Chapter 19

Explanatory pluralism across cultures and development

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Introduction

A dominant view of knowledge acquisition is that humans acquire knowledge through a rational process of theory construction and revision. Conceptual development in the individual has been likened to theory development in the history of science, in terms of both the content of children's developing knowledge (Carey, 2009) and the process by which children acquire that knowledge (Gopnik & Wellman, 2012). Recent studies motivated by this view of conceptual development have found that individuals of all ages are sensitive to the information conveyed by different patterns of covariation and can use that information to generate causally relevant explanations, predictions, and interventions (e.g., Gopnik, Glymour, Sobel, Schulz, Kushnir & Danks, 2004; Gopnik & Schulz, 2007; Steyvers, Tenenbaum, Wagenmakers & Blum, 2003). Moreover, children have been shown to update their beliefs in a rational manner, revising their initial explanations for why something happened in light of evidence that contradicts those explanations (Bonawitz, van Schijndel, Friel & Schulz, 2012; Legare, 2012, 2014; Schulz, Bonawitz & Griffiths, 2007).

This view of conceptual development has inspired several productive lines of research, but one of its central tenets—that people replace old explanations with new explanations as more information comes to light—has been called into question by the discovery that people maintain their original explanations when they acquire new ones (Legare & Gelman, 2008; Lombrozo, Kelemen & Zaitchik, 2007; Shtulman & Harrington, 2016; Shtulman & Valcarcel, 2012; Subbotsky, 2001; Zaitchik & Solomon, 2008). That is, people of all ages and cultures have been observed to hold several, contradictory explanations of the same phenomena, ranging from scientific explanations to superstitious explanations to religious explanations.

Access to natural as well as supernatural explanations is a pervasive experience across cultures (Astuti, Solomon & Carey, 2004; Campbell, 1972; Evans, Legare & Rosengren, 2011; Gelman & Legare, 2011; Legare, Evans, Rosengren & Harris, 2012). For example, with regard to the origin of species, both a creationist account (i.e., God placed humans on Earth) and an evolutionary account (i.e., humans evolved from different kinds of living things; see Evans, 2001; Legare, Evans & Lane, 2013) are available to adherents of

many of the world's religions. Similarly, both biological (e.g., viruses) and supernatural (e.g., witchcraft or supernatural punishment) explanations for the transmission and cure of serious illnesses are prevalent (Farmer, 1999; Legare & Gelman, 2008, 2009). Finally, although all humans are faced with the biological inevitability and finality of death, the vast majority of the world's population believes in an afterlife (Astuti & Harris, 2008; Harris & Giménez, 2005; Harris, 2011; Talwar, Harris & Schleifer, 2011).

There is a wide-ranging and influential body of research on the development of reasoning in natural domains (Carey, 2009; Gopnik & Schulz, 2007; Kuhn, 1989) and the development of causal explanatory reasoning in particular (Crowley & Siegler, 1999; Gopnik & Wellman, 2012; Keil, 2006; Keil & Wilson, 2000; Legare, Gelman & Wellman, 2010; Legare, Wellman & Gelman, 2009; Legare & Lombrozo, 2014), yet reasoning about supernatural or divine powers has not been studied as extensively or as systematically. Research on this topic is certainly being pursued (e.g., Barrett, 2000; Barrett, Richert & Driesenga, 2001; Bering, 2006; Lane, Wellman & Evans, 2010; Legare & Souza, 2012; McCauley, 2000; Rosengren, Johnson & Harris, 2000; Shtulman & Lindeman, 2016; Watson-Jones, Busch, Harris & Legare, 2017; Woolley, 2000), but investigators have rarely asked whether and *how* natural thinking and supernatural thinking are reconciled and integrated in the minds of those who practice both. The dearth of research on this topic is likely due to several factors, including the view that supernatural thinking is not amenable to empirical investigation (Rosengren et al., 2000) and the practice of studying cognitive development divorced from the cultural contexts in which it occurs (Callanan, 2006; Cole, 2005; Legare & Harris, 2016).

In spite of their dual prevalence, little is known about how natural and supernatural explanations co-develop or the extent to which children and adults recruit and accommodate both to explain the same events. We propose that coexistence is the typical end state of development—that individuals who hold only one explanation of a given phenomenon are few and far between. While the particular collection of explanations will vary by domain, humans universally appear to *collect* explanations rather than *replace* one explanation with another. Replacing explanations may be possible, but we propose that integrating explanations is a more likely outcome. And integrating explanations is not even the most likely outcome, as doing so requires sustained metacognitive effort.

Our aim in this chapter is to show that explanatory coexistence is an inherent feature of how humans represent and understand the natural world and thus speaks to general questions of knowledge acquisition, socialization, and the interaction of cognition and culture. We first review research demonstrating that the coexistence of natural and supernatural explanations is not a short-lived, transitional phenomenon that wanes in the course of development, but is instead evident (and widespread) among adults. We then speculate on the psychological origins of coexistence and discuss its implications for metacognition. We conclude by proposing directions for future research that will inform our understanding of how individuals incorporate natural and supernatural explanations across content domains, development, and cultures.

Explanatory coexistence is the rule not the exception

Anyone who has interacted with a diverse group of people knows that different people prefer different explanations for the same event. Most religious individuals, for instance, prefer to explain human origins in terms of divine creation, whereas many secular individuals prefer to explain the same phenomenon in terms of evolution by natural selection. While this type of inter-personal explanatory pluralism is readily apparent, it is less apparent that a similar kind of pluralism exists within the minds of each individual. That is, individual humans represent multiple and often incompatible explanations for the same phenomenon. We may explicitly endorse a single explanation, but typically we represent several more, and default to those alternative explanations in particular contexts (e.g., in church or at religious ceremonies) or under particular circumstances (e.g., when rushed or burdened). In this section, we will review three domains in which people have been shown to hold two—if not three or four—alternative explanations of the same phenomena: illness, death, and human origins.

Two cross-cutting distinctions can be made between coexisting explanations. One is the distinction between natural and supernatural explanations. We use the term "natural" to refer to explanations that evoke observable and empirically verifiable entities and processes (at least in principle—some natural explanations evoke entities or processes that can only be observed with specialized instruments). We use the term "supernatural" to refer to explanations that violate, operate outside of, or are distinct from the realm of the natural world or known natural law (Legare et al., 2012). Even when a particular cause is unknown, the general pattern of causation is assumed to be observable and verifiable in the case of natural explanations, but not in the case of supernatural explanations. The other distinction is between formal and informal explanations. Formal explanations are those that are culturally prescribed and culturally transmitted and include both scientific explanations (prescribed by the scientific community) and religious explanations (prescribed by a religious community). Informal explanations, on the other hand, are what are commonly referred to as "folk beliefs" or "intuitive theories" (Carey, 2009; Shtulman, 2017). Informal explanations can evoke either natural forms of causation or supernatural forms. Examples of these four types of explanation are provided in Table 19.1.

Coexisting explanations for illness

There are at least four ways to explain infectious illness. The scientific explanation is that microscopic organisms (e.g., bacteria, viruses, fungi, or parasites) are transferred from one body to another, where they then reproduce and monopolize the host's cellular resources. A folk explanation, on the other hand, is that engaging in imprudent behaviors, like getting cold or eating poorly, creates an imbalance in one's store of internal energy or "vital power" (Au et al., 2008). An alternative folk explanation is that illness results from supernatural forces linked to our social interactions, such as bewitchment by jealous neighbors (Legare & Gelman, 2008) or the karmic law that bad things happen to bad people (Raman & Winer, 2004). Lastly, the religious explanation for illness is that an

Table 19.1 Examples of distinct explanatory frameworks for illness, death, and origins

Domain	Explanation type	Putative cause
Illness	Scientific	Germs (bacteria, viruses)
	Folk-natural	Imprudent behavior (getting cold, eating poorly)
	Folk-supernatural	Consequences of interpersonal relations (witchcraft, karma)
	Religious	Divine retribution for immoral behavior
Death	Scientific	Breakdown of the bodily machine
	Folk-natural	Altered existence akin to prolonged sleep or estrangement
	Folk-supernatural	Spiritual transformation (becoming a ghost or ancestor)
	Religious	Soul departs world and enters an afterlife (Heaven, Hell)
Origins	Scientific	Evolution by natural selection
	Folk-natural	Need-based transformation of species' underlying essence
	Folk-supernatural	Theistic (God-directed) evolution
	Religious	Divine creation

omniscient and omnipotent being (God) monitors our behavior and sends illness to people who have committed moral transgressions (Lupfer, Brock & DePaola, 1992).

Individuals today tend to learn the scientific explanation for illness, but learning that explanation does not uproot either folk explanations or religious explanations, in which germs play no role. That is, individuals who explicitly endorse the idea that germs cause illness continue to endorse (at least implicitly) other, nonscientific explanations, as shown in studies where participants are allowed to endorse not just one but several explanation for illness (e.g., Legare et al., 2012) and studies where participants are asked to reason about illness across distinct contexts (e.g., Au et al., 2008). Coexisting explanations for illness have been observed among both children and adults (Au et al., 2008; Legare & Gelman, 2008; Raman & Winer, 2004) and among individuals from diverse populations, including South Africa (Legare & Gelman, 2008), India (Raman & Gelman, 2004), Vanuatu (Busch, Watson-Jones & Legare, 2017), and Vietnam (Nguyen & Rosengren, 2004).

Coexisting explanations for death

From a scientific point of view, death in humans results from the breakdown of the body. It is inevitable, irreversible, and universal (among living things), and results in the cessation of all bodily functions. Prior to developing a scientific explanation for death, children understand death as an altered state of existence—a prolonged sleep or prolonged estrangement that does not necessarily entail the cessation of bodily functions (Slaughter

& Lyons, 2003). An alternative explanation for death is one that distinguishes the body from some immaterial component of existence—the spirit or the soul—and assumes it is only the body that ceases to function. The immaterial component either lives on as a ghost or ancestor (Astuti & Harris, 2008) or departs the physical world and enters a nonphysical afterlife, such as Heaven or Hell (Harris & Giménez, 2005). Both beliefs evoke supernatural processes, but only the latter is endorsed by most formal religions.

Children tend to learn the scientific explanation for death between the ages of seven and ten (Slaughter & Lyons, 2003), but acquiring that explanation does not preclude learning supernatural explanations for death as well. Indeed, children are more likely to endorse supernatural explanations the older they are, after having acquired a scientific explanation (Harris & Giménez, 2005). Scientific and supernatural explanations then coexist throughout adulthood, leading to biological construals of death in contexts that emphasize the deceased's body but spiritual construals in contexts that emphasize the deceased's identity. This is true not only among American adults but also among adults in Madagascar (Astuti & Harris, 2008), Spain (Harris & Giménez, 2005), China (Brent, Speece, Lin, Dong & Yang; 1996), Mexico (Rosengren et al., 2014), and Vanuatu (Busch, Watson-Jones & Legare, 2017; Watson-Jones, Busch & Legare, 2015). Even adults who explicitly deny the possibility of an afterlife reason about death differently when considering the deceased's body or identity. That is, adults who explicitly deny the possibility of an afterlife take longer to affirm that dead people no longer experience psychological states, such as wanting or knowing, than to affirm that dead people no longer experience physiological states, such as needing to eat or needing to drink (Bering, 2002).

Coexisting explanations for human origins

Humans are biological creatures that evolved through the process of natural selection, but few people understand what natural selection is or how it works (Gregory, 2009). A more popular view of evolution is a view akin to metamorphosis. Evolution is construed as the cross-generational transformation of a species' underlying nature, or essence, with each organism predisposed to produce offspring more adapted to its environment than it was itself at birth. Natural selection plays no role on this view because species are construed as discrete types rather than populations of varied individuals (Shtulman & Calabi, 2013). Humans are thus believed to have metamorphosed from apes, which are believed to have metamorphosed from monkeys. An alternative view of human origins is that humans evolved from nonhuman organisms but that God, not natural selection, guided the process (Blancke, De Smedt, De Cruz, Boudry & Braeckman, 2012). The religious view of human origins, on the other hand, posits that humans have always existed in their current form, put on the Earth directly by God (Evans, 2001).

Human origins, like illness and death, are explained in different ways in different contexts. For instance, most people will endorse both evolutionary explanations and creationist explanations if given the opportunity to do so (Evans, Spiegel, Gram, Frazier, Tare, Thompson & Diamond, 2010), and many people who endorse evolutionary explanations for the origin of nonhuman organisms prefer creationist explanations for the origin of humans (Shtulman

& Calabi, 2012). In a similar vein, creationist explanations have been documented not only among religious fundamentalists, who explicitly endorse such beliefs, but also among secular children and adults who do not; these individuals do not explicitly claim that God created humans, but still appeal to a generic act of creation when asked where living creatures came from (Evans, 2001; Samarapungavan & Wiers, 1997). Indeed, arguments for the "intelligent design" of biological organisms have resonated with the general public for centuries and continue to resonate with the general public today, despite increased exposure to the scientific alternative of evolution by natural selection (Busch, Watson-Jones & Legare, 2017; Lombrozo, Shtulman & Weisberg, 2006; Tracy, Hart & Martens, 2011).

Coexisting explanations in other domains

The three cases of coexistence discussed already are only a subset of the many cases that have been discovered. People have been shown to hold contradictory explanations of several phenomena, including life (Goldberg & Thompson-Schill, 2009), matter (Potvin, Masson, Lafortune & Cyr, 2015), motion (Foisy, Potvin, Riopel & Masson, 2015), cosmography (Carbon, 2010), electricity (Masson, Potvin, Riopel & Foisy, 2014), human consciousness (Preston, Ritter & Hepler, 2013), rational numbers (Vamvakoussi, Van Dooren & Verschaffel, 2012), and physical causality (Kelemen, Rottman & Seston, 2013). These phenomena extend beyond the domain of biology and into the domains of physics, psychology, and mathematics.

In some cases, the explanations that coexist invoke only natural causes, while in other cases, they invoke a combination of natural and supernatural causes. A nonbiological example of the first type of coexistence (two natural explanations) comes from studies of how adults conceive of matter. Adults who know that material objects vary in density (weight per unit volume) often fail to use density when deciding whether an object will sink or float. Even when adults explicitly acknowledge that an object's average density is what determines its buoyancy, they still default to weight when making predictions about the buoyancy of very heavy objects or very light objects, similar to what young children do (Kohn, 1993; Potvin et al., 2015). A nonbiological example of the second type of coexistence (natural versus supernatural explanations) comes from studies of how adults explain the origin of the universe. Adults who explicitly endorse a scientific explanation for the origin of the universe (the Big Bang) increase their endorsement of a religious explanation (God) when they are primed to think that the scientific explanation may be flawed (Preston & Epley, 2009). These examples illustrate that even though explanatory coexistence may take different forms in different domains, it appears to be a developmental and cultural regularity nonetheless.

The origins of coexistence

How do we acquire competing explanations of the same phenomena? And why do we maintain those explanations across development? The answers to both questions, we argue, lie in the multifaceted nature of knowledge acquisition and knowledge application.

A plurality of knowledge sources

Humans acquire knowledge from three distinct sources: evolution, experience, and culture (Carey, 2009; Shtulman, 2017). Knowledge acquired through evolution is knowledge of a genetic origin, endowed in us by natural selection due to its utility in furthering the survival and reproduction of our ancestors. Knowledge acquired through experience is knowledge derived from first-hand observation and exploration of the physical world. Knowledge acquired through culture is knowledge initially derived by someone other than oneself but shared through the process of cultural transmission. All three sources of information shape each of the explanations we endorse. Experience, for instance, allows us to construct ecologically specific explanations from evolutionarily endowed concepts, and culture allows us to refine or restructure those explanations. Some sources, however, are more critical than others in constructing particular forms of explanation. Folk explanations tend to be heavily grounded in first-hand experience, whereas scientific and religious explanations require the cultural transmission of ideas developed by other people, often over multiple generations.

Consider explanations for astronomical phenomena, like the day–night cycle (Samarapungavan, Vosniadou & Brewer, 1996; Vosniadou, 1994). Across cultures, children develop mental models of the Earth and its relation to the Sun through the experience of navigating seemingly flat ground and observing the Sun rise and set relative to the ground. These models assume that the Earth is essentially a plane rather than a sphere and that day occurs when the Sun is above the plane, whereas night occurs when it is below the plane, obscured by the Earth itself. Cultural input may shape the nature of the models that children hold (e.g., the particular shape of the planar surface), but children develop similar models regardless of their culture of origin. Spherical models of the Earth, on the other hand, are the result of decades of scientific inquiry, and they are acquired not through experience (or innate knowledge) but through cultural transmission, either via formal instruction in the physical sciences or informal exposure to cultural artifacts like maps and globes.

The fact that humans acquire knowledge from many different sources—not to mention many different subsources (e.g., testimony from parents, teachers, or peers)—leads to inherent challenges in coordinating and systematizing that knowledge. Knowledge acquired from different sources can be compatible and even complementary, but it can also be incompatible and contradictory. Indeed, the cases of incompatibility that form the foundation of explanatory coexistence are cases in which two pieces of knowledge make fundamentally different assumptions about how the world works—i.e., fundamentally different assumptions about the kinds of entities that exist and the causal relations among them.

This form of incompatibility is exemplified by the tension between natural and supernatural explanations of the same phenomena (described already). The traditional view of the relation between natural and supernatural explanations is that the former replace the latter, both historically and ontogenetically. In developmental psychology, for example, it

has long been claimed that young children gradually abandon a belief in supernatural causation as they acquire a more objective, rational appreciation of cause and effect (Piaget, 1928; see also Harris, 2009). In cultural psychology, a classic body of research was taken to show that the twin engines of education and modernization accelerate various aspects of cognitive development (Luria, 1976; Vygotsky, 1978). These two lines of research point to the possibility that with more widespread access to education and modernity, a focus on natural explanations will increasingly compete with, and even displace, adherence to supernatural explanations.

This possibility is contradicted, however, by the finding that few adults, in any culture, endorse an exclusively natural view of the world, stripped of all references to the supernatural (Campbell, 1972; Misztal & Shupe, 1992; Raman & Winer, 2004; Tambiah, 1990). In fact, research on children's supernatural thinking indicates that this type of thinking *increases* with age rather than decreases (Astuti & Harris, 2008; Evans, 2001; Harris & Giménez, 2005; Legare & Gelman, 2008; Raman & Gelman, 2004; Watson-Jones et al., 2017; Woolley, Cornelius & Lacy, 2011). Adults are more likely than children to appeal to witchcraft as an explanation for AIDS (Legare & Gelman, 2008), immoral behaviors as an explanation for flu-like illnesses (Raman & Gelman, 2004), and the departure of the soul as an explanation for death (Harris & Giménez, 2005). This finding is difficult to explain on a rational, replacement-based view of conceptual development, but it is a direct prediction of the coexistence view. Supernatural explanations are shaped by cultural input—children do not invent supernatural constructs like *spirit, Heaven, karma*, and *witchcraft* on their own—and young children have not been exposed to that input for as long as older children have. Young children thus default to explanations grounded in first-hand experience; only older children and adults have both types of explanations available to them.

In short, supernatural explanations are a developmental achievement, not a developmental artifact. While supernatural explanations may fall short of scientific explanations in their predictive power and explanatory scope, they are not an outgrowth of irrational thought or emotional immaturity (contra Bloom, 1992; Dawkins, 2006), nor are they likely to be replaced by scientific explanations in the wake of technological advancements and other forms of modernization (contra Norris & Inglehart, 2004). Supernatural explanations have proven to be surprisingly resilient, persisting in the face of contradictory explanations not only within a society but within an individual. The question of why such explanations persist is different from the question of where they originate, and we turn to that question now.

A plurality of explanatory goals

One reason to posit that people use both natural and supernatural explanations to explain the same events is that they serve similar cognitive functions. Each offers an "attempt to explain and influence the working of one's everyday world by discovering the constant principles that underlie the apparent chaos and flux of sensory experience" (Horton, 1979, p. 355). Both natural and supernatural explanatory frameworks can provide answers to

questions of fundamental interest to humans. For example, both evolution and creationism explain the origin of human beings, both biomedicine and witchcraft explain the causes of serious illness, and both biology and religion explain what happens when we die. Given the shared objectives of natural and supernatural cognition—to enable us to explain, understand, and intervene in the world—there is much to be gained by investigating whether and how far a single cognitive system can entertain both kinds of thinking, even with respect to the same phenomenon.

That said, there are several aspects of a phenomenon that we might want to explain, and those aspects often lend themselves to different types of explanation. With respect to illness, we might want to explain both what causes a particular set of symptoms (e.g., fever, rash, and swollen glands) and why those symptoms have afflicted a particular person (e.g., our uncle). The most satisfying answer to the first question may be a natural explanation (e.g., he contracted HIV), whereas the most satisfying answer to the second question may be a supernatural explanation (e.g., a witch influenced his choice of sexual partners). The same is true for other phenomena. Questions about humans' resemblance to apes and monkeys may evoke natural explanations (e.g., humans evolved from primate ancestors), whereas questions about human uniqueness may evoke supernatural explanations (e.g., God endowed humans with an immortal soul).

A related reason for why we maintain multiple explanations is that some of those explanations may be associated with strong emotions. Death, for instance, raises anxiety about the fate of our personal identity, and supernatural (soul-based) explanations quell those anxieties. Questions about human origins, on the other hand, raise anxiety about humans' place in the biological world (Evans, 2001) or the seemingly negative implications of an evolutionary view of biological change (e.g., Evans, 2008; Brem, Ranney & Schindel, 2003), including the possible extinction of the human species (Poling & Evans, 2004). We may be particularly reluctant to relinquish explanations that relieve anxiety, even if those explanations contradict other information we believe to be true.

Nonscientific explanations are useful not only because they satisfy unique cognitive and emotional goals but also because they are embedded in cultural practices and narratives that predate our current scientific understanding and continue to exist alongside the relatively new tradition of science education. Prayer is a prime example. Individuals who engage in prayer often pray for a reprieve from illness (Bearon & Koenig, 1990). They do so not because they are unaware that infectious diseases are caused by germs but because they view God and germs as complementary (as will be discussed). The practice of prayer reinforces explanations for illness that are not emphasized in contexts that presuppose strictly natural explanations, like medical care or health education. The coexistence of diverse cultural practice can thus sustain diverse explanatory preferences, even if those preferences are logically contradictory. Indeed, in line with socio-cultural perspectives on development (Cole, 2005; Vygotsky, 1978), we argue that the development of both natural and supernatural explanatory systems requires a considerable amount of cultural

experience and participation in social rituals and other collaborative activities (Callanan, 2006; Harris & Koenig, 2006).

Implications of coexistence for metacognition

Explanatory coexistence appears to be a cognitive universal, but its particular manifestation may vary from one individual to another. That is, individuals who hold multiple explanations of the same phenomenon may make use of those explanations in different ways. For example, a person might explain AIDS using witchcraft in one instance and biology in another, or might combine the two in a third instance. Similarly, a person might explain the sequelae of death using a religious framework in one instance and a biological framework in another, or might combine the two frameworks in a third instance. We shall outline three solutions to the problem of coordinating coexisting explanations. The range of solutions is determined by whether a person (a) recognizes the contradictions inherent in their collection of explanations and (b) attempts to resolve those contradiction. Both of these tasks are metacognitive activities, since they entail thinking about one's thinking, and their success likely determines the coherence of one's explanatory beliefs.

Integrated reasoning

One way to resolve the contradiction between logically incompatible explanations is to integrate them into a larger causal structure. We refer to cases of such well-coordinated explanations as *integrated reasoning*. Integration can be achieved by using natural and supernatural explanations for different levels of analysis or different timescales of causation. For example, a natural cause can be regarded as proximate (in scope or time), and a supernatural cause as ultimate. Thus, in the case of theistic evolution, natural selection is regarded as a proximate cause, whereas God's intentions are regarded as the ultimate cause. Similarly, in the case of AIDS, unprotected sex is regarded as a proximate cause, whereas witchcraft is regarded as the ultimate cause (e.g., witches are believed to be capable of distorting your sense of good judgment or putting an AIDS-infected person in your path; see Legare & Gelman, 2008). To integrate diverse explanations, one must not only recognize that they exist but also devise a causal model capable of reconciling the ontological differences inherent in those explanations.

Synthetic reasoning

A second possibility is that diverse explanations are treated as alternative, yet equally plausible, interpretations of the phenomenon at hand. Both forms of explanation are invoked without assigning hierarchical or temporal precedence to either. Such dual explanations involve only a loose integration of causal relations, without any detailed consideration of how they would interact. We refer to this type of coordination as *synthetic reasoning* (Vosniadou, Vamvakoussi & Skopeliti, 2008). For example, one might invoke both witchcraft and unsafe sexual practices to explain contracting AIDS (Legare & Gelman, 2008) or

evoke both biological decay and spiritual metamorphosis to explain what happens after death (Harris & Giménez, 2005) without specifying how the two forms of explanation fit together. The only prerequisite for achieving synthetic reasoning is recognizing that one holds multiple explanations of the same phenomenon, which could happen either in the context of instruction (if differences between competing explanations are explicitly highlighted by an instructor) or in the context of explanation itself (if an event activates two explanations simultaneously).

Target-dependent reasoning

A third form of coexistence reasoning is when a person applies different explanations to distinct aspects of an event or phenomenon. Even if both explanations are recruited at once, they are applied independently, through separate modes of response or separate causal attribution. We label this type of inference *target-dependent reasoning*. For example, a natural framework might be used to explain the breakdown of all bodily processes at death, whereas a supernatural framework might be used to explain the continued existence of the spirit or soul after death. The analysis of death concepts in Spain, Mexico, and Madagascar provides evidence for the use of target-dependent reasoning. Supernatural explanations are evoked when considering the fate of the deceased's identity, whereas natural explanations are evoked when considering the fate of the deceased's body (Astuti & Harris, 2008; Harris & Giménez, 2005). Similarly, in the case of reasoning about the origin of species, an evolutionary framework might be recruited to explain the origin of nonhuman species, whereas a theistic framework might be recruited to explain the origin of human beings (Shtulman & Calabi, 2012). This way of coordinating coexisting explanations is not really coordination at all, since it requires neither recognition nor integration of those explanations.

Unanswered questions about coexistence

At present, we do not yet know why individuals engage in one kind of coexistence reasoning or another—that is, why some individuals form integrated explanatory models whereas others evoke different explanations in different contexts, seemingly unaware of the contradictions between them. Why do some individuals adopt a single explanatory approach when confronted with competing epistemologies? Why do people in general treat different epistemologies as complementary rather than mutually exclusive? It is plausible that some individual differences are due to differences in socialization and cultural input, but it is also plausible that certain cognitive characteristics influence whether an individual vacillates between contradictory ideas or attempts to unify them into an integrated causal model.

From a developmental point of view, we anticipate both increased compartmentalization and increased integration of competing explanations across development, contingent upon personal values, individual expertise, and cultural differences in how natural versus supernatural knowledge is organized (D'Andrade, 2008; Shweder, Much, Mahapatra &

Park, 1997). In the US, for instance, science and religion are often presented as contradictory or dichotomous explanatory systems. The presentation of the relationship between science and religion may well affect coexistence reasoning among either religious populations or secular populations, or both. We also anticipate that metacognitive skills, such as comprehension monitoring, set shifting, and inhibitory control, facilitate the capacity either to compartmentalize logically distinct explanations or to integrate them. These skills play a critical role in acquiring scientific explanations (Bascandziev, Powell, Harris & Carey, 2016; Zaitchik, Iqbal & Carey, 2014), and they likely play a role in coordinating those explanations with other, nonscientific explanations within the same domain. Coexistence reasoning is not, after all, inherently incoherent; integrated forms of coexistence reasoning are actually a conceptual achievement.

An additional direction for future research is to examine explanatory coexistence in a cultural context outside of Western culture. Natural and supernatural explanatory frameworks may actually be better integrated in individuals whose cultures do not cleave the world along a science–religion divide. We are currently extending previous research on the coexistence of bioscientific and Judeo-Christian accounts of death by examining the coexistence of natural (i.e., folk-biological) and supernatural (i.e., animist) explanations in a cultural context with limited exposure to Western cultural institutions: Tanna and Vanuatu.

In one study to date (Watson-Jones et al., 2017), we compared beliefs about the continuation of biological and psychological functions after death in Vanuatu and the US. Children, adolescents, and adults were primed with a story that contained either natural (non-theistic) or supernatural (theistic) cues. Participants were then asked whether or not different biological and psychological processes continue to function after death. US participants provided more continuation responses for psychological than biological processes following both the theistic and non-theistic primes, but Vanuatu participants provided more continuation responses for biological than psychological processes following the theistic prime. The data provide evidence for both cultural similarity and variability in afterlife beliefs and demonstrate that individuals use both natural and supernatural explanations to interpret the same events. Future cross-cultural research will continue to provide much needed insight into the development of explanatory systems across diverse cultural and religious contexts.

We argue that studying explanatory coexistence promises to inform not only our understanding of conceptual representations but also best practices in science education. If the typical outcome of science education is acquiring additional explanations of a domain—as opposed to better explanations—then students would be well served by instruction that helps them recognize and prioritize their newfound scientific knowledge. What factors promote the prioritization of scientific explanations over nonscientific ones? And what factors promote the construction of integrated, yet scientifically accurate, explanatory models? Studies that address these questions may help increase global scientific literacy, as well as critical reasoning in general.

Conclusion

The common assumption that natural and supernatural explanations are incompatible is psychologically inaccurate. Our research has demonstrated that individuals use both types of explanation to interpret the same events and that there are multiple ways in which both types of explanation coexist in individual minds. Contrary to traditional psychological accounts, we propose that supernatural explanations often increase with age and that reasoning about supernatural phenomena is an integral and culturally universal aspect of human cognition. Accordingly, we urge scholars of conceptual development to rethink the process of development itself, from acquiring a progressively more accurate (and more scientific) understanding of each domain to collecting several different domain-specific explanations—explanations that vary in source, content, and purpose. This framework not only paves new paths in the study of human conceptual representations, but also breaks new ground in how we understand the relation between science and religion as explanatory practices in and of themselves. Explanatory coexistence is a core feature of human cognition and should thus be an integral part of cognitive developmental theory.

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