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Contradictory or Complementary? Creationist and Evolutionist Explanations of the Origin(s) of Species

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Key Words
Creationist ideas · Dual-process theory · Evolutionary theory · Origin of species

Abstract

Almost half of the US public rejects the idea that humans originated via evolution rather than by supernatural design. Moreover, studies demonstrate that even biology teachers have difficulty teaching their students about evolution, often including creationist explanations as well. A typical response to such findings is the argument that greater exposure to evolutionary theory would eliminate these unscientific alternatives. However, creationist ideas are not easily extinguished. Even after repeated exposure to evolutionary concepts, creationist ideas are more likely to be *incorporated* into hybrid frameworks along with evolutionary ideas, rather than completely rejected. Thus, members of the public often find these ideas complementary rather than contradictory. In this review, we apply dual-process theory to examine individuals' understandings of the origins of species. We describe cognitive biases that operate at the intuitive-autonomous level (system 1 ~~processing~~), some of which, we argue, anchor belief in supernatural design, and others of which potentially anchor evolutionary ideas. At the other end of the continuum, reflective and abstract reasoning (system 2 ~~processing~~) processes are apparent in both scientific and theological explanations of origins. We conclude that presenting supernatural and natural explanations of biological origins as contradictory belies the way they function in everyday reasoning. By understanding the theological and the scientific arguments as well as the way most people intuitively reason about such existential questions, teachers might be better prepared to deal with these issues in the classroom.

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'On Evolution, Biology Teachers Stray from the Lesson Plan'

Cleverly captured in this New York Times title is yet another gloomy image of the teaching of evolution in the United States [Bakalar, 2011]. The article itself summarizes a national survey of over 900 public high school teachers, in which only 28% followed the expected lesson plan [Berkman & Plutzer, 2011]. Of the remaining teachers, most compromised by also including in their lessons the 'unscientific alternative' to evolution, creationism. Further fodder for the scientific gloom was the fact that a biology course is the only course in science taken by 25% of high school students and it is the most popular of the science courses for the rest [Berkman & Plutzer, 2011]. The usual solutions were trotted out: 'If they were better trained in science in general and in evolution in particular …' [Bakalar, 2011]. These results, however, should come as no surprise to anyone who has followed the national debate. For 20 years or more, annual Gallup Polls have consistently reported that almost half of the US public rejects the idea that humans originated via a natural rather than a designed process; only 13% or so (the actual number varies minimally from year to year) endorse evolutionary origins exclusively [Evans, 2008; Evans et al., 2010]. Given the persistence of these unscientific alternatives to evolution, a different approach would seem to be warranted; hurling more evidence at these seemingly recalcitrant individuals does not appear to work. As one professor of biology noted, 'These courses aren't reaching the creationists,' he said, 'They already know what evolution is. They were biology majors, or former biology students. They just reject what we told them' [Bakalar, 2011].

Although creationist ideas are not exclusively confined to the United States [e.g., Mansour, 2011], it is, along with Turkey, the most likely of all the industrialized countries to reject evolution [Miller, Scott, & Okamoto, 2006]. Clearly, exposure to creationist and evolutionary ideas is a critical factor in their dissemination. But exposure cannot be the sole explanation. The more interesting question is: Why do some of these ideas spread so easily and others encounter resistance? An epidemiological approach [Sperber, 1990] offers a multipart explanation that is more consistent with the evidence – exposure to the ideas is important, but *susceptibility* to the ideas is also critical. Not everyone is equally susceptible. Although there are individual differences, in this review we shall focus on the developmental differences in susceptibility to creationist and evolutionary concepts. We argue that a key indicator of susceptibility is the ease with which culturally available ideas about origins are incorporated into intuitive modes of reasoning. The resulting hybrid or *synthetic* frameworks [Vosniadou & Brewer, 1992] are common, found in young children's reasoning [e.g., Evans, 2000a, 2001], as well as in the reasoning of highly educated adult museum visitors [Evans et al., 2010]. A further indicator of susceptibility is persistence. Creationist ideas are not easily extinguished [Evans, 2000b]. As suggested by Berkman and Plutzer's [2011] analysis and by studies of biology teachers' beliefs [e.g., Nehm, Kim, & Sheppard, 2010], even after repeated exposure to evolutionary concepts, culturally available creationist ideas are more likely to be incorporated into hybrid frameworks along with evolutionary ideas, rather than completely rejected [Evans, 2001, 2005; Evans, Legare, & Rosengren, 2011; Legare, Evans, Rosengren, & Harris, in press]. These findings indicate that, at least in their everyday reasoning, members of the public do not find these ideas contradictory; indeed, they appear more likely to find them compatible.

In addition to analyzing the diverse ways individuals combine these explanations into complementary frameworks, we shall also describe those circumstances that might serve to emphasize the contradictions. As noted earlier, a typical response to the repeated findings that creationist explanations are prevalent in the US has been the argument that greater exposure to the scientific alternative, evolutionary theory, and to scientific reasoning in general, would eliminate such fanciful ideas [e.g., Dawkins, 1995]. In this review, we examine this suggestion from the perspective of dual-process theory, which offers a promising framework for interpreting diverse reasoning patterns. The proposition that information about the world is processed at two distinct levels has been advanced by several researchers [e.g., Evans, 2003; Kahneman, 2003; Sloman, 1996; Stanovich, 2009; Stanovich, Toplak, & West, 2008]. System 1 is characterized by a set of cognitive biases and heuristics that allow the rapid, effortless and spontaneous processing of information. This is often termed associate, intuitive, implicit, or autonomous processing, and it is generally unrelated to traditional measures of intelligence [Stanovich, 2009; Stanovich & West, 2008]. System 2, on the other hand, is characterized by reflective thought, which actively overrides system 1 processing, and algorithmic processing, which includes abstract and hypothetical reasoning [Evans, 2003; Stanovich, 2009]. System 2 processing is often described as analytic, explicit, or rational. Importantly, the system 1/system 2 dichotomy refers to *how* the information is processed, not necessarily whether that processing yields a 'correct' answer or interpretation.

Dual-process theory has been used to account for the way we think in a variety of areas, and here we apply it to help us make sense of the way that people process information about biological origins. From the perspective of evolutionary biology, it might seem obvious that endorsing evolutionary theory is a product of system 2 thinking, as an understanding of evolution requires analytical and abstract reasoning, whereas creationist thinking appears to represent a nonanalytical or intuitive mode of thinking – system 1 [Dawkins, 1995]. Although this analysis might seem plausible on the surface, we shall argue that, at least in everyday reasoning, such a clear dichotomy is not always evident. Furthermore, we find that both evolutionary and creationist reasoning modes can display elements of system 1 as well as system 2 thinking. Applying some of the insights from dual-process theory to the analysis of creationist and evolutionary reasoning patterns should improve our understanding of why these seemingly contradictory explanations are often combined in a complementary manner.

This analysis of creationist and evolutionist ideas is part of a larger enterprise to integrate the study of supernatural and natural explanatory frameworks and, in particular, to explain the development of these ideas. In this case, *natural* refers to processes that are, in principle, observable, materialistic, and operate according to the laws of nature, whereas *supernatural* processes are neither observable nor governed by natural law. Moreover, supernatural and natural explanations are often used simultaneously to explain the same phenomena, to make sense of the natural world and the human condition [Evans, Legare, & Rosengren, 2011; Legare, Evans, Rosengren, & Harris, in press]. Parsing them into competing explanatory frameworks ignores the fundamental role they *both* play in ordinary human cognition, particularly when humans are confronted with existential questions, such as the reasons for their existence and whether they will continue to survive as individuals, as a species, or as part of the living world. Although we focus on explanations for the origins of

living kinds in this review, our proposal – that natural and supernatural explanatory systems are both derived from and anchored in universally available intuitive conceptual frameworks – may be applied to other domains as well.

In the next two sections, we describe several cognitive biases that operate at the intuitive-autonomous level (system 1 thinking), some of which, we argue, help to anchor belief in supernatural beings who are responsible for our existence and others of which anchor evolutionary ideas about our origins. We then use this analysis to propose that within particular domains of knowledge, system 1 and system 2 thinking might represent ends of a continuum rather than a dichotomy. Such a proposal, however, is plausible only if these domains are construed in terms of theories that are subject to change, not as innate encapsulated modules [Fodor, 1983; Evans, 2003]. Thus, our working assumption in this review is that everyday, intuitive concepts are anchored in lay theories of mind, biology, and physics, the earliest manifestations of which are apparent in infancy [Wellman & Gelman, 1998]. Crucially, these concepts may be modified and may even yield entirely new concepts as a function of specific cultural experiences; even so, these intuitions remain available and are often discernible in adult resistance to scientific topics [Bloom & Weisberg, 2007].

Anchoring Creationist Ideas

Many theorists have attributed widespread beliefs in sentient, powerful and unseen beings, such as the Judeo-Christian God, to our anthropomorphic bias to detect agency and attribute intentionality, as well as biases towards artificialism and teleological reasoning [Bering, 2006, 2011; Evans, 2000b]. Our survival depends in part on our ability to read the minds of others, to make rapid inferences about other people's thoughts and feelings and to act accordingly. But such mental inferences are not reserved for our conspecifics. Indeed, we attribute mental states to things that are not even alive. In a now classic study, after viewing a film with simple geometrical shapes moving and interacting with one another, adults described the moving objects in terms of their underlying mental and emotional states, including their motives [Heider & Simmel, 1944]. Results like these point to what Guthrie [1993] has termed a *hyperactive agent-detection device* – a mechanism that biases people to detect agency in the environment even when agents do not really exist. Such a detection device may be partially responsible for why humans often attribute the occurrence of natural phenomena – including the weather, births, deaths, and human origins – to the minds of agents, including gods [Guthrie, 2001].

Yet, this tendency to detect minds, even supernatural minds, says little about the *kind* of mind we attribute to a god. The dual-process model can be used to interpret how we consider the minds of gods. Religious scholars and leaders have dedicated their lives to interpreting God's roles, abilities, and so on (consider, for example, the Jewish Talmud). Such interpretation of God is analytical, the product of deliberate, thoughtful, critical exchanges between scholars – clearly reflective of system 2 processing. However, although religious texts and teachings may attribute dramatically nonhuman, counterintuitive capacities to gods (e.g., omniscience), in their everyday thought, adults tend to conceptualize gods in terms that are more human-like [Shtulman, 2008]. Barrett and Keil [1996], for example, found that religious adults who reported that they believed in God's omniscience and omnipotence defaulted to con-

ceptualizing God in everyday anthropomorphic terms, as subject to mental and physical constraints. This suggests that even religious adults intuitively think of gods in terms that are more human-like and limited, and thus only minimally or moderately counterintuitive [Barrett, 2000; Boyer, 1996, 2001].

Perhaps the best evidence for the proposition that supernatural beliefs are anchored in our everyday theory of mind is gleaned from studies of children's ideas about God [Bering, 2011; Boyatzis, in press; Evans, 2000b; Evans & Wellman, 2006]. Some have contended that very young children think that all sentient agents are all-knowing [e.g., Barrett & Richert, 2003] and thus, unlike adults, children have no difficulty with the biblical depiction of God's mental infallibility [for studies inspiring these claims, see Barrett, Richert, & Driesenga, 2001; Knight, Sousa, Barrett, & Atran, 2004]. However, recent research conducted with children in the United States, Spain, and Greece, with children from religious and nonreligious backgrounds, has demonstrated just the opposite – young children initially attribute human-like, limited knowledge to humans and to extraordinary beings [Giménez-Dasí, Guerrero, & Harris, 2005; Lane, Wellman, & Evans, 2010, in press; Makris & Pnevmatikos, 2007]. Thus, when children first begin to understand that ordinary humans can be ignorant or can hold false beliefs (around 4 years of age), children tend to attribute those same fallibilities to other agents, even God. Prior to that point, children often judge God's knowledge and ordinary humans' knowledge by referring to reality [Lane et al., 2010, in press; Wellman & Bartsch, 1988]. Thus, if 3-year-olds have access to the information, they assume others do, too; but, this is far from attributing omniscience to others.

Once children begin to attribute fallible mental states to ordinary humans, an initial understanding of some extraordinary mental abilities emerges soon thereafter. By the end of the preschool years, children are willing to grant certain extraordinary beings privileged knowledge about the here and now (e.g., knowledge about the contents of closed containers) [Barrett et al., 2001; Giménez-Dasí et al., 2005; Lane et al., 2010; Makris & Pnevmatikos, 2007]. Moreover, this understanding emerges slightly earlier among children who are heavily exposed to ideas about extraordinary religious beings and who are reminded about agents' special capacities just prior to testing [Lane et al., in press]. Thus, children's ability to reason about God's mind is contingent on their developing theory of (the human) mind, which increases their susceptibility to the culturally available ideas about God's powers.

A god who is a creator, however, has to have more than privileged knowledge. Such a god has to be all-powerful, capable of intentionally designing the entire world. At a minimum, such a god (or person) who carries out an intentional action must have 'a desire for an outcome; beliefs about an action that leads to that outcome; an intention to perform the action; skill to perform the action; and awareness of fulfilling the intention while performing the action' [Malle & Knobe, 1997, p. 111]. These ideas are anchored in a folk theory of intentionality [Malle & Knobe, 1997], which develops over the early elementary school years. Initially, drawing upon their understanding of how artifacts are formed, children often reason that all things have creators, a tendency termed *artificialism* [Piaget, 1929/1969]. When asked about the origins of particular species, 5- to 7-year-olds tend to report that someone or something made them (see table 1 for examples). If they have been raised in Christian fundamentalist communities then they may well state that 'God made it' [Evans,

2000a, 2001], a synthetic explanation that integrates both the culturally available concept of a creative 'God' and the intuitive artificialist explanation, 'someone made it.' Even though preschoolers are sensitive to the desires and actions of a human creator, it is not until middle childhood (7 to 9 years of age) that children reference the full range of mental states when describing the intentionality of an act [Mull & Evans, 2010]. During this period, children also begin to entertain the notion that invisible beings can intentionally affect the physical world [Bering & Parker, 2006]. It is not surprising, therefore, that more complex creationist ideas (table 1) are found among children from both religious *and* more secular backgrounds during middle childhood [Evans, 2000a, 2001, 2008]. Both availability of religious concepts (e.g., 'God' as creator) and susceptibility to these ideas (i.e., a developmental period during which children grasp the full intentionality of an action) appear to be crucial factors in this development.

In addition to these cognitive biases, there is a strong emotional appeal to believing in superior beings who orchestrate the world. The idea of a loving God (or at least a god who loves believers) conveys to many a sense of comfort, and, consistent with attachment theory, perceived closeness to God is related to a range of mental health benefits [Hill & Pargament, 2003]. More focal to the current paper, believing in a god is central to many individuals' sense of meaning and purpose in life [Evans, 2000b; Numbers, 1992; Whitcomb, 1972], staving off the potentially negative effects of existential angst and nihilism. Indeed, having meaning in life is one of the three 'routes to happiness' identified by positive psychologists [Peterson, Park, & Seligman, 2005; Seligman, Steen, Park, & Peterson, 2005]. To account for how we simultaneously weigh evidence and emotional desires in our beliefs in deities, Thagard [2005] has applied his *theory of emotional coherence:* 'Inferences about what to do and believe are affected not only by hypotheses and evidence, but also by the emotional values that are attached to representations whose coherence is assessed' (p. 62). Using a computer simulation, Thagard [2005] weighed the explanatory coherence of arguments for materialism versus theism; the simulation concluded by rejecting the theistic hypothesis and accepting the materialistic hypothesis. Then Thagard ran a simulation that accounted not just for the explanatory coherence of the hypotheses but also for their *emotional* coherence. When four desired outcomes – comfort, social belonging, ethics, and eternal life – were included in the model (and identified as satisfied by belief in a god), the simulation proceeded to *accept* the theistic hypothesis.

Intense existential and moral anxieties are elicited by the idea that humans evolved through naturalistic means, rather than being created in God's image. Christian fundamentalist parents often express their fears about the implications of evolutionary theory: 'If children are nothing more than apes evolved, then we cannot expect them to act more than that to one another … We must instill the belief of their divine worth' [Evans, 2000b, p. 311]; 'I don't know what to believe, I just want my kids to go to heaven' [Evans, 2000b, p. 329]. In a series of studies, Brem and her colleagues demonstrated that this uneasiness about the moral implications of evolutionary beliefs is widespread, found among teachers and college students as well [Brem, Ranney, & Schindel, 2003; Griffith & Brem, 2004]. This body of work suggests that creationist ideas are embedded in a network of ethical and existential beliefs, which makes it unlikely that they can be easily supplanted by a simple appeal to scientific reasoning. Thus, the tendency to ~~sanction~~ the idea that supernatural beings are re-

sponsible for our existence is contingent, we claim, on an intuitive theory of mind, exposure to relevant religious beliefs, the emotional appeal of the ideas, as well as the moral certitude they engender.

Anchoring Evolutionary Ideas

Religious exposure, theory of mind, and the emotional and moral appeal of supernatural beliefs are not solely responsible for resistance to evolutionary theory. Moreover, they do not necessarily obstruct children's or adults' grasp of evolutionary theory; evolution and creationism can go hand in hand, as in the case of theistic evolution [Evans, 2008]. An additional set of cognitive biases make it difficult to both accept and understand evolutionary theory, including essentialist ideas that living kinds are stable and unchanging and the tendency to think of things as existing for a purpose – teleological reasoning [Mayr, 1982]. Essentialism plays a major role, we argue, in the resistance to Darwin's theory of common descent with modification, whereas intuitive ideas about intrinsic purpose impede a grasp of the mechanisms of change, particularly natural selection [Evans, 2000b, 2008].

Humans essentialize their world [Gelman, 2003; Gelman & Rhodes, ~~in preparation~~]. Even infants view the world of 'blooming buzzing confusion' [James, 1890/1983] through an interpretive lens in which objects are grouped into meaningful units. Moreover, these groups share properties that are not predictable based on their surface features alone [Gelman, 2003]. For example, children (and adults) believe that a tiger is a tiger even if you strip it of its overt 'tiger' qualities [Gelman, 2003] – raise a tiger among wolves, put it in a bear costume, train it to roll over and fetch, and it remains a tiger, not a wolf, a bear, or a dog. This intuitive sense that each kind of living being has distinct, enduring, underlying qualities makes it quite difficult to conceive of new species emerging from old ones over the course of evolutionary time; one kind cannot change into another without violating its essential nature. According to the Bible, however, the unique nature of each animal kind is God-given [Whitcomb, 1972]; God is responsible for the *origins* of all species. Darwin [1955/1859], of course, took a different view of this process. For him, all species have a common ancestor, primordial organisms that emerged naturally, the *origin* of species. To account for the origin(s) of species, both the theological explanations of religious scholars and the evolutionary explanations of scientists are the product of system 2 thinking, yet both, we claim, are anchored in an intuitive reasoning pattern of system 1 thinking. How is this possible? For creationism, the solution is relatively simple. The theological construct that each living kind has a God-given essence disseminates easily, we argue, because it does not violate an everyday intuition about kinds; in fact, it reinforces it [Evans, 2000b, 2001].

For evolution, dissemination is more complex. Evolutionary theory encompasses the counterintuitive idea that species are both the ancestors and descendents of different living kinds, which violates everyday intuition. Tracing the emergence of evolutionary ideas about the origin of species, both historically [Mayr, 1982] and in young children, reveals that a grasp of this idea is accomplished incrementally. Understanding the full import of evolutionary theory is a slow process, requiring a series of steps in which the counterintuitive nature of an evolutionary explanation is initially minimized. A full description of this developmental learning progression is

beyond the scope of this review [Evans, Rosengren, Lane, & Price, 2011], though we will describe a few key transitions. Initially, and in keeping with their intuitive essentialism, 5- to 7-year-olds from nonfundamentalist (and fundamentalist) communities often deny that one kind of animal could be the ancestor or descendent of a different kind [Evans, 2000a, 2001]. Moreover, children in this age group also appear to conceive of the world as stable, unchanging, and eternal [Evans, 2008]. Still, this existential stance does not prevent children from proposing a naturalistic explanation of animal origins, at least if they are from nonfundamentalist communities. Found historically [Mayr, 1982] and in young children [Evans, 2000a, 2001] is the idea that the very first of a species spontaneously appeared: it emerged from the ground or from someplace else (for examples, see table 1), where it was previously hidden from view. This naturalistic explanation preserves the original essentialist intuition. Once children begin to understand that living things did not previously exist nor will ~~continue to~~ exist, a plausible explanation for their origins may be derived from children's experience with the creation of artifacts, as described earlier (table 1) [Evans, 2008]. Children from Christian fundamentalist families are more precocious in this regard, probably because of their exposure to an explicit creationist model of origins [Evans, 2000b, 2001]. This use of artificialist explanations is not inevitable, however, as it can be counteracted by exposure to ideas of biological change.

The next incremental modification is marked by children's increasing knowledge that animals can change dramatically without violating their essential identity. Children who grasp the idea of biological change, from metamorphosis to fossils to adaptation [Evans, 2001, 2008], are more likely to accept the idea of evolutionary origins. Even so, there are several limitations to this understanding. Many children and adults will agree that animals that undergo metamorphosis also evolve (e.g., butterflies, frogs), whereas humans were created [Evans, 2001, 2008]. Moreover, the model of evolutionary change that supports this understanding, that evolution is brought about through individual developmental change, misconstrues the mechanism of change. This model, however, is prevalent; it is found historically [Chambers, 1844/1994], in contemporary college students [Poling & Evans, 2004; Shtulman, 2006; Shtulman & Schulz, 2008], in children [Evans, 2000], and in adult museum visitors, ~~as well~~ as in the following explanation for the evolutionary changes seen in HIV: 'As they grow they develop into other types of HIV' [Evans et al., 2010, p. 336].

As should be clear from this analysis so far, acceptance of the idea of evolutionary origins does not necessarily entail an understanding of the mechanisms that explain evolutionary change. In a study of highly educated adult visitors to a natural history museum, who were asked to explain why diverse species had changed over time, 72% displayed a synthetic reasoning pattern, combining intuitive and evolutionary explanations [Evans et al., 2010]. The remaining 28% added theological reasoning (creationist explanations) to this mix, particularly when asked about human evolution. The most commonly expressed intuitive explanation was what we call *need-based* reasoning [Evans et al., 2010], a form of teleological reasoning [Keil, 1995; Kelemen, 1999a, 1999b] in which the organism becomes adapted to a changed environment and survives. In the following example, a museum visitor explains why there were changes in the Galapagos finches' beaks over time: 'In order to survive their body parts had to adjust to certain things, similar to the way giraffes' necks probably grew long as they reached for the plants at the top of the trees, so the beak grew longer in order to deal with the tougher seeds' [Evans et al., 2010, p. 342].

This kind of reasoning is also widespread [e.g., Bishop & Anderson, 1990], yet it is an improvement on the developmental model described earlier, in which evolutionary change is seen as an unfolding of the innate potential of a particular living kind, as in metamorphosis. Although both processes are teleological in nature and neither of them reference mental states, in need-based reasoning the role of the environment, crucial to an evolutionary scenario, is incorporated into the explanation. We argue that this teleo-essentialist explanation [Atran, 1990] represents a major transition, which undergirds a grasp of natural selection. It is found historically, in the intellectual milieu in which Darwin was raised [Chambers 1844/1994], particularly in Lamarck's reasoning [Quammen, 2006]. It eschews the notion that a purposeful supernatural agent created all species, but instead references a natural nonmentalistic process that satisfies the intrinsic need of the organism to survive in a changed environment. Although Lamarck's proposed mechanism of evolutionary change was incorrect, it was a materialistic explanation [Mayr, 1982].

In children, we see an interesting developmental pattern, which bolsters the proposition that need-based reasoning provides an essential anchor for an understanding of natural selection. When asked to explain scenarios about change over several generations in the coloration of guppies, for example, younger children (5- to 7-year-olds) were likely to use anthropomorphic, mental-state reasoning to describe the change, such as, 'they didn't *want* to get eaten and they *knew* that if they were brightly colored they'll be seen more easily' (for other examples, see table 1). This pattern, which has its source in a theory of mind, is called want-based reasoning; crucially, it references an intrinsic process – an external agent does not bring about the change [Evans et al., 2010]. In older children, in contrast, need-based reasoning dominates: 'You don't evolve because you want to … you evolve because you have to' (table 1) [Evans, Lane, & Weiss, ~~in preparation~~]. Furthermore, while want-based language, often used by laypeople when describing natural phenomena, impedes young children's understanding, exposure to need-based language appears to scaffold a grasp of natural selection [Evans et al., 2010; Legare, Evans, & Lane, ~~submitted~~]. In need-based reasoning, children and adults alike recognize that if the environment changes, then the organism needs to change in order to survive. They reason, however, that all individuals in a population can change (e.g., giraffes stretch their necks to reach otherwise inaccessible leaves) and this change is passed on to subsequent generations. According to the theory of natural selection, in contrast, change is not a product of some sort of individual developmental process; it occurs at the population level: members of a population vary and those organisms that *already* possess advantageous features (such as slightly longer necks) are more likely to survive and reproduce. Thus, in descendent populations, there are changes in the proportion of organisms possessing that trait. The crucial transition from need-based to natural selection reasoning is achieved with the realization that variation in the population is tied to *differential survival* of members of that population (table 1); from this point onwards it is a short step to grasping differential reproduction, the last of the key components of natural selection [Evans et al., 2010; Legare, Evans, & Lane, ~~submitted~~].

Thus, adults and older children are increasingly willing to accept the idea of evolutionary origins, at least for some species, especially if they are knowledgeable about the natural world. However, an interesting question is whether this means that they have abandoned their intuitive essentialism [Evans, 2001]. We think this is unlikely. As described earlier, essentialist construals of living kinds do not depend on

Table 1. Examples of supernatural and natural explanations for the origin(s) of species and for within-species change (species question)

	Supernatural explanations	Natural explanations
Origin of species	*Artificialism* 7-year-old: 'Someone put them on earth' (bears)[1] 10-year-old: 'Someone made it' (deer)[1]	*Spontaneous generation* 5-year-old: 'Just appeared' (spiggles)[2] 7-year-old: 'Grew on earth from eggs, like a bird' (dinosaurs)[3]
	Creationism 12-year-old: 'Maybe God put them there' (spiggles)[2] 10-year-old: 'God made a clay figure and breathed into it and made Adam' (humans)[3]	*Evolution* 10-year-old: 'They evolved from something else' (rabbits)[1] 11-year-old: 'It evolved from, maybe another animal or a smaller animal' (rats)[1]
Within-species change	*Creationism* Adult: 'Ok, I believe … God created a pair, a male and female of everything with the ability to diversify. So I guess what I meant at the time of the flood … they had the genetic background to be able to diversify into all of them, like for instance, dogs, and all the different kinds that we have … just a creationistic view' (dogs)[4]	*Want-based reasoning* 6-year-old: 'They wanted to be colorful' (guppies)[1] 10-year-old: 'Well maybe their color, the colorful lizards wanted to change into the plain colored and they might have changed their color into a plain color …' (lizards)[1]
		Need-based reasoning 14-year-old: 'They had to camouflage to the new setting, and they camouflaged to the brownish sand' (lizards)[1]
		Natural selection 12-year-old: 'The colored guppies got eaten by bigger fish and the plain guppies, they were safe and they made more babies and they inherited their mom or dad's color scales' (guppies)[1]

[1] Evans, Lane, & Weiss [in preparation]. [2] Evans [2000[redacted]]. [3] Evans [2008]. [4] Evans et al. [2010].

surface features, but on nonobvious properties [Gelman, 2003]. An essence is a placeholder. Upon learning about the evolution of birds, for example, children, who initially thought that birds and dinosaurs were 'not the same kind of thing,' reason as if they are variations of a single living kind [~~Evans et al., 2011a~~]. Similarly in their search for the molecular fingerprints that identify a particular ancestral line in the tree of life, evolutionary biologists discover the underlying essence (DNA) of a specific taxonomic grouping, whose members might be quite diverse. Once the placeholder essence is filled by genes known to be preserved across all species over time, all living things could, in principle, be represented by single underlying essence, based on common ancestry, as Darwin predicted.

From System 1 to System 2 Reasoning

We have argued that diverse intuitive reasoning modes, in various combinations, anchor both creationist and evolutionary reasoning patterns. Moreover, we have offered some evidence of systematic developmental change in those reasoning patterns as a function of particular cultural experiences. This analysis offers a rather different view of dual-process theory, at least for domain-specific reasoning. Instead of construing system 1 and system 2 reasoning as dichotomous processes, it might be more accurate to think of them as a continuum, at least within a domain. For any particular domain, theological or scientific, the initial reasoning pattern is likely to be an intuitive one, as individuals struggle to make sense of particular phenomena, drawing on whatever cognitive resources they have at hand. Eventually, the same phenomena are evaluated through a more analytic or reflective lens. Evidence that the more analytic process is anchored in everyday or intuitive reasoning is the ease with which individuals who are capable of using the most rational form of thought revert to an intuitive process. We have described how religious individuals have difficulty holding onto the idea of an omniscient god [Barrett & Keil, 1996], often defaulting, instead, to an anthropomorphic god with human frailties. This is also true in the scientific realm. Evolutionary biologists are notorious for reverting to anthropomorphic or teleological language when describing biological phenomena [Jungwirth, 1975; Legare, Evans, & Lane, ~~submitted~~], as in this example:

> It may be said that natural selection is daily and hourly scrutinising, throughout the world, every variation, even the slightest; rejecting that which is bad, preserving and adding up all that is good. [Darwin, 1955/1859, p. 84]

Importantly, counter to the assertions of some outspoken critics [e.g., Dawkins, 1995], we do not view religious thought and evolutionary thought as representing opposite ends of the intuitive-reflective spectrum. Religious scholars dedicate their lives to a search for the meaning of life and they hold a strong belief in an omniscient creator. Reflective or analytic thought is necessary to contemplate such ideologies. Since young children are initially resistant to the idea that any being can possess extraordinary mental abilities [e.g., Lane et al., in press; Makris & Pnevmatikos, 2007], and even adults overattribute psychological constraints to God in their everyday reasoning [Barrett & Keil, 1996], we suspect that the capacity to conceptualize a truly omniscient God may not emerge until the end of the elementary school years, or even later. Further, as described, some adults will accept evolutionary theory as true in part because it is the dominant view in their culture, even though they have an inaccurate understanding of the mechanisms [Evans, 2000b]. Although members of the public in other industrialized countries are more likely to accept evolution, they, too, often misunderstand natural selection, using intuitive teleological reasoning instead [Abraham-Silver & Kisiel, 2008].

Intuitive beliefs are not necessarily discarded as analytic beliefs come to the fore. Of the intuitive reasoning modes described here, essentialism bolsters the dissemination of creationist ideas about human origins, whereas it initially hinders the spread of evolutionary ideas. On the other hand, modified essentialist construals of living kinds may eventually anchor more sophisticated evolutionary concepts, though this requires extensive immersion in the natural world before these

concepts emerge. One prediction that arises from the differential impact of essentialism on creationist and evolutionary ideas is that while creationists might reject the evolutionary theory of common descent because it violates their culturally reinforced essentialist beliefs that one kind cannot be the ancestor of a different living kind, they might be more amenable to the idea of change within a kind, such as natural selection. In the latter case, the essential nature of the kind is not destroyed. This pattern is espoused by creationist scholars [Evans, Legare & Rosengren, 2011; Legare et al., in press], college students [Poling & Evans, 2004], and natural history museum visitors, as in the following response of a creationist visitor, who continued to resist evolutionary theory while endorsing differential survival in Galapagos finches:

> Because of my biblical world view, I don't believe in evolution. … Um, my guess would be that there were probably larger beaked finches but there weren't as many of them and the small beaked ones would have died out because they couldn't get the food … [Evans et al., 2010, p. 343]

Given the tendency to hold onto creationist ideas, in part because such ideas are embedded in a broader network of moral beliefs that also offer emotional sustenance, it would not be surprising that when evolutionary theory is embraced it does not supplant creationist beliefs but complement them. Indeed, that is exactly what we find. The synthetic pattern, just described, in which intuitive beliefs are loosely combined with evolutionary or creationist terms or concepts, is a typical pattern [Poling & Evans, 2004]. But there are more coherent analytic forms in which evolutionary and creationist explanations are more tightly linked. A target-dependent coexistent pattern in which humans are thought to have been created whereas other animals evolved is found in about a third of adult samples [Evans, 2001; Evans et al., 2010]. Leading scientists and theologians are most likely to embrace an integrated model, such as theistic evolution or target-dependent reasoning [Evans, Legare, & Rosengren, 2011; Legare, Evans, & Lane, submitted]. While Pope John Paul II believed that God created the human soul, he thought that the human body was a consequence of evolutionary processes; Frances Collins, a leading geneticist and Director of NIH, accepts a form of theistic evolution in which God is the prime mover, but naturalistic explanations, such as evolution, are rigorously embraced. Moreover, it should not be forgotten that the birth of modern science was hastened by natural historians who were thought to be pursuing God's work [Evans, 2000b] at a time when science was construed as 'religion's truest handmaid' [Shapin, 1996, p.142].

The tendency to consciously transcend and question intuitive beliefs is related, in part, to individual differences in one's goals and thinking dispositions [Stanovich, 2009], but the ability to do so effectively is a product of executive function, particularly of inhibitory mechanisms and attention-shifting capacities [Best & Miller, 2010; Evans, 2003; Stanovich et al., 2008]. Such capacities seem to require a fully functioning frontal cortex [Best & Miller, 2010; Evans, 2003; Shallice & Evans, 1978]. Although there is evidence of marked age-related improvements in these capacities, even the youngest elementary school children can inhibit prepotent responses and demonstrate the metacognitive ability to shift between tasks [Best & Miller, 2010]. For fully trained theologians and scientists, most of the time system 2 thinking overrides system 1 thinking, at least when they contemplate informa-

tion within their domains of expertise. Whereas it is clear that scientists and theologians engage in system 2 thinking, it is less clear if members of the public and children are doing so. We would argue that the deliberate inclusion of culturally derived constructs in an explanation, such as evolutionary or theological terms or concepts, marks a shift from an intuitive to a more reflective reasoning process. In this section, we have argued that creationist, evolutionist and intuitive reasoning patterns coexist and that individuals who endorse such hybrid beliefs are often engaged in reflective thinking, a characteristic of system 2 processing. Further, this demonstration of causal flexibility, the ability to rapidly shift between different reasoning patterns [Poling & Evans, 2002], might well be the hallmark of human reasoning. How else could we come up with novel explanations for seeming inexplicable phenomena?

Conclusion

Supernatural and natural explanatory frameworks are both used to explain our origins, in contemporary industrialized societies as well as in societies over the millennia [e.g., Mayr, 1982]. Presenting them as competing or contradictory explanations, one representing an analytic or scientific framework and the other an intuitive one, belies the way they function in everyday reasoning. Our basic argument echoes those articulated by cultural psychologists who examine differences in reasoning between Western and East Asian societies. In an analysis of whether analytic thinking, favored in the West, and holistic thinking, favored in the East, map onto the system 1 and system 2 thinking of the dual-process framework, respectively, Buchtel and Norenzayan [2009] concluded that the answer is partially 'yes' and partially 'no.' Similarly, we find that evolutionary (naturalistic) and creationist (supernatural) reasoning both map onto elements of system 1 and system 2 thinking. Which elements are manifest depends on whether a particular explanation maps onto an intuitive reasoning pattern or whether it represents the reflective and systematic bodies of knowledge found in modern theology as well as modern science. Moreover, we claim that intuitive reasoning processes anchor these bodies of knowledge and, at least for these domains, they represent opposite ends of a continuum, rather than dichotomous reasoning processes.

In this review, we argue that in their everyday reasoning many members of the public are likely to treat these modes of thinking as compatible and combine them in diverse ways both to explain the problem in hand and, simultaneously, to satisfy a broader need for meaning and systematicity in their lives. This type of dialectical reasoning in which there is both a tension between conflicting ideas and a resolution of that tension is perhaps more widespread in the West than is commonly acknowledged [Peng & Nisbett, 1999]. It might behoove those who educate teachers to address these issues more directly in the science classroom. If education courses explicitly addressed the different theological stances that teachers are likely to encounter, and the reasoning behind these stances, teachers might be more confident about dealing with them in the classroom. Moreover, teachers may be more comfortable teaching evolutionary theory if they realize that it does not necessarily contradict their own or their students' religious understanding of origins, but can *complement* it. By appreciating both the theological and the scientific arguments as well as the

way most people reason about existential questions, teachers might be better prepared to deal with these issues in the classroom and be more likely to adhere to the lesson plan.

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