the studies described above have little to do with primitive religion: formal meditation was a relatively late development in religious thought, appearing at the earliest towards the middle of the first millennium BCE, when religion underwent major changes under the impact of expanding literacy.

Claims that studies like this may someday identify a "God spot" (to cite a credulous *Scientific American* article) or things similar clash with everything known about the distributed nature of brain functions, which are discussed later in this paper: cognitive functions (including those involving religion) are located in circuits linking many brain areas, and not in single regions. The conclusion is that little help can be expected in understanding primitive myth and religion by the kinds of "neurotheology" widely discussed in recent years in the mass press.[7]

2.3 Darwin's dog and chimpanzee rain dances: standard cognitive approaches to the origins of religion

Starting in the 1990s, a growing number of researchers began to return to naturalistic views of the origins of anthropomorphism discussed in the tradition extending from Hume to Lubbock, Tylor, McLennan, Darwin, and other early evolutionary theorists. The first influential work of this type is by the anthropologist Stewart Guthrie, found in a major book, *Faces in the clouds: A new theory of religion* (1993) and a number of shorter studies (cf., e.g., Guthrie 2002). Guthrie's model is not grounded in a detailed discussion of the brain, but it does take cognitive research and evolutionary studies of behavior seriously. Guthrie's model illustrates both the uses and limitations of current evolutionary approaches to myth and religion — including the problem of deciding between alternative models in the absence of ways to test those models — and is worth discussing in detail.[8]

Guthrie expands on a suggestion in Darwin in extending to the animal world in general what can be broadly viewed as "animism," which he sees as an ancient adaptive mechanism tied to evolutionary survival. He takes his inspiration in one recent paper

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[7] Two recent papers by Kapogiannis *et al.*, published after this article was in press, that associate activation of neural networks linked to the so-called social brain with different sides of anthropomorphic religious belief are more useful, although they persist in misrepresenting single cognitive functions with localized brain regions.

[8] A number of later studies follow the general path taken by Guthrie. My discussion of his work below must stand in lieu for a broader discussion of the literature. A few major studies at least indirectly influenced by Guthrie's views of anthropomorphism and the origins of religion — all also discuss a wider range of religious topics — include Pascal Boyer, *Religion explained: The evolutionary origins of religious thought* (2001); Scott Atran, *In gods we trust*: *The evolutionary landscape of religion* (2002); David Sloan Wilson, *Darwin's cathedral: Evolution, religion, and the nature of society* (2002); Sam Harris, *The end of faith: Religion, terror, and the future of reason* (2004); Daniel Dennett, *Breaking the spell: Religion as a natural phenomenon* (2006); and Richard Dawkins, *The god delusion* (2006). Reasons proposed for the origins of religion in these studies range from variants

from a wonderful passage from the *Descent of man* (1871), which I quote here a bit more fully than Guthrie does in his paper:

> The tendency in savages to imagine that natural objects and agencies are animated by spiritual or living essences, is perhaps illustrated by a little fact which I once noticed: my dog, a full-grown and very sensible animal, was lying on the lawn during a hot and still day; but at a little distance a slight breeze occasionally moved an open parasol, which would have been wholly disregarded by the dog, had any one stood near it. As it was, every time that the parasol slightly moved, the dog growled fiercely and barked. He must, I think, have reasoned to himself in a rapid and unconscious manner, that movement without any apparent cause indicated the presence of some strange living agent, and that no stranger had a right to be in his territory (Guthrie 2002; Darwin 1871, ch. 3).

Darwin tied these animistic tendencies to what he characterized as religion's ugliest features, including human sacrifice aimed at appeasing anthropomorphic deities. He continues in *Descent of man* in a passage not quoted by Guthrie; Darwin here clearly endorses the idea that religion is an unwanted side-effect of evolution:

> The same high mental faculties which first led man to believe in unseen spiritual agencies…would infallibly lead him…to various strange superstitions and customs. Many of these are terrible to think of — such as the sacrifice of human beings to a blood-loving god; the trial of innocent persons by the ordeal of poison or fire; witchcraft, &c….As Sir J. Lubbock [in *Pre-historic times*] has well observed, "it is not too much to say that the horrible dread of unknown evil hangs like a thick cloud over savage life, and embitters every pleasure." These miserable and indirect consequences of our highest faculties may be compared with the incidental and occasional mistakes of the instincts of the lower animals.

Guthrie expands on Darwin's suggestion involving his dog with evidence drawn from studies of animal behavior. The tendency to ascribe animacy to nature, as Guthrie sees it, is rooted in questions of survival, in the "horrible dread of unknown evil" noted by Lubbock and Darwin. The gravest dangers to animals and early man were not inanimate but animate, and the two were not always easy to distinguish. Camouflage

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of the old claim that religion was selected for in evolution to enhance group survival (a view proposed in updated form in Wilson's work) to a diverse set of theories (in Boyer, Atran, Harris, Dennett, and Dawkins), more in harmony with the model developed in this paper, that most sides of religion were non-adaptive side-effects of human evolution. There is a great deal of useful material in these studies, but as in the case of Guthrie's seminal work, there is little discussion in any of them of the detailed neurobiological underpinnings of their models or of empirical tests that would allow us to verify or falsify them; as a result, no broad consensus has emerged in the field on the origins of myth and religion, outside of agreement that those origins can be explained in biological terms and often involve the so-called social brain. A deeper problem arises from the fact that none of these studies distinguishes clearly between primitive myth and religion and their later transformations in literate traditions, with the result that their models (like those of James and his followers) are largely ahistorical, which limits their usefulness in broader studies of comparative mythology and the history of thought.

and mimicry are employed by predators and prey alike, making it difficult to detect animate dangers on the rapid time scales needed to guarantee survival. As a result, animals tend to evolve heightened perceptual mechanisms to detect animate objects. In the case of sudden movement or suspicious noises the default condition, as illustrated by Darwin's dog, is to assume that the sources are alive. Guthrie writes:

> Like us, other animals appear to attribute characteristics of life and agency to the inanimate world. In this sense, other animals are animists. This is because we all respond to perceptual ambiguity in a strategic way, produced by natural selection: when in doubt about whether something is animate or intentional, or is the result of action by something animate or intentional, we assume that it is (2002).

Drawing on a classic paper that compares cognition in animals and children, Guthrie writes: "An S-shaped object on a woodland path might be either a stick or a snake. As Ristau (1998: 139) puts it, a 'fail-safe mechanism for most species would be to interact with an unknown object as though it were animate, and probably predacious'"(Guthrie 2002). The "better safe than sorry" explanation that Guthrie proposes to explain why animals have heightened animate detection systems is repeated by many others, including Boyer 2002, Atran 2002, and Dennett 2006.

Guthrie reviews interesting if anecdotal evidence of animals behaving "as though in the presence of unseen agents (for example, even with no predator in sight, they often act cautiously — though occasionally, as in the chimpanzee rain dance, with bravado)" (2002). He points to evidence of perceptual bias in detecting animate objects, including rapid responses in animals and children to eyes or anything resembling them — reflected in the common development of false eye-spots as defenses against predators. After reviewing a number of similar examples, he returns to the chimpanzee rain dance as an epitomal example of "animal animism" (2002):

> Finally, and most tellingly, wild chimpanzees…often respond to thunderstorms, to rapid streams and to waterfalls with the kind of display (shaking and dragging branches and rushing about vigorously) that they use as a threat against predators and other chimpanzees. Observers have reported this behaviour in six communities of African chimpanzees, out of nine communities that have been closely studied….Goodall and many other chimp-watchers think this behaviour is indeed a threat directed toward these inanimate targets as though they were alive. The response is both widespread and indiscriminable from those toward actual, natural agents, visible or not.

I will return to chimpanzee rain dance, which is in fact of significant importance in understanding the origins of myth, in Section 3.6 below.

2.4 Animate detection systems: partial support for the standard model

Guthrie and the long line of later writers after him who have developed similar models frequently allude to cognitive psychology and the brain, but do not attempt to explain the mechanisms behind their models in detailed neurobiological terms. But part of those models can find support in recent brain research, especially those parts involving animate detection systems. Studies of the eternal war between rats and cats provide a nice example. Recent studies have confirmed that rat brains have what we can picture as built-in cat detectors, mediated by pheromones in cat urine. Even a slight whiff of cat will trigger aversive reactions in rats, mediated by circuits in the amygdala and linked cortical and subcortical fear centers (Takahashi *et al.* 2005; Blanchard *et al.* 2005). Unfortunately for rats, a protozoan parasite known as *Toxoplasma gondii* has evolved ways to breech these cat-detection systems for its own selfish benefit. *Toxoplasma* has the unique property of living in rats but reproducing only in cat intestines; at appropriate times in the parasite's life cycle *Toxoplasma* cysts implanted in the rat's amygdala emit chemicals that convert the rat's innate fear of cats into a fatal attraction — allowing the parasite to complete its life cycle in a predictable fashion (Vyas *et al.* 2007). Few better examples exist of the perversity of "Nature, red in tooth and claw" that underlies modern cognitive models of "animal animism."

Moving up the evolutionary ladder, the best-known studies of higher brain systems specialized to detect animate dangers involve innate fears in primates of snakes. Inspired by the studies of Alfred Brehm (1829-84), Darwin once again lies at the center of the story, which involves experiments described both in *The descent of man* (1871) and *The expression of the emotions in man and animals* (1872). Darwin showed monkeys and baboons at the London Zoological Gardens stuffed snakes, dead fish, mice, and turtles to check their reactions. Depending on the stimulus, the responses of the primates ranged from total indifference to curiosity to fear and aggression — which was intense in the case of snakes. Many later researchers have replicated Darwin's work, leading to the consensual view today that most primates (there are a few exceptions) including humans have an innate fear of snakes.

These examples involve responses to specific animate threats, and hence can only provide limited support for Guthrie's model of "animal animism." But recently a study by New *et al.* in the *Proceedings of the National Academy of Sciences* provided evidence of attention biases to animate objects of a generalized sort that go much further (New *et al.* 2007, Ohman 2007). While the study does not mention religion, it implicitly provides some of the best evidence of neural processes that might be cited in support of the model of the origins of primitive religion proposed by Guthrie and later writers in his tradition.

Like Guthrie and these writers, New *et al.* hypothesized that the brain evolved rapid-detection systems to spot animate dangers in the environment. They tested this idea by showing human subjects outdoor scenes modified randomly by the insertion of computer images of animate or inanimate objects. All their subjects identified the animate objects in the scenes much faster and more reliably than the inanimate objects. This was even true when the inanimate objects were vehicles, whose detection might have life-or-death consequences in modern life. The researchers argue from the latter finding that animate monitoring biases emerged early in evolution and did not derive from cultural conditioning. The paper concludes:

> Changes to animals, whether human or non-human, were detected more quickly and reliably than changes to vehicles, buildings, plants or tools. Better change detection for non-human animals than for vehicles reveals a monitoring system better tuned to ancestral than to modern priorities. The ability to quickly detect changes in the state and location of vehicles on the highway has life-or-death consequences ….Yet subjects were better at detecting changes to non-human animals, an ability that had life-or-death consequences for our hunter-gatherer ancestors but is merely a distraction in modern cities and suburbs. This speaks to the origin of the selection criteria that created the animate monitoring bias (New *et al.* 2007).

Still another recent paper has similarly found that new-born babies have innate biases to attend to biological as opposed to non-biological motions. The paper supports the thesis that these biases are "presumably part of an evolutionarily ancient and nonspecies-specific system predisposing animals to preferentially attend to other animals" (Simion *et al.* 2008). It can finally be noted that this thesis can also be supported by studies of brain-damaged subjects who selectively lose the ability to name living or nonliving things, which similarly suggest that the living/nonliving distinction may be intrinsic to brain processing (cf. Damasio *et al.* 1996; Martin *et al.* 1996; for a different interpretation, see Marques 2002, Marques *et al.* 2008). All these studies can be tied at least suggestively to neurobiological models of the origins of myth.

2.6 From animism to anthropomorphism: inadequacy of the standard model

Before these papers appeared, Guthrie had already claimed that perceptual biases involving animate danger were linked to the origins of anthropomorphic gods. But neither Guthrie nor later writers in his tradition (Boyer, Atran, Dawkins, etc.) have proposed any detailed model of the neurobiological sides of those links. To verify their models we would need to specify the exact path that leads from animate detection biases to the generation of anthropomorphic deities. That generation obviously cannot be explained simply by invoking models of "animal animism," which picture animism as a general survival strategy in a world teeming with animate dangers: humans may be the most dangerous of animals, but they are obviously not the only ones, as the case of snakes makes evident. The evidence in the recent papers by New *et al.* and Simion *et al.* suggest that human attention systems were primed by evolution to be as alert to the presence of other animals as to humans; this being the case, why should we expect human and not animal traits to dominate in religion? Even ancient myths involving animal worship heavily anthropomorphized the objects of worship, as suggested in the earliest prehistoric hints we have of myths (cf. again the Hohlenstein-Stadel lion on the paper cover). The result is that even if "animal animism" might have been involved in early religion, that concept does not lead us to the anthropomorphism in ancient myths.

Guthrie himself acknowledges that anthropomorphism and not heightened awareness of animacy lies at the heart of human religion: his emphasis on the latter is apparently meant only to suggest that religion has deep evolutionary roots. His longest study, *Faces in the clouds* (1993), provides a useful anthology of hundreds of examples of anthropomorphism — the best to date — not only in religion but in science, philosophy, the arts, and popular culture. Here and elsewhere (e.g. 2002) Guthrie also discusses a number of primitive perceptual biases, including human face-recognition systems, that can be linked at least intuitively to anthropomorphic modeling of the world. The book reviews tendencies of children to draw faces on inanimate objects and survivals of those tendencies in adults when they talk to their animals or pets.

In a key passage cited below, Guthrie explains his views of the origins of anthropomorphism; interestingly, despite the 250 years separating their works, those views do not provide an advance over the commonsense (if fundamentally untestable) view that Hume expressed in 1757 (above, Sec. 2.2): anthropomorphism is part of a quasi-rational if misguided search for order in the world:

> My explanation of anthropomorphism closely resembles that for animism. Both phenomena stem from the search for organization and significance, and both consist in overestimating them. Scanning the world for what most concerns us — living things and especially humans — we find many apparent cases. Some of these prove illusory. When they do, we are animating (attributing life to the nonliving) or anthropomorphizing (attributing human characteristics to the nonhuman). Central among human characteristics is symbolic interaction. Animism and anthropomorphism are on a continuum and may coexist: in verbally urging a balky computer, we both animate (give it life) and anthropomorphize (give it language) (Guthrie 1993: 62-3).

Elsewhere he writes that “we believe in gods mainly because facing uncertainty, perception and cognition default to the most important possibilities we know. If those possibilities are actualities, we gain from having anticipated them, and if not, we lose little” (Guthrie 2002).

This view is no less plausible — nor any more satisfactory — than it was in Hume’s time. To bring this intuitive view into the realm of testable science, we need a biological understanding of why primitive man defaulted to anthropomorphism when modeling the world. Fast responses to animate danger undoubtedly had survival value in prehistoric times, but those responses do not need to be linked to any models of the world. In fact, responses like these arise from activation of subcortical regions that occur long before conscious awareness of danger arises in the cortex (cf. LeDoux 1994, 1996, 2007), where such models are constructed. Nor can fast response to animate danger be linked credibly to anthropomorphic myths involving the sun, moon, planets, constellations, seasons, times of the day, weather patterns, or other natural forces, let alone cultural entities like cities, which were mythologized and worshipped far into premodern times. Recalling the links Darwin drew between anthropomorphism and unsavory sides of religion including human sacrifice, it is difficult to agree with Guthrie in picturing it as part of a quasi-rational strategy in which we “lose little” if wrong. Darwin seems closer to the truth in picturing these as unwanted (and quite costly) side-effects of neural processes, or as he put it as “miserable and indirect consequences of our highest faculties.”

Models like Guthrie's and later cognitive psychologists fail not only in not adequately explaining how anthropomorphism arose in neural terms but also in ignoring how it changed over time. Modern survivals of anthropomorphism are common, but outside of their expression in children, in followers of primitive religions, or in subjects with rare neuropathologies (discussed in Section 4.1 below), these survivals pale in intensity when compared with the pervasive anthropomorphism found in all premodern societies. There is a transformational side to anthropomorphism in the history of religion that requires study as well. Neither the neurobiological nor literate mechanisms underlying those transformations figure in Guthrie's work nor in recent naturalistic studies of myth and religion like those of Boyer, Atran, Wilson, Harris, Dennett, and Dawkins. If we wish to moderate the uglier sides of religion, or to retain any of its beneficial side-effects, if there are any, we must understand both its biological and historical sides as deeply as that of any other part of human culture. And any such endeavor must begin with an attempt to develop models not only of how myth originated but also how it changed over time (Farmer 1998, 2008; Farmer, Henderson, and Witzel 2002; Farmer forthcoming).

3.1. Overview of a testable neurodevelopmental model of the origins of anthropomorphism

The rest of this paper introduces a neurobiological model of the origins of anthropomorphism. The model agrees with recent studies that argue that the roots of anthropomorphism can be linked some way to animate detection biases in perception; but it extends those views by pointing to developmental processes that link these biases to the ways that brain maps reality in general, allowing us to develop explicit tests of the model. The broader conclusion emerges that anthropomorphism is a costly side-effect of the emergence of the social brain — diverse sets of distributed brain systems involved in face-recognition, reading of emotions and sexual signals, modeling the intentions of others (development of a "theory of mind" or TOA to use the technical term), the internalization of cultural codes of behavior, and so on. The difference between this and related models does not lie in the claim that anthropomorphism arises from overextensions of social models to the external world, which in the last half decade has become the consensual view; but in the evidence it provides that the anthropomorphism underlying primitive religion and myth is a direct consequence of normal neurodevelopmental processes.

There are large consequences to this neural twist on old views of myth. As side effects of brain development, anthropomorphism cannot be pictured as an adaptive result of evolution, as has been claimed in the case of "animal animism." Myth and early religion instead appear to be costly in biological terms, as Darwin suggested in *Descent of man*. That does not mean that anthropomorphism might not have isolated secondary benefits, but only that it was not positively selected for in evolution.[9]

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[9] The claim that religion and myth were directly selected for — a view recently updated by Wilson (who claims that religion enhances group survival) — have begun in the last decade to give way to a broad consensus that myth and religion are "spandrels" of neural development, e.g. in studies by Boyer, Atran, Harris, Dennett, and Dawkins. The recent books by the latter three devote much time to debunking

An understanding of three basic brain principles is sufficient to construct a testable neurodevelopmental model of the origins of anthropomorphism:

1. **Perception and cognition exist in distributed and not localized brain systems;**

2. **Lower-level perceptual systems are heavily weighted to detect social data;**

3. **Normal neurodevelopment occurs in orderly layered ways, with lower-level 'maps' guiding the development of higher-level 'maps,' which helps keep distributed systems in sync.**

Combining these principles allows us to explain why the brain in its default states overextends human physical, mental, and social properties to the external world. Survivals of these tendencies can be detected in everyone in subtle experiments, but those tendencies show up in the most extreme form in preliterate cultures and children before literate forces have "worked up" these states in abstract forms.

As in the work of Guthrie and others noted above, one center of the model lies in the heavy social biases found in lower levels of brain processing. The brain is not a generalized computer, as was once widely assumed, but is made up of highly specialized sets of analogical or correlative or mirroring systems — often referred to as "topographic" brain maps in the neurobiological literature [10] — that are heavily biased to process social information. Due to the step-like and layered ways in which neural maps emerge throughout development, in normal individuals social biases in perception detectable at birth are mirrored in all "higher" brain programs, including those associated with the social brain. On the model, the anthropomorphism expressed in primitive myth and religion arises naturally from the analogical extension of those maps to general models of the world. The model thus confirms intuitive views of anthropomorphism endorsed by a long line of writers from antiquity (e.g., in fragments ascribed by tradition to Xenophanes) to Hume and Darwin and Guthrie and Dawkins.

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claims that diverse sides of religion provide selective advantages to individuals *or* groups. The view that anthropomorphic elements in religion are evolutionary byproducts without adaptive functions can also be claimed for many other sides of religion not touched on in this paper, including those involving ritual, imitative magic, concepts of faith, priestly intercession, sacrificial rites, social bonding, ideas of life after death, and ethical sides of religion, etc. On these issues, some also susceptible of tests, see Farmer forthcoming. Some but not all of these are also briefly treated in Farmer 1998; Farmer, Henderson, and Witzel 2002; and Farmer 2008.

[10] For detailed reviews of the perceptual and cognitive functions of such maps, see Simmons and Barsalou 2003; Thivierge and Marcus 2007; on topographic maps in joint brain-culture studies, see Farmer, Henderson, and Witzel 2002; Farmer 2008. Reference here is often made as well to putative "mirror neurons," originally claimed to exist in the premotor cortex. Due to the ubiquity of topographic mapping in the brain and the distributed nature of brain maps, I prefer to avoid these terms, which misleading suggest that such mappings are properties of an isolated class of neurons and not of distributed neural assemblies in general.

But since the model is rooted in neurodevelopmental principles, it can be tested in studies of neurological conditions that impact the social brain.

3.2. An overview of distributed brain processes

Any understanding of the origins of anthropomorphism requires a brief understanding of the distributed ways in which brains process information. In the 80s and 90s, one brain model that was popular with linguists and researchers in the socalled cognitive sciences — it found few supporters among neurobiologists — pictured brain processing as occurring in highly localized brain modules. The best known of these models was described in 1983 in a popular book by the philosopher Jerry Fodor entitled *The modularity of mind*, which heavily influenced linguists in the Chomskyan tradition. The most controversial side of these models involved claims about language modules, whose development was often said to depend on special genes that supposedly differentiated man from other animals.[11] Naïve adoption of such theories can encourage the idea that some special module for religion — or in its crassest form a "God spot" — exists somewhere in the brain.

Neurobiological research from dozens of subfields can be used to demonstrate that module theories of the brain are mistaken. Much evidence in the last decade has confirmed views proposed by a long line of earlier neuroscientists and network modelists (e.g., Jackson 1873; Luria 1974; Mountcastle and Edelman 1982; Rumelhart *et al.* 1986; McClelland *et al.* 1986) that all higher brain functions including those involved with language occur not in localized but in distributed systems; in brief, brain functions involve the interaction of many neural assemblies in widely separated regions; the coordinated firings of these assemblies is facilitated by feedforward and feedback loops linking these assemblies in every part of the brain. Damage to certain parts of the brain (e.g., Broca's or Wernicke's areas, the regions most popularly associated with language) may in fact affect functions like language more drastically than damage in other areas; in a similar way, damage to key transmission stations in a power grid may be more destructive than damage elsewhere. But that does not mean that language is localized in Broca's or Wernicke's areas, any more than the electricity in a power grid is localized in the transmission stations; in fact, neuropsychological tests can typically detect subtle language deficits from damage to nearly any major brain system. The claim that language or any brain functions, including those involving religion, can be localized in any one region grossly oversimplifies a complex situation.

To pick a handful of linguistic examples: the processing of words is known to occur in different brain regions depending on the language being spoken (Valaki *et al.* 2004), on whether the speaker is literate or illiterate (Petersson *et al.* 2000; Li *et al.* 2006), on the class of words being spoken (e.g., verbs or nouns) (Damasio *et al.* 1996; Martin *et al.* 1996), and even on whether the sense of the words is known from first-hand experience (say from milking a cow) or second-hand experience (from seeing a picture

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[11] Hence all the excitement among linguists like Pinker when what was quickly dubbed the "language gene" (FOXP2) was identified in 2001. Its supposed special association with language came in the fact that one rare type of speaking disorder was associated with damage to the gene. The excitement has since faded as evidence has surfaced that FOXP2 is a general regulatory gene with widespread functions in the brain and body; for discussion, see Farmer forthcoming.

of a cow and hearing stories about how cows are milked). Location of language encoding in individuals may also change as experience with the referent changes (e.g., the speaker finally milks a cow) (cf. Pulvermüller 2002a, 2002b).

Many of these findings, which have been confirmed in studies both of brain damaged patients and normal subjects, show how far we have come from the simple "language module" theories that were popular until a few years ago, at least among cognitive psychologists. Recent studies have even shown that reading disorders can be triggered by different sorts of brain damage depending on the nature of the writing system (e.g., on whether it is an alphabetic system or one like Chinese) (cf., e.g., Siok WT *et al.* 2004, 2008).

3.3. Distributed brain systems and layered developments in brain maps

The fact that brain functions are distributed over wide regions of the brain has important implications for understanding how all higher-level cognitive systems — including those involving primitive religion and myth — emerge during development. If the distribution of brain functions not only differs in different people, but even in single persons over time, how does the brain insure that the distributed systems stay in sync?

Evidence suggests that this synchronization depends in part on alignment of neural maps that exhibit high levels of structural symmetry throughout much of the brain — the mirroring or topographic (or correlative or analogical) brain maps mentioned in Sec. 3.1. Research in neurogenetics, brain imaging studies, neural network simulations, and other rapidly developing fields all suggest that the job of keeping these maps aligned during development is facilitated by the layered development of the neocortex and related brain systems; the general idea is that the structure of neural maps in early maturing brain systems (e.g. those involving perception) guides the development of maps in later developing systems (e.g. those that involve cognition and higher-level models of the world).

The kinds of topographic or analogical maps that emerge from this process can be said to underlie all cognition in the brain — from spatial concepts to the analogical or metaphorical constructs that underlie all meaning in language (cf. Lakoff and Johnson, 1980, 1999). The same kinds of analogical maps can also be linked to many "default conditions" besides anthropomorphism that show up globally in primitive thought — including the types of analogical reasoning found in imitative magic, in so-called correlative thinking and premodern systems of correspondences, and a wide range of similar analogical ideas (Farmer 1998, 2008; Farmer, Henderson, and Witzel 2002).

In terms of development, the idea that the structure of "lower" maps guides the development of "higher" ones differs radically from the ideas involved in older modular views of the brain, which typically assumed that special genes (including "language genes") were independently responsible for bringing higher cognitive functions to maturity (for a succinct overview of the differences in these two types of models, see Mareschal *et al.* 2007: Vol. 1: 57 ff.).

One of the many advantages of the analogical and layered ways in which brain maps develop involves what might be termed epigenetic or neurocultural economy, which makes the most of neural plasticity: the layered development of brain systems allows the gradual plastic adaptation of the brain during development to the specific language, traditions, and technologies of different cultures without requiring any underlying genetic change, except the change involved in gene expression. A prime case involves the ways in which in some premodern societies professional reciters (including mythic storytellers) were capable of allocating large areas of cortical space to the memorization of vast oral traditions in ways beyond the capabilities of modern intellectuals. Conversely, in literate societies large areas of the brain have become partly specialized for reading and writing without the need for any specialized "literacy genes," freeing other brain regions from memorization tasks. These plastic reallocations of brain space have major effects on other cognitive abilities and on the evolution in literate traditions of broad models of the world (Farmer forthcoming).

3.5 The development of the 'social brain' and of anthropomorphic deities

How can this view of brain development help us build a testable model of the origins of myth and religion? The answer to that question lies in a grasp of the depths of the social biases that we can identify in brain processing. Those biases are a major element in social models of the origins of intelligence, which have become increasingly influential since they were introduced over four decades ago (e.g., Jolly 1966; Whiten and Byrne 1988; Dunbar 1993, 1997; Barrett and Henzi 2005). In summary, these models hold that the enlarged primate brain, and in humans the prefrontal cortex in particular, evolved to enhance survival in complex social environments, and not to facilitate more abstract calculations.

Regardless of what other evolutionary pressures can be linked to the enlarged brain, social models of the origin of intelligence explain massive imbalances in the allocation of human cortical space: by far the largest part of the neocortex is dedicated to processing data involving faces, emotions, gestures, language, sexual and social cues, and related signals, and not socially neutral data. Although social deception certainly was not the only force involved in brain expansion, it indisputably does play a major role in the primate world, as has been shown now in many carefully designed field studies stretching back over two decades (e.g., Cheney and Seyfarth 1990). In humans, the enlarged cortex among other things allows us to invent stories and tell effective lies, whose uses in enhancing personal survival and sexual success are obvious. One much-discussed paper by Byrne and Corp (2004) claims that cortical size can in fact be directly related to primate "deception rates": the amusing (or melancholic) implication is that the ability to lie — unlike primitive religious impulses — may have been specifically selected for in evolution.

Social biases in human brain processing are far more prominent in the human brain than the general animate attentional biases discussed earlier, emphasized so strongly by Guthrie or New *et al*., etc., that involve non-human animals. These social biases can be identified in fact in every early processing area of the brain involved in perception or attention. A few examples that show up at or near birth include orientation biases involving faces (even three "blobs" that remotely suggest facial structure will catch a normal infant's attention) (Morton and Johnson 1991; Simion *et al.* 2007); crying and sucking responses, guided in part by smell, touch, and sight of the mother (Doucet *et al.* 2007); and preferences in hearing (apparently appearing even in the fetal environment) for human speech over other types of audio input (Vouloumanos and Werker 2007; Rosen and Iverson 2007).

Higher-level systems that emerge out of these primitive biases from infancy to adulthood include sophisticated face-reading systems capable of evaluations of complex emotions; social-bonding systems mediated by neurohormones like oxytocin and arginine vasopressin, which in part involve the senses of smell and touch; linguistic systems that generate narrative behaviors following stereotypical social "plots"; and ultimately, especially in prefrontal cortex and linked subcortical centers, high-level models that integrate all these abilities into complex temporal and spatial social models of the world. Layered models of development can even explain ways in which facial recognition programs detectable in newborns slowly narrow in preference over time, similar to the ways in which babbling progressively narrows to a specific language, leading to so-called "other-race" or "cross-race" effects (Kelly *et al.* 2009; Goodman *et al.* 2007), which can contribute to ethnocentric preferences and incipient racism even in young children.

Expanding on words ascribed by tradition to Aristotle: man is not only a social animal but the most social of all animals, due to our nearly total reliance on other humans for survival. When social biases in early map formation are absent or attenuated, as is the case in some developmental disorders, preventing the normal formation of social models of the world, the consequences in later cognition in general are typically catastrophic.

3.6. Dating the earliest myths, and more on chimpanzee rain dances

The combined weight of these data suggest that the origins of anthropomorphism seen in primitive religion and myth can be modeled in a straightforward way as the product of heavy social biases in early brain processing, on the one hand, and the orderly step-like ways in which normal brain maps form, on the other.

One benefit of the model is that it makes a clear statement about the antiquity of early mythic thinking. As a side-effect of normal brain development, human anthropomorphic modeling of the world can be expected to have appeared no later than anatomically modern man, which on current data places its origins no later than ca. 200,000 years BP. This differs radically from recent claims that religious thinking is related to the sudden appearance of special abilities in human cognition that go back at best to the upper Paleolithic (Bloch 2008). How far back we choose to imagine the existence of narrated myths about the social activities of anthropomorphic gods and spirits depends on when we decide that sufficient language was in place to encode such narratives.

One interesting implication of these views revolves around what they imply about the cognitive systems of other social animals, whose basic cortical structures are similarly topographically organized. While chimpanzees lack language, on the model it is reasonable to suggest that something like the claim ascribed to Xenophanes is probably correct: that in the chimpanzee rain dance described by Goodall and others (Section 2.3 above), whatever "storm gods" the chimps appear to be threatening are probably viewed by them as beings rather like themselves.

4.1 Testing the model: hyper-anthropomorphizing tendencies in one form of synesthesia

As noted earlier in the paper, one advantage of this model is that it can be rigorously tested, and by implication is falsifiable. In this and the next section I will discuss two such tests. The first involves studies of exaggerated anthropomorphizing tendencies in one remarkable type of synesthesia and the second dampened anthropomorphizing tendencies in subjects with autistic disorders.

Let's look first at exaggerated anthropomorphism. One side of the model depends on the layered ways in which brain maps develop, with higher-level cognitive maps topologically mirroring the structure of perceptual maps. Applying this principle to the origins of religion, the model suggests that in normal brain development social biases in perception present at birth are progressively elaborated in higher cognitive maps, eventually giving rise to the anthropomorphic models of the world associated with primitive myth and religion.

One kind of evidence that confirms that brain maps are organized in these mirroring ways lies in studies of synesthesia, the remarkable condition in which sensory data (taste, touch, smells, colors, etc.) or even abstract concepts (letters, numbers, days of the week, etc.) evoke mirrored responses in linked perceptual, cognitive, emotional, or motor circuits. The result is that synesthetes may "taste" words, "hear" or "smell" shapes, or reliably attach specific emotions to specific colors, days, or abstract concepts.

Synesthesia is by no means rare, as was believed even a few years ago. One recent study suggests that in clinical forms it shows up in over 4% of the population (Simner *et al.* 2006). In a less extreme ways all of us are synesthetes; this is illustrated most dramatically in the impact of music and dance on emotional and motor systems. Research in the last few years in fact suggests that synesthesia is closely related to normal sensory integration going on in everyone below the level of consciousness (cf. Mulvenna and Walsh 2006; Sagiv and Ward 2006). The suggestion is that clinical forms of synesthesia simply involve higher-than-normal activation of synaptic links binding analogical maps in different brain systems.

Research on synesthesia began in the nineteenth century, but for a long time the condition was viewed as an oddity in psychology.[12] That changed in the early 1990s, when studies of brain mapping encouraged the recognition that the condition throws light on how brains integrate information in general. Good arguments exist that

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[12] For a regularly updated bibliography of studies from the nineteenth century to the present, see https://www.sussex.ac.uk/synaesthesia/publications/wider-literature maintained by researchers at the University of Sussex. Only the more recent of these are found in the PubMed data base.

synesthesia currently provides a broad window on the neural grounds of analogical thinking, which is critical to many primitive default conditions in human thought, including premodern myth and religion. The exaggerated tendencies of synesthetes to "taste" or "smell" words, "touch" sounds, to attach colors (or moral qualities) to letters or numbers, and so on, can be related to the biological roots of imitative magic, numerology, religious rituals involving music and dance, and the elaborate correspondences and mirroring cosmologies that eventually emerged in all mature premodern cultures. Recent studies have even identified one type of visual-touch synesthesia that leads some subjects to literally "feel the pain" observed in others, which in less extreme forms can be said to lie at the primitive roots of empathy and ultimately of ethical thinking (Banissy and Ward 2007).

In the model of the origins of myth introduced above, anthropomorphism is pictured as a side-effect during normal brain development of social biases in attention that can be identified even in newborns. One prerequisite for the model is the maintenance throughout development of topographic symmetry in brain maps as higher-level cognition is shaped by the biases of lower-level systems. If we toss into the model the heightened awareness of such symmetries found in synesthesia, the model makes an interesting and testable prediction. Just as some synesthetes have a heightened awareness of topographic mapping between tastes and sounds, or colors and numbers, and so on, we can expect others to have heightened awareness of anthropomorphism expressed in different perceptual and cognitive neural domains.

Remarkably, two recent studies amply confirm this prediction. The studies expand on reports of extreme anthropomorphizers that have appeared sporadically since the late nineteenth century. One recent study by Smilek *et al.* (2007) discusses a remarkable seventeen year-old girl, "TE," who attributes inanimate objects including letters, numbers, abstract shapes — and even her bedroom furniture! — with personalities and social interactions, which include "friendships" and "hatreds" between numbers and letters. The authors describe not only the girl's synesthetic associations between different letters, colors, and numbers, but as well the human qualities she ascribes to these and other classes of objects in her life.

In the passage below, the girl is quoted on her reaction to the number "Three," to which she had a deep dislike since early childhood. Her dislike of the "personality" of the number is mitigated by what appears to be a touch of empathy evoked by "Three's" youth and lowly social status:

> Three is pure blue, the same color as [the letter] E. Three is male; definitely male. Three is such a jerk! He only thinks of himself. He does not care about any other numbers or anything. All he wants is to better himself and he'll use any sneaky, underhanded means necessary. But he's also pretty young; he doesn't understand anything and he doesn't have much power, as far as social status is concerned. So he tries to hang out with Eight (who's also a bad number) just so he can feel better about himself. But really, none of the numbers can stand him. He's a real jerk. He'll pretend as though he's your friend, but then he'll manipulate you and stab you in the back if he feels he can gain something from it. Then he'll never speak to you again. If Three had

> parents, even his parents would hate him. It's not as though what he does has some purpose or something behind it, he's just a really nasty number. He just wants things for himself. He doesn't care in what he does [sic]. If he had a voice, it wouldn't be high-pitched, but it wouldn't be deep. It'd be on the high side, a very annoying voice. He'd be short and very thin, very annoying (Smilek *et al.* 2007: 981).

Smilek and coworkers tested TE over a long period, confirming that the "personalities" of objects and the social relations she attributed to them were not invented on the fly but remained stable over long periods. The human traits she assigned to them were also complex. Smilek *et al.* note that TE used no less than 190 unique characteristics to describe the personalities of inanimate objects with whom TE had intimate relations. Interestingly, the personalities she attributed to shapes that she had not seen before were far simpler than those she assigned to familiar objects — just as most people would attribute personality traits more hesitantly to new acquaintances than old ones. The suggestion is that TE routinely overextends maps of the social brain to the exterior world in general, as predicted in the views of myth discussed above. This view is supported by the fact TE often made moral judgments about inanimate objects, even demanding that her father remove furniture from her bedroom of whose "personalities" she disapproved.

TE's description of relations between numbers, letters, and objects even mirrored what we might refer to as dominance hierarchies in the human world, which in her case includes a touch of religion. Thus TE described the numbers "Zero" and "One" — which are interestingly the only numbers she failed to assign gender — as the "gods of the numbers." It is worth noting in passing that TE's attribution to numbers of moral traits — distinguishing "good" and "bad" numbers — was a feature of numerological traditions found globally in all major premodern civilizations.

Another paper by Simner and Holenstein (2007), published almost simultaneously with the previous study, discusses a number of similar cases, only limited this time to subjects who only anthropomorphize numbers and letters. They also review earlier case histories going back to the nineteenth century, when anthropomorphizing versions of synesthesia were first identified. They describe a recent case involving a well-educated twenty-three-year-old woman who (much like TE) assigned rich personalities, moral traits, and social relations to letters and numbers. The researchers assigned the dozens of anthropomorphic qualities that the subject ascribed to these graphemes to eight categories, including gender, general personality traits, physical appearance, occupation, family relationships (e.g., mother, daughter), other social relationships (neighbor, friend), and emotional ties to other letters or numbers (lovers, friends, etc.).

Other reports they cite in their paper are similar in character. The following passage that they translate from an 1893 French study suggests again how extensive the social dimensions are of these extreme anthropomorphizers:

> 1, 2, 3 are children [who] play together. 4 is a good peaceful woman, absorbed by down-to-earth occupations … 5 is a young man, ordinary and common in his tastes and appearance, but extravagant and self-centered. 6 is a young man … polite, gentle, … average intelligence; orphan. 7 is a bad sort, although brought up well; spiritual, extravagant, gay, likeable; capable of very good actions on occasion … 8 is a very dignified lady, who acts appropriately…. She is the wife of 9 [who is] self-centered, maniacal, grumpy, endlessly reproaching his wife for one thing or another (Simner and Holenstein 2007, translating Flournoy 1893).

One perceptive comment made by Simner and Holenstein is that the "personality types" of numbers and letters described in these studies "tend to reflect the society that is contemporary with the report. Older studies, for example, mention 'society girls' and 'housekeepers,' whereas such descriptions are less apparent in modern accounts." Extending this comment to studies of myth would lead us to expect that the specific *kinds* of anthropomorphizing found in premodern traditions should reflect local social norms, much as Durkheim and Mauss claimed a century ago.

For now, it is enough to suggest that this remarkable form of synesthesia supports the thesis that anthropomorphic models of the world arise as natural extensions of the systems of the social brain to the inanimate world, as predicted by the model developed in this paper.

4.2 A reverse test: attenuated anthropomorphizing tendencies in autism

At the opposite extreme are people with autism spectrum disorder (ASD), a catch-all term applied to individuals with developmental dysfunctions involving impairments of social cognition and communication. Sometimes these deficits are linked to savant-like abilities in fields demanding few social skills, including mathematics, music, and drawing.

Autism is currently labeled a "spectrum disorder" since the types and severity of the condition vary along a wide range. For our purposes, the most useful subjects are those with Asperger's syndrome and other high-functioning forms of autism, in which intelligence is largely spared. In subjects with high-functioning autism, the most obvious problems are not intellectual but social impairments. Typical problems include failure to make eye contact and difficulties reading the intentions of others *via* speech, facial expression, body language, and other nonverbal forms of communications. Often the condition includes problems empathizing with others, the reverse of the situation of the visual-touch synesthetes mentioned above.

While the causes for ASD appear to be multiple, there is general agreement that all types of ASD involve disruption during neurodevelopment of the so-called social brain. The early social biases in perception underlying these developments are often missing or abnormal in infants later diagnosed as having ASD. Thus "gaze cueing"— tendencies of normal infants to follow an adult's eyes to a target — is often absent or aberrant in children who later develop autism (Johnson *et al.* 2005). This deficiency can be linked to the common failure of ASD children to develop the "joint attention" with adults that is critical to normal intellectual development (Mundy and Acra 2006). Facial recognition systems too are often abnormal in children who develop ASD, and even more broadly, tendencies to prefer human to inanimate stimuli are absent in many ASD subjects.

On our model of the origins of myth, we can predict that abnormal social biases in perception in infancy, or anomalies in the ways that brain maps develop that prevent these biases from being elaborated in accustomed layered ways in higher systems, should disrupt the social brain and normal anthropomorphizing tendencies. The implication follows that subjects with high-functioning autism should exhibit far fewer anthropomorphizing tendencies than normal subjects.

4.3 Relevance to these tests of the Heider-Simmel experiment

Evidence supporting these views comes from studies of perception that reach back to World War II. In 1944 Fritz Heider and Mary-Ann Simmel made a short animated cartoon involving two triangles, a small disc, and a schematic picture of a house. In the cartoon, the triangles (which come in two sizes) and small disc move around each other and in or out of the house in patterns designed to suggest human activities. Typical actions include aggressive behaviors (e.g., the triangles “strike” one another), elation (e.g., the small triangle and disc move quickly around each other in circles), and so on.[13]

The original Heider and Simmel study suggested that normal individuals typically project elaborate social narratives on those movements that go far beyond what the authors scripted in the cartoon. Subjects often characterized the big triangle as an aggressor and the smaller triangle as a protector or “lover” of the disc. In one section of the animation, human subjects often interpret the small triangle and disc as escaping the large triangle, who had earlier cornered the disc in the “house” for reasons Heider and Simmel leave to the viewer’s fertile imagination.

Normal subjects typically ascribe gender, emotion, short- and long-term goals, and complex personal relationships to the triangles and circle. Just as in the case of hyper-anthropomorphizing synesthetes, the contents of the stories vary widely in individuals with different cultural values. Informal experiments I have conducted with the animations suggest that researchers in the hard sciences regularly report far less detailed anthropomorphic narratives than humanistic researchers — or in some cases may report no anthropomorphic narratives at all. But this probably simply involves biases derived from their professional training, since when prompted to report anthropomorphic stories about the animations they can readily do so, sometimes

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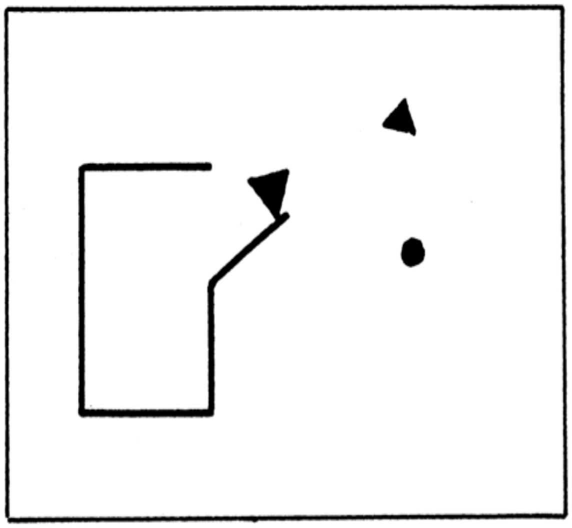
[13] The original version of the 1944 Heider-Simmel animation can be found online at https://www.youtube.com/watch?v=VTNmLt7QX8E

volunteering that they actively suppressed reporting such stories in their first pass on the test.[14]

People with damage to brain regions associated with the so-called social brain may associate some of the simple movements of the geometric figures with anthropomorphic action, but on the whole they fail to elaborate these into the rich social narratives spontaneously reported by normal controls. Thus Heberlein and Adolphs (2004), who used the original Heider-Simmel animations in one series of experiments, report one patient with bilateral damage to the amygdala whose stories about the animation were "entirely asocial, in purely geometric terms, despite normal perceptual processes." Similar results have been observed in numerous patients with high-functioning autism shown these or closely related animations under well controlled conditions (see, e.g., Abell *et al.* 2000; Bowler and Thommen 2000; Klin 2000; Castelli *et al.* 2002).



Exposure-Objects Displayed in Various Positions and Configurations from the Moving Film.
Large triangle, small triangle, disc and house.

Figure reproduced from Heider and Simmel 1944. The movements of the triangles and disc in the animation were scripted to suggest human motivations behind the movements. Normal subjects tend to invent complex social plots to explain those motivations, which go far beyond what was originally scripted into the animation. Patients with damage to neural areas involved in processing social data and autistic subjects report simpler narratives devoid of most anthropomorphic details when compared with those of matched controls. For an online version of the animation, see footnote 13.

These studies suggest that normal overextension of anthropomorphic mental states to the inanimate world is sharply impaired in autistic subjects, even in cases of Asperger's syndrome where general intelligence is normal. Further support for this view comes in studies of drawings by autistic subjects, which frequently favor inanimate over human subjects. There are exceptions to this rule in some autistic savants (Cox and Eames 1999), presumably due to wide variation of subjects classified as having ASD. In general, however, when children classified as having Asperger's syndrome are asked to draw humans, their abilities to do so are badly impaired when

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[14] This is an apparent example of the kinds of cultural overwriting of anthropomorphic tendencies discussed earlier.

compared to normal children, even when their abilities to draw trees or houses are equal to that of controls (Lim and Slaughter 2007).

The result is that just as in the opposite extreme — involving hyperanthropomorphizing synesthetes — studies of subjects with autism further support the thesis that the anthropomorphic tendencies in cognition we find in primitive religion and myth develop in layered ways out of social biases in perception identifiable even in infants; when those social biases are missing or layered map development is disrupted, normal anthropomorphizing tendencies are also disrupted.

It can be further predicted on the model that tests of intensity in religious belief of individuals with high-functioning autism, using measures like the Duke Religion Index (Koenig *et al.* 1997), can be expected to be significantly lower than those of matched controls, at least so far as those tests reflect anthropomorphic sides of religion. Conversely, the model predicts that hyper-anthropomorphizing synesthetes should score much higher on those tests than normals.[15] The model makes no clear predictions concerning other types of self-reported religious experience that do not involve anthropomorphization, including those measured by the "Magical Ideation" inventory (Eckblad and Chapman 1983).

5.1 Summary and conclusions

The paper began with a discussion of how a neurobiological model of the origins of primitive religion and myth can contribute to scientific approaches to comparative mythology. It continued with a review of previous naturalistic models of anthropomorphism, ranging from those of Hume to Darwin to modern writers including Guthrie and others in the tradition of cognitive psychology (including Boyer, Atran, Wilson, Harris, Dennett, and Dawkins). It argued that none of these models are detailed enough on the neurobiological level to be rigorously tested, which has prevented the formation of any consensus in the field capable of transforming studies of myth into a rigorous science.

The rest of the paper developed a model of anthropomorphism grounded in recent studies of neurodevelopment. In brief, the model posits that heavy social biases in perception and attention detectable in infancy are elaborated during normal development into the high-level systems of the social brain. Due to the layered and topographic (or mirroring) ways in which normal brain maps are generated, the result is that in the brain's default state anthropomorphic models are routinely overextended into the non-human world.

The paper also suggested reasons why as a corollary of normal brain development the roots of mythic thought can be claimed at a minimum to be as old as the first anatomically modern humans. If we take seriously the evidence published in the last few decades involving the so-called chimpanzee rain dance, there are reasons to claim

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[15] The same can be predicted for subjects with Williams syndrome, not discussed in this paper, as noted in Farmer forthcoming.

on the same evidence that something crudely equivalent to mythic thinking existed in man's hominid ancestors long before myth could be elaborated in linguistic form.

One of the novel advantages of the model is that it makes testable predictions that can be used to support or falsify it. The chapter discussed several of these involving exaggerated anthropomorphizing tendencies observed in one type of synesthesia and attenuated anthropomorphizing tendencies in subjects with high-functioning forms of autism. Further tests are proposed following the model's predictions of higher or lower than normal religious sentiments in these two classes of subjects.

There is much to more to say on these topics that I have not been able to take up in this paper. One key issue I have not discussed relates to which "emotionally salient parts of reality" (*supra*, Sec. 0.1) tend to be anthropomorphized in myth and which ones are not. Some light on this topic is thrown by recent lab studies involving animations a bit like those used in the original Heider-Simmel test, which suggest that decisions in this case may involve significant cultural entrainment (Schlottmann *et al.* 2006). Other issues I have not dealt with in detail include ways in which premodern peoples communicated with anthropomorphic spirits, how myths were transformed abstractly over long periods in literate traditions, and how such transformations can be simulated in computer models of the growth of scholastic-type systems in manuscript traditions. These and related topics are discussed in already published or forthcoming studies (e.g., Farmer 1998; Farmer, Henderson, and Witzel 2002; Farmer, Henderson, Witzel, and Robinson 2002; Farmer 2008; and Farmer forthcoming).

The deep object of this paper has been to suggest that recent work in neurobiology and culture can produce testable models that are of considerable use in studies of comparative mythology and cross-cultural studies of the evolution of thought. The fact that construction of models of this type is possible today suggests that in the coming decades combined historical and neurobiological research can be expected to deeply challenge thousands of years of assumptions about the evolution of human thought.

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