UNIVERSITY OF CALIFORNIA

Santa Barbara

How the mind builds evolutionarily new concepts

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Psychology

by

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December 2017

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ABSTRACT

How the mind builds evolutionarily new concepts

by

Michael Barlev

The human mind is equipped with a variety of evolved mechanisms, each specialized for representing concepts from an adaptively important domain, such as persons and their mental states, animals and their biology, plants, and physical objects and their mechanical properties. But how does the mind build concepts that were not targets of natural selection, that is, concepts that go beyond or even conflict with the inferences engineered into these evolved mechanisms? Are evolutionarily new concepts built out of nothing (as domain-general learning theories predict), or are they built by initially co-opting evolved concepts? And if evolutionary new concepts initially co-opt evolved ones, do they later revise the evolved concepts, or do they co-exist alongside them? I evaluate these questions using the Christian God concept as a case study.

I demonstrate using a novel sentence verification paradigm that, first, the God concept is built by co-opting the evolved person concept, and, second, that in the minds of Christian religious adherents, acquired theological representations of God which conflict with person representations (e.g. infallibility) co-exist alongside and do not revise them. In the experiments reported here, Christian religious adherents were asked to evaluate

statements for which core knowledge intuitions about persons and acquired Christian theology about God were *consistent* (i.e., true according to both [e.g., "God has beliefs that are true"] or false according to both [e.g., "All beliefs God has are false"]) or *inconsistent* (i.e., true on intuition but false theologically [e.g., "God has beliefs that are false"] or false on intuition but true theologically [e.g., "All beliefs God has are true"]). Exp. 1 demonstrated that participants were less accurate and slower responding to inconsistent versus consistent statements, suggesting that the core knowledge intuitions both co-existed alongside and interfered with the acquired theological representations. Exp. 2 tested the effects of cognitive load on response interference. Exp. 3 ruled out a plausible alternative interpretation of these findings, by demonstrating that response interference is found for God but not for an ordinary entity (a priest). Exp. 4 demonstrated that response interference is invariant with age and with theological experience. Indeed, response interference was found even in Christian religious adherents with a lifetime of theological experience. Finally, Exp. 5-6 expanded on the findings of the previous experiments, which primarily focused on God's psychology, to God's physicality. I discuss the implications of these findings to domain-general versus domain-specific theories of learning.

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Introduction to how the mind builds evolutionarily new concepts

The way we see the world, and the reason why we find some things intuitively easy to grasp and others hard, is that *our brains are themselves evolved organs:* on-board computers, evolved to help us survive in a world - I shall use the name Middle World - where the objects that mattered to our survival were neither very large nor very small; a world where things either stood still or moved slowly compared with the speed of light; and where the very improbable could safely be treated as impossible. (Dawkins, 2006, p. 412)

Our own experience provides the basic material for our imagination, whose range is therefore limited. It will not help to try to imagine that one has webbing on one's arms, which enables one to fly around at dusk and dawn catching insects in one's mouth; that one has very poor vision, and perceives the surrounding world by a system of reflected high-frequency sound signals; and that one spends the day hanging upside down by one's feet in an attic. In so far as I can imagine this (which is not very far), it tells me only what it would be like for me to behave as a bat behaves. But that is not the question. I want to know what it is like for a bat to be a bat. Yet if I try to imagine this, I am restricted to the resources of my own mind, and those resources are inadequate to the task. I cannot perform it either by imagining additions to my present experience, or by imagining segments gradually subtracted from it, or by imagining some combination of additions, subtractions, and modifications. (Nagel, 1974, p. 439).

1. Introduction

Nagel (1974) argues that organisms have a “subjective character of experience”, that is, an experience of what it is like for that organism to be that organism. The problem, he argues, is that one organism cannot know what it is like for another organism to be that

organism. That is, the answer to the question he advances – "what is it like to be a bat?" – is intractable to a human: while we can imagine which of our experiences are most like those of a bat, we cannot know what the experience of being a bat is like for a bat.[1]

In the spirit of Nagel's example, consider what it might be like to be a viper. The sensory systems of different animals are engineered to solve the adaptive problem of spatially representing the environment around them. In humans and in phylogenetically related animals like chimpanzees, this problem is partially solved by chemical reactions in proteins within photoreceptor cells in the retina transduce electromagnetic radiation of a range of wavelengths to neural signals. In other animals, though, natural selection has engineered a very different solution: some families of snakes (vipers, pythons, and boas) have specialized facial structures called pit organs, which contain a heat-sensitive membrane. The pit organ collects heat from infrared radiation, and the membrane transduces this heat energy into neural signals (Gracheva et al., 2010). Although infrared sensation in snakes is often discussed as a component of snake vision, the pit organ receives direct input from the somatosensory system, not the visual system (Gracheva et al., 2010). Further, the mechanism by which heat energy is transduced (thermotransduction) is dissimilar to the photochemical transduction of electromagnetic radiation in humans (Gracheva et al., 2010), and, parenthetically, the receptor doing so (TRPA1) is involved in nociception, not vision, in humans (that is, in humans it detects chemical irritants; e.g. Caterina et al., 1997). While infrared and visual perceptions may be integrated in the snake's brain, we do not know the extent to which this infrared sensation in snakes is analogous to human vision.

[1] The experience of any two humans, in contrast, is similar enough so that, with relatively high precision, we can simulate what the experience of another human is like; intersectionality and the hesitation that can be read in Nagel (1974) notwithstanding, the question "what is it like to be a (/ another) human?" is not intractable.

Nowadays, humans can "see" infrared radiation using technology which either detects and amplifies low amounts of light, or detects emitted heat. But it is not at all clear that this technology allows us to see like snakes see, only to use the same infrared information snakes use to spatially represent the environment around us (the human brain can only represent infrared radiation via the somatosensory system as heat) – infrared radiation still needs to be mechanically converted to formats the human visual system can represent.[2] Our best and in fact only possible estimation of how snakes experience the world, then, is through information-processing systems that already exist in our brain. The same basic principle applies to the extraordinary color vision of the mantis shrimp (which has twelve types of photoreceptors in contrast to three types in humans), echolocation in toothed whales (e.g. dolphins and orcas) and many species of bats, and so on.

Thus, what is it like to be a viper, or a bat? As Nagel (1974) puts it, the best that we can do is to use those of our experiences that we imagine to be most like those of a bat, experiences that are the outputs of information-processing systems that already exist in our brains, and bend those experiences as far as they will go as we try to comprehend the answer to this question.

A parallel puzzle concerns not experience but concepts or bundles of information: how does our mind come to represent concepts that are outside of the conceptual repertoire of Middle World (Dawkins, 2006) – things that are very small or very large, like subatomic particles or the universe, processes that are very slow or very fast (e.g. geological and evolutionary processes), and extraordinary beings like the omniscient, omnipotent,

[2] Incidentally, a failure to recognize this is a weakness of many embodied cognition positions, particularly extended cognition (e.g. Andy Clark).

omnipresent, and incorporeal Christian God. We may again not be able to do better than to bend already existing concepts. But this is an empirical question, and the topic of this dissertation. But before that, a few preliminaries.

The past few decades of research in cognitive development have revolutionized our most basic theories about the ontogeny of concepts, which Carey (2009) defines as abstract mental representations not specifiable from sensori-motor information. Examples include the representation of depth (Gibson & Walk, 1960), and the representation of causality (for adults see Michotte, 1963, and for 6-month-old infants see Leslie & Keeble, 1987). Classic empiricist theories assume little to no innate mental content, with new concepts acquired through sensori-motor experience and domain-general learning processes (e.g. Piaget, 1954). However, this "blank slate" view has been challenged by modern nativist (also termed rationalist) theories which assume that the mind includes innate concepts and domain-specialized learning mechanisms (Carey, 2009, terms these "innate perceptual input analyzers"), that scaffold conceptual development.

The nativist view of conceptual development is closely allied in its battle against empiricism with an evolutionary view of psychology (Cosmides & Tooby, 1994) according to which the human conceptual repertoire was designed by natural selection to represent fitness-relevant properties of the environments in which humans evolved. The evolutionarily psychological view proposes that the brain is a behavior-regulating machine made out of neural circuits or "modules." These modules were designed by natural selection to solve adaptive problems, defined as those cross-generationally recurrent problems the solution of which increased fitness (survival and reproduction). A fundamental insight of this view is that our brains do not form veridical representations of the world. As Boyer (2015, p. 185)

put it, they do not "carve nature at its joints" as is often assumed, because nature does not have joints that are equally relevant to organisms of different species. Rather, our brains form representations that were relevant for the survival and reproduction of our ancestors (Tooby, Cosmides, & Barrett, 2005; Boyer, 2015). Furthermore, the adaptive problems our modules solve are those that existed in ancestral environments (i.e. those environments in which those modules evolved) and may or may not exist nowadays.

Because our brains form representations relevant for survival and reproduction, some features of the world that are irrelevant for survival and reproduction are not represented. For example, while we predict the downward motion of unsupported objects, we do not represent the concept of "gravity". As Cosmides and Tooby (1994) put it, we are blind to the existence of this and other instincts. Moreover, because we are blind to the existence of this instinct that unsupported objects fall, we are blind to the fact that gravity is a thing in nature to be explained (nature could be otherwise, e.g., unsupported objects could remain stationary in midair).

However, the starting point of empiricist investigations, and a fact which must be taken seriously by an evolutionary theory of human psychology, is that in addition to our reliably developing conceptual repertoire we are able to learn concepts that are radically different from those of Middle World: subatomic particles, the universe, geological and evolutionary processes, or extraordinary beings. Thus, under a nativist or an evolutionary psychological theory, how do we do this?

As I noted above, the brain consists of evolved adaptations – mental mechanisms designed by natural selection to solve ancestral fitness-relevant problems. Critically, these

mechanisms can be co-opted to serve functions for which they were not designed.[3] Sperber and Hirschfeld (2004) advance the useful distinction between the proper and actual domains of a mechanism, the proper domain being the narrower set of stimuli the mechanism evolved to process, and the actual domain being the broader set of stimuli it can process. For example, mechanisms for verbal language comprehension are co-opted to solve the evolutionarily novel problem of written language comprehension (Pinker, 1994). Spoken words are in the proper domain of language comprehension mechanisms, while spoken as well as written words are in their actual domain. Similarly, evolved concepts or bundles of information may be co-opted for representing things which they were not designed to represent.

The aim of this dissertation is to investigate how humans build evolutionarily new concepts, that is, concepts that were not targets of natural selection, by investigating in detail two related phenomena: representation co-options, already mentioned above, and representation co-existence. The latter is a phenomenon highlighted in research on science education, wherein core knowledge intuitions or early-acquired science concepts were shown to co-exist alongside later-acquired science concepts. The case study this dissertation uses is the Christian God concept as it exists in the minds of Christian religious adherents. Below, I articulate a view for why core knowledge mechanisms should be resistant to functional reorganization (i.e. should not be revisable), thereby articulating a theoretical basis for the representational co-existence hypothesis. Then, I highlight similarities between the Christian God concept and concepts in science, all of which are evolutionarily new, and discuss why

[3] When the novel problem is fitness-relevant then evolution may select for structural and functional changes to the formerly co-opted mechanism, at which point the now new mechanism comes to be referred to as an exaptation. Of course, all new adaptations were built from prior structures, whether adaptations or by-products.

the Christian God makes for a particularly interesting case study of the representational co-option and co-existence hypotheses. I conclude by briefly outlining the experiments reported in this dissertation. The key phenomena investigated in this dissertation are summarized in Fig. 1 below.

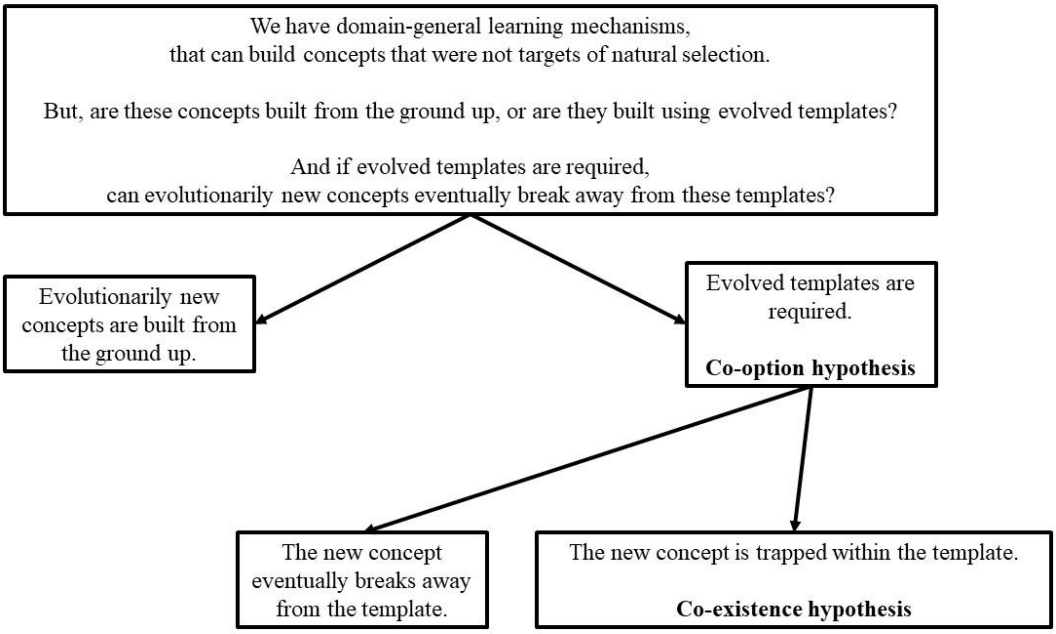


Fig. 1. The representational co-option and representational co-existence hypotheses.

2. Natural selection and functional reorganization

The design specifications of psychological mechanisms are closely linked to the adaptive problems these mechanisms evolved to solve. In theory, these design specifications can include the capacity to be partially or fully reorganized to solve different adaptive problems (particularly relevant, for example, when adaptive problems exist only in some life history stages), or the capacity to be temporarily or permanently digested if the neural tissue

is no longer needed. The question is not whether these capacities can evolve, but whether the requisite selection pressure for their evolution would have existed. The answer is yes, we can expect the psychological mechanisms of humans and other organisms to in fact be designed in this way, because neural tissue is energetically costly to build and maintain, so once it is no longer needed it should be reorganized or digested, with the energy used for the building and maintenance of other systems.[4]

For example, the sea squirt has a well-developed nervous system in the larval stage of its life during which it disperses. But once it metamorphoses into the adult, sedentary phase of its life, it digests most its nervous system – once it no longer needs a nervous system it is better off digesting it and using the energy for the building and maintenance of other systems. A less extreme example (yet one which strongly challenges empiricist intuitions) is the unique strategy to survive in winter evolved in shrews as an alternative to hibernation or migration to warmer climates. In winter, shrews temporarily digest some of their brain and body mass, which they subsequently re-build in spring (for recent data with the red-toothed shrew see Lázaro, Dechmann, LaPoint, Wikelski, & Hertel, 2017).

We find similar adaptations in humans. For example, critical periods in humans and related species may involve instances of local neural tissue reorganization (e.g. see Pinker, 1994, for critical periods in language development; critical periods have similarly been found for many other capacities such as face recognition in humans and in macaques). The reorganization of the visual cortex in the congenitally blind for auditory and tactile perception is a more extreme example of a neural reorganization in humans, though possibly not one that was naturally selected (and possibly one that is highly limited in that the visual

[4] A second, albeit more speculative argument for functional reorganization, is that mechanisms that are no longer needed may interfere with the functioning of ones that are.

cortex may have evolved to represent spatial relationships and can therefore only be reorganized in these two ways).

However, naturally selected local, and especially more general, neural tissue reorganization should be uncommon to the extent that most psychological mechanisms continue to serve adaptive functions that are necessary throughout the life of an organism. The human visual system, for example, is just as critical for the survival of a toddler as it is to the survival of an adult.

Moreover, in humans, some psychological mechanisms may evolve to be resistant to functional reorganization. Since mental mechanisms track fitness-relevant features of the world, selection pressures may specifically design some mechanisms to not be re-programmable so as to resist occasional inconsistent bits of information, either direct (personal experience) or indirect (communication), when this decreases fitness. Indeed, the existence of an entire set of adaptations designed to evaluate communicated information (Sperber et al., 2010) is strong evidence that resisting being manipulated by communicated information was an ancestrally fitness-relevant problem. For example, no person is omniscient, ancestrally or nowadays, therefore, even if particular personal experiences were compatible with an interpretation of another as omniscience, a well-designed mechanism should not choose this interpretation but instead continue searching for alternative ones.[5]

The need to resist occasional inconsistent information corrupting the functional organization of some psychological mechanisms is related to the notion of cognitive

[5] Note that this is separate from error management considerations which predict that we may occasionally attribute individuals with more knowledge than they actually have. For example, this is the "liar-liar-pants-on-fire" or the Pinocchio phenomenon wherein when we lie we may attribute others with knowledge of our lies (we feel as if others can "see" that we lied), to among other functions motivate us to confess to our lies.

impenetrability, wherein some mechanisms are partially or completely impenetrable to information from other mechanisms. For example, in the Müller-Lyer illusion, two lines of identical lengths appear to the visual system to be of different lengths. The visual system "believes" that the lines are of different lengths, and this belief is impenetrable to consciously held beliefs that the lines are of identical lengths.

In both this and the aforementioned cases of resistance to functional reorganization, mental mechanisms resist inconsistent information, either in long-lasting re-programming of their neural circuits or in short-lasting information processing and behavior regulation.

3. Previous research on representational coexistence in scientific concepts, and the problem of personal experience

Previous research on the acquisition of evolutionarily new concepts in science seems to support the position that core knowledge concepts cannot be revised. A few well-documented cases are:

(1) Core knowledge concepts about physical entities and their spatio-temporal mechanics (also termed the "object concept"), or "naïve beliefs" that elaborate on the object concept, have been argued to co-exist alongside conflicting theories in quantum physics and cosmology (Shtulman & Valcarvel, 2012; Shtulman & Harrington, 2016).

(2) Shtulman and colleagues (Shtulman, 2006; Shtulman & Schulz, 2008) have argued that essentialist intuitions, which are intuitions wherein individuals within a species have "essences" that do not change, co-exist alongside the conflicting theory of evolution by

natural selection wherein these essences (which evolutionary biologists tell us are called "genes") do change or mutate.

(3) Goldberg and Thompson-Schill (2009) have demonstrated that childhood beliefs wherein moving inanimate entities such as the sun or moon, but not nonmoving living entities such as plants, are believed to be alive, still exist in the minds of adults, including biology professors (Piaget, 1929/1960, termed these intuitions, which link animacy to motion, "childhood animism").

However, in all the above instances (and others not reviewed here[6]), core knowledge concepts (or naïve theories) are confounded with personal experience: core knowledge concepts are consistent with personal experience, but acquired science concepts are inconsistent with it. Thus, the argument that core knowledge concepts are stabilized by personal experience is an alternative to the argument that core knowledge concepts have evolved to be resistant to functional reorganization.

First, consider the object concept and personal experience with physical objects. While to our perceptual systems physical objects are solid, quantum physics tells us that they are made out of nuclei surrounded by probability clouds, or while to our perceptual system physical objects move in a continuous path through space, quantum physics tells us that

[6] For example, Kelemen and colleagues (e.g. Kelemen, 1999) have shown that children erroneously reason about the natural world as purpose-based (e.g. they will preferentially endorse statements such as "rocks are pointy so that animals won't sit on them" rather than "rocks are pointy because bits of stuff piled up over time"; this has been termed "promiscuous teleology"); adults do not exhibit erroneous purpose-based reasoning on explicit tasks, but do on implicit tasks (Kelemen & Rosset, 2009; Kelemen, Rottman, & Seston, 2012). Furthermore, explicit erroneous purpose-based reasoning such as that exhibited by children is exhibited by older adults with Alzheimer's disease (Lombrozo, Kelemen, & Zaitchik, 2007).

particles can disappear in one location and reappear in another. [7] Further, personal experience with physical objects is consistent with elaborated naïve beliefs. For example, consider the belief that the earth revolves around the earth. A person's visual system will receive information about the changing spatial position of an object if the person is in motion or if the object is in motion. But, if the person is standing in place his mind will rule-out the former and conclude that the object is moving, and this conclusion will be valid for almost all physical objects this person will interact with throughout his life. However, this inferential process may also be what gives rise to the belief that the sun is moving around the earth.[8] [9] We may therefore acquire the new scientific belief that the earth revolves around the sun, but not revise our naïve belief that the sun revolved around the earth either because it is built around the object concept, and the object concept cannot be revised, or because it is stabilized by personal experience.

Second, evolution by natural selection almost always occurs on time scales that are too slow for people to perceive in a single lifetime. Because of this, it might seem as if individuals within a species have essences (genes) that do not change from generation to generation (a notable exception might be artificial selection of domesticated animals). We

[7] A notable case where personal experience with physical objects seems to be inconsistent with naïve beliefs is the studies by McCloskey and colleagues (e.g. McCloskey, Caramazza, & Green, 1980) of curvilinear motion.

[8] Acknowledging that technically that the sun is moving around the earth is not wrong: it's all a matter of how one chooses their frame of reference (what is moving relative to what). It is, however, simpler to describe the motion of the planets if one chooses a frame of reference in which the planets move relative to the sun.

[9] Dawkins proposes a slightly different explanation for this illusion: "In the limited world in which our brains evolved, small objects are more likely to move than large ones, which are seen as the background to movement. As the world rotates, objects that seem large because they are near - mountains, trees and buildings, the ground itself - all move in exact synchrony with each other and with the observer, relative to heavenly bodies such as the sun and stars. Our evolved brains project an illusion of movement onto them rather than the mountains and trees in the foreground." (2006, p. 367)

may therefore acquire the new scientific belief that genes mutate (and that natural selection acts on phenotypes that are built by these different genotypes), but not revise our naïve belief that species have essences either because this belief is built around essentialist intuitions, and essentialist intuitions cannot be revised, or because it is stabilized by personal experience.[10]

Third, Leslie (1994) has argued that the Theory of Bodies (ToBy) mechanism searches for cues of self-propelled motion and from these infers the agency of physical entities or "bodies". As far as ToBy is concerned, plants are more perceptually similar to inanimate objects than to animals, because neither plants nor inanimate objects show cues of self-propelled motion. Thus, acquiring the new scientific belief that plants are alive may not revise our naïve belief that plants are inanimate either because this belief is built around the plant core knowledge concept, or because it is stabilized by personal experience including ToBy inferences (see Wertz & Wynn, 2014a,b, for recent evidence that the mind contains a core plant concept); the opposite applies to the scientific belief that moving entities such as the sun or moon are not alive.

In sum, processes of conceptual development are responsive to both personal experience and communication, the latter likely being the primary means by which new science concepts are acquired. However, findings that core knowledge concepts co-opted to form new science concepts coexist alongside the science concepts can either be due to a unique property of core knowledge concepts wherein they cannot be revised, or due to

[10] A related point is that individuals within most non-human species also appear to be phenotypically similar, because most phenotypic differences are not visible and/or attended to. Consider that the most distinctive feature we use in differentiating human: the face. The face is of little to no use to human adults in differentiating individuals from other species, even ones closely related to humans like monkeys (Pascalis, Haan, & Nelson, 2002); our brains simply did not evolve to differentiate individuals from other species. A related possibility, then, is that our personal experience with other species is consistent with intuitions about species as phenotypically identical, and inconsistent with another requirement of evolution by natural selection, which is that there be phenotypic differences between individuals within a species.

personal experience that is consistent with the core knowledge concepts and inconsistent with the new science concepts; strong evidence that core knowledge concepts cannot be revised requires a domain where there is little to no personal experience that is consistent with the core knowledge concepts co-opted to acquire the new ones.

4. Religious concepts may circumvent the problem of personal experience

In contrast to science concepts, religion concepts such as concepts of extraordinary beings are not inconsistent with personal experience: religious adherents mostly have no personal experience with extraordinary beings. In fact, the lack of personal experience with extraordinary beings may be considered as evidence consistent with particular characteristics of these beings. For example, the lack of personal experience with a material God can, to Christian religious adherents, be evidence of God's incorporeality.[11]

However, religious adherents do report having religious experiences (e.g. Taves, 1999, 2011); does this undermine the argument that the God concept can be used as a case study of the hypothesis that core knowledge concepts cannot be revised? Experiences that are interpreted as religious experiences are ubiquitous across the world's religious traditions (Taves, 2011), and are often at the core of new religious movements (Kinsella, 2016; Taves, In Press). Evangelical Christians in the Midwestern U.S., for example, focus on religious experiences which they try to bring about via various practices: for example, they learn to interpret bodily sensations as communication from God (Luhrmann, 2012; most other Protestant denominations focus on religious experience significantly less, though religious

[11] Acknowledging that Christian religious adherents do have certain experiences that can be very loosely interpreted as experiences with a material God, as for example Catholics who believe that Jesus is literally physically present in the consecrated Eucharistic wafer.

experiences are nonetheless a part of the theologies of these denominations; e.g., on Aldersgate Day, Methodists commemorate the religious experience of John Wesley, one of the founders of Methodism); or the "Afterlife Movement", a new religious movement of primarily New Age spiritual-but-not-religious practitioners, focuses on a variety of experiences, including "meaningful coincidences" that are often interpreted as signs of the presence of extraordinary beings or God (Kinsella, 2016).

The studies reported herein were conducted with participants affiliated with Catholicism, Protestantism, and Evangelicalism (a branch of Protestantism). While Catholics and Protestant are mostly not experientially oriented (with the notable exceptions of Charismatic Catholics and historically Black Protestants), Evangelicals are. But which experiences do experientially oriented Christians reports? Charismatic Catholics, historically Black Protestants, and Evangelicals focus on religious experiences as a way to have a personal relationship with God. Critically, in many instances these experiences are inconsistent, not consistent, with the core person concept. For example, Evangelical Christians might learn to hear the voice of God or to otherwise interpret bodily sensations as communication from God (Luhrmann, 2012). But an experience of hearing the voice of God in the absence of God's physical presence is an experience consistent with the belief that God is incorporeal, and inconsistent with a person representation of God (we hear the voices of persons when they are physically present). In other instances, religious experiences might be neutral with respect to the core person concept, such as when experientially oriented religious adherents learn to feel God's love.

Thus, the existence of ordinary experiences that are interpreted to be personal experiences of God does not necessarily undermine the argument presented herein. The God

concept can be used as a case study of the hypothesis that core knowledge concepts cannot be revised because unlike science concepts it controls for the effects of personal experience. Religious adherents mostly have no personal experiences with God, and when they do, these experiences are either consistent with an omniscient, omnipotent, omnipresent, and incorporeal God concept, and not with a person representation of God, or they are neutral with respect to both (e.g. feeling God's love).

5. Dissertation experiments

My dissertation includes six experiments in total. In the sentence verification paradigm used throughout the experiments reported here, Christian religious adherents were asked to evaluate statements for which core knowledge intuitions about persons and acquired Christian theology about God were *consistent* (i.e., true according to both [e.g., "God has beliefs that are true"] or false according to both [e.g., "All beliefs God has are false"]) or *inconsistent* (i.e., true on intuition but false theologically [e.g., "God has beliefs that are false"] or false on intuition but true theologically [e.g., "All beliefs God has are true"]).

In Exp. 1-3 (Chapter 2) I review early findings on representational co-option and co-existence (Barrett & Keil, 1996; Barrett, 1998), along with more recent criticism of these studies (Shtulman, 2008). I then present data in support of representational co-option and co-existence. Exp. 1-2 present findings of worse performance on items that are inconsistent versus consistent with core concepts (i.e., lower accuracy and slower response time on inconsistent versus consistent items). Exp. 3 rules out an alternative interpretation of these findings by showing that there are no differences in performance between items when the extraordinary religious entity (God) is replaced with an ordinary one (a priest).

In Exp. 4 (Chapter 3) I expand on the findings of Exp. 1-3, showing that representational co-existence is invariant with age, and that core knowledge intuitions of God as a person may not be revisable even with many decades of experience with Christian theology.

In Exp. 5-6 (Chapter 5) I expand on the findings of the previous experiments, which primarily focused on God's psychology, to God's physicality. I critically evaluate the intuitive mind-body dualism hypothesis (Bloom, 2005; extensively discussed in Chapter 4), showing that, contra Bloom and colleagues (e.g. Bloom, 2005) and Shtulman and Lindeman (2016), the God concept co-opts an embodied person concept, not a disembodied person concept.

CHAPTER 2

Core knowledge intuitions about persons co-exist and interfere with acquired Christian theology about God

1. Introduction

The tendency to attribute supernatural beings (e.g. gods, spirits, ancestor spirits, and divine beings) with person-like characteristics is widespread among present and past human cultures; indeed, it is noted in writings dating as far back as ancient Greece (e.g. Boyer, 1994a, b; 2001). However, it was only with relatively recent theoretical advances in cognitive science that this tendency could be explained via the evolved, universal information-processing architecture of the human mind: supernatural beings are attributed with person-like characteristics because they are formed by co-opting the evolved person concept (also referred to as a "person template"; e.g. Boyer, 2001; Boyer & Ramble, 2001). The person concept consists of default inferences about persons, such as about their physicality, biology and psychology which reliably develop from a skeletal set of inferences about persons present in infancy and from associated learning adaptations (e.g. Baillargeon, 2004; Baillargeon, Scott, & Bian, 2016; Carey, 1985, 2009; Inagaki & Hatano, 2002, 2006; Spelke, 1990).

However, supernatural beings are also believed to have extraordinary characteristics which are inconsistent with default inferences about persons.[12] The exact characteristics

[12] We do not evaluate in the current study whether acquisition of these beliefs constitutes conceptual change or belief revision (see Carey, 2009, for a thorough discussion of this distinction).

depend on the supernatural being and the theological tradition. For example, in all mainstream Christian denominations God is believed to be omniscient, while persons are intuitively believed to have limited perceptual and mental abilities (e.g. Boyer, 1994a,b, 2001; Boyer & Ramble, 2001). In this study we investigate the hypothesis proposed by Sperber and colleagues (Sperber, 1985, 1996, 1997, 2000; Mercier & Sperber, 2009; also see Boyer 1994a, b, 2001; Boyer & Ramble, 2001; Barrett & Keil, 1996; Barrett, 1998, 1999) according to which characteristics attributed to supernatural beings which are inconsistent with default inferences about persons (1) do not replace these inferences, but (2) co-exist with them in the minds of religious believers.[13]

1.1. Previous research

A variety of studies have examined the psychological, biological, and physical characteristics adults attribute to God, concluding that they are quite willing to attribute to God certain human characteristics, especially certain kinds of mental states (e.g. Gray, Gray & Wegner, 2007; Epley, Converse, Delbosc, Monteleone, & Cacioppo, 2009; Shtulman, 2008, Shtulman & Lindeman, 2016; see Heiphetz, Lane, Waytz, & Young, 2016, for a recent review of psychological attributions to God by children and adults). For example, Gray, Gray, and Wegner (2007) suggested that there are two distinct dimensions of mental state

[13] Sperber and colleagues further hypothesize that (3) acquired beliefs that are inconsistent with core intuitions exist in a specialized meta-representational "bubble" which isolates them from core concepts which exist in a mental data-base of beliefs. In contrast to the data-base of beliefs which can be accessed unconsciously and spontaneously, meta-representations can only be accessed consciously (e.g. Sperber, 1997, 2000; Mercier & Sperber, 2009; for a related discussion of dual-process theory see Evans, 2003, 2008; Evans & Stanovich, 2013; also see Mercier & Sperber, 2011). We do not evaluate this hypothesis which, while interesting, is beyond the scope of the experiments reported here.

attributions: Agency (consisting of mental states such as self-control, morality, memory, emotion, recognition, planning, communication, and thought) and Experience (consisting of mental states such as hunger, fear, pain, pleasure, rage, desire, personality, consciousness, pride, embarrassment, and joy), and that adults are significantly more likely to attribute to God Agency than Experience. Additionally, in their study participants reporting stronger religious beliefs were more likely to attribute Agency to God (see their Supplementary Material); elsewhere other individual difference variables such as attachment style (e.g. Granqvist & Kirkpatrick, 2008; Kirkpatrick, 2005) were found to be associated with different mental state attributions.

Although these studies are compatible with the co-existence hypothesis they are also compatible with two (not mutually exclusive) alternatives. First, it is possible that some adults in these studies did not acquire the relevant theological doctrines to fully replace all default inferences about persons in their representations of God. The developing understanding of God's extraordinary characteristics is compatible with this alternative: for example, although the ability to attribute infallibility (a component of omniscience) to God is acquired in childhood, a full understanding of omniscience requires many years to develop. Lane, Wellman, and Evans (2010) found that at the age when children begin attributing false beliefs to persons on explicit tasks (between 4 and 5 years) they also attribute false beliefs to God, but that this latter tendency decreases with age as children begin attributing infallibility to God; Lane, Wellman, and Evans (2012) found that religiously schooled children begin attributing false beliefs to God at earlier ages than secularly schooled children, and that in children who attribute fallibility to persons (e.g. by explicitly attributing to persons false beliefs), familiarity with information about God is associated with earlier attributions of

infallibility to God. Incidentally, religiously schooled children in their study attributed infallibility to beings other than God at earlier ages as well (e.g. Mr. Smart, who was described as a man who knows everything). This suggests that religiously schooled children may be earlier to understand extraordinary mental states in general, not solely God's mental states (see also Lane, Wellman, & Evans, 2014).

However, a full understanding of omniscience develops significantly later: although the breadth of omniscience (having knowledge of all domains) is fully appreciated by middle childhood, the depth of omniscience (having all knowledge within a specific domain) is only appreciated by late adolescence to early adulthood (Lane, Wellman, & Evans, 2014). Thus, it is possible, given the years it takes to acquire a full understanding of certain extraordinary characteristics (e.g. omniscience), that a full understanding of only some extraordinary characteristics develops by early adulthood (the age typically examined in studies of adults' attributions of characteristics to God); studies showing explicit attributions of human characteristics to God may, therefore, merely show that adults do not fully know or understand the nature of God' extraordinary characteristics in Christian theology.

Second, in studies investigating the attribution of various characteristics to God using self-report methodologies it is possible that some adults have acquired the relevant theological doctrines but intentionally deviated from them in their reports. For example, in her ethnographic study of Evangelical Christians in Chicago and the Bay Area Luhrmann (2012) found that many of her participants attributed person-like mental states to God. But, when pressed, they would acknowledge that these attributions deviated from the theology of their group; these attributions, they said, allowed them to experience God more closely and intimately.

The primary line of research to have investigated the co-existence hypothesis (often termed "theological incorrectness") which controls for the above alternatives, are the studies of memory confusions in religious adults by Barrett and colleagues (Christian adults in Barrett & Keil, 1996; Hindu adults in Barrett, 1998). For example, in Barrett and Keil (1996) participants asked to recall narratives, such as about God intervening to answer a prayer, were shown to mistakenly add physical and/or psychological limitations to God's actions not present in the original narratives (e.g. that to intervene God has to finish answering another prayer or stop another action, such as helping an angel work on a crossword puzzle), and which were not in accord with the participants' self-reported theological beliefs. Barrett and Keil interpreted these memory confusions as showing that in recalling the narratives about God participants mistakenly relied on their intuitions about persons (e.g. sequential action).

However, one major critique of the studies by Barrett and colleagues is that a person-like representation of God was implied in the narratives themselves (e.g. Shtulman, 2008; see Hyde, 1990, for a similar critique of studies in which children are asked to draw an image of God). As Shtulman (2008) notes:

> "God was described in other stories as pushing a large stone, looking at the rock, listening to the birds, enjoying the smell, and helping an angel work on a crossword puzzle. Any participants who might have disagreed with the anthropomorphic implications of these statements were still required to reason on their basis. To these participants, stories about a looking, listening, helping God would be as incongruent with their personal beliefs as stories about a looking, listening, helping teapot, yet one could hardly fault them for drawing anthropomorphic inferences consistent with the stories' premises."

Shtulman (2008) considers it plausible that this language may have contributed to the person concept based responses in the recall of the narrative in the Barrett and Keil (1996) and Barrett (1998) studies.[14]

[14] A second objection raised by Shtulman concerns the overall rate of anthropomorphic responding in the studies by Barrett and colleagues for narratives involving religious agents, which he points out was (1) lower than 100%, and (2) not substantially different from the rate of anthropomorphic responding observed for narratives involving a supercomputer (a non-religious agent with full information access; ibid. p. 1125). However, a problem with evaluating this objection is that there is no consensus on what amount of

1.2. The current study

The primary goal of the current study is to provide a novel test of the co-existence hypothesis in religious beliefs, using the case of Christian beliefs about God. The methodology used is the sentence verification task of Shtulman and Valcarcel (2012) which consists of an explicit measure of response accuracy, and an implicit measure of response time. In the task participants are required to endorse or reject statements of two broad kinds: consistent statements that are true or false according to both core intuitions about persons and Christian theology about God (e.g. "God has beliefs that are true"; "All beliefs God has are false"), and inconsistent statements that are either true intuitively but false theologically (e.g. "God has beliefs that are false") or false intuitively but true theologically (e.g. "All beliefs God has are true").

As per the outline of the person concept in the introduction, intuitive beliefs about persons were derived from reliably developing default inferences about persons that have been well established by research with infants and toddlers. Acquired beliefs about God were derived from the most common Christian theological beliefs about God: omniscience, omnipotence, omnipresence, and incorporeality. As reviewed in Section 1.1., previous studies suggest that acquisition of these beliefs begins as early as the preschool years (e.g. Lane, Wellman, & Evans, 2010, 2012), and these beliefs are therefore highly likely to be known to adult religious adherents (e.g. see Lane, Wellman, & Evans, 2014, for the developing understanding of omniscience).

anthropomorphism – beyond demonstrating that it exists – is required to support the co-existence hypothesis, or how minimal such responding needs to be to refute it.

The current study examined four primary predictions which follow from the co-existence hypothesis:

(1) If core intuitions co-exist with acquired beliefs that are inconsistent with them, then they might also interfere with those beliefs, and this interference might cause inconsistent statements to be responded to less accurately and more slowly than consistent statements. In principle co-existence is possible without interference (and interference might be so weak as to be imperceptible to our methods), but since interference necessarily requires co-existence, to demonstrate interference would also be to demonstrate co-existence. The first prediction therefore aims to support and extend the co-existence hypothesis as shown for scientific beliefs (e.g. Shtulman & Valcarcel, 2012) to the domain of religious beliefs.

(2) If acquired beliefs and core intuitions are in conflict then it is plausible that there are cognitive mechanisms involved in resolving this conflict, and that the efficiency of the functioning of these mechanisms might be decreased by putting participants under cognitive load. For example, previous findings suggest that when participants are put under time pressure their tendency to endorse intuitive but erroneous teleological (purpose- or function-based) explanations for natural phenomena is increased (e.g. Kelemen & Rosset, 2009; Kelemen, Rottman, & Seston, 2012). Therefore, we predicted that when put under time pressure participants would show a decrease in accuracy on inconsistent statements more so than on consistent statements.

(3) Kelemen and Rossett (2009) proposed that executive inhibition suppresses erroneous teleological explanations, and found that a measure of inhibition (the behavioral Stroop task) was one predictor of scientific accuracy on their task. Similarly, Lindeman and Aarnio (2007) argue that ontological confusions are based on intuitions, and there is recent

evidence that the tendency to make ontological confusions is related to individual differences in the efficiency of inhibition (Svedholm & Lindeman, 2013; see also Lindeman, Riekki, & Hood, 2011). If inhibition is the mechanism which resolves conflicts between intuitions and acquired beliefs then it is plausible that individual differences in inhibition, as indexed by the behavioral Stroop task (Kelemen & Rosset, 2009; Kelemen, Rottman, & Seston, 2012; Lindeman, Riekki, & Hood, 2011; Svedholm & Lindeman, 2013), more so than other executive functions such as working memory (Broadway & Engel, 2010; Redick et al., 2012), would be related to performance on the sentence verification task.

(4) We consider it unlikely that any amount of practice with acquired beliefs could replace inconsistent intuitions (e.g. Goldberg & Thompson-Schill, 2009; Kelemen, Rottman, & Seston, 2012; Shtulman & Harrington, 2016), but some findings suggest that practice could attenuate the effects of interference from inconsistent intuitions (e.g. Kelemen & Rosset, 2009; these findings and others are discussed in more detail in Section 5.4.). We therefore predicted that individual differences in practice with acquired religious and scientific beliefs (indexed with measures of religion education and science education) would be related to performance on the sentence verification task.

In contrast to the predictions listed above, the alternative hypothesis whereby theological characteristics replace default inferences about persons (but adults intentionally deviate from theology in self-report measures) predicts that: (1) under time pressure there should be an identical decrease in response accuracies on consistent and inconsistent statements, because participants are given less time to select a response, and (2) among correct responses – those responses where person-like characteristics would not have been

applied – there should be no difference in response times between consistent and inconsistent statements.

A secondary goal of the current study was to conduct a full replication of the Shtulman and Valcarcel (2012) experiment assessing the parallel case of the co-existence of early- and later-acquired scientific beliefs. Early-acquired scientific beliefs are often inconsistent with culturally transmitted (later-acquired) scientific beliefs, yet they are common in children and were historically common among the educated adults of various cultures (Vosniadou & Brewer, 1992). For example, 6-year-olds hold beliefs about the shape of the earth which are inconsistent with the culturally transmitted model of a spherical earth with people living all around it, but are consistent with a mental model of a flat earth with people living on its top surface (Vosniadou & Brewer, 1992). Vosniadou and Brewer (1992; also see Baumard & Boyer, 2013) have proposed that similarities in early scientific beliefs are due to developmental constraints caused by universal core intuitions (in the case of beliefs about the shape of the earth, Vosniadou & Brewer, 1992, proposed that these are due to universal intuitions that unsupported objects fall); the acquisition of novel scientific beliefs, similarly to the acquisition of theology, may therefore require resolving a conceptual conflict with core intuitions.

Finally, in the current climate of concern over the replicability of findings across science, but especially in psychological science (e.g. Ioannidis, 2005; Nosek & Lakens, 2014; see also other papers in that special issue), undertaking replications of existing findings alongside attempted extensions is one valuable additional tool available to the psychological scientific community that might eventually offset the problem of (lack of) replication. Accordingly, the new religion statements were intermixed in the current study with the entire

set of science statements used by Shtulman and Valcarcel (2012) so as to determine if that result replicates, albeit in a slightly different design. It was predicted that the same pattern of findings would emerge.

2.0. Experiment 1

2.1. Method

2.1.1. Participants

Participants were 44 university students (56% female), ranging in age from 18 to 24 (M = 20), and drawn from two different samples: (1) two local churches, one Catholic and one Charismatic, that serve an almost exclusively college-aged population (these participants were paid for their time), and (2) the psychology participant pool at the University of California, Santa Barbara (these participants received class credit). Fifty four percent of participants identified as White, 25% identified as Hispanic or Latino, and 20% identified as Asian.

In order to ensure primary exposure to and belief in Christianity, participants were pre-selected to have been brought up within, and currently identify with, Christianity. Despite this initial preselection, five participants did not match these criteria (all were brought up as atheist or agnostic or currently identified as such). These five were not included in the final sample (N = 39). Participants were assigned pseudo-randomly to receive the task under speeded instructions (n = 20) or unspeeded instructions (n = 19). Of the final sample, 95% of participants were brought up within the same Christian denomination with

which they currently identified, and 95% identified as religious believers (indexed as a minimum rating of "slightly religious" on a religiosity question).

Of the final sample, 50% of participants identified as Roman Catholic, 41% identified as simply "Christian", and 9% identified as one of a number of Protestant Christian denominations (e.g. Baptist, Lutheran). Most participants who identified as "Christian" in this sample reported being affiliated with the local Charismatic church. On a 4-point Likert scale (range 0 to 3; Not at all, Slightly, Moderately, Very), participants on average reported being moderately religious (M = 2.20, SD = .83) and moderately spiritual (M = 2.08, SD = .87), and the two were highly correlated (r = .522, p = .001).

2.1.2. Design

The primary dependent variable was response accuracy, and with respect to this dependent variable, the design was a 2 (Domain: Religion versus Science) x 2 (Consistency: Consistent versus Inconsistent) x 2 (Instructions: Speeded versus Unspeeded) factorial with within-subjects repeated measures on the first two factors.

A secondary dependent variable, response time, was collected for participants in the speeded instructions condition. For this dependent variable the design was a 2 (Domain: Religion versus Science) x 2 (Consistency: Consistent versus Inconsistent) factorial with within-subjects repeated measures.

2.1.3. Materials

The religion statements (48 in total) were constructed in groups of four statements, with each group targeting a particular characteristic of God that is inconsistent with a core

intuition about persons (see section 1.2 for a more detailed discussion). Following Shtulman and Valcarcel (2012), each group of statements was constructed such that there was one that was true on both intuition and theology, one that was true on neither, one that was true only on intuition, and one that was true only on theology. In this way one set of statements (consistent on intuition and theology) served as a baseline to which the other (inconsistent on intuition and theology) could be compared, and within each group there was an equal number of statements that were objectively true or false. Additionally, the four statements within each group were balanced in terms of overall sentence structure, complexity, and length in words. Example statements appear in Table 1, and a full list of all religion statements can be found in the Supplementary Material.

Table 1

Sample Statements from the Domain of Religion.

Consistency	Intuition	Theology	Religion Statements
Consistent	T	T	God has beliefs that are true.
	F	F	All beliefs God has are false.
Inconsistent	T	F	God has beliefs that are false.
	F	T	All beliefs God has are true.
Consistent	T	T	God can hear what I say out loud.
	F	F	God can't hear what I say out loud.
Inconsistent	T	F	God can't hear what I say to myself.
	F	T	God can hear what I say to myself.
Consistent	T	T	God can be present at my church and at other churches as well.
	F	F	God is never present at my church, nor is He present anywhere else.
Inconsistent	T	F	Sometimes God is at my church, and sometimes He is at other churches.
	F	T	God is at all times both at my church and at other churches.

Note. Consistent satements are true on both intuition and theology; inconsistent statements are true on one and false on the other.

The science statements were the same 200 statements used by Shtulman and Valcarcel, covering 10 areas of mathematics and science (astronomy, evolution, fractions, genetics, germs, matter, mechanics, physiology, thermodynamics, and waves). Example statements appear in Table 2, and a full list of all science statements can be found in the Supplementary Material.

Table 2

Sample Statements from the Domain of Science.

Consistency	Intuition	Science	Science Statements
Consistent	T	T	Rocks are composed of matter.
	F	F	Numbers are composed of matter.
Inconsistent	T	F	Fire is composed of matter.
	F	T	Air is composed of matter.
Consistent	T	T	People turn food into energy.
	F	F	Rocks turn food into energy.
Inconsistent	T	F	Plants turn food into energy.
	F	T	Bacteria turn food into energy.
Consistent	T	T	Humans are descended from tree-dwelling creatures.
	F	F	Humans are descended from plants.
Inconsistent	T	F	Humans are descended from chimpanzees.
	F	T	Humans are descended from sea-dwelling creatures.

Note. Consistent satements are true on both intuition and science; inconsistent statements are true on one and false on the other. Statements are from Shtulman & Valcarcel (2012).

Because the executive functions and practice measures were included to evaluate their relationship with interference, a sentence verification task interference score was calculated for each participant as the difference between consistent and inconsistent statements (for both response accuracies and times), with higher scores indicating stronger interference.

Additional materials included (1) a 144-item behavioral Stroop task (modified from Stroop, 1935) which included the following three conditions (48 items per condition): Congruent (the words RED, BLUE, GREEN, and YELLOW appearing in red, blue, green, and yellow color, respectively), Incongruent (the words RED, BLUE, GREEN, and YELLOW appearing in a color different than the one they spell), and Neutral (the words LOT, SHIP, KNIFE, FLOWER – length-matched and frequency-matched to the color words, appearing in colors); a Stroop response time interference score is then calculated by averaging the difference between the Incongruent and Neutral, and Incongruent and Congruent conditions, (2) a running span working memory task (Broadway & Engel, 2010), and (3) a short survey seeking demographic information, self-report measures of religiosity and spirituality, extent of participants' religious education, and extent of math and science education (indexed by asking participants to list all math and science courses they have taken in college). An education composite score (range 0 to 4) was calculated by summing the number of content areas – mathematics, biology, chemistry, and physics – participants took at least one course in.

2.1.4. Procedure

In a quiet testing room, groups of up to 6 participants took the experiment at semi-private computer testing stations. Participants in both the speeded and unspeeded instructions conditions completed, in this order, the sentence verification task, the behavioral Stroop task, the working memory task, and the survey. In the speeded instructions condition the instructions to the sentence verification task emphasized both response accuracy and speed (in multiple parts of the instructions participants were told to "respond as quickly as you can,

while making as few mistakes as you can" and that "speed and accuracy are both very important"), and responses were collected via key presses to facilitate faster and less deliberate responding (presented via E-Prime software). In the unspeeded instructions condition the instructions emphasized accuracy only, and responses were presented in survey form (presented via Qualtrics software) to facilitate slower and more deliberate responding. In both instructions conditions the sentence verification task items were presented one-by-one and in a randomized order (with religion and science items intermixed), and whether the right or left hand were used to respond "true" or "false" was randomized between participants.

2.2. Results

2.2.1. Sentence response accuracy

The primary hypothesis under test was that participants will be more accurate responding to items in which core intuitions are consistent with acquired beliefs in the domains of religion and science (see the Supplementary Material for response accuracies on individual items). The sentence response accuracy data were entered into a 2 (Domain: Religion versus Science) X 2 (Consistency: Consistent versus Inconsistent) X 2 (Instructions: Unspeeded versus Speeded) mixed analysis of variance (ANOVA) with repeated measures on the first two factors, revealing main effects of Domain ($F_{1, 37} = 348.7$, $p < .001$, partial $\eta^2 = .90$) and Consistency ($F_{1, 37} = 226.2$, $p < .001$, partial $\eta^2 = .86$) qualified by an interaction between Domain and Consistency ($F_{1, 37} = 50.5$, $p < .001$, partial $\eta^2 = .58$); there was no main effect of Instructions, and the Instructions factor did not enter into any two- or three-

way interactions (all *F*s < 1.3, all *p*s = n.s.), so no further analyses involving it are reported. The interaction between Domain and Consistency is shown for both Instructions factors in Fig. 1.

Simple main effect analyses confirmed that participants performed better on the religion than on the science items for both consistent and inconsistent items [*t* (38) = 12.42, p < .001, *d* = 2.75, and *t* (38) = 15.93, *p* < .001, *d* = 2.78, respectively], and that the interaction resulted from the size of the effect for consistency being more than twice as large for the science items than for the religion items [*t* (38) = 16.90, *p* < .001, *d* = 2.81, and *t* (38) = 6.06, *p* < .001, *d* = 1.15, respectively]. [15]

[15] Shapiro-Wilk tests revealed that several of the response accuracy distributions were not normal (consistent religion items in the unspeeded instructions condition: *SW* = .455, *df* = 20, *p* < .001; consistent and inconsistent religion items in the speeded instructions condition: *SW* = .599, *df* = 19, *p* < .001, *SW* = .681, *df* = 19, *p* < .001, respectively). The simple main effects were therefore analyzed with non-parametric tests to supplement the parametric tests reported here. A series of planned comparisons using the Wilcoxon Signed-Rank Test confirmed all findings reported here (all *Z*s < -4.83, all *p*s < .001).

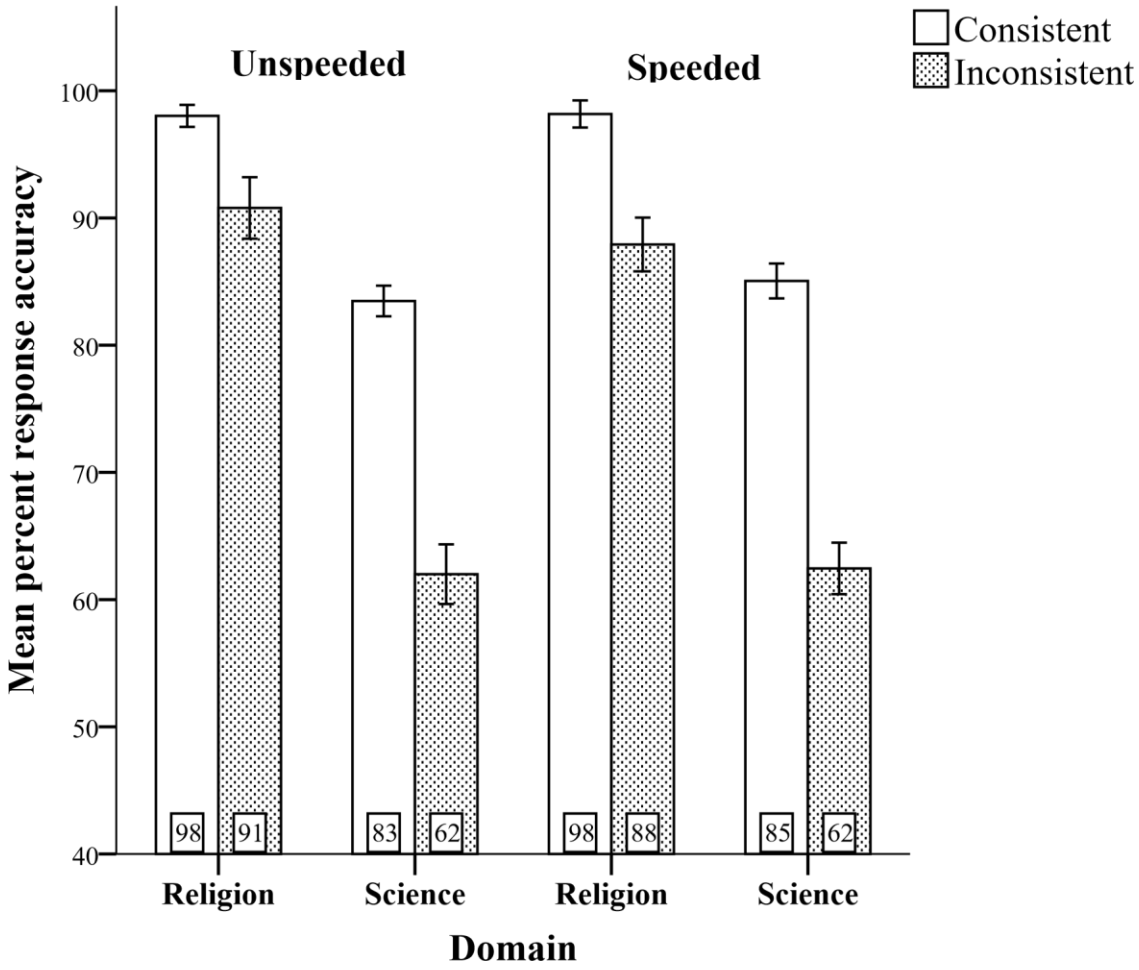


Fig. 1. Mean percent response accuracy on consistent and inconsistent items in the domains of religion and science, for both the speeded and unspeeded instructions conditions. Error Bars: +/- 1 SE.

2.2.2. Sentence response time[16]

Sentence response time data were collected for those participants who received speeded instructions (see the Supplementary Material for response times on individual items). Response time data for correct responses were entered into a 2 (Domain: Religion versus Science) X 2 (Consistency: Consistent versus Inconsistent) repeated measures

[16] A very small number of response time data points (<1%) were removed for being more than 3SD above or below the mean response time.

ANOVA, revealing a main effect of Consistency ($F_{1, 19} = 40.88$, $p < .001$, partial $\eta^2 = .68$); there was no main effect of Domain and no interaction (both Fs < 1.0, ps = n.s.). The main effect of Consistency is shown in Fig. 2. Simple main effect analyses confirmed that participants were faster on consistent than inconsistent items for both religion and science items ($F_{1, 19} = 11.58$, $p < .005$, $d = 0.34$ and $F_{1, 19} = 29.55$, p < .001, $d = 0.61$, respectively), and that there were no differences in response times between science and religion items for either consistent or inconsistent items (both Fs < 1.0, ps = n.s.).

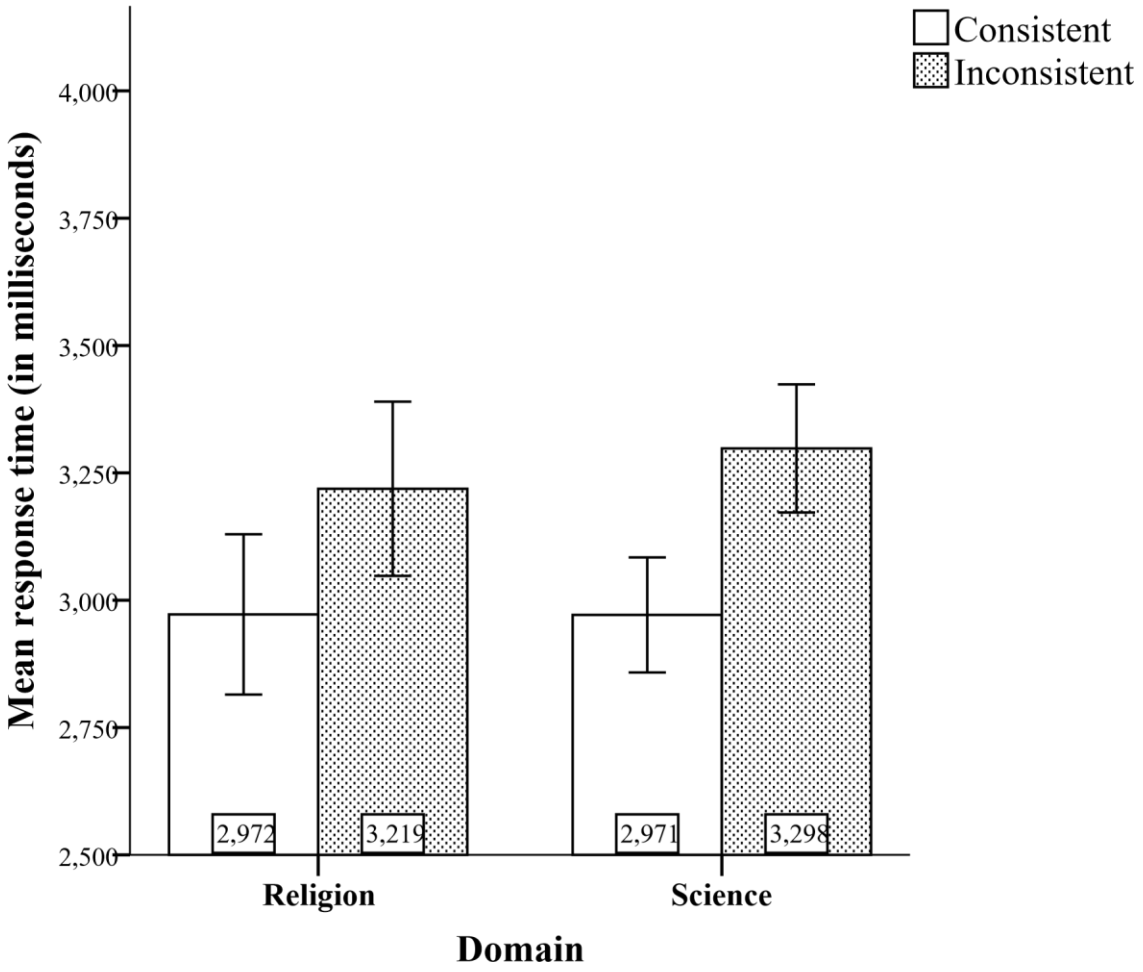


Fig. 2. Mean response time (in milliseconds) on consistent and inconsistent items in the domains of religion and science, for the speeded instructions condition only. Error Bars: +/- 1 SE.

2.2.3. Associations with measures of executive functions

The inhibition[17] (Stroop response time interference scores: *M* = 95ms, *SD* = 72ms, for correct responses only) and working memory (*M* = 25.62, *SD* = 12.26) measures were entered into a correlational analysis with interference scores on accuracy (both speeded and unspeeded instructions) and response time (speeded instructions only) on the sentence verification task, for both the religion and science items. Neither of the two executive functions measures were correlated with either the accuracy or response time interference scores in either the religion or science domains (all *p*s = n.s.). The executive functions measures also were not correlated with each other (*p* = n.s.).

2.2.4. Associations with measures of education

The composite science education measure (*M* = 2.67, *SD* = 1.03) did not correlate with either accuracy (both speeded and unspeeded instructions) or response time (speeded instructions only) interference scores for science items (both *p*s = n.s.). Shtulman and Valcarcel (2012) similarly collected data on the math and science courses their participants took, and using a slightly different variable (total number of courses taken, rather than the composite score for content areas used here) did not find that it predicted any of the effects reported in their study.

[17] Three participants did not complete the behavioral Stroop task, and 2 participants' scores were removed for being more than 2SD above the mean Stroop response time interference score; 2 participants' scores were removed for being more than 2SD above or below the mean working memory score.

Because both religious education variables were strongly skewed, Spearman's rank-order correlations were used instead of Pearson's correlations. For religion items, neither church attendance nor theology study predicted interference scores for either accuracy (both speeded and unspeeded instructions) or response time (speeded instructions only); all *p*s = n.s.

The lack of correlation is not because the religious education variables were too insensitive to pick up on differences in what people had learned about God. Church attendance did predict accuracy on consistent religion items ($r = .376$, $p < .05$), and marginally predicted accuracy on inconsistent religion items ($r = .284$, $p = .079$, respectively).

3.0. Experiment 2

The results of Experiment 1 support our first prediction by replicating and extending the findings of Shtulman and Valcarcel (2012) to show that, as in the domain of science, there is conflict between core intuitions and acquired beliefs in the domain of religion. Note that there was a large effect of domain on the accuracy scores reported in Experiment 1, with religion items being responded to more accurately than science items. While a comparison of the science and religion items was not a focus of this study, the difference was expected, given that the religion items were specifically derived from the most common characteristics attributed to God in Christian theology (omniscience, omnipotence, omnipresence, and incorporeality), to make sure they would be known to adult religious adherents.

Our second prediction that the difference in response accuracies between consistent and inconsistent items would be greater under instruction to respond quickly was not supported; participants responded with almost identical levels of accuracy under speeded and unspeeded instructions.

The lack of an effect for the instructions manipulation in the current study is not critical for evaluating the co-existence hypothesis, particularly given the strong effects of consistency on response accuracy and speed. Indeed, in Kelemen and Rosset (2009) and Kelemen, Rottman, and Seston (2012) there is evidence of the co-existence of teleological intuitions alongside scientific beliefs at the slowest response rates imposed. In their two experiments, endorsements of teleological explanations ranged from 29% to 42% in the unspeeded conditions, versus 47% to 54% in the speeded conditions.

The most likely explanation for this outcome is that instructions to respond quickly alone were not a strong enough manipulation to put participants under time pressure in the speeded instructions condition. In some previous studies that used a speeding manipulation, instructions to respond quickly were accompanied by time limits on participants' response windows (e.g. Kelemen & Rossett, 2009, Kelemen, Rottman, & Seston, 2012; Lindeman, Riekki & Hood, 2011; Svedholm & Lindeman, 2013). In Experiment 2, therefore, response time limits were added to the speeding manipulation.

3.1. Method

3.1.1. Participants

Participants were 75 university students (80% female), ranging in age from 18 to 24 (M = 19), and drawn from the psychology participant pool at the University of California, Santa Barbara. All participants received class credit for their time. Thirty eight percent of participants identified as White, 29% identified as Hispanic or Latino, and 29% identified as Asian, and 4% identified as "Other".

Participants were pre-selected according to criteria stricter than in Experiment 1. In addition to the selection criteria used in Experiment 1, the Christian denomination in which participants were raised had to be the same as the one with which they currently identified, and participants had to identify as religious believers, indexed as a minimum rating of "slightly religious" on a religiosity question. Four participants did not match these criteria, despite the initial pre-selection, and were not included in the final sample. The 71 participants who met these criteria were assigned pseudo-randomly to receive the task under time limit (n = 32) or no time limit (n = 39).

Of the final sample, 40% of participants identified as Roman Catholic, 39% as non-denominational Christian, and 21% as one of a number of Protestant Christian denominations (e.g. Presbyterian, Baptist). Unlike in Experiment 1, where most of the participants who identified as "Christian" reported being affiliated with the local Charismatic church, none of the participants who identified as "Christian" in this experiment did. On a 4-point Likert scale (range 0 to 3) participants on average reported being moderately religious (M = 1.93, SD = .64) and moderately spiritual (M = 1.83, SD = .83), and the two were highly correlated (r = .571, p < .001).

3.1.2. Design

As in Experiment 1 the primary dependent variable was response accuracy, and a secondary dependent variable was response time, which was collected for participants in both conditions. The design was a 2 (Domain: Religion versus Science) x 2 (Consistency: Consistent versus Inconsistent) x 2 (Condition: Time Limit versus No Time Limit) factorial design with within-subjects repeated measures on the first two factors.

3.1.3. Materials

The materials used were identical to those used in Experiment 1 with the exception of the behavioral Stroop task, which was modified to resemble the task used by Lindeman, Riekki and Hood (2011) and Svedholm and Lindeman (2013). The goal of this was to rule-out a possible interpretation of the failure to find an association between the sentence verification task and the version of the behavioral Stroop task used in Experiment 1: In informal debriefings some participants reported using a response strategy whereby they only attended to the color in which words appeared by either directing their gaze to the periphery of the display or by squinting their eyes, thereby blurring the words which appear at the center of the display. In this modified version of the Stroop task the Neutral condition was replaced with a Word-Naming condition in which the words RED, BLUE, GREEN, and YELLOW appear in black, and participants are required to respond to the words that appear, which controls for the above response strategy by requiring them to direct their gaze to the center of the display. The Congruent condition was replaced with a Color-Naming condition in which a string of Xs appears in red, blue, green, or yellow color and participants are required to respond to the color in which the Xs appear. The Incongruent condition (the words RED, BLUE, GREEN, and YELLOW appearing in a color different than the one they

spell) remained the same. A Stroop response time interference score is then calculated by subtracting response times on the Color-Naming condition from the Incongruent condition.

3.1.4. Procedure

The procedure was the same as in Experiment 1, with one exception: in the speeded condition participants were also told that each statement will appear for a short duration, and that the durations will be of variable times. The actual times (M = 3298ms, SD = 962ms; range 1605ms to 6749ms) were determined through pre-testing (N = 15) as the average reading time plus two standard deviations of each statement. The rationale for using variable times was that an arbitrary time limit would be insensitive to any overall differences in reading times for the sentences; variable times allowed us to approximately equate the time available for responding after reading. In the unspeeded condition the instructions emphasized response accuracy only and statements appeared until participants responded. In both the speeded and unspeeded conditions, responses were collected via key presses (presented via E-Prime software).

3.2. Results

3.2.1. Sentence response accuracy[18]

As in Experiment 1, the primary hypothesis under test was that participants should be more accurate responding to items in which core intuitions are consistent with acquired

[18] In the time limit condition responses that were timed-out were included in the analysis and considered incorrect. The response patterns reported in this section remained the same if instead responses that were timed-out were excluded from the analysis.

beliefs in the domains of religion and science. The accuracy data were subjected to a 2 (Domain: Religion versus Science) X 2 (Consistency: Consistent versus Inconsistent) X 2 (Condition: Time Limit versus No Time Limit) mixed analysis of variance (ANOVA) with repeated measures on the first two factors, revealing main effects of Domain ($F_{1, 69} = 480.2$, $p < .001$, partial $\eta^2 = .87$), Consistency ($F_{1, 69} = 576.4$, $p < .001$, partial $\eta^2 = .89$), and Condition ($F_{1, 69} = 60.5$, $p < .001$, partial $\eta^2 = .47$), qualified by interactions between Domain and Consistency ($F_{1, 69} = 60.0$, $p < .001$, partial $\eta^2 = .46$) and Consistency and Condition ($F_{1, 69} = 4.8$, $p < .05$, partial $\eta^2 = .06$). The interaction between Domain and Condition was not statistically significant ($F_{1, 69} = 2.4$, $p = .123$, partial $\eta^2 = .03$), and the factors did not enter into a three-way interaction ($F_{1, 69} = 2.7$, $p = .105$, partial $\eta^2 = .04$). The interaction between Domain and Consistency is shown for both the unspeeded (no time limit) and speeded (time limit) conditions in Fig. 3.

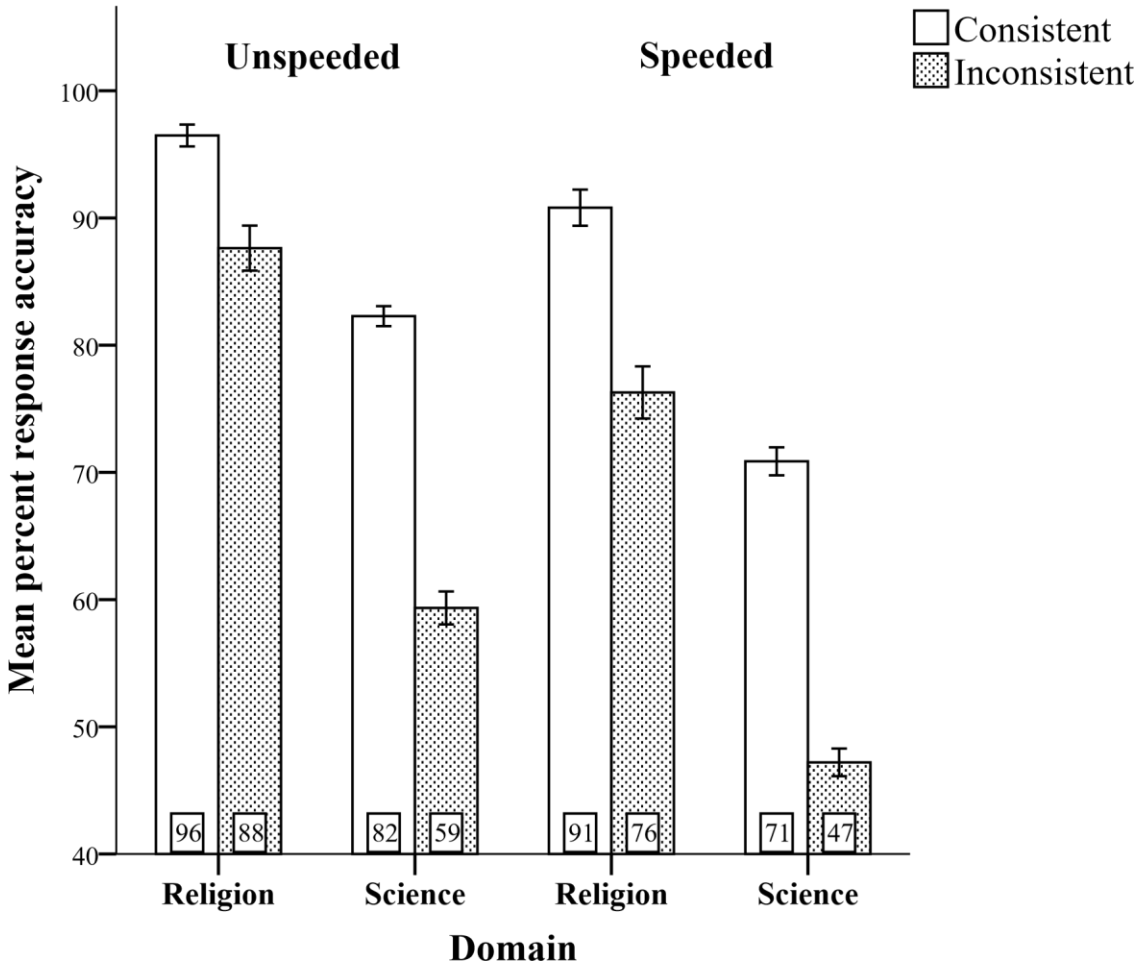


Fig. 3. Mean percent response accuracy on consistent and inconsistent items in the domains of religion and science, for both the time limit and no time limit conditions. A mean response accuracy of 50% represents chance responding. Error Bars: +/- 1 SE.

Simple main effect analyses replicated the findings reported in Experiment 1 by confirming that participants performed better on the religion items than on the science items for both consistent and inconsistent items [t (70) = 14.92, p < .001, d = 2.17, and t (70) = 20.32, p < .001, d = 2.56, respectively], and the interaction between Domain and Consistency reflected an effect size for consistency that was more than twice as large for the science items

than for the religion items [t (70) = 30.01, $p < .001$, $d = 2.67$, and t (70) = 9.30, $p < .001$, $d =$ 1.12, respectively]. [19]

An examination of the mean differences, separated by condition, between consistent and inconsistent religion ($M_{\text{unspeeded}} = 5.67\%$, versus $M_{\text{speeded}} = 11.35\%$) and science ($M_{\text{unspeeded}} = 11.41\%$, versus $M_{\text{speeded}} = 12.13\%$) items revealed that the two-way interaction between Consistency and Condition was primarily carried by the religion items.[20] The response accuracy data suggest that this was caused by a floor effect in responses to inconsistent science items in the time limit condition: responses were at chance.

An analysis of the timed-out responses in the time limit condition further supports this interpretation. A 2 (Domain: Religion versus Science) X 2 (Consistency: Consistent versus Inconsistent) repeated-measures ANOVA with proportion of incorrect responses that were due to time-outs as the DV revealed main effects of Domain ($F_{1, 38} = 5.75$, $p < .05$, partial $\eta^2 = .13$) and Consistency ($F_{1, 38} = 15.48$, $p < .001$, partial $\eta^2 = .29$) and no interaction. A larger number of incorrect responses on science items than on religion items were due to time-outs ($M_{science} = 25.60\%$ versus $M_{religion} = 18.70\%$), and a larger number of

[19] Shapiro-Wilk tests revealed that several of the response accuracy distributions were not normal (consistent and inconsistent religion items in the no time limit condition: $SW = .731$, $df = 32$, $p < .001$, $SW = .872$, $df = 32$, $p = .001$, respectively; consistent religion items and inconsistent science items in the time limit condition: $SW = .874$, $df = 39$, $p < .001$, $SW = .941$, $df = 39$, $p < .05$, respectively). The simple main effects were therefore analyzed with non-parametric tests to supplement the parametric tests reported here. A series of planned comparisons using the Wilcoxon Signed-Rank Test confirmed all findings reported here (all Zs < -6.67, all ps < .001).

[20] A separate examination of the religion and science items each via a 2 (Consistency: Consistent versus Inconsistent) X 2 (Condition: Time Limit versus No Time Limit) repeated measures analysis of variance (ANOVA) further confirmed that despite the absence of a three-way interaction the two-way interaction between Consistency and Condition was carried by the religion items (religion: $F_{1, 69} = 5.1$, $p < .05$, partial $\eta^2 = .07$; science: $F_{1, 69} = .22$ p = n.s., partial $\eta^2 = .00$). The results from this mixed ANOVA were additionally replicated with an Extended Linear-Mixed Effects Model, which accommodated different error-variances between the two Consistency factors (the error variance was greater for consistent than for inconsistent items in both Condition factors). The interaction for Consistency and Condition for the religion domain remained significant at $p < 0.05$.

incorrect responses on consistent items than on inconsistent items were due to time-outs ($M_{consistent}$ = 27.90% versus $M_{inconsistent}$ = 16.40%). A plausible interpretation of this is that overall the science items were more difficult than the religion items, but since they were allowed similar (or often shorter, given that the science items were often shorter) response windows, participants who tried to think about them for too long before responding were timed-out. The finding that there were more errors due to time-outs for consistent than inconsistent items is puzzling. A plausible interpretation of this is that participants were more likely to choose an answer at random for inconsistent items because these (particularly inconsistent science items) were more difficult.

3.2.2. Sentence response time[21]

Response times in the speeded condition were truncated by the time limit manipulation and were therefore excluded from this analysis. The mean response times for correct responses in the unspeeded condition are shown in Fig. 4. These data were entered into a 2 (Domain: Religion versus Science) X 2 (Consistency: Consistent versus Inconsistent) repeated measures analysis of variance (ANOVA). This revealed a main effect of Consistency ($F_{1, 31}$ = 37.86, p < .001, partial η^2 = .55) and an interaction between Domain and Consistency ($F_{1, 31}$ = 21.98, p < .001, partial η^2 = .42). Simple main effect analyses revealed no effect of Consistency for the religions items (t (31) = 1.21, p = n.s., d = .14). There was, however, a significant effect of Consistency for the science items (t (31) = 9.22, p < .001, d = .84). There was no main effect of Domain ($F_{1, 31}$ = 1.53, p = n.s., partial η^2 = .05). Although consistent items elicited similar response times across the two domains,

[21] A very small number of response time data points (<2%) were removed for being more than 3SD above or below the mean response time.

inconsistent items did not: Responses were faster when the inconsistent sentences involved religion compared to science (t (31) = 3.36, p = .002, d = .51).

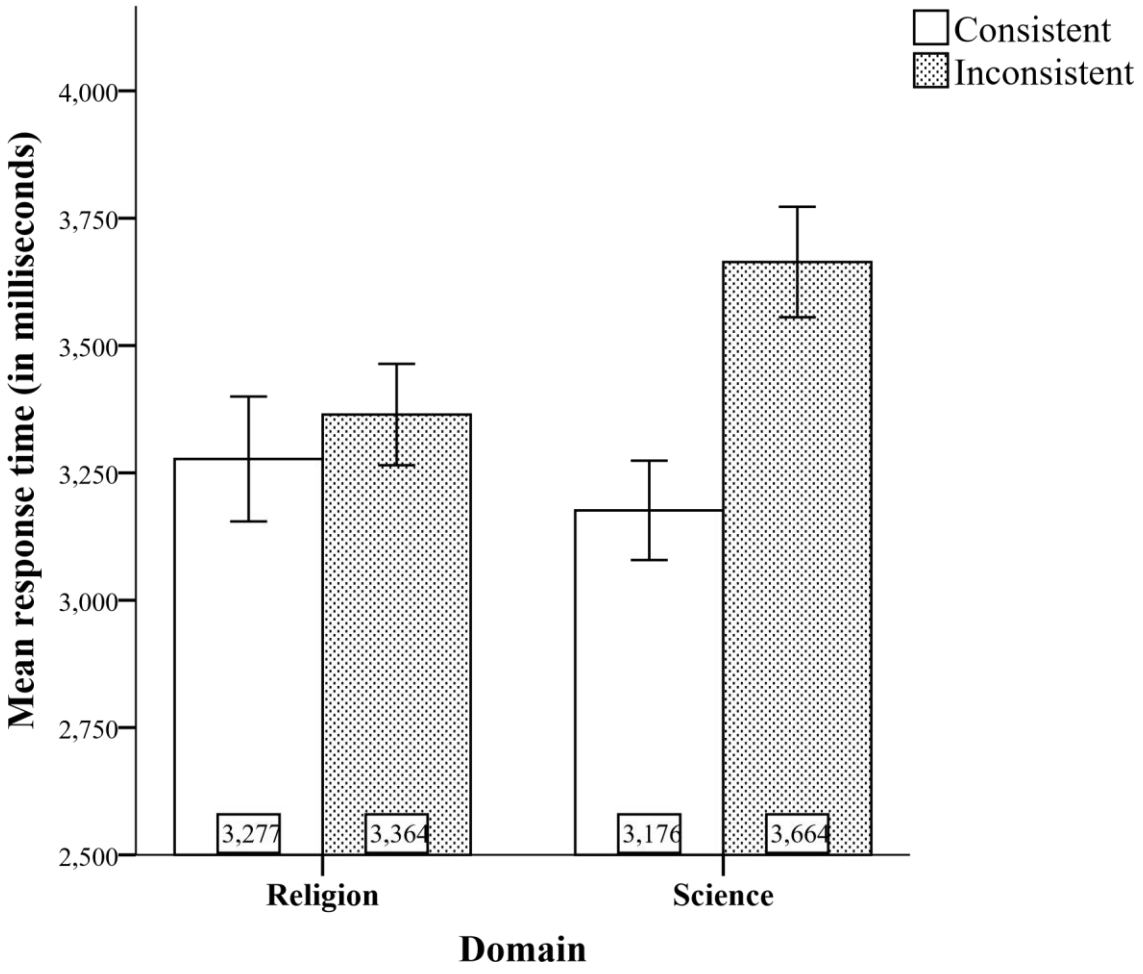


Fig. 4. Mean response time (in milliseconds) on consistent and inconsistent items in the domains of religion and science, for the no time limit condition only. Error Bars: +/- 1 SE.

3.2.3. Associations with measures of executive functions

As in Experiment 1, inhibition (Stroop response time interference scores: M = 178ms, SD = 110ms, for correct responses only) and working memory (M = 22.75, SD = 10.46) were entered into a correlational analysis with interference scores on accuracy (analyzed

separately in the time limit and no time limit conditions) and response time (analyzed in the no time limit condition only) on the sentence verification task, for both the religion and science items.[22] Neither inhibition nor working memory were correlated with accuracy or response time interference scores in any domain (all *p*s = n.s.). As in Experiment 1, the executive functions measures were not correlated with each other (*p* = n.s.), but the higher mean response time interference score on the behavioral Stroop task was nearly identical to that reported elsewhere in similar populations (e.g. Miyake, Friedman, Emerson, Witzki, & Howerter, 2000), supporting our interpretation that the new version of the task used in this experiment controlled for the use of response strategies reported by some participants in Experiment 1.

3.2.4. Associations with measures of education

The composite science education variable (*M* = 2.32, *SD* = 1.08) did not correlate with interference scores for the science items, either in terms of accuracy (analyzed separately in the time limit and no time limit conditions) or response time (analyzed in the no time limit condition), both *p*s = n.s.

Because both religious education variables were strongly skewed, Spearman's rank-order correlations were used instead of Pearson's correlations. For religion items, neither church attendance nor theology study predicted interference scores for either accuracy (analyzed separately in the time limit and no time limit conditions) or response time (analyzed in the no time limit condition); all *p*s = n.s. However, for consistent and

[22] Seven participants did not complete the behavioral Stroop task, and 3 participant's scores were removed for being more than 2SD above the mean Stroop response time interference score; 4 participants' scores were removed for being more than 2SD above or below the mean working memory score.

inconsistent religion items in the no time limit condition, church attendance was correlated with accuracy (r = .623, p <.001, and r = .483, p <.01, respectively).

4.0. Experiment 3

The primary prediction of the current study, that inconsistent statements would be responded to less accurately and more slowly than consistent statements, was supported in Experiments 1 and 2. The goal of Experiment 3 was to control for the possibility that this pattern was caused by systematic low-level biases in the statements used, rather than by co-existence and interference of core intuitions on acquired beliefs. For example, processing of the inconsistent versus consistent statements within each group might have been more difficult due to a systematic syntactic bias which was not controlled for during statement construction (e.g. passive versus active, or affirmative versus negative, sentences; e.g., see Wason, 1959, for a classic study of response time differences between affirmative and negative sentences). Note that although no such systematic low-level biases were identified a-priori we nonetheless considered it important to include this control experiment. To test this, in a subset of the religion statements in Experiment 3, the supernatural entity "God" was replaced with a non-supernatural religious agent ("my priest"). It was predicted that since participants hold no acquired beliefs inconsistent with core intuitions about this non-supernatural agent, there should be no differences in accuracy or response time on the modified "inconsistent" and "consistent" statements (these terms were retained for ease of comparison).

4.1. Method

4.1.1. Participants

Participants were 37 university students (81% female) ranging in age from 18 to 21 (M = 19) drawn from the psychology participant pool at the University of California, Santa Barbara. All participants received class credit for their time. Thirty eight percent of participants identified as White, 24% identified as Hispanic or Latino, 8% identified as black, 19% identified as Asian, and 11% identified as "Other".

Participants were pre-selected according to the same criteria used in Experiment 2 (see section 3.1.1 for details). Four participants did not match these criteria, despite the initial pre-selection, and were therefore not included in the final sample (N = 33).

Of the final sample thirty percent of participants identified as Roman Catholic, 37% identified as non-denominational Christian, and 33% identified as one of a number of Protestant Christian denominations (e.g. Methodist, Pentecostal). On a 4-point Likert scale (range 0 to 3) participants on average reported being moderately religious (M = 1.85, SD = .51) and moderately spiritual (M = 1.61, SD = .70), and the two were highly correlated (r = .44, p = .01).

4.1.2. Design

As in Experiments 1-2 the primary dependent variable was response accuracy and a secondary dependent variable was response time. The design was a 2 (Domain: Religion versus Science) x 2 (Consistency: Consistent versus Inconsistent) factorial design with within-subjects repeated measures.

4.1.3. Materials

A subset of the religion statements (sets T3, T5, T6, T8, and T9; see the Supplementary Material) was modified by replacing the word “God” with “my priest”. The religion statements modified in this manner were not selected at random, but were selected because they could be modified and still remain coherent. For example, a number of statements could not be modified because they pertained to God listening to prayers, and prayers are directed toward God but not toward priests. Example statements appear in Table 3.

The modified religion statements were presented in random order along with the remaining unmodified religion statements and the entire set of science statements. No measures of executive functions or education were administered in this experiment.

Table 3

Sample Modified Statements from the Domain of Religion.

Intuition	Theology	Religion Statements	Modified Religion Statements
Consistent			
T	T	God has beliefs that are true.	My priest has beliefs that are true.
F	F	All beliefs God has are false.	All beliefs my priest has are false.
Inconsistent			
T	F	God has beliefs that are false.	My priest has beliefs that are false.
F	T	All beliefs God has are true.	All beliefs my priest has are true.

Note. The terms "consistent" and "inconsistent" do not apply to the modified religion statements but are used for illustrative purposes only. The modified religion statements are true or false according to intuition only.

4.1.4. Procedure

The procedure was the same as in Experiments 2, except that all participants were assigned to the same unspeeded condition (identical to the unspeeded condition in Experiment 2).

4.2. Results

4.2.1. Sentence response accuracy

A paired-samples t-test revealed no response accuracy difference between the modified "consistent" and "inconsistent" religion items ($M_{\text{consistent}}$ = 77.30 %, $SD_{\text{consistent}}$ = 15.47%, versus $M_{\text{inconsistent}}$ = 73.90%, $SD_{\text{inconsistent}}$ = 18.53%; t (32) = .69, $p > .5$, d = .20). Note that the response accuracies for the modified religion items are relatively low. We think that this is because in replacing "God" with "my priest" we introduced ambiguity into the pragmatic interpretations of some items, which were designed to evaluate beliefs about God rather than about priests. For example, the items "my priest knows of various things that happened in the past" or "my priest doesn't know of things that happened in the past" may be interpreted as proclamations about knowledge in general, in which case the correct response to the first item is "true" and to the second item "false", because people have at least some knowledge of the past. Alternatively, these items may be interpreted as proclamations about the priest's competence, in which case responses to these items are dependent on particular priests. In any case, what is critical for our purposes is that items were evaluated relative to others in their group – the relevant data are within-group differences between "consistent" and "inconsistent" items, not overall accuracy.

In contrast, a paired-samples t-test on the unmodified versions of these same items (using the "God" rather than "my priest" wording) from the no time limit condition from Experiment 2 revealed a response accuracy difference between the consistent and inconsistent items [$M_{consistent}$ = 96.60 %, $SD_{consistent}$ = 5.45%, versus $M_{inconsistent}$ = 88.70%, $SD_{inconsistent}$ = 13.62%; t (31) = 3.14, $p < .01$, d = .76].

Next, to examine if the main findings from Experiments 1-2 replicated in this experiment, the response accuracy data were subjected to a 2 (Domain: Religion versus Science) X 2 (Consistency: Consistent versus Inconsistent) repeated measures analysis of variance (ANOVA) with the unmodified religion items only. The analysis revealed main effects of Domain ($F_{1, 32}$ = 195.41, $p < .001$, partial η^2 = .86) and Consistency ($F_{1, 32}$ = 307.20, $p < .001$, partial η^2 = .91), qualified by an interaction between Domain and Consistency ($F_{1, 32}$ = 53.23, $p < .001$, partial η^2 = .62).

Simple main effect analyses confirmed that as in Experiments 1-2 participants performed better on the religion items than on the science items in both the consistent [$M_{religion}$ = 97.19%, $SD_{religion}$ = 6.67%, versus $M_{science}$ = 81.61%, $SD_{science}$ = 5.66%; t (32) = 10.78, $p < .001$, d = 2.52] and inconsistent conditions [$M_{religion}$ = 85.06%, $SD_{religion}$ = 9.68%, versus $M_{science}$ = 57.61%, $SD_{science}$ = 7.82%; t (32) = 13.77, $p < .001$, d = 3.12]. The interaction entailed the size of the effect for consistency being more than twice as large for the science items [$M_{consistent}$ = 81.61%, $SD_{consistent}$ = 5.66%, versus $M_{inconsistent}$ = 57.61%, $SD_{inconsistent}$ = 7.82%; t (32) = 19.18, $p < .001$, d = 3.52] than for the religion items [$M_{consistent}$ = 97.19%, $SD_{consistent}$ = 6.67%, versus $M_{inconsistent}$ = 85.06%, $SD_{inconsistent}$ = 9.68%; t (32) = 8.83, $p < .001$, d = 1.46].

4.2.2. Sentence response time[23]

Paired-samples t-tests revealed no response time differences on correct responses between the modified "consistent" and "inconsistent" items [$M_{consistent}$ = 3770ms, $SD_{consistent}$ = 1178ms, versus $M_{inconsistent}$ = 3541ms, $SD_{inconsistent}$ = 992ms; t (32) = .96, p = n.s., d = .21], and no response time differences on correct responses on the unmodified versions of these same items from the no time limit condition from Experiment 2 [$M_{consistent}$ = 3277ms, $SD_{consistent}$ = 693ms, versus $M_{inconsistent}$ = 3364ms, $SD_{inconsistent}$ = 563ms; t (31) = 1.21, p = n.s., d = .14]; however, response times on consistent and inconsistent items were in the predicted direction for the unmodified items from Experiment 2 (consistent < inconsistent), and in the opposite direction for the modified items (consistent > inconsistent).

Next, to examine if the main findings from Experiments 1-2 replicated in this experiment the response time data on correct responses were subjected to a 2 (Domain: Religion versus Science) X 2 (Consistency: Consistent versus Inconsistent) repeated measures analysis of variance (ANOVA) with the unmodified religion items only. The analysis revealed main effects of Domain ($F_{1, 32}$ = 7.44, p = .01, partial η^2 = .19) and Consistency ($F_{1, 32}$ = 68.12, p < .001, partial η^2 = .68) qualified by an interaction between Domain and Consistency ($F_{1, 32}$ = 8.36, p < .01, partial η^2 = .21).

Simple main effect analyses revealed that participants were faster on the science than on the religion items for consistent items [$M_{science}$ = 2991ms, $SD_{science}$ = 632ms, versus $M_{religion}$ = 3284ms, $SD_{religion}$ = 715ms; t (32) = 3.99, p < .001, d = .43], and that there was no difference in response times between the science and religion items for inconsistent items [$M_{religion}$ = 3576ms, $SD_{religion}$ = 791ms, versus $M_{science}$ = 3538ms, $SD_{science}$ = 779ms; t (32) =

[23] A very small number of response time data points (<2%) were removed for being more than 3SD above or below the mean response time.

.49, p = n.s., d = .05]. The interaction entailed the size of the effect for Consistency being nearly twice as large for the science items [$M_{consistent}$ = 2991ms, $SD_{consistent}$ = 632ms, versus $M_{inconsistent}$ = 3538ms, $SD_{inconsistent}$ = 779ms; t (32) = 9.19, p < .001, d = .77] than for the religion items [$M_{consistent}$ = 3284ms, $SD_{consistent}$ = 715ms, versus $M_{inconsistent}$ = 3576ms, $SD_{inconsistent}$ = 791ms; t (32) = 3.91, p < .001, d = .39].

5.0. General discussion

5.1. Support for the co-existence of inconsistent acquired beliefs and core intuitions

The primary goal of the current study was to test the hypothesis that, in the minds of adult religious adherents, acquired Christian beliefs about God co-exist with, rather than replace, an initial representation of God formed by co-option of the evolved person concept. The experiments reported here utilized a task where participants were required to evaluate statements that were true or false according to both core intuitions about persons and Christian theology (consistent statements), and statements that were either true intuitively but false theologically or false intuitively but true theologically (inconsistent statements). In Experiments 1 and 2, participants were less accurate and slower in evaluating inconsistent versus consistent statements, thereby demonstrating both co-existence and interference in the domain of religion.

Furthermore, by replicating and expanding on the findings of Shtulman and Valcarcel (2012) with earlier- and later-acquired scientific beliefs the current study brings attention to

the theoretical parallels in co-existence in the domains of religion and science, which have thus far been studied mostly independently.

In contrast to previous studies purporting to show that adults attribute person characteristics to God, the current study controlled for two plausible alternative interpretations. According to one, attributing person-like characteristics to God is caused by some adults not having acquired the relevant theological doctrines to fully know which characteristics God is thought to have. However, the very high performance on inconsistent religion statements and near perfect performance on consistent religion statements suggests that the acquired beliefs about God examined in this study were known to the participants tested (as indeed was predicted, given that the sentences used reflect the most common theological beliefs about God – see Section 1.2.).

Additionally, an examination of response accuracies on individual religion statements (see the Supplementary Material) shows that for the most part errors are relatively evenly distributed among the different statements. That is, there was a small but reliable probability that participants would make an error on any given statement regardless of the characteristic the statement pertained to. The alternative whereby participants did not know certain parts of the relevant theology predicts clustering of errors around only few statements, for example statements pertaining to characteristics of God talked about ambiguously and/or rarely.

The results also rule out another alternative interpretation of prior results: that attributing person-like characteristics to God is caused by some adults intentionally deviating from theology (that is, speaking of God metaphorically; see e.g. Luhrmann, 2012). This alternative predicts, for correct responses, no difference in response times between consistent and inconsistent statements. However, in both conditions of Experiment 1 and in the no time

limit condition of Experiment 2, inconsistent religion statements were responded to significantly more slowly than consistent religion statements. Additionally, this alternative predicts an identical decrease in response accuracies on consistent and inconsistent statements when participants respond under time pressure versus no time pressure. But in the time limit condition in Experiment 2, response accuracies decreased significantly more for inconsistent than for consistent religion statements.

Finally, by showing that the difference between consistent and inconsistent statements disappeared when replacing the term "God" with "my priest" in a subset of the statements in Experiment 3, we controlled for the possibility that the findings reported here were caused by systematic low-level biases (e.g. syntactic biases) in the statements used rather than by co-existence.

5.2. Support for the existence of mechanisms that resolve conflicts between inconsistent beliefs

If core intuitions co-exist and interfere with acquired beliefs that are inconsistent with them, then certain mechanisms should exist to resolve the interference or conflict created by tasks in which both representations are engaged (e.g. Kelemen & Rossett, 2009; Kelemen, Rottman, & Seston, 2012; Lindeman, Riekki & Hood, 2011; Svedholm & Lindeman, 2013). A second prediction of the co-existence hypothesis that was tested here is that the effect of Consistency on response accuracy will increase when participants are made less able to or have less time to resolve conflicts between inconsistent beliefs.

In Experiment 2 a subset of participants was assigned to a speeded responding condition where a time limit was set on responses, and another subset received the task with no such time limit (unspeeded responding condition). The findings demonstrated that when participants are made to respond quickly they disproportionately make more errors on inconsistent versus consistent religion statements. While this finding does not as yet highlight any specific mechanism (also see section 5.3), the effect of cognitive load in the form of time pressure does support the prediction that those cognitive mechanisms that resolve conflicts between inconsistent beliefs have limited efficiency, and intuitive beliefs are more likely to lead to errors in responding when there is less time to resolve conflicts between them and acquired beliefs.

Note that these findings are compatible with, although they do not uniquely support, the suggestion by Sperber and colleagues (Sperber, 1997, 2000; Mercier & Sperber, 2009; also see Barrett, 1999) and by dual-process theorists (Evans, 2003, 2008; Evans & Stanovich, 2013; also see Mercier & Sperber, 2011) that acquired beliefs inconsistent with core intuitions exist in a specialized representational format or mechanism that is distinct from that of intuitive beliefs (see our footnote 2). If this is the case then under cognitive load religious adherents are more likely to rely on erroneous intuitive beliefs not only because of a limitation of conflict resolution mechanisms, but because intuitive beliefs require significantly fewer processing resources than acquired religious beliefs (e.g. executive functions: see Evans, 2003, 2008; Evans & Stanovich, 2013).

5.3. No correlations with executive inhibition

A third prediction derived from the co-existence hypothesis that was tested here was that executive inhibition, as indexed by the behavioral Stroop task, is the process that resolves the interference or conflict of core intuitions with acquired beliefs. Previous studies are equivocal with respect to this question. For example, on the one hand Kelemen and Rossett (2009) showed that variance in endorsing teleological explanations was uniquely explained with the behavioral Stroop task (*ibid*, p. 141), and similarly, Svedholm and Lindeman (2013) showed that a measure of ontological confusions (argued by these authors to be based on intuitions) was strongly correlated with the behavioral Stroop task (albeit using a different configuration of task conditions and coding than those used by Kelemen & Rossett, 2009). In addition, Zaitchik, Iqbal, and Carey (2014) found evidence that executive functions, including inhibition, uniquely explained variance in performance, controlling for age and verbal IQ, on a biological reasoning task in 5- to 7-year-old children. The authors argue that executive functions are necessary for both the acquisition of beliefs about biology at this age range, and for performance on their task in children who have acquired these beliefs (this is because to perform accurately on their task children had to resolve a conflict between their intuitions about biology and newly acquired biological beliefs).

On the other hand, Kelemen, Rottman, and Seston (2012) found no relationship between teleological intuitions and the behavioral Stroop task in their study of college students, professional scientists, and community members (*ibid*, p. 1079).

The results reported here using task conditions and coding similar to those adopted by Kelemen and colleagues in Experiment 1, and Svedholm and Lindeman (2013) in Experiment 2, repeatedly failed to show a relationship between performance on the sentence verification task and the behavioral Stroop task. We think it likely that this failure to find a

correlation between performance on the sentence verification task and the behavioral Stroop task is due to the fact that executive inhibition can be measured in a variety of ways and, more broadly, a range of different executive functions likely jointly contribute to performance on complex tasks (e.g. see the latent variable analysis and thorough discussion in Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). In the future, researchers might consider the use of a more varied and rigorous battery of inhibitory and other executive functions measures.

5.4. No correlations with practice

A final prediction derived from the co-existence hypothesis that was tested here was that practice with acquired beliefs would attenuate the effect of interference from inconsistent intuitions. Experiment 1 and the time limit condition of Experiment 2 found that regular church attendance was positively correlated with accuracy on consistent and inconsistent religion items; however, none of the practice measures used correlated with accuracy or response time interference scores in either the religion or science domains. The failure to find such an effect in the current study parallels that of Shtulman and Valcarcel (2012). In contrast, the investigation by Kelemen and Rosset (2009) in a similar population of university undergraduates did find a relationship between science education (indexed by questionnaires on geoscience and natural selection) and a tendency to make teleological errors.

A different way to evaluate practice with acquired beliefs, which has been used in previous studies, is to compare novices with experts (e.g. university undergraduates with

professors); however, these studies are equivocal. Goldberg and Thompson-Schill (2009) find a smaller bias in preferentially ascribing animacy to animals than to plants in biology professors versus undergraduates, but they find similar biases in these groups in, for example, preferentially ascribing animacy to moving than to nonmoving artifacts, which are categories not studied in biology departments. More recently, Shtulman and Harrington (2016) found, using a sentence verification task identical to that of Shtulman and Valcarcel (2012), that the accuracy difference between consistent and inconsistent science items was lower in science professors (9%) than in humanities professors (13%), and in turn lower in humanities professors than in community members of similar ages (20%).

The findings of Shtulman and Harrington (2016) and Goldberg and Thompson-Schill (2009) suggest that practice with acquired beliefs can explain differences in interference, albeit within circumscribed domains. On the other hand, while Kelemen, Rottman, and Seston (2012) demonstrated that the tendency to make teleological errors was greater in undergraduates than in science professors, they did not find such a difference between science and humanities professors, which suggests that differences between undergraduates and professors other than differences in practice might be responsible for differences in interference between these groups (the findings of a difference between humanities professors and community members in Shtulman & Harrington, 2016, is compatible with this interpretation as well). In the future, researchers might consider the use of more nuanced indexes and combinations of multiple indexes to further investigate questions pertaining to the effects of practice on interference during co-existence; for instance, both questionnaires as in Kelemen and Rosset (2009) and populations that more strongly differ in practice or

expertise as in Kelemen, Rottman, and Seston (2012) and Goldberg and Thompson-Schill (2009).

5.5. Implications for theories of religious beliefs and behavior, and future directions

The evidence provided in the current study for the co-existence hypothesis has significant implications for foundational theories of the cultural transmission of supernatural concepts, including those concepts deemed religious. Boyer's "cognitive optimum" theory (1994a,b, 2001; Boyer & Ramble, 2001) postulates that the historical and cross-cultural prevalence of specific supernatural beliefs (e.g. beliefs in agents with extraordinary mental characteristics) is in part due to a memory and transmission advantage of beliefs that are inconsistent with core intuitions (there termed "counter-intuitive" beliefs). The current study suggests that, as required by the cognitive optimum theory, conflicts between counter-intuitive beliefs and core intuitions cannot be permanently resolved, and counter-intuitive beliefs may therefore retain their memory and transmission advantage within and between individual minds.

Additionally, the co-existence hypothesis explains two "on-the-ground" observations by social scientists and humanists (see Sperber, 1985, for an early discussion of these observations under the more general question of why people hold "irrational" beliefs): discrepancies between an individual's reported beliefs, and between reported beliefs and behavior (also see Slone, 2004). For example, Christian religious believers often simultaneously describe God as person-like (e.g. loving, fallible) and abstract (infallible; not describable using human emotion terms). Similarly, although God in Christian theology is

all-knowing, believers nonetheless tell Him their prayers (the contradiction, of course, is that if God is all-knowing, believers do not need to tell Him anything – He already knows everything; for children's developing understanding of extraordinary communication see Lane, Evans, Brink, & Wellman, 2016). Future studies are needed to further investigate the "on-the-ground" conditions under which core intuitions versus acquired theological beliefs are verbalized, and the variable role of each in regulating religious behavior.

Finally, while in this study we assumed that the person concept is co-opted to form a representation of God (e.g. see Boyer, 2001; Boyer & Ramble, 2001), at least one other hypothesis is potentially compatible with our findings: Bloom (2005) and others (e.g. Shtulman, 2008; Shtulman & Lindeman, 2016) hypothesized that the concept co-opted to form representations of supernatural agents, including the Christian God, is that of a disembodied mind (however, see Hodge, 2008, In Revision). In the current study we did not carefully differentiate between different characteristics of God, but post-hoc analyses on statements pertaining to God's physicality versus psychology showed that the reported effects held for both (which is compatible with co-option of the person concept and not of a disembodied mind concept). However, we hesitate to draw strong conclusions on this question, since the current study was not designed to evaluate it.

In any case, the findings we report regarding co-existence are independent from hypotheses about the exact concept that is being co-opted. Future studies are needed to investigate a range of interesting specific hypotheses regarding the different possible concepts which might be co-opted in representations of God and other supernatural entities in both Christianity and other religious traditions – including the possibility of individual differences in the concept co-opted for a given supernatural entity (see, for example, the

work of Cohen, 2007, 2008, who hypothesized that among believers in the Afro-Brazilian syncretic cult *Candomblé,* representations of certain possessing spirits co-opt the pathogen concept).

In conclusion, beyond providing novel evidence for the co-existence hypothesis in the domain of religion, and bringing attention to the theoretical parallels in co-existence in religion and science, we aim to highlight the explanatory utility of cognitive science to religious phenomena. Recent reviews have disproportionately focused on the present limitations of cognitive science in explaining supernatural beliefs and beliefs deemed religious (for example, see Purzycki & Willard, 2015, and the commentaries to their article). With the current study we aim to reorient focus to the contributions cognitive science can make to the study of religion (and culture more broadly) and to possible novel directions of empirical and theoretical investigation.

CHAPTER 3

Core knowledge intuitions of God as a person are not revised by Christian theology despite lifelong experience

1. Introduction

The past few decades of research in cognitive development have revolutionized our most basic theories about the ontogeny of concepts. In infancy, domain-specialized learning mechanisms scaffold the development of concepts of physical entities and their mechanical properties, animate agents and their patterns of self-propelled motion, intentional agents and their mental states, natural kinds and their properties, numerosities, and others (Baillargeon, Scott, & Bian, 2016; Carey, 2009; Inagaki & Hatano, 2002; Spelke, 1990). The architecture of this reliably developing conceptual repertoire has been designed by natural selection to track fitness-relevant features of the environments in which humans evolved. A fundamental insight of this view is that our representations of the world are not necessarily veridical – rather, organisms of different species carve the world along lines that were relevant for the survival and reproduction of the ancestors of that species (Tooby, Cosmides, & Barrett, 2005).

Beyond this core conceptual repertoire, however, humans have the capacity to acquire "evolutionarily new" concepts, or concepts that were not targets of natural selection (Sperber & Hirschfeld, 2004, refer to these as concepts that exist within the actual but not proper domain of evolved mechanisms): of subatomic particles, of an infinite universe, of geological

and evolutionary processes, and of extraordinary beings.[24] What is the relationship between these concepts and the core conceptual repertoire? We address this question by focusing on the case study of the God concept in Christian theology.

The God concept is formed by co-opting the person concept, a reliably developing set of core knowledge intuitions about the physicality, biology, and psychology of persons (see Boyer, 2001).[25] For example, Lane, Wellman, & Evans (2010) showed that Midwestern U.S. children younger than 5 who explicitly attributed constrained knowledge to persons (e.g. their mom) on verbal response tasks did so also to God. That is, initially children conceptualize God's knowledge as that of a person. The God concept is then modified to represent those characteristics that set God apart from ordinary persons. In Lane et al. (2010), children older than five differentiated between persons and God, to whom they attributed extraordinary knowledge.[26] A question that follows from this is whether the modified God concept, which includes characteristics incompatible with the person concept, replaces the person representations on which it is initially formed (see Barret, 1999; Barret & Keil, 1996; Boyer, 2001).

[24] A debate in the literature concerns whether natural selection shaped our minds to represent concepts of extraordinary beings. Notably, Norenzayan (2013) argues that representations of omniscient and moralizing gods were culturally and perhaps genetically selected to promote cooperation in large groups. A full discussion of this debate is beyond the scope of this article, but we consider the by-product view, most notably advanced by Boyer (2001), more likely. See for example Baumard, Hyafil, Morris, and Boyer (2015) for a cogent critique of Norenzayan (2013).

[25] We use the term "core knowledge intuitions" throughout this manuscript to capture our view that it is the output of such cognitive mechanisms that is responsible for the initial person representation of extraordinary supernatural entities. For brevity, we also use this term to capture representations in the domain of science (see e.g. pp. 6-7), though it is important to note that the status of these representations is less precisely captured by this term. In the domain of science initial core knowledge intuitions are elaborated into what may be thought of as "naïve" scientific beliefs, which develop reliably and early but which are not necessarily directly the output of core knowledge mechanisms.

[26] See Heiphetz, Lane, Waytz, and Young (2016) for a recent review of children's representation of the psychology of God.

Barlev, Mermelstein, and German (2017) found evidence that later-acquired Christian theological representations of God do not replace initial person representations of God, but rather co-exist alongside them. In three studies young adult Christian religious adherents evaluated as true or false statements in which their formal theology about God and intuitions about persons were consistent or inconsistent. If initial person representations of God are replaced by later-acquired representations, then accuracy and response time should be independent of consistency with intuitions about persons. For example, statements like "God has beliefs that are true" (true according to both intuition and theology) and "all beliefs God has are false" (false according to both), should be responded to with the same accuracy and time as statements like "God has beliefs that are false" (false theologically but true intuitively) and "all beliefs God has are true" (true theologically but false intuitively). However, if initial person representations of God co-exist with later-acquired representations, then they might interfere with them. Indeed, participants in Barlev et al. (2017) made more theological errors and were slower when evaluating inconsistent as compared to consistent statements (see Chapter 2).

Lane, Wellman, and Evans (2014) suggest that a full understanding of extraordinary characteristics such as omniscience develops slowly. In their Experiment 1, participants varying in age (3-5, 6-12, and 18-21) were introduced to an agent (Mr. or Ms. Smart) who "knows everything about everything" and were asked six questions about this agent's mental states (e.g. "Does Mr./Ms. Smart know what you're thinking right now?"). Only 16% of the youngest participants attributed full omniscience to Mr./Ms. Smart ("yes" answers to all six questions about the breadth and depth of omniscience, i.e. knowledge of all domains, and all

knowledge within a specific domain), while 63% (statistically not different from chance performance) and 83% of participants in the middle and older groups, respectively, did so.

Since a full understanding of omniscience, and possibly of other extraordinary characteristics, develops slowly, it is possible that the young adult participants in Barlev et al. (2017) had not yet acquired a full understanding of God's omniscience, omnipresence, and incorporeality, or had not had enough experience with it for it to fully replace their initial understanding of God. The present study aims to expand on Barlev et al. (2017) by searching for behavioral signatures of representational co-existence in a sample of Christian religious adherents that varies in theological experience, as indexed by age.

While there are no prior studies of representational co-existence in the God concept of older adults, recent studies of older adults show evidence of co-existence in science concepts. Shtulman and Harrington (2016) presented adult participants varying in age with statements where naïve and scientific theories were consistent (i.e. true according to both, or false according to both) or inconsistent (i.e. true naively but false scientifically, or false naively but true scientifically). Both younger and older adults made more scientific errors and were slower responding to inconsistent statements (e.g. "the earth revolves around the sun" which is scientifically true but intuitively false) as compared to consistent statements (e.g. "the moon revolves around the earth" which is scientifically true but intuitively false). In the present study, the full set of science items used by Shtulman and Harrington (2016) are embedded among the religion items for comparison.

The present study aims to answer two primary questions:

(1) Are initial representations of God as a person replaced by acquired Christian representations of an omniscient, omnipresent, and incorporeal God in participants with extensive maturation and/or theological experience?

(2) If initial representations of God as a person are not replaced (indeed, if they are not replaceable), does maturation and/or theological experience attenuate conflict between them and acquired Christian representations of God?

We additionally aim to answer two secondary questions concerning individual differences in religious expertise and executive functions. We present these in the Supplementary Materials.

2. Methods

2.1. Participants

Participants were recruited from Christian churches in Southern California. Participants[27] (N = 67; 24 males) ranged in age from 18 to 87 (M_{age} = 46, SD_{age} = 24); approximately 30% of participants were 18 to 21 (owing to the proximity of some of these churches to a university), approximately 45% were between 22 and 64, and approximately 25% were 65 and older. Sixty percent of participants identified as White, 19% identified as Hispanic or Latino, 15% identified as East Asian, and 6% identified with another ethnicity or background.

[27] Nine participants were excluded from this final sample: 2 for identifying as atheist or agnostic, 3 for identifying with non-Christian religions, 1 for identifying as a Christadelphian, which is a Christian denomination with non-mainstream theological doctrines (e.g. nontrinitarianism), 1 for experimenter failure to record religious affiliation, and 2 for participant failure to follow instructions on the sentence verification task.

Eighty-two percent of participants identified as Roman Catholic, 8% identified as Episcopalian, and the remaining 10% identified with a variety of other mainstream Protestant denominations. The majority of participants (96%) reported growing up with a mainstream Christian religion (with the remainder reporting growing up without a religion but of having been affiliated with their present religion for many – up to 45 – years); 76% currently identified with the religion with which they grew up, with 82% of participants currently identifying as Catholic having also grown up as Catholic. Eighty-five percent of participants identified as moderately or very religious ($M_{\text{religiosity}} = 2.27$, $SD_{\text{religiosity}} = .75$; 0 = Not at all, 1 = Slightly, 2 = Moderately, 3 = Highly), 90% of participants identified as moderately or very spiritual ($M_{\text{spirituality}} = 2.46$, $SD_{\text{spirituality}} = .68$), and the two were strongly correlated ($r(65) = .44$, $p < .001$).

2.2. Design

The dependent variables were the magnitude of interference between consistent and inconsistent statements, calculated for both accuracy and response time, for each of the two domains (religion and science) in a repeated-measures design. Theological experience was indexed by age, which was coded as a between-subjects factor in two separate ways: dichotomized to create a two-level between-subjects age factor (Older versus Younger), and tertilized to create a three-level between-subjects age factor (Older versus Middle versus Younger). Finally, age was also analyzed continuously in a linear regression.

2.3. Materials

The religion statements (n = 48), pertaining to doctrines about the physical and psychological characteristics of God in mainstream Christian theology, were from Barlev et al. (2017). Statements were constructed in quartets, with each quartet pertaining to a particular theological doctrine (e.g. infallibility). In each quartet there was a pair of **consistent** statements (true according to both intuitions about persons and Christian theology about God, or false according to both) and a pair of **inconsistent** statements (true intuitively but false theologically, or false intuitively but true theologically). See Table 3.1 for examples.

The science statements (n = 200), pertaining to theories about 10 areas of mathematics and science (astronomy, evolution, fractions, genetics, germs, matter, mechanics, physiology, thermodynamics, and waves), were from Shtulman and Harrington (2016), and were similarly constructed. See Table 2 for examples.

Table 1

Sample Statements from the Domain of Religion.

Consistency	Intuition	Theology	Religion Statements
Consistent	T	T	God has beliefs that are true.
	F	F	All beliefs God has are false.
Inconsistent	T	F	God has beliefs that are false.
	F	T	All beliefs God has are true.
Consistent	T	T	God can hear what I say out loud.
	F	F	God can't hear what I say out loud.
Inconsistent	T	F	God can't hear what I say to myself.
	F	T	God can hear what I say to myself.
Consistent	T	T	God can be present at my church and at other churches as well.
	F	F	God is never present at my church, nor is He present anywhere else.
Inconsistent	T	F	Sometimes God is at my church, and sometimes He is at other churche
	F	T	God is at all times both at my church and at other churches.

Note. Consistent satements are true on both intuition and theology; inconsistent statements are true on one and false on the other. Statements are from Barlev et al. (2016).

Table 2

Sample Statements from the Domain of Science.

Consistency	Intuition	Science	Science Statements
Consistent	T	T	Rocks are composed of matter.
	F	F	Numbers are composed of matter.
Inconsistent	T	F	Fire is composed of matter.
	F	T	Air is composed of matter.
Consistent	T	T	People turn food into energy.
	F	F	Rocks turn food into energy.
Inconsistent	T	F	Plants turn food into energy.
	F	T	Bacteria turn food into energy.
Consistent	T	T	Humans are descended from tree-dwelling creatures.
	F	F	Humans are descended from plants.
Inconsistent	T	F	Humans are descended from chimpanzees.
	F	T	Humans are descended from sea-dwelling creatures.

Note. Consistent satements are true on both intuition and science; inconsistent statements are true on one and false on the other. Statements are from Shtulman and Valcarcel (2012).

Thus, within each quartet there were two true and two false statements according to religion or science. The four statements within each quartet were further balanced in terms of overall sentence structure, complexity, and length in words. The full list of statements can be found in the Supplementary Materials.

On the Sentence Verification Task**, accuracy interference** was calculated by subtracting the mean accuracy on inconsistent statements from the mean accuracy on consistent statements, and **response time interference** was calculated by subtracting the mean response time on consistent statements from the mean response time on inconsistent statements. Thus, for both accuracy and response time, performance on consistent statements was a baseline with which performance on inconsistent statements was compared; higher

accuracy and response time interference scores indicate poorer performance on inconsistent versus consistent statements.

Additionally, participants took a survey which included demographic questions, and the following indices of explicit beliefs about God: “Do you believe that God is physical in the same manner humans are physical?” (Yes/No/Unsure), “Do you believe God has feelings and thoughts in the same manner humans have feelings and thoughts?” (Yes/No/Unsure).[28]

2.4. Procedure

Participants were tested in semi-private computer stations in an experimental psychology laboratory (87%), or on laptop computers in a quiet side-room of their church (13%). A typical study session lasted between 30 and 60 minutes, but with up to 120 minutes for the older participants who were generally slower on all parts of the study; participants received $20.

The sentence verification task items were presented one-by-one and in a randomized order, and whether the right or left hand was used to respond “true” or “false” was randomized between participants. The instructions to the sentence verification task emphasized accuracy but not response time, and responses were collected via key presses (presented via E-Prime software).

3. Results and Discussion

The analyses presented here use accuracy and response time interference scores. See Supplementary Materials for pirate plots of consistent and inconsistent items separately. The

[28] These questions were added to the experiment after it had started, and data on these questions is therefore missing for 17 participants.

data used in the analyses presented here were manipulated by removing data points above or below 3 SD from each participants' mean response time, separately on consistent and inconsistent religion and science items; less than 2% of data points were removed in this way. Additionally, to maximize transparency, we present both response time data computed from correct responses only (as in Barlev et al., 2017), and from correct and incorrect responses. Lastly, following the recommendation by Steegen, Tuerlinckx, Gelman, and Vanpaemel (2016), we present a multiverse analysis exploring different outlier removal strategies. The overall conclusions of the present study remain the same with all outlier removal strategies explored, including the strategy of not removing outliers at all.

3.1. Response interference is evident in older adults

We first tested for response interference in the full sample, and then, to evaluate whether response interference exists in older adults, in the sample dichotomized and tertilized by age. The dichotomized sample was comprised of two groups: 18- to 45-year-olds (n = 34) and 46- to 87-year-olds (n = 33), and the tertilized sample was comprised of three groups: 18- to 25-year-olds (n = 22), 26- to 60-year-olds (n = 23), and 62- to 87-year-olds (n = 22). The accuracy and response time differences were analyzed using one-sample t-tests. Table 3 presents the results of these analyses, and Tables 4a-b in the Appendix present a multiverse analysis.

Table 3

Response Accuracy (ACC) and Time (RT) Interference Scores Throughout Adulthood.

		Full Sample	Dichotomized		Tertiarized		
			Younger	Older	Younger	Middle	Older
Religion	ACC	7% ***	7% ***	7% ***	7% ***	8% ***	6% **
	RT [1]	308ms **	152ms	469ms **	196ms	231ms	500ms **
	RT [2]	459ms ***	260ms ‘	663ms ***	287ms ‘	394ms ‘	698ms *
Science	ACC	20% ***	20% ***	21% ***	20% ***	19% ***	22% ***
	RT [1]	1039ms ***	887ms ***	1194ms ***	840ms ***	916ms ***	1366ms ***
	RT [2]	866ms ***	742ms ***	993ms ***	704ms ***	819ms ***	1076ms ***

Note. Interference scores are computed as consistent minus inconsistent for response accuracy, and inconsistent minus consistent for response time. RT [1] are computed with correct responses. RT [2] are computed with correct and incorrect responses. *** $p < .001$. ** $p < .01$. * $p < .05$. ‘ $p < .10$.

In the full sample, religion and science response interference was evident from both accuracy and response time differences between consistent and inconsistent items. In the dichotomized and tertilized samples, religion response interference was fully evident in the older group, and partially evident in the younger group (dichotomized sample) and in the younger and middle groups (tertilized sample), where response time differences achieved marginal statistical significance when computed with correct and incorrect responses, but did not achieve statistical significance when computed with correct responses only. In both the dichotomized and tertilized samples, science response interference was fully evident in all groups.

3.2. Response interference is invariant with maturation and theological experience

A series of Bayesian linear regressions (computed using JASP 0.8.1.2.) were used to evaluate the relationship between theological experience and response interference, using age (our index of experience) as a continuous predictor. Since a plausible hypothesis considered in the present analysis is the null, Bayes factors showing support for the null versus the alternative were computed (with priors set to the default in JASP 0.8.1.2. which is $r = .354$).

The Bayes Factors in support of the null hypothesis that religion and science accuracy interference scores did not vary with age were 3.91, and 3.63 (both moderate evidence in support of the null). The Bayes Factors in support of the null hypothesis that religion and science response time interference scores did not vary with age were 1.39 and 0.67 (which support neither hypothesis).[29] [30] See Tables 5a-b in the Appendix for a multiverse analysis. The regressions are displayed in Fig 3.1.

[29] Since the data reported here are not normally distributed, Bayesian Kendall's tau coefficients were additionally calculated. The tau tests yielded identical conclusions to those reported here using the Bayesian regressions.

[30] In fact, the trend in the response time interference scores is in the direction opposite to that expected under a replacement hypothesis.

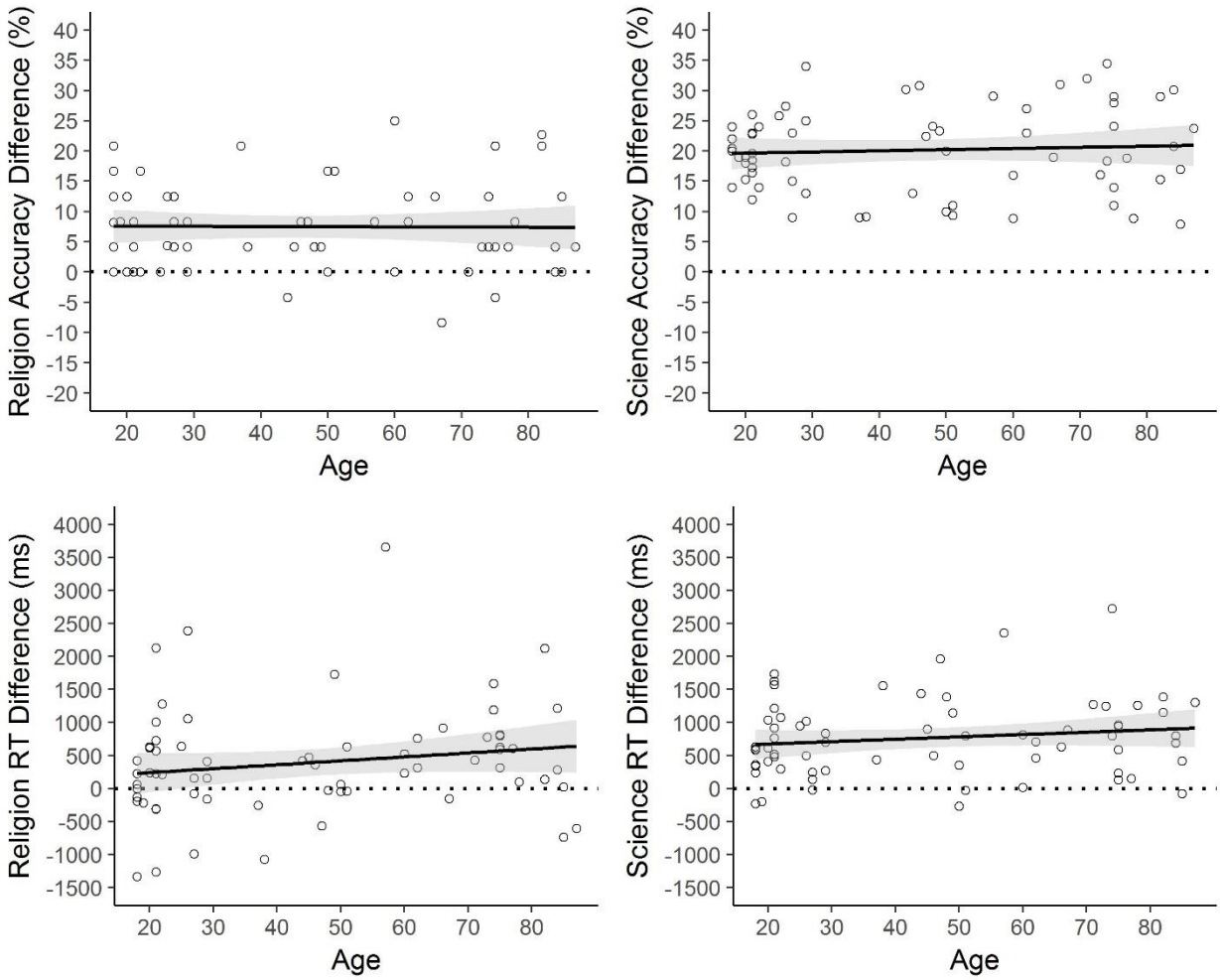


Fig. 1. Scatterplots of performance on the sentence verification task with age. Circles represent participant accuracy (% correct) or response time (milliseconds) interference scores. The shaded areas around the regression lines represent the 95% CIs.

Additionally, in our sample there were 3 participants with Master's degrees in Theology, and with decades of experience teaching theology, each in a different setting (a religious school, a Youth Ministry, and a church). We viewed these participants as case studies of particularly high theological expertise. The religion accuracy interference scores of 2 of the 3 were in the predicted direction (4%, 8%, and -4%) and all 3 had religion response time interference scores in the predicted direction (425ms, 361ms, and 607ms, respectively).

3.2. Response interference is invariant with explicit beliefs about God

As noted above, a full understanding of God's extraordinary characteristics is difficult to acquire. This may mean that some individuals in our sample explicitly believe that some of God's characteristics are quantitatively but not qualitatively different from those of a person. For instance, they might represent God's mental states not as omniscient ("knows everything about everything") but as extensive ("knows very many things about very many things"); an 85-year-old participant who said that God has feelings and thoughts in the same manner humans have feelings and thoughts commented to the experimenter "But billions of times more. I can't imagine what He is like." Overall, in our sample 18% of participants reported believing that God is physical in the manner humans are physical (6% were unsure), and 36% reported that God has feelings and thoughts in the same manner humans have feelings and thoughts (14% were unsure).

Thus, is it possible that core knowledge intuitions are replaced only among individuals who explicitly believe that God is qualitatively different from a person? A categorical explicit beliefs composite variable, indexing the extent to which participants explicitly attributed person characteristics to God, was computed as follows: participants providing two "no" answers were coded as explicitly believing in an abstract God, participants providing two "yes" or "unsure" answers were coded as explicitly believing in a person-like God, and participants providing one "no" and one "yes" or "unsure" answers were coded as explicitly believing that God is both abstract and person-like (regarding different characteristics). The representational co-existence hypothesis predicts that we will find evidence of response interference among participants who report explicitly believing in

an abstract God. We stacked the cards against this prediction by coding "unsure" along with "yes". The findings reported below are the same if we code "unsure" with "no".

One-sample *t*-tests showed that religion accuracy interference was significantly different from zero in all three explicit beliefs groups, and that religion response time interference, when computed with correct and incorrect responses, was different from zero in one of the three groups (marginal when computed with correct responses only), and marginally different in another.[31] Thus, response interference is invariant with explicit beliefs about God. See Table 6 for a summary.

Table 6

Religion Sentence Verification Task Response Accuracy (ACC) and Time (RT) Interference Scores Given Different Explicit Beliefs About God

	Abstract (n = 23)	Both (n = 17)	Person-like (n = 10)
ACC	9% (9%) ***	6% (6%) **	3% (3%) *
RT ¹	276ms (697ms) ˙	469ms (918ms) ˡ	166ms (1063ms)
RT ²	512ms (1260ms) ˡ	587ms (968ms) *	185ms (1064ms)

Note. RT ¹ are computed with correct responses. RT ² are computed with correct and incorrect responses. *** p < .001. ** p < .01. * p < .05. ˡ p < .10.

4. Conclusions

The present study evaluated the hypothesis that intuitions about God as a person co-exist with acquired Christian theology about God, and are not revised even with maturation and extensive theological experience. We indexed representational co-existence with

[31] Note that the trend of smallest accuracy and response time interference scores among participants who believe in a person-like God is opposite to that expected under a replacement hypothesis.

performance on a task in which participants were asked to evaluate as true or false statements for which core intuitions about persons and acquired Christian theology about God were consistent (both true or both false) or inconsistent (true on one and false on the other). If the intuitions on which initial representations of God are based are replaced by Christian theology, then performance should not differ between consistent and inconsistent statements. However, if these intuitions are not replaced then they may interfere with Christian theology, resulting in worse performance on inconsistent statements.

First, it was found that Christian religious adherents made more theological errors and were slower responding to inconsistent versus consistent statements. Importantly, this response pattern was found among older adults when they were examined separately. Further, this response pattern was found in participants who reported explicitly believing in an abstract God. We can therefore conclude that it is not likely that initial representations of God as a person are replaced by Christian theological representations of God as omniscient, omnipresent, and incorporeal, even following extensive theological experience – indeed, a lifetime of experience.

Second, performance on the task was invariant with maturation and theological experience: age did not attenuate conflict between core intuitions about persons and Christian theology about God. The same null findings for age were found for science items. In contrast, Shtulman and Harrington (2016) found that, compared to younger adults, older adults in their study (community members and university professors) made slightly fewer scientific errors but were slightly slower responding to inconsistent versus consistent statements. While this response pattern might be due to the effects of scientific experience, it might alternatively be

due to a changing response strategy wherein among older adults response time is traded off for accuracy (e.g. Starns & Ratcliff, 2010).

The findings reported here are compatible with the idea that one way in which humans form concepts that were not targets of natural selection is by co-opting and modifying the conceptual output of mechanisms that are part of our evolved core cognitive architecture. In the case of scientific theories, initial theories of the world impede the fluidity with which later acquired theories are utilized (Shtulman & Valcarcel, 2012), even after much scientific experience has been accumulated (Shtulman & Harrington, 2016; see Shtulman, In Press, for a recent review). The same pattern has been demonstrated here for the case of Christian theology about God. We speculate that co-existence with core knowledge concepts, and consequent interference from those concepts, is a signature property of reasoning about bodies of evolutionarily new knowledge in general.

APPENDIX FOR CHAPTER 3

1. Religious expertise

Previous studies are equivocal on whether expertise with theology or science attenuates interference between core knowledge intuitions (or early-acquired beliefs) and later-acquired theological doctrines or scientific theories (e.g. Barlev et al., 2017; Goldberg & Thompson-Schill, 2009; Kelemen & Rosset, 2009; Kelemen, Rottman, & Seston, 2012; Shtulman & Harrington, 2016; Shtulman & Valcarcel, 2012). In the present study one additional way in which we measured theological expertise is via the following four items:

- "On average how frequently did you attend church throughout your life?" (At least every day; At least a few times a week; At least once every week; At least a few times a month; At least once every month; At least a few times a year; At least once every year or less)
- "On average how frequently did you contemplate God throughout your life?" (Not at all; A small amount; A moderate amount; A significant amount)
- "On average how frequently did you study theology (formally or informally, by yourself or with others) throughout your life?" (Not at all; A small amount; A moderate amount; A significant amount)
- "Please think about other adults of your religious denomination in your community as a point of reference. Compared to them how well versed are you with the theology of your religious denomination"? (Significantly less versed; Moderately less versed;

Slightly less versed; Approximately the same; Slightly more versed; Moderately more versed; Significantly more versed)

The majority of participants (82%) reported having attended church, on average throughout their lives, every week or more frequently, with 26% reporting having attended church a few times a week or every day. On average, participants reported having contemplated God between a moderate and a significant amount throughout their lives (all participants reported having contemplated God at least a small amount). On average, participants reported having studied theology between a small to a moderate amount, and of knowing theology approximately the same to slightly better than other adults of the same religious denomination in their community.

Frequency of theology study was strongly correlated with self-evaluation of theological competence (r (48) = .62, p < .001) and with contemplating God (r (48) = .39, p = .005; theological competence and contemplating God were also correlated: r (48) = .31, p = .029). Church attendance did not strongly correlate with any of these variables (all ps > .05). Age did not strongly correlate with any of these variables (all ps > .05).

1.2. Response interference is invariant with individual differences in religious expertise

The four theological expertise measures were added to the Bayesian linear regressions of age on religion accuracy and response time interference scores (see Section 3.2. of the manuscript), and Bayes factors showing support for the null versus alternative were computed. The null hypothesis was slightly to strongly supported for all four variables and their interactions; the alternative hypothesis was not supported. A multiverse analysis

confirmed that these findings were invariant to whether response times were computed with correct responses only, or with correct and incorrect responses, and to outlier removal strategies, including the strategy of not removing outliers. Because of the strong correlations between some of the religious expertise variables, each variable was additionally entered into the regression by itself. The null hypothesis was still supported over the alternative hypothesis for each variable.

The null findings in the present study among adults varying in age parallel the null findings of Barlev et al. (2017) among young adults. We still consider it possible that theological expertise attenuates interference between representations that coexist alongside and interfere with one another. However, a performance-based measure such as the one used in Kelemen and Rosset (2009) may be a more direct index of expertise than the measures used in the present study (also see Barlev et al., 2017, and Shtulman & Valcarcel, 2012). We are not aware of existing performance-based measures of theological expertise. We are presently developing such a measure and intend to validate and report on it in future.

2. Executive functions

We have previously argued that if core knowledge intuitions co-exist alongside and interfere with acquired Christian theology, then certain mechanisms should exist that resolve this interference or conflict (Barlev et al., 2017). We investigated here whether executive functions may be part of this conflict resolution mechanism, that is, whether individual differences in executive functions predict sentence verification task performance.

The executive functions measures were: (1) A 144-item behavioral Stroop, which included the following three conditions (48 items per condition): **color-naming** (a string of Xs appears in red, blue, green, or yellow color and participants are required to respond to the color in which the Xs appear), **incongruent** (the words RED, BLUE, GREEN, and YELLOW appear in a color different than the one they spell and participants are required to respond to the color in which the words appear), and **word-naming** (the words RED, BLUE, GREEN, and YELLOW appear in black, and participants are required to respond to the word that appears). A **Stroop Accuracy Interference Score** is calculated by subtracting the mean accuracy on the incongruent condition from the mean accuracy on the color-naming condition; a **Stroop Response Time Interference Score** is calculated by subtracting the mean response time on the color-naming condition from the mean response time on the incongruent condition. Thus, performance on the color-naming condition functions as a baseline index of accuracy and response time, with higher scores indicating greater difficulty inhibiting, in the incongruent condition, automatically reading the color words. The word-naming condition functions to discourage a response strategy where participants only attend to the color in which a word appears by either directing their gaze to the periphery of the display or squinting their eyes, thereby blurring the written words.

(2) A running span working memory task (Broadway & Engel, 2010).

All participants had to complete the sentence verification task to be included in the study. However, because of the physical health of some of the older participants, those who reported difficulties with the behavioral Stroop task and/or the working memory task were permitted to omit either or both. Seven participants omitted the behavioral Stroop task, 4 participants omitted the working memory task, and 11 participants omitted both.

2.2. Response interference is mostly invariant with individual differences in executive functions

The behavioral Stroop data were manipulated by removing data points above or below 3 SD from each participant's mean response time, separately on the color-naming, incongruent, and word-naming conditions; less than 2% of data points were removed in this way. Additionally, to maximize transparency, we present both response time data computed from correct and incorrect responses, and correct responses only. Age, the Stroop interference scores (accuracy and response time), and the working memory scores ("score" and "total"; see Broadway & Engel, 2010 for details), were correlated with the religion and science interference scores (accuracy and response time). The correlations are presented in Table 3.7. On the behavioral Stroop task, higher interference scores (accuracy or response time) indicate worse task performance, while on the working memory task, higher scores indicate better task performance.

Table 7

Correlations Between Religion and Science Interference Scores and Executive Functions

		Behavioral Stroop			Working Memory	
		ACC	RT [1]	RT [2]	Score	Total
Age		**.30 ***	**.55 *****	**.54 *****	**-.31 ***	**-.36 ****
Religion	ACC	n.s.	n.s.	n.s.	n.s.	**-.24 [ı]**
	RT [1]	**.27 [ı]**	n.s.	n.s.	n.s.	n.s.
	RT [2]	**.28 [ı]**	n.s.	n.s.	n.s.	n.s.
Science	ACC	**.28 ***	n.s.	n.s.	**-.24 [ı]**	n.s.
	RT [1]	**.31 ***	n.s.	n.s.	n.s.	n.s.
	RT [2]	n.s.	n.s.	n.s.	n.s.	n.s.

Note. RT [1] calculated using correct and incorrect responses. RT [2] calculated using correct responses only. Correlations with significance levels above .1 not shown. *** $p < .001$. ** $p < .01$. * $p < .05$. [ı] $p < .1$.

Age was positively correlated with the Stroop interference scores (accuracy and response time) and negatively correlated with the working memory scores, such that performance on both executive functions measures worsened with age. However, neither the religion nor science response interference measures reliably correlated with either the behavioral Stroop or working memory measures.

The mostly null findings in the present study among adults varying in age parallel the null findings of Barlev et al. (2017) among young adults. We still maintain that certain mechanisms resolve conflict between representations that coexist alongside and interfere with one another, such as core knowledge intuitions about persons and acquired Christian theology about God. However, inhibition and working memory may have no role, or may

only play a minimal role, in resolving these conflicts. See Barlev et al. (2017) for a more extensive discussion of this issue.

Table 4a

Multiverse Analysis of Response Accuracy Interference Scores

	Religion						Science					
		Dichotomized		Tertilized				Dichotomized		Tertilized		
Data processing	Total	Younger	Older	Youngest	Middle	Oldest	Total	Younger	Older	Youngest	Middle	Oldest
						p -value						
No-transform.												
None	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
± 0.5%	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**.004**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
± 2.5%	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**.004**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
± 2SD	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**.002**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
± 3SD	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**.002**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
Log-transform.												
None	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
± 0.5%	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**.004**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
± 2.5%	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**.004**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
± 2SD	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**.002**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
± 3SD	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
						BF_{10}						
No-transform.												
None	**> 1000**	**> 1000**	**> 1000**	**312.13**	**> 1000**	**54.72**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**
± 0.5%	**> 1000**	**> 1000**	**686.17**	**164.69**	**219.58**	**11.22**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**
± 2.5%	**> 1000**	**> 1000**	**686.17**	**164.69**	**219.58**	**11.22**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**
± 2SD	**> 1000**	**> 1000**	**> 1000**	**275.37**	**701.19**	**17.18**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**
± 3SD	**> 1000**	**> 1000**	**> 1000**	**321.82**	**842.26**	**18.56**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**
Log-transform.												
None	**> 1000**	**> 1000**	**> 1000**	**312.13**	**> 1000**	**54.72**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**
± 0.5%	**> 1000**	**> 1000**	**686.17**	**164.69**	**219.58**	**11.22**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**
± 2.5%	**> 1000**	**> 1000**	**686.17**	**164.69**	**219.58**	**11.22**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**
± 2SD	**> 1000**	**> 1000**	**> 1000**	**316.85**	**968.55**	**21.87**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**
± 3SD	**> 1000**	**> 1000**	**> 1000**	**312.13**	**> 1000**	**59.23**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**

Note . Data were processed with or without log transformation, and by removing no outliers or by removing outliers using different cut-offs: ± .5%, ± 2.5%, ± 2SD, or ± 3SD most extreme scores. Bayes Factors reported are likelihood probabilities in favor of the alternative hypothesis.

Table 4b

Multiverse Analysis of Response Time Interference Scores

	Religion												Science											
			Dichotomized				Tertilized								Dichotomized				Tertilized					
	Total		Younger		Older		Youngest		Middle		Oldest		Total		Younger		Older		Youngest		Middle		Oldest	
Data processing	C	C+I	C	C+I	C	C+I	C	C+I	C	C+I	C	C+I	C	C+I	C	C+I	C	C+I	C	C+I	C	C+I	C	C+I
												p-value												
No-transform.																								
None	**.002**	**< .001**	.184	**.041**	**.002**	**< .001**	.230	**.092**	.215	**.064**	**< .001**	**.001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
± 0.5%	**< .001**	**< .001**	.129	**.030**	**< .001**	**< .001**	.142	**.052**	.198	**.059**	**< .001**	**.001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
± 2.5%	**< .001**	**< .001**	.129	**.030**	**< .001**	**< .001**	.142	**.052**	.198	**.059**	**< .001**	**.001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
± 2SD	**< .001**	**< .001**	**.070**	**.023**	**.006**	**< .001**	**.045**	**.014**	.375	.156	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
± 3SD	**.002**	**< .001**	.240	**.063**	**.002**	**< .001**	.241	**.081**	.227	**.082**	**.002**	**.011**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
Log-transform.																								
None	**.001**	**< .001**	.133	**.009**	**.002**	**< .001**	**.082**	**.008**	.301	**.059**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
± 0.5%	**< .001**	**< .001**	.127	**.015**	**< .001**	**< .001**	.101	**.018**	.217	**.046**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
± 2.5%	**< .001**	**< .001**	.127	**.015**	**< .001**	**< .001**	.101	**.018**	.217	**.046**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
± 2SD	**.003**	**< .001**	.239	**.051**	**.002**	**< .001**	.131	**.025**	.324	.109	**.001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
± 3SD	**.003**	**< .001**	.195	**.022**	**.003**	**< .001**	.138	**.022**	.301	**.047**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**
												BF_{10}												
No-transform.																								
None	**13.71**	**335.70**	.43	1.33	**15.35**	**66.12**	.44	.84	.45	1.09	**34.62**	**68.52**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**351.48**	**451.01**	**94.76**	**714.30**
± 0.5%	**67.74**	**531.80**	.55	1.71	**44.12**	**72.04**	.61	1.30	.48	1.16	**27.29**	**124.38**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**506.29**	**530.12**	**165.20**	**973.12**
± 2.5%	**67.74**	**531.80**	.55	1.71	**44.12**	**72.04**	.61	1.30	.48	1.16	**27.29**	**124.38**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**403.28**	**344.38**	**191.54**	**689.70**
± 2SD	**26.46**	**394.80**	.87	2.18	**6.71**	**38.52**	1.47	**3.68**	.32	0.56	**85.94**	**59.59**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**524.42**	**576.68**	**96.32**	**254.86**
± 3SD	**15.02**	**62.78**	.35	.95	**19.43**	**38.52**	.42	.93	.43	0.90	**18.56**	**23.54**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**209.94**	**224.28**	**100.41**	**758.70**
Log-transform.																								
None	**23.46**	**> 1000**	.54	**4.61**	**19.08**	**389.2**	.91	**5.94**	.36	1.17	**54.72**	**375.12**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**
± 0.5%	**56.68**	**> 1000**	.55	**3.15**	**59.44**	**416.7**	.78	**3.07**	.45	1.42	**285.36**	**273.78**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**
± 2.5%	**56.68**	**> 1000**	.55	**3.15**	**59.44**	**416.7**	.78	**3.07**	.45	1.42	**285.36**	**273.78**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**
± 2SD	**8.57**	**> 1000**	.36	1.12	**17.18**	**118.9**	.65	2.37	.33	.73	**21.87**	**53.12**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**
± 3SD	**9.55**	**> 1000**	.41	2.60	**12.04**	**202.1**	.62	2.60	.36	1.38	**45.43**	**121.28**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**	**> 1000**

Note . Data were processed with or without log transformation, and by removing no outliers or by removing outliers using different cut-offs: ± .5%, ± 2.5%, ± 2SD, or ± 3SD most extreme scores. C = Correct responses only. C+I = Correct and incorrect responses. Bayes Factors reported are likelihood probabilities in favor of the alternative hypothesis.

Table 5a

Multiverse Analysis of Age Predicting Response Accuracy Differences

	Religion	Science	Religion	Science
	p-value		BF_{01}	
No-transformation				
None	.983	.626	4.00	3.61
± 0.5%	.687	.571	3.73	3.48
± 2.5%	.687	.644	3.73	3.64
± 2SD	.766	.685	3.85	3.72
± 3SD	.820	.636	3.91	3.63
Log-transformation				
None	.983	.626	4.00	3.61
± 0.5%	.687	.571	3.73	3.48
± 2.5%	.687	.658	3.73	3.67
± 2SD	.740	.632	3.81	3.62
± 3SD	.994	.551	4.00	3.43

Note. Data were processed with or without transformation, and by removing no outliers or by removing outliers using different cut-offs. BF_{01} are likelihood probabilities in favor of the null hypothesis.

Table 5b

Multiverse Analysis of Age Predicting Response Time Differences

	Religion		Science		Religion		Science	
	C	C+I	C	C+I	C	C+I	C	C+I
	p -value				BF_{01}			
No-transformation								
None	.236	.116	**.074**	.333	2.18	1.37	1.00	2.67
± 0.5%	**.081**	.110	**.036**	.146	1.06	1.32	.58	1.60
± 2.5%	**.081**	.110	**.035**	.100	1.06	1.32	.58	1.23
± 2SD	.330	.263	**.057**	.169	2.65	2.32	.82	1.76
± 3SD	.119	.103	**.043**	**.099**	1.39	2.82	.67	3.98
Log-transformation								
None	.412	.369	.839	.563	2.99	2.82	3.93	3.46
± 0.5%	.219	.312	.592	.793	1.06	2.57	1.72	3.88
± 2.5%	.219	.312	.717	.794	2.08	2.57	3.78	3.88
± 2SD	.351	.263	.568	.169	2.74	3.15	3.47	3.98
± 3SD	.417	.369	.668	.913	3.01	2.82	3.69	3.98

Note. Data were processed with or without transformation, and by removing no outliers or by removing outliers using different cut-offs. BF_{01} are likelihood probabilities in favor of the null hypothesis. C = Correct responses only. C+I = Correct and incorrect responses.

CHAPTER 4

The mind is *more than* but not *separate from* the body: On the default functional integration of mind and body representations and the intuitive non-reducibility hypothesis

1. Introduction

The belief that there exist beings without physical bodies (e.g. animistic spirits, ancestors spirits, angels, demons, and gods) is ubiquitous in present and past religious traditions, and is the focus of many: *Candomblé,* an Afro-Brazilian syncretic religion, is focused on ritualized interactions with disembodied spirits which can possess human bodies, often speaking and acting through them (Cohen, 2007); while usually more peripheral, beliefs in spirit possession are found in many other religious traditions (Bourguingnon, 1968). By contrast, mainstream monotheistic religions focus on a god which is not only believed to be disembodied, but unconstrained by physical laws entirely. Conversely, a somewhat less common but nonetheless recurrent belief, according to Bloom (2005), is that there exist "mind-less" bodies, such as the Golem in Jewish folklore or Haitian zombies. What explains the existence of these beliefs, and in the case of disembodied beings, their ubiquity?

Bloom (2005), in *Descartes' Baby,* advances one highly influential hypothesis. Bloom begins with the theory, corroborated over decades of research in cognitive development, that there exist evolved and functionally specialized cognitive mechanisms for representing

intentional agents and their psychology on the one hand, and bodies and their physicality and spatio-temporal mechanics such as continuous motion on the other (e.g. Carey, 2009). For example, infants understand that intentional agents have goals (Meltzoff, 1995), expect them to behave in accordance with those goals (Woodward, 1998, 1999), and to achieve those goals through behavior that is rational (Csibra et al., 1999); infants understand that physical entities are cohesive (objects are bounded wholes, and neither separate nor join together), spatio-temporally continuous (objects move on a connected path, and two or more objects cannot occupy the same space at the same time), and act on each other if and only if they come into contact; i.e. objects do not interact at a distance (e.g. Spelke & Van de Walle, 1993).

Bloom then posits that as a by-product of the existence of these functionally specialized mechanisms, default representations of intentional agents ("minds") are not functionally integrated with, i.e. they are *separate from*, representations of physical entities ("bodies"). Bloom posits that this default "Cartesian dualism" is at the foundation of more elaborated beliefs about disembodied beings and "mind-less" bodies (see also Bloom, 2007; Forstmann & Burgmer, 2015; 2017; Hood, Gjersoe, & Bloom, 2012; Kuhlmeier, Bloom, & Wynn, 2004; Shtulman & Lindeman, 2016; see Baumard & Boyer, 2013, for a more general view of intuitions as the foundations of certain religious beliefs).

In this paper I first explain why with an adaptationist perspective on human cognition we should expect mechanisms for representing minds to be functionally integrated with mechanisms for representing bodies, not separate from them. Second, I carefully re-evaluate key empirical studies purporting to favor intuitive mind-body dualism, including in light of recent findings by Barlev, Mermelstein, and German (In Prep) that among Christian religious

adherents, God is represented as an embodied person. I advance the hypothesis that while mechanisms for representing minds are functionally integrated with mechanisms for representing bodies, they are not computationally nor phenomenologically reducible to them. I reinterpret some of the studies purporting to favor intuitive mind-body dualism via this intuitive non-reducibility hypothesis. Third, I propose that the study by Chudek et al. (2017), purporting to favor intuitive mind-body dualism, rather sheds light on two particularly interesting and related phenomena – explanatory prioritization and a preference for plausible impossibilities over unconvincing possibilities – which warrant their own independent investigations. Fourth, I argue that beings such as the Golem and Haitian zombies are not represented as mind-less, because physical entities exhibiting the requisite behavioral and/or morphological cues are automatically categorized as intentional agents. I conclude with a discussion of the cognitive optimum hypothesis (Boyer, 1994a,b; 2001; Boyer & Ramble, 2001) as an explanation for the ubiquity of beliefs about disembodied beings.

1.1. A prelude on core knowledge, and on why an adaptationist perspective should make us skeptical of intuitive mind-body dualism

The brain consists of reliably developing and functionally specialized mechanisms for representing the world ("core knowledge" mechanisms: e.g. Carey, 1985, 2009; Carey & Spelke, 1994; Pinker, 1994; Spelke, Breinlinger, Macomber, & Jacobson, 1992; Spelke & Kinzler, 2007). The set of mechanisms that evolved for representing physical entities and their spatio-temporal motion properties are termed "naïve physics". A small subset of physical entities is capable of self-propelled motion, that is, they have an internal and invisible source of energy which, in contrast to most other physical entities, makes them able

to move without an external and visible physical cause (e.g. Leslie & Keeble, 1987). Leslie (1994) suggests that a specialized mechanism, the "Theory of Bodies" (ToBy) mechanism, evolved to categorize physical entities as self-propelled by attributing to them the property of "force". While the motion of all self-propelled biological organisms is non-random, the non-random motion of a small subset of biological organisms is fitness relevant to humans: the motion of persons and animals (both predators and prey), for example. The "Theory of Mind" (ToM) mechanism has evolved to categorize this subset of self-propelled, physical entities as "intentional agents" and to explain and predict their non-random motion in terms of invisible internal representations, i.e. mental states (Leslie, 1994). Kovacs et al. (2010) found evidence of the functioning of this mechanism in infants as young as 7 months (also see Onishi & Baillargeon, 2005, and Surian, Caldi & Sperber, 2007, for evidence using a different experimental paradigm with slightly older infants; Baillargeon, Scott, & Bian, 2016, for a review).

Although these mechanisms are functionally specialized, they are generally thought of as functionally integrated (e.g. see Leslie, 1994). Luo, Kaufmann, & Baillargeon (2009) empirically demonstrated just this with ToBy and naïve physics: in their study, infants age 5—6.5 months were surprised when an object hidden by a screen disappeared (spatio-temporal continuity; Exp. 5), when one object seemed to pass through another (solidity; Exp. 2), and when an unsupported or inadequately supported object remained stable in midair (support relations; Exp. 4). Once objects were shown to be self-propelled, infants' inferences about possible and impossible physical events involving them changed. However, this only had to do with properties relevant to "force"; infants continued to represent the physicality and spatio-temporal motion properties of self-propelled objects. For example, infants were

not surprised if self-propelled objects reversed direction while in motion (Exp. 1), remained stationary when hit or pulled (Exp. 3), or remained stable in midair when unsupported or inadequately supported; but they were surprised if self-propelled objects disappeared when hidden by a screen or passed through another object.

Indeed, the notion of functional integration is a fundamental property of the brain and requires further elaboration before I continue. The unit which constitutes a "functionally specialized mechanism" is relative because it depends on the adaptive function specified. For example, the human visual system evolved for processing electromagnetic radiation in a certain range of wavelengths for the adaptive function of constructing a mental representation of the surrounding environment. The eyes are a part of the visual system that evolved for phototransduction, that is, converting electromagnetic radiation into electrical signals, and the proper functioning of the visual system is dependent on the functioning of the eyes, and so on (we can break the eyes down into their own specialized subcomponents for, for example, collecting, focusing, and transducing light). The visual system can therefore be considered a single specialized mechanism, or its distinct units, such as the eyes or the cones, can each be considered as different functionally specialized units. However, these functionally specialized mechanisms are not functionally separate from each other, but are rather functionally integrated for solving the general problem the visual system was designed to solve. That is, functional specialization is a relative construct, and importantly, does not necessitate functional separation.

What about the Theory of Mind mechanism? A priori, should we hypothesize it to be functionally integrated with naïve physics, and with ToBy?[32] Yes. The brain is a behavior

[32] By this I mean that the outputs of each mechanism be available as inputs to each other, rather than that the inferences internal to each mechanism be accessed by inferences internal to each other.

regulating organ, made out of neural circuits (modules) which were designed by natural selection to solve adaptive problems. By "adaptive problems" I mean those cross-generationally recurrent problems the solution of which increased fitness (survival and reproduction) in the ancestral environments in which these modules evolved. A fundamental insight of this perspective is that modules evolved to track fitness-relevant properties of our ancestral environments. Since persons *are* physical entities, and the ability to appropriately represent persons, including both their physicality and psychology is highly fitness relevant, any module which does not by default represent both the physicality and psychology of persons is not likely to evolve. That is, we interpret the behavior of intentional agents in terms of underlying mental states such as goals, but we should additionally apply the laws of physics to these agents because, in order for an agent to achieve its goal, it must interact with its physical surroundings, and this interaction is constrained by both the physicality of the environment and the agent moving in it and acting on it. Thus, to interpret the motion of an agent in terms of its mental states, such as goals, the brain must not only consider those goals but also the physical means the agent uses to achieve them.

2. Re-evaluating the evidence for intuitive mind-body dualism

2.1. Re-evaluating findings purporting to show that infants do not represent persons as physical entities

Contrary to the above view wherein naïve physics is functionally integrated with the Theory of Mind mechanism, Kuhlmeier, Bloom, and Wynn (2004), by focusing on the property of spatio-temporally continuity, purport to show that by default 5-month-old infants

do not represent persons as physical entities. [33] Note, first, that the Kuhlmeier et al. view is hard to reconcile with the view that physical movement is used to decide to shunt information to the ToM mechanism (see Leslie, 1994). Second, although Kuhlmeier et al. is commonly cited as evidence for intuitive mind-body dualism, it is not at all clear that intuitive mind-body dualism predicts that human bodies not be viewed as physical entities (see Hodge, 2008, p. 409, for a similar point).

Kuhlmeier et al. use a violation-of-expectations looking-time paradigm modeled after the classic findings of Spelke, Kestenbaum, Simons, Wein (1995). In Exp. 1, 5-month-old infants were habituated to video displays in which a box slowly moved the length of a stage and behind two spatially separated screens, large enough such that when the box moved behind either it was entirely hidden from view. In the continuous motion condition the box moved behind the first screen, continued through the space between the two screens, and behind and out from the second screen. In the discontinuous motion condition the box moved behind the first screen but did not continue through the space between the two screens, instead appearing from behind the second screen, giving the illusion that the box disappeared behind the first screen and reappeared behind the second. Then, infants watched two test displays (order counter-balanced between subjects) where either one or two boxes were shown moving on the stage. In Exp. 2 infants were habituated to a similar display, except that instead of a box now there was a person walking the length of a stage. Then, again, infants watched two test displays where either one or two persons were shown moving on the stage (identical twins were used for the two persons display).

[33] As summarized by Saxe, Tzelnic, and Carey, 2006, p. B2, Kuhlmeier et al. "suggest that for young infants, categorization as an intentional agent implies 'all bets are off' with respect to the principles that characterize core knowledge of naive physics".

Kuhlmeier et al. argue that their data shows that infants apply the principle of continuity to boxes, but not to persons. However, consider the Kuhlmeier et al. data displayed in Table 4.1.

Table 1

Kuhlmeier, Bloom, and Wynn (2004) findings.

	Experiment 1		Experiment 2	
	One box outcome	Two boxes outcome	One person outcome	Two persons outcome
Continuous motion condition	5.53 (3.80) n = 1	7.23 (4.19) n = 9	6.57 (6.62) n = 5	7.50 (5.42) n = 5
Discontinuous motion condition	6.40 (3.91) n = 6	5.61 (3.73) n = 4	8.62 (5.19) n = 5	7.58 (3.94) n = 5

Note. Means and standard deviations are shown in seconds. In each condition (10 subjects), n shows the number of infants looking for longer at each of the two outcomes.

Kuhlmeier et al. report repeated measures ANOVAs on the looking time data, but not paired samples t-tests. Because computing paired samples t-tests requires raw data for calculating differences between matched pairs, I am not able to reanalyze the looking time data. I did reanalyze the number of infants looking longer at each outcome using a Bayesian binomial test (using JASP v. 0.8.1.2). In Exp. 2, as reported by Kuhlmeier et al., there is no difference in looking times between the one person and two persons outcomes in either the continuous (BF_{10} = 0.37) or discontinuous (BF_{10} = 0.37) motion conditions. However, in Exp. 1, contrary to what is reported by Kuhlmeier et al., the expected cross-over interaction

(see Spelke et al., 1995) is not found. In Exp. 1, while looking time is longer toward the two boxes outcome than the one box outcome in the continuous motion condition (BF_{10} = 9.31 or p = .021), there is no difference in looking times between the two outcomes in the discontinuous motion condition (BF_{10} = 0.44 or p = .754; the Spelke et al., 1995, finding is longer looking time toward the one box outcome than the two boxes outcome).[34] Thus, since the argument that infants do not represent the physicality of persons is based on negative rather than positive results, i.e. it is based on a failure to reject the null in Exp. 2, the failure to reject the null in the discontinuous motion condition of Exp. 1 casts doubt on the Kuhlmeier et al. data as a whole.

However, more fundamentally, if ToM and ToBy are functionally integrated, what looking time pattern might we expect to find in Exp. 2? Kuhlmeier et al. argue that, in both the continuous and discontinuous motion conditions, failure to find a difference in looking times between the one person and two persons outcomes will supports the intuitive mind-body dualism hypothesis. However, if infants do not represent the physicality of persons by default, such that persons are able to disappear and reappear without infants finding this unexpected, at a minimum, given a low-level perception bias to prefer two things over one thing, infants in both the continuous and discontinuous motion conditions should show longer looking times at the two-persons outcome than at the one person outcome (indeed, Kuhlmeier, Wynn, & Bloom, 2004, p. 110, themselves note the existence of this low-level perception bias).[35]

[34] See similar critique by Rakison & Cicchino, 2004, pp. 105-6.

[35] I was tempted to predict this looking time pattern under a numerical reasoning view, e.g. Wynn, 1992. However, if we take the position of Kuhlmeier et al. seriously, addition and subtraction of small numbers, which is a property of naïve physics (Carey, 2009), is ruled-out by the view that 5-month-old infants do not apply naïve physics to persons.

What might explain the Kuhlmeier et al. findings, then? Rakison and Cicchino (2004) and Saxe, Tzelnic, and Carey (2006) argue that Kuhlmeier et al. failed to incorporate appropriate controls in their study. Rakison and Cicchino point out that infants have difficulty processing both dynamic local cues and global cues, and propose that infants in Exp. 2 of Kuhlmeier et al. might have attended to the former (i.e. moving body parts such arms and legs) rather than the latter (e.g. continuous versus discontinuous motion paths). Saxe, Tzelnic, and Carey propose an additional experience-based explanation, pointing out that persons often take circuitous paths between two points, for example, leaving via one door and coming back via another.

More recently, Saxe, Tzelnic, and Carey (2006) found evidence that 5-month-old infants *do* represent persons as physical entities, focusing on the physicality property of solidity rather than continuity. Saxe et al. used as a stimulus a human arm[36] (satisfying the requirement of Rakison & Cicchino, 2004, regarding minimizing dynamic local cues) which was shown moving behind a screen on one side and appearing from its other side. In one set of trials the arm seemed to pass through a large wall partially visible from behind the screen, while in another set the arm seemed to pass in front of a small wall similarly partially visible. Saxe et al. found longer looking times at seeming violations of solidity whether a human arm or a toy train were used. (Note that a reanalysis of the number of infants looking longer at each of the two sets of trials in the toy train condition, using a Bayesian binomial test, failed to reject the null, contrary to what is reported by Saxe et al. Critically, though, this analysis did reject the null in the two sets of trials in the human arm condition.)

[36] Regarding the appropriateness of using human arms as stimuli, Saxe, Tzelnic, & Carey, 2006 note that most infant studies of humans as intentional agents use human arms rather than full humans as stimuli, e.g. Woodward, 1998.

In sum, the weight of the evidence seems to be against the Kuhlmeier et al. hypothesis. First, Kuhlmeier et al. is based on a failure to reject the null and is therefore open to a variety of critiques (Rakison & Cicchino, 2004; Saxe, Tzelnic, & Carey, 2006). In particular, that the study only partially replicated Spelke et al. (1995), and that the study as a whole failed to incorporate appropriate controls. Second, if infants do not represent the physicality of persons by default, we can plausibly predict them to show a looking time pattern different than that predicted by Kuhlmeier et al. Third, a more recent study (Saxe et al., 2006), which controlled for factors that Kuhlmeier et al. did not, found that 5-month-old infants do represent persons as physical entities.

2.2. The non-reducibility of ToM and naïve physics as an alternative to mind-body dualism

I already articulated the adaptationist logic for why ToM should be functionally integrated with naïve physics (and with ToBy), however, this does not mean that ToM should be reducible to naïve physics (and ToBy). That is, default properties applied to intentional agents such as goals should not be reducible to properties applied to self-propelled entities ("force") and inanimate entities, computationally or phenomenologically. For an example of functionally integrated mechanisms which are not reducible to one another consider vision and touch: Streri and Spelke (1988) showed that, contrary to Piaget (1954), 4-month-old infants already integrate input from the visual and tactile systems in their representations of physical objects. The systems for processing tactile and visual information are functionally specialized and therefore computationally different (the input they take in is different, they process this input via different specialized machinery, and their outputs are different), and

moreover, their outputs are and phenomenologically different. Thus, while the outputs of the visual and tactile systems are integrated, these outputs are not computationally or phenomenologically reducible to one other.

I posit that phenomenological or intuitive non-reducibility is likely a property of many different mechanisms, including functionally integrated mechanisms, not limited to but including the representation of physical objects via vision and touch, and the representation of persons via ToM, ToBy, and naïve physics.

Importantly, the intuitive non-reducibility of ToM and naïve physics in representations of persons is compatible with key studies previously interpreted via intuitive mind-body dualism, such as duplication studies modeled after the classic philosophical thought experiment by Parfit (1984). Hood, Gjersoe, and Bloom (2012) introduced 5- to 6-year-olds to a hamster and told the children three physical properties about this hamster (e.g., that it had a broken tooth in the back of its mouth where it was not visible). Then, the hamster was given three memories (e.g., children showed the hamster pictures they drew). The children were then shown a machine consisting of two boxes with flashing lights and buzzers, and the hamster seemed to duplicate via this machine (the trick consisted of a hidden experimenter and a similar looking hamster). Then, the children were asked about the physical properties and memories of the old and new duplicated hamster. While children were less likely to attribute both physical properties and memories to the new versus the old hamster, they were less likely to respond that the new hamster had the old hamster's memories versus physical properties. That is, memories did not replicate to the same degree as physical properties. In a further analysis it was shown that 48% of children did not distinguish physical properties and memories, while 52% did, responding that the new

hamster had fewer memories than physical properties (no children responded that the new hamster had fewer physical properties than memories).

Recently, Forstmann and Burger, 2015, conceptually replicated and expanded on Hood et al. with an adult population, using hypothetical duplication vignettes. Both Hood et al. and Forstmann and Burger interpret their findings via intuitive mind-body dualism. However, their results are similarly compatible with intuitive non-reducibility. Both hypotheses predict that in a duplication scenario (either a display of seeming duplication or a hypothetical duplication vignette), intuitions about minds be different from intuitions about bodies. Note that I may be cutting the mind-body dualism hypothesis too much slack, because arguably if minds and bodies are intuitively separate, and if duplication only involves duplicating the physical body, then one should predict that participants in the Hood et al. and Forstmann and Burger studies would attribute none of the memories of the old hamster to the new duplicate hamster.

The intuitive non-reducibility hypothesis similarly applies to other evidence marshalled on the side of intuitive Cartesian dualism. This includes historical data on the differentiation of "mind" and "body" in pre-221 BCE China (Slingerland & Chudek, 2011; however, see Klein & Klein, 2012); anecdotal observations, such as the disproportionate interest by laypersons and scientists in neuroimaging findings that locate mental processes such as memory in the physical brain (where else could these processes be?); infamous "my brain made me do it" legal defenses (Gazzaniga, 2005); and, indeed, the mere existence of a debate about the mind-brain problem in philosophy (e.g. Nagel, 1974).

2.3. Explanatory prioritization, and the probably impossible versus the unconvincingly possible

Chudek, McNamara, Birch, Bloom, and Henrich (2017) showed Canadian children and Fijian children and adults (indigenous iTaukei Fijians from Yasawa Island, Fiji) displays involving a pentagon named "Penny". First, participants were introduced to Penny and learned that Penny is an intentional agent with the goal of getting cake. Then, participants saw a scene where Penny's path to the cake was blocked by a wall with a small gap. In one condition (the near-eyes condition), Penny moves toward a triangle standing motionless and stops. The eyes disappear from the pentagon and reappear on the triangle. The triangle starts moving, moving through the gap and toward the cake. In other conditions minor features of this display varied, for example in the far-eyes condition (shown to Canadian children only) Penny moved away from rather than toward a triangle. Finally, participants are asked to "point to Penny". Chudek et al. found that compared to a baseline condition, Canadian and Fijian children, and Fijian adults, were all more likely to point to the triangle than to the pentagon in the far-eyes and near-eyes conditions.

What is going on here? Consider stage magic. The whole point of stage magic is for the magician's tricks to defy the audience's intuitions about the world: the magician seems to levitate, thereby defying intuitions about support relations; he makes other persons or physical objects levitate, thereby additionally defying intuitions about contact causality; he seems to make persons or inanimate entities disappear and reappear, thereby defying intuitions about solidity and spatio-temporal continuity; or he seems to defy intuitions about psychology by acquiring information that only exists in the head of an audience member. Consider David Copperfield's levitation trick. What makes this particular trick stand out is

that the magician's assistants seem to pass hoops around the levitating magician so as to show the audience that the magician is not held by hidden wires. (In reality the magician is held by hidden wires tied to a harness and controlled by a computer, and the hoops do not actually pass around him but by a slight-of-hand touch the wires and are then rotated in the other direction.). While few adult audience members will readily say that the magician somehow defied the laws of physics, most will concede that the magician certainly made it seem as if he did. What can we conclude on the basis of this and the findings by Chudek et al.?

First, humans output multiple candidate explanations with associated probabilities for a given observation, including but not limited to stage magic and displays that come to be interpreted as mind transfer. In fact, this is likely a design feature of many cognitive mechanisms. The ToM model proposed by Leslie, Friedman, and German (2004) has at its core precisely this process of selection from among a set of candidate mental state explanations (see Wertz & German, 2007, 2013, for experimental evidence of this). Second, humans do not rule-out candidate explanations which violate physical laws. Note that this does not have to be the case, because like the android hosts in the HBO TV series Westworld, who are programmed to be unable to perceive anything that hints at the artificiality of their world, we could have evolved to be unable to articulate candidate explanations that defy our core knowledge intuitions – it is noteworthy that this is not the case. Third, by default, humans prioritize certain explanations over others, and perhaps most interestingly, humans sometimes prioritize explanations which contradict core knowledge intuitions over ones that do not.

However—and this is an important take-away—explanations are not separable from the observations they purport to explain. The finding that default explanations for stage magic, the Chudek et al. displays, or, for that matter, ecstatic motor and verbal behaviors, including ecstatic dancing and speaking in voices, that come to be interpreted as spirit possession (Cohen, 2007), contradict core knowledge intuitions, does not mean that these explanations are common, let alone default.

Moreover, while participants interpreted the Chudek et al. displays as mind transfers, a close examination of the Chudek et al. findings reveals hints that participants were not representing the mind transfers as non-physical: Canadian children were *more* likely to point to the triangle than to the pentagon (that is, to interpret the display as mind transfer) in the condition where the pentagon moved toward (near-eyes) rather than away from (far-eyes) the triangle. However, physical motion should not be computed in these scenario under the view wherein minds and mind transfer are represented without physicality information; it should be computed under the Leslie (1994; Leslie & Keeble, 1987) view wherein motion is used to decide to shunt information to the ToM mechanism (e.g. see Woodward, 1998, for a classic demonstration of the link between motion and goal inferences).

In any case, the above considerations of stage magic and the Chudek et al. study leave at least one interesting question outstanding: why should the brain be designed to output explanations which contradict core knowledge intuitions, and in fact prioritize them over explanations which do not? This design property of the human brain has been known for a long time. Aristotle advises writers of fiction that they "prefer a probable impossibility to an unconvincing possibility". As Schulz (2017) put it: "Better for Odysseus to return safely to Ithaca with the aid of ghosts, gods, sea nymphs, and a leather bag containing the wind than

for his wife, Penelope, to get bored with waiting for him, grow interested in metalworking, and abandon domestic life for a career as a blacksmith."[37]

One possibility is that counter-intuitive explanations, at least in the stage magic and Chudek et al. examples, are placeholders with predictive potential greater than that of other candidate explanations: while David Copperfield is not levitating by defying the laws of physics it sure seems like he is, and for purposes of predicting what he can and cannot do, it might be most useful to provisionally hold this explanation as true rather than weave a tangled alternative.[38] I might then, as an audience member, hold this counter-intuitive explanation as provisionally true, though unable to incorporate it into my database of beliefs as definitively true, while isolating it to this particular observation (this particular instance of levitation) rather than generalizing it ("David Copperfield can levitate") or revising my core knowledge intuitions on the basis of it ("all people can levitate" or a broader revision of the principle of support relations). Moreover, as predicted by Sperber's hypothesis of metarepresentations as adaptations for learning from others (Sperber, 1996, 1997, 2000), I should continue searching for other explanations rather than be satisfied with the counter-intuitive one.

2.4. Christian religious adherents represent God as an embodied person

Shtulman and Lindeman (2016) had participants from three samples (Finland, the US, and India) attribute properties to God (the Christian God, or, for Hindu Indians, the God that

[37] In a similar vein, an unnamed dissertation committee member finds the HBO TV series Game of Thrones unconvincing because two protagonists, a brother and sister, have an incestuous relationship, not because of the dragons, shadow assassin, humanoid ice warriors, or reanimated dead.

[38] Note also that finding these experiences attention grabbing and memorable, as we do, may be considered an extension of the Sperber (1996, 1997, 2000) and Boyer (2001) hypotheses, which refer to communicated information rather than experiences.

is most personally important to them[39]). The property types were psychological (beliefs, desires, intentions, emotions, and perceptions), and physiological (biological processes such as growth and reproduction, having bodily organs, the ability to act on the physical world such as move material objects, and having physical properties such as height and weight). In Exp. 1, Finnish participants were more likely to attribute psychological (53%) than physiological (22%) properties to God, but with significant variability within property type: for example, only 20-30% attributed God with perceptions, while 50-70% attributed God with the ability to act on the physical world. Further, psychological and physiological properties mostly clustered separately (with notable exceptions; e.g., perceptual properties other than seeing and hearing clustered with physiology), suggesting that psychology and physiology are in fact two mostly separate dimensions.

Exp. 2 (US) and 3 (India) replicated and expanded on the above, finding that participants were not only more likely to attribute psychological than physiological properties to God, they were also faster and more confident in doing so; when denying properties the reverse was found, with participants slower and less confident denying psychological than physiological properties. Notably, while US and Indian participants did not differ in the proportion of psychological properties they attributed to God, Indian participants were much more likely to attribute God with physiological properties than US participants. In sum, the Shtulman and Lindeman findings suggest that participants are mostly viewing God's psychological and physiological properties differently. But what is the cause of this?

[39] I will for convenience, despite the existence of many gods in Hindu theology, continue referring to a singular Hindu "God".

Shtulman and Lindeman hypothesize that God is intuitively represented via a disembodied mind concept, and that the physiological properties some participants attribute to God are not part of their intuitive representation of God but rather are learned. (This seems like an odd hypothesis because in mainstream Christianity what is learned it is that God *lacks* such properties.) Note that it is not clear whether Shtulman and Lindeman view persons as similarly represented via this disembodied mind concept or whether they view the disembodied mind concept as distinct from an embodied person concept. In any case, the Shtulman and Lindeman findings are similarly compatible with the alternative interpretation wherein God is initially represented via an embodied person concept, with the differences between property types, and the between-sample differences (Finland and the US versus India), explainable by different emphases in formal theologies on God's different properties.

Christian theology details in length God's psychology, primarily God's belief, desires, intentions, morality, and ability to perceive human behavior, but not God's physiology, with the exception of God's existence and God's ability to act on the physical world. In contrast, in the Hindu pantheon both the psychological and physiological properties of many gods are detailed (e.g. the elephant head of Ganesha or the four faces and arms of Brahma). The Shtulman and Lindeman findings are precisely compatible with the interpretation wherein the differences between psychological and physiological properties observed are caused by these theological emphases, as well as the differences between the Finnish and US samples on the one hand, and Indian sample on the other. Indeed, since people are capable of learning a theology, why shouldn't we expect them to respond, when asked what God is like, more or less congruently with this theology?

A close examination of the Shtulman and Lindeman findings further supports this interpretation. First, Shtulman and Lindeman compared attributions of psychology and physiology to chance (50%) and, except for the Indian sample, participants were less likely than chance to attribute physiology to God (in all samples they were more likely than chance to attribute psychology to God). However, under a disembodied mind view, why should participants attribute physiological properties (e.g. that God has bodily organs or that God has weight and height) to God at all? The more appropriate comparison may be to 0%, an attribution threshold which all properties seem to pass.

Second, in Exp. 1, there is an interaction between religiosity and attributions, such that the more religious participants are, the larger the difference between their psychological and physiological attributions (the same analyses are not reported for Exp. 2). This is compatible with the above hypothesis wherein the difference between psychological and physiological attributions is caused by a difference in theological emphases.

Third, in Exp. 2, the speeded block was followed by a block where participants were asked to attribute the same properties to God but under un-speeded conditions. While attributions between the two blocks were very similar, similarity was higher for psychology than for physiology, and further, participants who attributed physiological properties to God in the speeded block were more likely to deny them in the un-speeded block than the other way around (i.e. to initially deny physiological properties to God and then attribute them). The same was not observed for psychological properties. This is predicted by a view wherein there is more ambiguity around God's physiological than psychological properties, but it is not predicted by a view wherein God's physiology (but not psychology) is learned (under this

view, the un-speeded condition should yield more physiological attributions than the speeded conditions).

Finally, in Exp. 2, participants wrote open-ended justifications for their attributions. Psychological attributions were most commonly rationalized by mentioning God's properties or actions on the world and making further inferences from these (God-based), while physiological properties were most commonly rationalized by comparing God to persons (person-based). This is predicted by a view wherein Christian and Hindu theologies detail God's psychology and actions on the world more so than god's physiology. The Shtulman and Lindeman view may predict the opposite, wherein physiological properties, if learned, would more so than psychological properties have God-based rationalizations.

In sum, the Shtulman and Lindeman findings, which are used to argue that God is represented as a disembodied mind, are similarly if not more compatible with an alternative hypothesis wherein God is represented as both an embodied person and via learned theology which among both Christians and Hindus emphasizes god's psychology more so than God's physiology, and emphasizes God's physiology more so among Hindus than among Christians.

A different way of evaluating how religious adherents represent God, which might plausibly bypass some of the difficulties of interpreting the Shtulman and Lindeman findings, was recently used by Barlev, Mermelstein, and German (2017, Accepted, In Prep). For example, that God has beliefs or information (in Shtulman and Lindeman these are the three beliefs questions) is part of formal Christian and Hindu theologies (in Shtulman and Lindeman these are attributed to God by 70% of responders in the Finnish sample). But that God does not have all information or that God has false information are properties true of

persons but false of God, but which were not examined in Shtulman and Lindeman. By examining differences in attributions of these nuanced views of God's beliefs, Barlev et al. (2017, Accepted, In Prep) were able to make comparisons within attribution type, and via this shed further light on how God is represented in the minds of religious adherents.

Barlev et al. (2017, Accepted, In Prep) evaluated the hypothesis that in the minds of adult Christian religious adherents, representations of God are based on both core knowledge intuitions about persons and Christian theology about God. The representational co-existence hypothesis specifies that multiple conflicting representations of God are possible: God can both be conceptualized as a person and as an abstract being; this hypothesis does not yet take a position on whether different representations are implicit versus explicit (more on this distinction at the end of this section). Barlev et al. used a sentence verification task where participants responded "true" or "false" to statements that were consistent or inconsistent between core knowledge intuition about persons and acquired theology about God. For example, while infants as young as 7-months represent persons as having false beliefs (Kovács, Téglás, & Endress, 2010; also see Onishi & Baillargeon, 2005, for evidence with 15-month-old infants using a different method), the God of Christian theology does not have false beliefs. Thus, the statement "God has beliefs that are false" is true based on core knowledge intuitions about persons, but false based on Christian theology about God (inconsistent), while the statement "God has beliefs that are true" is true based on both (consistent). See Table 4.2 for sample items from Barlev, Mermelstein, and German (In Prep).

Table 2

Sample Religion Statements from Barlev, Mermelstein, and German (In Prep).

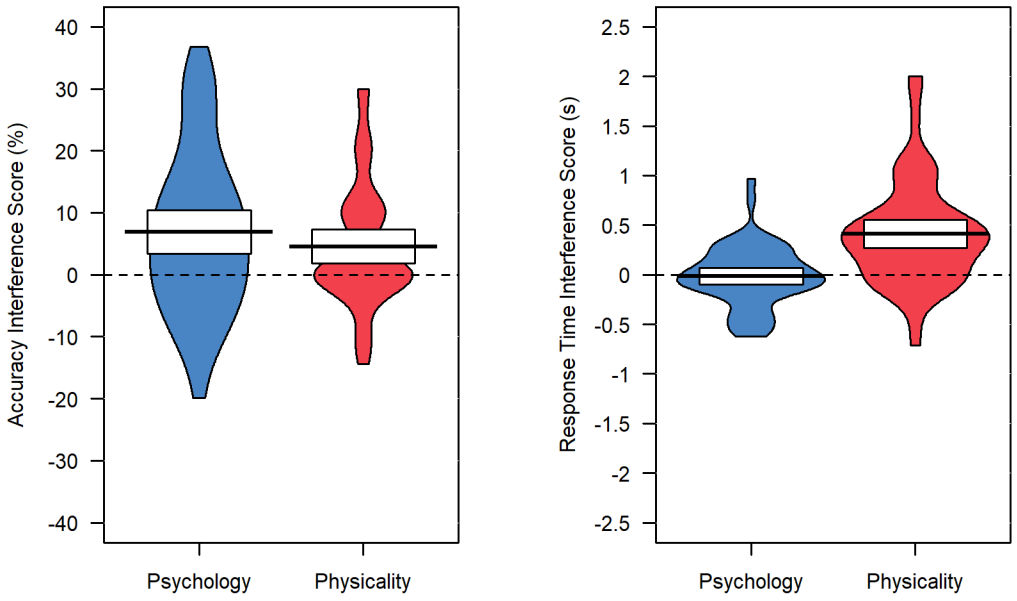
Domain	Consistency	Intuition	Theology	Item
Psychology: Beliefs	Consistent	T	T	God has true beliefs.
		F	F	All God's beliefs are false.
	Inconsistent	T	F	God has false beliefs.
		F	T	All God's beliefs are true.
Psychology: Perceptions	Consistent	T	T	God can sometimes see what I'm doing.
		F	F	God can never see what I'm doing.
	Inconsistent	T	F	Sometimes God can't see what I'm doing.
		F	T	God can always see what I'm doing.
Physicality	Consistent	T	T	God can be at my church and at other churches.
		F	F	God is never at my church or at other churches.
	Inconsistent	T	F	God is at my church when He is not at other churches.
		F	T	God is at all times at my church and at other churches.

Note. Consistent satements are true on both intuition and theology; inconsistent statements are true on one and false on the other. Statements are adapted from Barlev et al. (2017).

The logic of the sentence verification task is that if representations of God in the minds of Christian religious adherents are based on core knowledge intuitions about persons then these intuitions may interfere with Christian theology about God. Indeed, Barlev et al. repeatedly found behavioral evidence for representational interference— worse performance on inconsistent versus consistent statements (lower accuracy and higher response time). In contrast, if representations of God were solely based on Christian theology about God, then performance on inconsistent and consistent statements should have been similar (the terms "inconsistent" and "consistent", which imply two different truth values, only make sense in light of the representational co-existence hypothesis).

Barlev, Mermelstein, and German (In Prep) specifically targeted God's psychological and physical properties. The findings from Exp. 1 of this study are shown in Fig. 4.1-4.2 below. The figures present accuracy and response time differences between inconsistent and

consistent items. Critically, contrary to the hypothesis that God is represented as a disembodied person, Christian religious adherents showed worse performance on inconsistent versus consistent physicality items, as indexed by lower response accuracy (consistent – inconsistent) and higher response time (inconsistent – consistent).



As a concluding, more speculative note, in the studies by Barlev et al. on representational coexistence we tried to stay agnostic about whether different representations are implicit versus explicit and on the mechanisms by which different representations are held. I wonder, however, whether the intuitive/reflective or implicit/explicit distinctions that are commonly used in this literature may be somewhat incoherent when referencing the different representations investigated. Shtulman and Lindeman note (e.g. in Exp. 2 when discussing the similarity between their speeded and un-speeded blocks) that even under un-

speeded conditions participants may strongly deviate from formal theology. I interpret this and the substantial individual differences in the magnitude of deviations from formal theology as a property of the co-existence of multiple, conflicting representations that are not distinctly implicit versus explicit or integrated into a fully coherent concept. The behavioral indices different tasks yield may be characterized as implicit versus explicit—for example, response time is a candidate for an implicit measure—but it is not obvious that representations can be characterized as such. Indeed, if formal theology was explicit and everything else implicit (whether a disembodied mind or an embodied person concept) then we would expect religious adherents to always respond in accordance with theology on explicit tasks, including always denying God person-like psychological properties, but this is not the case in Shtulman and Lindeman or the studies by Barlev et al.

2.5. On Mind-less Bodies, Intentional Agents, and Autism Spectrum Disorders

The converse to disembodied beings are mind-less bodies. Bloom (2005) claims that beliefs in mind-less bodies such as Haitian zombies and the Golem in Jewish folklore are a by-product of default Cartesian dualism. However, here I argue that the Golem and Haitian zombies are likely not represented as mind-less bodies at all: only very minimal morphological or behavioral cues are required for a physical entity to be categorized as an intentional agent, such that the Golem and Haitian zombies are likely attributed with intentionality. Moreover, historical and ethnographic evidence does not support the claim that the Golem and Haitian zombies are mind-less.

We automatically categorize physical entities as intentional agents via relatively minimal morphological and/or behavioral cues. For example, infants ascribe goals to human

hands but not to rods (e.g. Woodward, 1998). The classic study by Heider and Simmel (1944) showed that adults ascribe intentionality to geometric figures lacking human morphology but exhibiting human behavioral cues. Later studies with adults (Berry, Misovich, Kean, & Baron, 1992) and preschool children (Berry & Springer, 1993) confirmed that these ascriptions are due to human behavioral cues rather than morphological such as size and shape. The minimal behavioral cues required for an entity to be categorized as an intentional agent are difficult to isolate in Heider and Simmel. The geometric figures in Heider and Simmel displayed several candidate cues: repeated self-generated movement, changes in speed and direction of movement, as well as contingent interaction with each other and with the inanimate entities onscreen (see also Johnson, Slaughter, & Carey, 1998) and dispositional states (see also Kuhlmeier, Wynn, Bloom, 2003).

A few recent studies by Schlottman and colleagues have addressed what some of these minimal behavioral cues are by showing that infants ascribe intentionality to stimuli such as a two-dimensional square moving in a non-rigid, rhythmic manner (Schlottman & Surian, 1999; Schlottman, Surian, & Ray, 2009; Schlottman & Ray, 2010; also see Michotte, 1963).[40]

A notable exception to the above might be individuals with Autism Spectrum Disorder (ASD). Baron-Cohen, Leslie and Frith (1985) argued that ASD individuals may have a dysfunctional Theory of Mind mechanism and are unable to represent the mental

[40] The square was displayed moving like a caterpillar with two anchoring points, first expanding half its body as it progressed forward, and then contracting the other half. For example, Schlottman and Ray (2010) found that 6-month-olds ascribed goals to this pattern of motion, but not to one displaying repeated self-generated movement or an equivalent amount of deformation but in a direction perpendicular to the direction of motion. Interestingly, the authors suggest that rather than responding to abstract behavioral cues, infants have innate knowledge of different kinds of biological motion: this two-anchor, caterpillar-like motion is different from the human motion infants encounter in their environment, and is therefore not likely to have be learned.

states of others via this mechanism (also see Baron-Cohen, 1997). Klin (2000) administered the Heider and Simmel (1944) task to high-functioning ASD individuals, finding a significant decrease in attributions of mental states to the geometric figures among ASD individuals compared to neurotypical individuals; a variety of other deficits in ASD individuals strongly suggestive of an absence of intuitive mental state attributions has been documented (e.g. Senju, Southgate, White, & Frith, 2009).

In any case, given the evidence presented above on the automatic categorization as intentional agents (i.e., the attribution of minds) of physical entities exhibiting the requisite behavioral or morphological cues, it is highly unlikely that neurotypical individuals categorize entities such as Haitian zombies and the Golem as mind-less. Rather, as suggested by ethnographic findings, these entities are attributed with intentionality, albeit perhaps a subservient one. For example, in Davis (2010) Haitian zombies are not described as mind-less, but as subservient to their masters; they are still able to fulfill tasks assigned to them, that is, they can still act to achieve specific goals, even if the goals are their masters'. The Golem in Jewish folklore is similarly described as created by Rabbi Loew with the specific goal of protecting the Jews of Prague; problems arise when the actions the Golem takes to achieve this goal become destructive.

3. Discussion

The present paper lays out a deflationary view of the intuitive mind-body dualism hypothesis (e.g. Bloom, 2005, 2007; Forstmann & Burgmer, 2017), and the hypothesis that it is this intuition that is at the heart of more elaborated beliefs in disembodied beings (e.g.,

possessing spirits, the Christian God) and mind-less bodies. Indeed, the present paper argues that, contra (Bloom, 2005), mind-less bodies such as the Golem in Jewish folklore and Haitian zombies are not represented as mind-less at all. Instead, the present paper advances the non-reducibility hypothesis, according to which minds are more than, but not separate from, bodies. That is, in representations of persons, ToM and naïve physics (and ToBy) are functionally integrated with one another, but the outputs of these mechanisms are not representationally or phenomenologically reducible to one other. Note that while my concern here was with the non-reducibility of ToM and naïve physics, intuitive or phenomenological non-reducibility is likely a property of many different mechanisms, including functionally integrated ones (representational non-reducibility is implied by the notion of functional specialization).

In light of the above, how, then, is the cross-cultural and historical ubiquity of beliefs in disembodied beings explained? A partial answer is given by the cognitive optimum hypothesis: Boyer (1994a,b; 2001; Boyer & Ramble, 2001) proposed that beliefs in disembodied beings are cultural attractors – that is, transmitted cultural representations across different human groups converge on these beliefs – because they are inconsistent with core knowledge intuitions. Note that while intuitive Cartesian dualism suggests that beliefs in disembodied beings are ubiquitous because they're natural, the cognitive optimum theory suggests that they are ubiquitous exactly because they are un-natural.

Sperber and colleagues (Sperber, 1985, 1996, 1997, 2000; Mercier & Sperber, 2009 theorized that acquired information that is inconsistent with preexisting beliefs (stored in a so-called database of beliefs) is quarantined in a specialized meta-representational "bubble". For example, the statement "there are millions of suns in the universe", learned by a child

who understands the term "Sun" to be a proper name for our Sun, will hold this information in her meta-representation mechanism until it can be reconciled with her preexisting beliefs. In this case, it might occur by revising these preexisting beliefs. The child might learn the distinction between a planet and a star, that a sun is a star at the center of a planetary system, not solely our planetary system, and that "sun" can refer to any of those stars (Sperber, 1997). According to Sperber and colleagues, when information is held in the meta-representation mechanism we preferentially attend to and remember this information, and are motivated to talk about it with others so as to collect more information about it, so as to reconcile it with our preexisting beliefs. In the process of talking about it we transmit it broadly.

However, what if the statement the child learns is "the Father, the Son, and the Holy Ghost are one"? In this case, Sperber (1997) argues, this information is inconsistent with core knowledge intuitions, and since these cannot be revised the learned information and core knowledge intuitions cannot be reconciled. The learned information ("the Father, the Son, and the Holy Ghost are one") thus maintains its preferential transmission potential, spreading more broadly than information that becomes incorporated into the database of beliefs.

Boyer points out that many religious concepts, concepts about disembodied beings included (e.g. the Christian God), are inconsistent with core knowledge intuitions and are therefore cultural attractors in this way. For example, the omniscient, omnipotent, omnipresent, and incorporeal God of Christian theology activates a person concept (thereby supporting many inferences about God), but is inconsistent with core knowledge intuitions about the psychology, biology, and/or physicality of persons.[41] Thus, out of the possible set

[41] A further prediction of the cognitive optimum theory is that religious concepts will be minimally counter-intuitive, that is, that they will not contain too many inconsistencies with core knowledge intuitions.

of religious concepts which could exist across different human groups, only a relatively circumscribed set actually does exist, and the cognitive optimum hypothesis at least partially explains this historical and cross-cultural similarity.

The Christian God concept does not seem to fit this prediction. Why? First, it is important to distinguish between the concept as it is represented in formal theology, and the concept as it is represented in human minds, the latter showing fewer inconsistencies with core knowledge than the former (e.g. Barlev et al., 2017; Accepted, In Prep). Second, this prediction is motivated by a consideration of the limits of human memory – that a concept with too many features that need to be held in the meta-representation mechanism will be easier to forget (it is not clear from Boyer's hypothesis whether the entire concept or only certain features will be forgotten). But with the advent of public representation technologies such as writing it is possible to form concepts which, at least as they are publically represented, are no longer merely minimally counter-intuitive.

CHAPTER 5

Christian religious adherents represent God as an embodied person, not a disembodied mind

1. Introduction

The hypothesis advanced by Bloom (2005) in *Descartes' Baby*, which has become quite influential in cognitive developmental psychology and in the psychology of religion, posits that mechanisms for representing the mental states of intentional agents on the one hand, and physical entities and their spatio-temporal properties on the other, are not functionally integrated. As a consequence, it posits, persons are intuitively represented as disembodied minds (also see e.g. Bloom, 2007; Forstmann & Burgmer, 2015; 2017; Hood, Gjersoe, & Bloom, 2012; Kuhlmeier, Bloom, & Wynn, 2004; Shtulman & Lindeman, 2016). Bloom further proposes that around these dualistic intuitions form more elaborated beliefs, such as beliefs about disembodied beings like animistic spirits, ancestor spirits, possessing spirits, demons, and gods, and therein is the cross-cultural and historical ubiquity of these beliefs.

I critically evaluated the intuitive mind-body dualism hypothesis and empirical evidence purporting to support it in the previous chapter, so I will do so here only briefly. First, there are serious problems with the study by Kuhlmeier, Bloom, and Wynn (2004) purporting to show that infants do not intuitively represent persons as physical entities. Critically, Kuhlmeier et al. did not control for a variety of alternative explanations for their findings (see Rakison & Cicchino, 2004, and Saxe, Tzelnic, & Carey, 2006), including the

straightforward possibility of a false negative (the argument in Kuhlmeier et al. is based on a failure to reject the null). A more controlled study by Saxe, Tzelnic, and Carey (2006) found that infants do intuitively represent persons as physical entities.

Second, a recent study by Chudek, McNamara, Birch, Bloom, and Henrich (2017) purporting to show that children and adults find it intuitive that minds can move from body to body is better understood as showing that, under certain conditions, events are explained as mind transfer events; however, this does not mean that mind transfer is intuitive, only that under certain conditions it is prioritized over other candidate explanations. I illustrated this in the previous chapter using the example of stage magic. The whole point of stage magic is to provoke in the minds of audience members explanations for observed events which are incompatible with core knowledge intuitions; indeed, in stage magic we could find examples of events incompatible with every documented core knowledge intuition, including about physical entities and their spatio-temporal mechanics, and about the addition and subtraction of small numbers of objects (e.g. Wynn, 1992). However, we should not on these grounds overturn our theory of core knowledge (or of the physicality of persons); rather, this phenomenon of explanatory prioritization, already documented for mental state attributions (Wertz & German, 2007, 2012; also see Leslie, Friedman, & German, 2004), should be studied in its own right.

Third, the studies by Forstmann and Burgmer (2015; 2017), Hood, Gjersoe, and Bloom (2012), and others (e.g. Cohen & Barrett, 2008a,b; Cohen, Burdett, Knight, & Barrett, 2011), purporting to show that minds are intuitively conceptualized as *separate from* bodies are better understood as showing that minds are intuitively conceptualized as *more than* or as *non-reducible to* bodies, but still functionally integrated with bodies. I extensively discussed

this alternative, which I termed the intuitive non-reducibility hypothesis, in the previous chapter. I additionally articulated the adaptationist logic that I propose underlies our evolved person concept, which coheres with the intuitive non-reducibility hypothesis but not with mind-body dualism.

The aim of the present study is to experimentally evaluate the mind-body dualism hypothesis, in part in light of recent findings by Shtulman and Lindeman (2016). Shtulman and Lindeman found that participants were more likely to attribute psychological rather than physiological characteristics to God (Exp. 1-3) and were faster and more confident doing so (Exp. 2-3). Shtulman and Lindeman concluded on the basis of this that in adults, representations of God are not based on an embodied person concept, but on a disembodied mind concept. However, if we consider that formal theology emphasizes God's psychological characteristics more so than God's physiological characteristics, why should we expect psychological and physiological characteristics to be attributed to God equally? The Shtulman and Lindeman findings may be better interpreted via the representational co-existence of acquired formal theology and core knowledge intuitions about embodied persons (Barlev, Mermelstein, & German, 2017; Under Review; Shtulman & Harrington, 2016; Shtulman & Valcarcel, 2012).

Barlev, Mermelstein, and German (2017; Under Review) evaluated the hypothesis that in the minds of adult Christian religious adherents, representations of God based on core knowledge intuitions about persons, specifically person psychology, co-exist alongside acquired theology about God. Barlev et al. used a sentence verification task where participants responded "true" or "false" to statements that were consistent or inconsistent between core knowledge intuition about persons and acquired theology about God. For

example, while infants as young as 7-months represent persons as having false beliefs (Kovács, Téglás, & Endress, 2010; also see Onishi & Baillargeon, 2005; for evidence with 15-month-old infants using a different method), the God of Christian theology does not have false beliefs; thus, the statement "God has beliefs that are false" is true based on core knowledge intuitions about persons, but false based on acquired theology about God (inconsistent), while the statement "God has beliefs that are true" is true based on both (consistent).

The logic of the sentence verification task is that if representations of God in the minds of Christian religious adherents are based on core knowledge intuitions about persons then these intuitions may interfere with acquired Christian theology about God. Barlev et al. (2017) found behavioral evidence for this representational interference: worse performance on inconsistent versus consistent statement (lower accuracy and slower response time). In contrast, if representations of God were solely based on acquired theology about God (that is, if core knowledge intuitions did not exist or were not used to form the God concept), then performance on inconsistent and consistent statements should have been similar.

The present study uses the same sentence verification task as Barlev et al. but with the addition of statements that target God's physicality. The primary question the present study aims to answer is whether the Christian God is represented as an embodied person (as opposed to a disembodied mind). If God is represented as an embodied person, then Christian religious adherents will show representational interference on statements targeting God's physicality (as well as psychology), with lower accuracy and slower response times when acquired Christian theology and core knowledge intuitions about embodied persons are inconsistent versus consistent.

The present study additionally aims to answer the following secondary question: is response interference magnified under cognitive load? The findings of Barlev et al. (Exp. 2) regarding this question were inconclusive. Sperber and colleagues (Sperber, 1985, 1996, 1997, 2000; Mercier & Sperber, 2009) hypothesized that acquired representations that are inconsistent with core knowledge intuitions are quarantined in a specialized meta-representational "bubble". In contrast to core knowledge intuitions, which can be accessed unconsciously and spontaneously, meta-representations can only be accessed consciously (for a related discussion of dual-process theory, see Evans, 2003, 2008; Evans & Stanovich, 2013; also see Mercier & Sperber, 2011). The hypothesis of Sperber and colleagues predicts that the utilization of acquired beliefs that are inconsistent with core knowledge intuitions (versus acquired beliefs that are consistent with them) should be more dependent on executive function resources and therefore differentially influenced by cognitive load.

2. Methods

2.1. Participants

2.1.1. Experiment 1

Participants were Christian religious adherents recruited from the Psychological & Brain Sciences Department Subject Pool at the University of California, Santa Barbara, to fulfill course requirements. Participants were prescreened to have grown up with, and currently identify with, a Christian religious tradition, and to identify as at least slightly religious and slightly spiritual. One participant was excluded for identifying with a non-

mainstream Christian religious tradition, and three participants were excluded for having religion Sentence Verification Task scores at or below 50% (which may be a sign of adhering to non-mainstream theological doctrines).[42]

The final sample of N = 118 (78% F) had a mean age of 19 (range 18 – 24). Participants identified as Hispanic or Latino (46%), White (26%), East, Southeast, or South Asian (15%), Black (5%), or as another race or ethnicity (7%). The majority of participants identified as Roman Catholic (60%), with the remainder mostly identifying with a variety of Protestant religious denominations including 20% who simply identified as "Christian"[43]. Ninety seven percent currently identified with the religious tradition with which they grew up (the exception being participants who formerly identified as Roman Catholic and now identified as "Christian"). Finally, on a scale of 0 = Not at all to 100 = Very, participants identified as M = 64 (SD = 20) on religiosity and M = 67 (SD = 22) on spirituality.

2.1.2. Experiment 2

Participants were Christian religious adherents recruited from Amazon Mechanical Turk and paid $2.00 for their participation. Participants were prescreened using the same criteria as in Exp. 1, except for a stricter prescreening of religious identification: only Catholics and Protestants were allowed to participate. Participants were assigned to one of three cognitive load conditions: Baseline (no response window; n = 37), Slow (1,000 ms per

[42] If the scores were equal to or slightly larger than 50% one-sample t-tests were used to confirm that they were not statistically different from 50%. This exclusion strategy is conservative in that it assigns equal weight to consistent and inconsistent items.

[43] In Barlev, Mermelstein, and German (2017), the majority of participants recruited from this subject pool who identified as "Christian" reported being affiliated with the local Charismatic church (Evangelical Christians usually identify themselves a simply "Christian"); it is quite likely, then, that the majority of these participants are Evangelical Christians.

word response window; n = 24), and Fast (500 ms per word response window; n = 31). (Because of experimenter error, data for the baseline condition were collected after the Slow and Fast conditions; participants were assigned to the Slow and Fast conditions randomly.) Six participants were excluded for having religion Sentence Verification Task scores at or below 50% (3 each in the Slow and Fast conditions), and 2 participants in the Fast condition were removed for having 100% time-outs (suggesting that they did not actually take the task).

The final sample of N = 92 (63% F) had a mean age of 43 (range 25 – 81). Participants identified as White (76%), Black (12%), Hispanic or Latino (4%), or as another race or ethnicity (8%). Participants identified as Roman Catholic (44%), Evangelical (37%), or with a variety of non-Evangelical Protestant religious denominations (20%). Eighty eight percent currently identified with the religious tradition with which they grew up. Finally, on a scale of 0 = Not at all to 100 = Very, participants identified as M = 70 (SD = 21) on religiosity and M = 76 (SD = 19) on spirituality.

2.2. Design

The independent variables are psychology versus physicality statements. The dependent variables are interference scores for accuracy and response time.

2.3. Materials

Statements about the psychological (beliefs and perceptions, each n = 20) and physical (n = 20) characteristics of God were constructed in quartets, with each quartet concerning a particular theological doctrine (e.g., infallibility, omnipresence, or

incorporeality). In each quartet there was a pair of **consistent** statements (true according to both intuitions about persons and Christian theology about God, or false according to both) and a pair of **inconsistent** statements (true intuitively but false theologically, or false intuitively but true theologically). Additionally, statements (n = 64) concerning mathematics and science (from Shtulman & Valcarcel, 2012) were added as distractors. We do not present analyses of this data here.

Thus, within each quartet there were two true and two false statements according to Christian theology. The four statements within each quartet were further balanced in terms of overall sentence structure, complexity, and length in words. Compared to our previous studies we eased the requirement that the number of words per statement be equal within each quartet to instead emphasize conceptual clarity and reading clarity.

Accuracy and response time interference scores were calculated as the mean difference between consistent and inconsistent statements, such that performance on consistent statements was a baseline with which performance on inconsistent statements was compared. Thus, accuracy and response time interference scores different from zero can be interpreted as the presence of response interference, and scores higher than zero can be interpreted as worse performance (lower accuracy and higher response time) on inconsistent than on consistent statements.

Lastly, participants took a survey which included demographic questions, indices of explicit beliefs about God, a 30-item theological expertise scale constructed with extensive feedback from a professor of Religious Studies specializing in the history of Christianity and from a Catholic priest, and the 24-item Christian Orthodoxy Scale (Fullerton & Hunsberger, 1982). We do not present analyses of the TES and COS here.

2.4. Procedure

Participants in Exp. 1 were tested in semi-private computer stations in an experimental psychology laboratory, while participants in Exp. 2 were tested online. The experiment lasted 20 to 30 minutes.

Statements were presented one-by-one and in a randomized order (using Inquisit software), and responses were collected via key presses; participants were instructed to respond with their dominant hand, and whether the index or ring finger was used to respond "true" or "false" was randomized between participants. The instructions to the sentence verification task emphasized both response accuracy and time.

3. Results and Discussion

All analyses were performed using JASP 0.8.1.2. The data analysis strategy was as follows: First, data points that were above or below 3SD from the mean response time of each statements were removed (about 2% of data points). Second, response time interference scores were calculated using both correct and incorrect responses. Third, for simplicity, only analyses on interference scores are reported, however, the findings are the same if consistent and inconsistent statements are analyzed separately, that is, without calculating interference scores, using a Bayesian repeated-measures Analysis of Variance.

3.1. Experiment 1

The full list of items along with accuracy and response time data are displayed in Tables 1-2.

Table 1

Psychology Items Accuracy and Response Time Data.

					Mean Accuracy (%)		Mean RT (ms)	
Subtype	Consistency	Intuition	Theology	Item	Per Item	Per Pair	Per Item	Per Pair
Beliefs	Consistent	T	T	God has true beliefs.	0.91	0.94	1650	1766
		F	F	All God's beliefs are false.	0.96		1882	
	Inconsistent	T	F	God has false beliefs.	0.91	0.84	1753	1794
		F	T	All God's beliefs are true.	0.78		1835	
Beliefs	Consistent	T	T	God can know what I want even if I don't tell Him.	0.89	0.93	3551	3829
		F	F	God won't know anything I want even if I tell Him.	0.96		4107	
	Inconsistent	T	F	God can know everything I want only if I tell Him.	0.73	0.77	3500	3253
		F	T	God knows everything I want even if I don't tell Him.	0.82		3007	
Beliefs	Consistent	T	T	God and doctors both know about medicine.	0.80	0.89	2697	2701
		F	F	Neither God nor doctors know about medicine.	0.98		2706	
	Inconsistent	T	F	Doctors know more about medicine than God.	0.70	0.66	2814	2748
		F	T	God knows more about medicine than doctors.	0.61		2681	
Beliefs	Consistent	T	T	God can know where people were born.	0.96	0.95	2136	2083
		F	F	God doesn't know where anyone was born.	0.94		2030	
	Inconsistent	T	F	God only knows where some people were born.	0.91	0.91	2420	2144
		F	T	God knows where everyone was born.	0.91		1869	
Beliefs	Consistent	T	T	God knows about past events.	0.98	0.99	1481	1869
		F	F	God doesn't know about any past events.	1.00		2258	
	Inconsistent	T	F	God only knows about some past events.	0.94	0.94	2078	1983
		F	T	God knows about all past events.	0.95		1887	
Perceptions	Consistent	T	T	God can sometimes see what I'm doing.	0.69	0.83	2072	2002
		F	F	God can never see what I'm doing.	0.96		1931	
	Inconsistent	T	F	Sometimes God can't see what I'm doing.	0.98	0.98	1989	1854
		F	T	God can always see what I'm doing.	0.98		1720	
Perceptions	Consistent	T	T	God can sometimes hear what I'm saying.	0.73	0.85	2222	2134
		F	F	God can never hear what I'm saying.	0.96		2046	
	Inconsistent	T	F	Sometimes God can't hear what I'm saying.	0.95	0.93	2148	2015
		F	T	God can always hear what I'm saying.	0.91		1881	
Perceptions	Consistent	T	T	God can listen to people's prayers.	0.95	0.95	1766	1886
		F	F	God can't listen to people's prayers.	0.96		2005	
	Inconsistent	T	F	God listens to people's prayers one at a time.	0.51	0.71	3044	2798
		F	T	God listens to all people's prayers at once.	0.91		2553	
Perceptions	Consistent	T	T	At any given moment God can see what people are doing.	0.93	0.95	2678	2938
		F	F	At any given moment God cannot see what anyone is doing.	0.96		3198	
	Inconsistent	T	F	At any given moment God only sees what some people are doing.	0.80	0.89	3257	2885
		F	T	At any given moment God sees what everyone is doing.	0.98		2513	
Perceptions	Consistent	T	T	On any given day God can listen to people's prayers.	0.98	0.95	2803	3181
		F	F	On any given day God cannot listen to anyone's prayers.	0.91		3558	
	Inconsistent	T	F	In a single day God only listens to some people's prayers.	0.85	0.90	2903	2730
		F	T	In a single day God listens to everyone's prayers.	0.95		2557	

Table 2

Physicality Items Accuracy and Response Time Data.

				Mean Accuracy (%)		Mean RT (ms)	
Consistency	Intuition	Theology	Item	Per Item	Per Pair	Per Item	Per Pair
Consistent	T	T	God can be at my church and at other churches.	0.96	0.98	2226	2178
	F	F	God is never at my church or at other churches.	1.00		2130	
Inconsistent	T	F	God is at my church when He is not at other churches.	0.87	0.93	4051	3600
	F	T	God is at all times at my church and at other churches.	0.98		3149	
Consistent	T	T	God can act on different objects at different times.	0.98	0.95	2573	2719
	F	F	God can't act on any object at any time.	0.93		2865	
Inconsistent	T	F	God can only act on some objects at a time.	0.82	0.86	3001	2855
	F	T	God can act on all objects at the same time.	0.91		2709	
Consistent	T	T	God can be in different places at different times.	0.96	0.97	1741	2267
	F	F	God can't be in any place at any time.	0.98		2794	
Inconsistent	T	F	God can only be in one place at a time.	0.98	0.98	2062	2416
	F	T	God can be in every place at the same time.	0.98		2770	
Consistent	T	T	God can occupy the physical space next to me.	0.84	0.85	2266	2686
	F	F	God can't occupy the physical space next to me.	0.85		3107	
Inconsistent	T	F	God can't occupy the exact physical space that I do.	0.76	0.77	3105	2915
	F	T	God can occupy the exact physical space that I do.	0.78		2725	
Consistent	T	T	God can occupy the physical space inside a cloud.	0.73	0.78	2722	3058
	F	F	God can never occupy the physical space inside a cloud.	0.83		3395	
Inconsistent	T	F	God can never occupy the physical space inside a boulder.	0.85	0.75	3320	3260
	F	T	God can occupy the physical space inside a boulder.	0.64		3201	

3.1.1. Evidence of response interference from an embodied person concept

Bayesian one-sample t-tests showed that for physicality items, the hypothesis that interference scores are different from zero was 19.95 times more likely than the null for accuracy, and > 300 times more likely for response time. The hypothesis that interference scores for psychology items are different from zero was supported for accuracy (BF_{10} = 102.27), but not for response time (BF_{10} = 0.16 or BF_{01} = 6.36), thereby only partially replicating our past findings on this (Barlev et al., 2017, and Barlev et al., Accepted). See Fig. 1 for pirate plots.

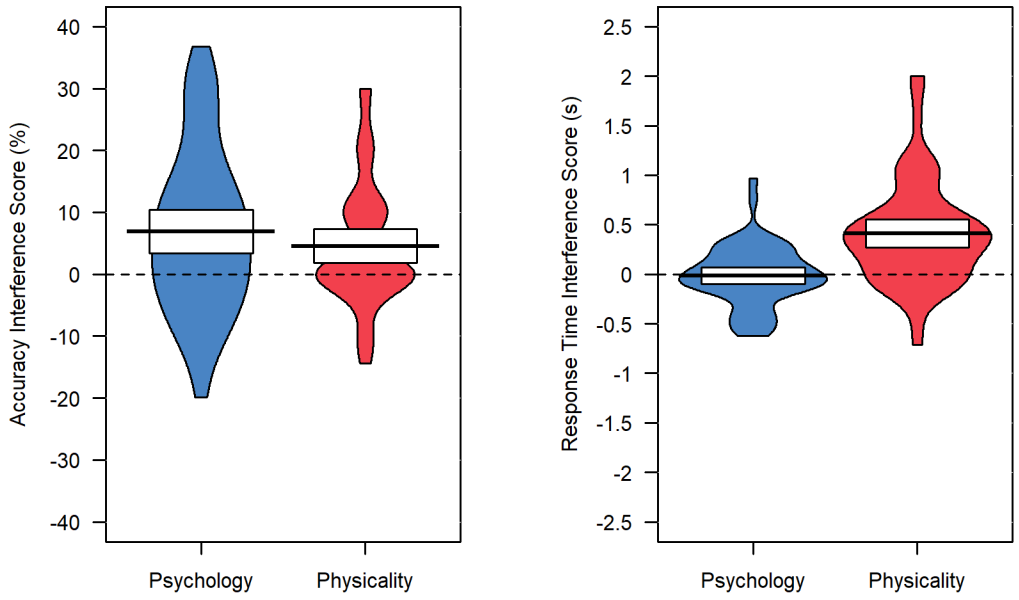


Fig 1. Pirate plots of mean accuracy (%) and response time (s) interference scores on psychology and physicality items. The inference bands correspond to the 95% confidence intervals.

Additional Bayesian paired-samples t-tests found no difference between accuracy interference scores on physicality and psychology items (BF_{10} = 0.29 or BF_{01} = 3.41), but physicality items had larger response time interference scores than psychology items (BF_{10} > 300).

3.2. Experiment 2

The analyses reported here marked timed-out responses as incorrect; excluding them from analysis yields identical results. Additionally, because there were only very few time-

outs (none in the Slow condition, and 4.60% in the Fast condition), response time data for the Slow and Fast conditions is displayed. However, this data should be interpreted with caution because the upper limit of this data is artificially truncated.

3.2.1. Evidence of response interference from an embodied person concept

Bayesian one-sample t-tests showed that for physicality items, the hypothesis that response accuracy and time interference scores are different from zero was supported in the Baseline and Slow conditions, and partially supported in the Fast condition. In the Baseline condition, the experimental hypothesis was 7.69 (accuracy) and > 300 (response time) more likely than the null; in the Slow condition it was 9.18 (accuracy) and 13.01 (response time) more likely than the null; and in the Fast condition it was 0.46 (accuracy) and 9.90 (response time) more likely than the null.

The hypothesis that interference scores for psychology items are different from zero was for the most part not supported. In the Baseline condition, the experimental hypothesis was .52 (accuracy) and 0.38 (response time) more likely than the null; in the Slow condition it was 0.39 (accuracy) and 0.41 (response time) more likely than the null; and in the Fast condition it was 0.46 (accuracy) and 9.90 (response time) more likely than the null. See Fig. 2.

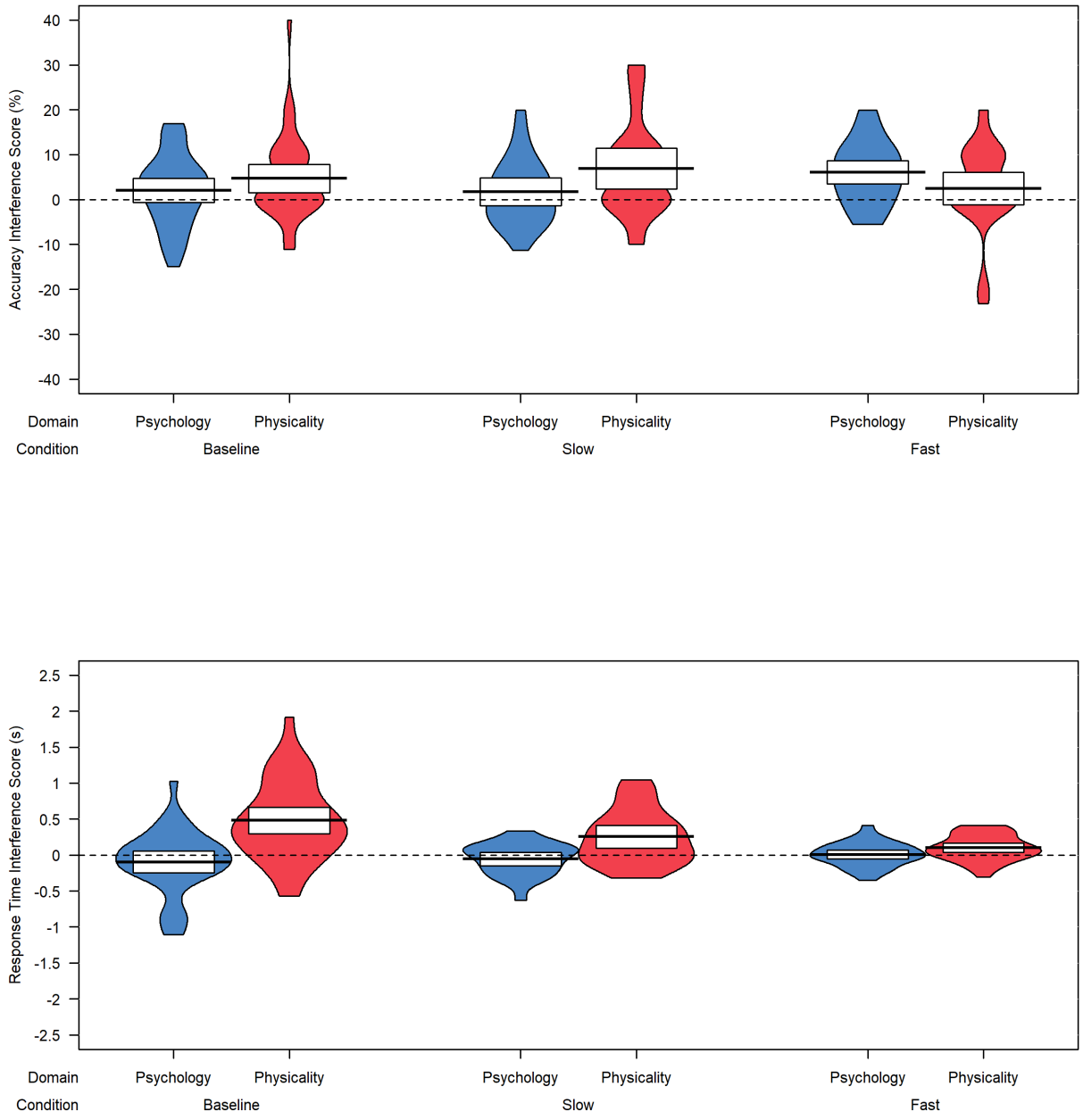


Fig 2. Pirate plots of mean accuracy (%) and response time (s) interference scores on psychology and physicality items for the three cognitive load conditions. Baseline (no time limit), Slow (1s per word), and Fast (.5s per word). The inference bands correspond to the 95% confidence intervals.

3.2.2. No evidence that response interference is magnified under cognitive load

Bayesian one-way ANOVAs found no support for the hypothesis that accuracy interference varied with the cognitive load manipulation (psychology: BF_{10} = 1.17; physicality: BF_{10} = 0.28). The results for response time interference were mixed (psychology: BF_{10} = 0.20; physicality: BF_{10} = 30.50), however, the pattern is the opposite of that predicted (lower response time interference in the Fast condition than the Baseline and Slow conditions) and is likely due to an artificial truncation of response times by the cognitive load manipulation used here.

4. Conclusions

The primary question the present study aimed to answer was whether the Christian God is represented as an embodied rather than a disembodied person (e.g. Bloom, 2005; Shtulman & Lindeman, 2016). The method used was a sentence verification task previously used by Barlev, Mermelstein, and German (2017; Under Review) to test representations of God's psychology, modified in the present study to additionally test representations of God's physicality. In two samples of Christian religious adherents (recruited via a university undergraduate subject pool or Amazon Mechanical Turk), task performance revealed evidence of conflict or interference between an acquired Christian theological representation of God and an embodied person concept: in Exp. 1 and in the Baseline and Slow conditions of Exp. 2 accuracy and response time were worse on statements where theological representations of God and an embodied person concept were inconsistent (e.g. "God is at my church when He is not at other churches") than on statements where they were consistent (e.g. "God can be at my church and at other churches"). The hypothesis wherein God is

represented as a disembodied person predicts no accuracy or response time differences, and was therefore not supported.

However, in contrast to the above findings on (embodied) person concept physicality, the present study only partially replicated previous findings of interference between acquired Christian theological representations of God and person concept psychology (Barlev et al., 2017; Under Review). The accuracy findings replicated in Exp. 1 and in the Fast condition of Exp. 2, but not in the Baseline and Slow conditions of Exp. 2; the response time findings did not replicate in either experiment. Why?

The psychology statements used in the present study were modified from previous studies, and a close examination of the statement-by-statement data (Table 1) reveals a partial possible answer: there was an error in the structure of two perceptions statements from two separate quartets (though these statements were similarly constructed and the error was therefore the same): "God can sometimes see what I'm doing" and "God can sometimes hear what I'm saying". Both statements were coded as true intuitively and true theologically, but have unusually low accuracies (in Exp. 1, 69% and 73%, respectively, with similarly low accuracies in the three conditions in Exp. 2). The modifier "sometimes" in both may have been interpreted as "only sometimes" by some participants, thereby making these participants respond "false".

When data from these two quartets were excluded, Bayesian one-sample t-tests of accuracy interference scores in Exp. 2 showed very strong support for the experimental hypothesis (Baseline: BF_{10} = 40.52; Slow: BF_{10} = 16.89; Fast: BF_{10} > 300); response time interference scores, however, were still inconclusive or showed weak support for the null (Baseline: BF_{10} = 0.18; Slow: BF_{10} = 0.23; Fast: BF_{10} = .034).

The secondary question the present study aimed to answer, motivated by the theorizing of Sperber and colleagues (Sperber, 1985, 1996, 1997, 2000; Mercier & Sperber, 2009) on the meta-representational mechanism and on the related literature on dual-process theory (e.g. Mercier & Sperber, 2011), was whether response interference is magnified under cognitive load. A comparison of the three cognitive load conditions in Exp. 2 (no cognitive load baseline, Slow, and Fast) failed to find evidence in support of this.

Why did Barlev et al. (2017) find evidence that religion response interference is magnified under cognitive load (see Exp. 2) but the present study did not? A comparison of the two studies reveals two possibilities. First, Barlev et al. used shorter response windows than even the Fast condition in the present study (403ms versus 500ms on average per word). Second, rather than the blanket 500ms or 1,000ms per word cut-off used here, Barlev et al. calculated cut-offs for each statement based on reading times for that statement (range 289ms to 727ms per word). In future, response windows can be calculated in a way more similar to that used in Barlev et al., or alternatively, other cognitive load manipulations can be used (e.g., see Study 2 in Forstmann & Burgmer, 2015).

4.1. The cognitive optimum theory can explain the historical and cross-cultural ubiquity of beliefs in disembodied minds

A central advantage of the intuitive mind-body dualism hypothesis is in its purported ability to explain the historical and cross-cultural ubiquity of beliefs in disembodied beings. However, if dualistic intuitions are not attractors around which more elaborated beliefs in disembodied beings form, what are? Boyer (1994a,b; 2001; Boyer & Ramble, 2001) proposed that one such attractor is inconsistencies with core knowledge intuitions.

The motivation for this is the theorizing of Sperber and colleagues (Sperber, 1985, 1996, 1997, 2000; Mercier & Sperber, 2009) on the meta-representational mechanism. Sperber and colleagues argue that acquired information that is inconsistent with preexisting beliefs (stored in an intuitive database of beliefs) is quarantined in a specialized meta-representational "bubble". We attend to and remember this information, and are particularly motivated to talk about it, because we try to collect additional information so as to reconcile it with our preexisting beliefs. In the process of talking about it we transmit it broadly. However, if this acquired information is inconsistent with core knowledge intuitions then there is no additional information that could reconcile between the two; consequently, the meta-represented information cannot be incorporated into the intuitive database of beliefs. Thus, for as long as we hold on to this information, we continue transmitting it to others.

Boyer pointed out that in many religions, the psychology, biology, and/or physicality, of extraordinary beings is inconsistent with intuitions about persons (in Christianity, an omniscient, omnipotent, omnipresent, and incorporeal God is inconsistent with all three). Indeed, while intuitive mind-body dualism suggests that beliefs in disembodied minds are ubiquitous because they are a natural way in which the human mind represents intentional beings, Boyer's cognitive optimum theory suggests that these beliefs are ubiquitous because they are un-natural. The fact that sentences about God's physicality elicit speaks against the view that God is represented as a disembodied mind; it is, however, compatible with Boyer's view that God is represented as an embodied person, and that acquired Christian theology about God is inconsistent with different core knowledge intuitions, including those about physicality.

CHAPTER 6

Discussion and future directions

1. Introduction

The aim of this dissertation was to investigate how the brain builds evolutionarily new concepts, and, in the process, bring new data to bear on debates about whether learning is caused by domain-general, "blank slate" mechanisms or domain-specialized, content-rich ones (sometimes termed core knowledge mechanisms). By the domain-specialized view presented here, evolved, content-rich mechanisms scaffold learning within evolutionarily relevant domains, such as objects, their spatio-temporal properties, and physical causality (naïve physics); animals and plants (naïve biology); persons; mental states and the relationship between mental states and behavior (naïve psychology), coalitions (e.g., in-group versus out-group, physical formidability, dominance hierarchy, and cheater), and many others.

But how are concepts that were not targets of natural selection built? I argued that evolutionarily new concepts are not built out of nothing, as domain-general theories predict, but as predicted by the domain-specialized view presented here, out of representations embedded in core knowledge mechanisms. The Christian God concept, I argued, is built by using the existing person template which is subsequently elaborated to include properties attributed to God in Christian theology, including properties inconsistent with the person

template that was initially co-opted (e.g., omniscience, omnipotence, omnipresence, and incorporeality).

The primary question I investigated is whether the Christian God concept continues to engage core knowledge intuitions about persons, such that these co-exist with inconsistent acquired Christian theological representations, or whether these acquired representations disengage from core knowledge intuitions about persons. That is, it is possible that while learning evolutionarily new concepts is initially possible only through our repertoire of evolved, content-rich mechanisms, the brain also contains domain-general learning mechanisms with which we can break the chains of our evolutionary past on our modern psychology.

If the God concept continues to engage core knowledge mechanisms, then the representations generated by core knowledge mechanisms and inconsistent acquired Christian theological representations may conflict. I hypothesized that, if so, then when Christian religious adherents are asked to evaluate statements that activate conflicting representations, then these representations may interfere with each other. The co-existence hypothesis predicts, therefore, that accuracy and response time will be worse for statements that activate core knowledge mechanisms and inconsistent acquired Christian theological representations compared to statements that activate consistent acquired representations. Alternatively, if acquired representations disengage from core knowledge intuitions about persons, then there is no representational conflict – the only representations activated will be the acquired ones.

Past research has shown that science concepts that are inconsistent with core knowledge intuitions show response interference as predicted by the representational co-

existence hypothesis (e.g. Goldberg & Thompson-Schill, 2009; Shtulman & Harrington, 2016; Shtulman & Valcarcel, 2012). I argued, however, that these experiments do not provide a clean test of the co-existence hypothesis because they confound core knowledge intuitions and knowledge acquired through personal experiences. For example, the data about objects provided by one's senses is consistent with the inferences of the core object mechanism: for example, core object intuitions say that rocks are made of matter but air is not, but science says that both air and rocks are made of matter. What science says conflicts with information delivered by the core object mechanism, but what science says also conflicts with information delivered by our perceptual systems. Thus, science concepts acquired early in development could interfere with later-acquired science concepts for two distinct reasons: (1) early-acquired science concepts are based on core knowledge intuitions, and these core knowledge intuitions cannot be revised, or (2) learners have personal, perceptual experiences that are consistent with the early-acquired science concepts, and inconsistent with the later-acquired science concepts.

In Chapter 1 I argued that studies of how Christian religious adherents represent the concept of God are a cleaner test of the co-existence hypothesis. Because knowledge of God comes from other people, not from the data of one's senses, it bypasses the problem of personal experience, that is, in this case study core knowledge intuitions and perceptual experiences are not confounded. Thus, if the God concept is shown to engage representations that conflict with Christian theology about God (e.g. fallibility), then these representations must be the operation of core knowledge mechanisms rather than knowledge acquired from perceptual experiences.

In Chapter 2 I reviewed early findings on representational co-option and co-existence (Barrett & Keil, 1996; Barrett, 1998), along with more recent criticisms of them (e.g. Shtulman, 2008). I then presented data in support of representational co-option and co-existence using a novel sentence verification task methodology. Exp. 1-2 showed that Christian religious adherents performed worse on inconsistent versus consistent items (lower accuracy and higher response time), while Exp. 3 ruled-out an alternative interpretation of these findings by showing that there are no differences in performance between items when the extraordinary religious entity (God) is replaced with an ordinary one (a priest). The findings presented in Chapter 2 additionally cast doubt on the hypothesis by Barrett and colleagues that the God concept is based on an omniscient person concept (the preparedness hypothesis). In Chapter 3 (Exp. 4) I expanded on the findings of Chapter 2, showing that representational co-existence is invariant with age. Thus, core knowledge intuitions of God as a person may not be revisable even with many decades of experience with Christian theology of God as an omniscient, omnipotent, omnipresent, and incorporeal being. In Chapter 5 (Exp. 5-6) I critically evaluated the hypothesis by Bloom and colleagues that extraordinary being concepts co-opt a disembodied person concept (this so-called intuitive mind-body dualism hypothesis is extensively discussed in Chapter 4). I showed that, as hypothesized by Boyer (1994a,b; 2001; also see Barrett & Keil, 1996; Barrett, 1998), the God concept co-opts an embodied person concept, not a disembodied person concept.

2. The implications of the representational co-existence hypothesis for theories of transmitted culture

2.1. Historical and cross-cultural similarities in religious concepts and the cognitive optimum hypothesis

Under a blank slate and domain-general learning view, the set of religious concepts which could exist is infinite. In contrast to concepts of perceptible entities like rocks, trees, and animals, religious concepts such as extraordinary beings cannot be argued to be built from and stabilized by personal experiences. Because of this, there should be no historical and cross-cultural similarities between religious concepts except that caused by phylogenetic relatedness. However, under a content-rich and domain-specialized learning view of the mind, concepts, including non-perceptible ones, should be highly ordered, being scaffolded and constrained by core knowledge mechanisms. Indeed, historical and cross-cultural surveys of religious concepts find precisely this (Boyer, 1994a,b; 2001).

In a highly influential hypothesis, Boyer (2001; Boyer & Ramble, 2001) proposed that some of this order is due to the higher transmission potential of concepts that are minimally counter-intuitive. Boyer argued that concepts that engage a core knowledge mechanism while also violating a small number of core knowledge intuitions are attended to and remembered more than concepts that violate no core knowledge intuitions (or concepts that violate too many). The findings reported in Chapters 2, 3, and 5 support Boyer's cognitive optimum hypothesis because they show that, indeed, the Christian God concept contains violations of core knowledge intuitions: acquired Christian theological representations of God as omniscient, omnipotent, omnipresent, and incorporeal do not revise the core knowledge intuitions or become reconciled with them. In particular, the strongest support for this theory is in Chapter 3, which shows that representational co-existence is invariant with theological experience as indexed by age. This suggests that counter-intuitive

concepts may maintain their higher transmission potential for as long as they continue existing in an individual's mind.

3. Future directions

The argument advanced in the present dissertation is that concepts that were not targets of natural selection are built by co-opting an evolved concept. The present dissertation showed that in the minds of Christian religious adherents, the God concept co-opts the evolved person concept. A non-mutually exclusive possibility, however, is that a different concept is co-opted for at least some Christian religious adherents. Bering (2011) presents the cases of two high-functioning Autism Spectrum Disorder scientists (Temple Grandin and Edgar Schneider), neither of whom are able to conceptualize of God as an intentional agent. However, in the words of Bering, to both "God seems to be a faceless force in the universe that is directly responsible for the organization of cosmic structure—arranging matter in an orderly fashion, or 'treating' entropy—or He's been reduced to cold, rational scientific logic altogether." What concept might be co-opted here? Relatedly, Cohen (2008) suggests that possessing spirits that are believed to be the causes of illness may co-opt the evolved pathogen concept; it is further possible that in this and other instances multiple concepts (e.g. the person concept and the pathogen concept) are co-opted for building mixed representations of possessing spirits – since the present dissertation demonstrated that multiple representations can co-exist and even conflict, it seems possible that multiple distinct core knowledge representations can be engaged by the same evolutionarily new concept.

A possible extension of the research presented here is to explore the above possibilities, that concepts other than the person concept can be co-opted, for at least some people, for building representations of extraordinary beings such as God, or that extraordinary beings such as the Holy Spirit co-opt a different concept altogether. The Holy Spirit, especially among Catholics and Evangelicals, is described as consubstantial with God, that is, of one nature with God. Yet, religious adherents talk about having a personal relationship with God or with Jesus (Luhrmann, 2012), but not with the Holy Spirit. Rather, the Holy Spirit is talked about as bestowing "fruits" or "gifts" (certain personality traits), or as otherwise acting on believers by for example healing them. The prediction here is that if the Holy Spirit is not conceptualized as a person, or at least not to the same extent as God, accuracy and response time interference scores on a sentence verification task modified by replacing the word "God" with "Holy Spirit" will be lower for the Holy Spirit than for God.

4. Conclusion

What are the broader implications of these findings? The past few decades of research in cognitive development have revolutionized our understanding of the ontogeny of concepts and more broadly of the evolved design of the mind. In particular, research on language development (Pinker, 1994) and on core knowledge mechanisms (e.g. Carey, 1985; 2009), made possible by remarkable methodological advances in experimentation on pre-verbal infants, have shifted the weight of the evidence away from "blank slate" empiricism (little to no evolved mental content, with novel concepts acquired through sensori-motor experience and domain-general learning processes) toward moderate to strong nativism (evolved concepts and domain-specialized learning mechanisms).

Still, the starting point of empiricism—and a fact which nativist theories of human psychology must explain—is that we are able to learn concepts radically different from our core knowledge intuitions: concepts of very small or very large things like subatomic particles or the universe; processes on a very slow timescale (e.g. geological and evolutionary processes); abstract mathematics; and extraordinary beings like the Christian God. Maybe, then, an empiricist theorist might say, our brain contains domain-general learning processes with which we can sever the hold of our evolutionary past on our modern psychology. The findings reported here suggest that this is probably not so.

First, in the case of the Christian God concept, and perhaps in cases of evolutionarily new concepts more broadly, the brain builds evolutionarily new concepts by co-opting evolved ones. This speaks against blank slate and domain-general learning theories because, contrary to the predictions of these theories, it suggests that the brain cannot build evolutionarily new concepts out of nothing. Second, while the brain may acquire new representations about the evolutionarily new concept, including ones which conflict with the co-opted concept (e.g. that God is omniscient, omnipotent, omnipresence, and incorporeal), the co-opted concept continues to be engaged, such that the inferences it generates co-exist alongside the new representations. This further speaks against domain-general learning theories because it shows that certain reliably developing representations are not revisable, but continue to exist alongside conflicting representation; or put differently, this shows that evolutionarily new concepts cannot severe the hold of the concepts initially co-opted to build them.

Dawkins concludes The God Delusion with an optimistic question, which he leaves open: “Could we, by training and practice, emancipate ourselves from Middle World, tear off

our black burka, and achieve some sort of intuitive – as well as just mathematical – understanding of the very small, the very large, and the very fast?" (p. 420). The answer may be "no". What is certain is that the human capacity to learn concepts that were not targets of natural selection is highly constrained by ones that were.

SUPPLEMENTARY MATERIALS FOR CHAPTER 2

Religion

				M Proportion Correct		M Response Time (ms)	
Category	**Intuition**	**Reflection**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
T1	T	T	Many people around the world pray, and day after day God listens to their prayers toward Him.	0.97	0.99	2523	2862
	F	F	Many people around the world pray, and God doesn't listen to any of their prayers toward Him.	1.00		3202	
	T	F	Many people around the world pray, and in one day God listens to some of their prayers.	0.77	0.77	1824	2226
	F	T	Many people around the world pray, and in one day God listens to all of their prayers.	0.77		2629	
T2	T	T	When I say the Lord's Prayer quietly at my home, God hears it very well.	0.95	0.95	4895	4961
	F	F	When I say the Lord's Prayer quietly at my home, God has difficulty hearing it.	0.95		5027	
	T	F	When I say the Lord's Prayer on a busy street, God has difficulty hearing it.	0.90	0.91	3607	2818
	F	T	When I say the Lord's Prayer on a busy street, God hears it very well.	0.92		2030	
T3	T	T	God can be present at my church and at other churches as well.	1.00	1.00	3300	3528
	F	F	God is never present at my church, nor is He present anywhere else.	1.00		3757	
	T	F	Sometimes God is at my church, and sometimes He is at other churches.	0.82	0.89	2675	3393
	F	T	God is at all times both at my church and at other churches.	0.95		4111	
T4	T	T	God listens to people's prayers all the time.	0.90	0.95	3475	3218
	F	F	God doesn't listen to people's prayers at all.	1.00		2962	
	T	F	God listens to people's prayers one by one.	0.49	0.64	2275	2148
	F	T	God listens to people's prayers all at once.	0.79		2021	
T5	T	T	God can act on the world in various ways.	1.00	0.98	2929	2973
	F	F	God can't act on the world in any way.	0.95		3016	
	T	F	God needs a body to act on the world.	0.98	0.98	3808	3516
	F	T	God can act on the world without a body.	0.98		3225	
T6	T	T	God can see people's actions.	1.00	1.00	1886	2063
	F	F	God can't see people's actions.	1.00		2240	
	T	F	God needs eyes to see.	0.95	0.95	3217	2737
	F	T	God can see without eyes.	0.95		2256	
T7	T	T	God can see what it is I am doing.	0.98	0.98	3125	2876
	F	F	God can never see what it is I'm doing.	0.98		2627	
	T	F	God needs to look to see what I'm doing.	0.90	0.95	2346	2542
	F	T	God always sees what it is I am doing.	1.00		2738	

T8	T	T	God has beliefs that are true.	0.97	0.99	2621	2867
	F	F	All beliefs God has are false.	1.00		3114	
	T	F	God has beliefs that are false.	0.98	0.95	1881	3028
	F	T	All beliefs God has are true.	0.92		4174	
T9	T	T	God knows of various things that happened in the past.	0.97	0.99	2830	2857
	F	F	God doesn't know of things that happened in the past.	1.00		2883	
	T	F	God knows only some things that happened in the past.	0.95	0.98	2985	2806
	F	T	God knows of all things that happened in the past.	1.00		2627	
T10	T	T	God hears my prayers and the prayers of other people well.	1.00	1.00	2992	3205
	F	F	God hears my prayers worse than the prayers of other people.	1.00		3418	
	T	F	God hears my prayers better than the prayers of other people.	0.95	0.82	3042	3484
	F	T	God doesn't hear my prayers better than those of other people.	0.69		3927	
T11	T	T	God can hear what I say out loud.	0.97	0.97	2707	2648
	F	F	God can't hear what I say out loud.	0.98		2588	
	T	F	God can't hear what I say to myself.	0.95	0.96	2579	3072
	F	T	God can hear what I say to myself.	0.97		3564	
T12	T	T	God knows what I want and what I pray for.	1.00	1.00	2731	3354
	F	F	Even if I pray for it, God won't know what I want.	1.00		3976	
	T	F	God won't know what I want unless I pray for it.	0.92	0.91	4136	3708
	F	T	God will know what I want even if I don't pray for it.	0.90		3280	

Astronomy

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Planet	T	T	Planets are more massive than moons.	0.82	0.85	3366	3337
	F	F	Asteroids are more massive than planets.	0.89		3309	
	T	F	Planets are more massive than stars.	0.68	0.67	2323	3119
	F	T	Stars are more massive than planets.	0.66		3915	
Star	T	T	The sun produces light.	1.00	0.84	2236	2215
	F	F	The sun produces sound.	0.68		2195	
	T	F	The moon produces light.	0.68	0.57	2186	2760
	F	T	The sun produces gravity	0.45		3335	
Solar system	T	T	The moon revolves around the earth.	0.89	0.92	3977	3327
	F	F	The sun revolves around the moon.	0.95		2677	
	T	F	The sun revolves around the earth.	0.90	0.92	2881	2893
	F	T	The earth revolves around the sun.	0.93		2905	
Lunar phase	T	T	Phases of the moon are caused by changes in illumination.	0.35	0.64	5012	4893
	F	F	Phases of the moon are caused by clouds.	0.93		4773	
	T	F	Phases of the moon are caused by the earth's shadow.	0.47	0.62	4617	4119
	F	T	Phases of the moon are caused by the moon's orbit.	0.77		3621	
Season	T	T	A change in overall sunlight causes the seasons.	0.38	0.36	5304	4759
	F	F	The earth's rotation causes the seasons.	0.34		4213	
	T	F	The earth's distance from the sun causes the seasons.	0.48	0.67	4857	4380
	F	T	The earth's tilt causes the seasons.	0.86		3903	

Evolution

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Common Ancestry	T	T	Humans are more closely related to apes than monkeys.	0.61	0.66	4027	4309
	F	F	Whales are more closely related to plants than fish.	0.72		4592	
	T	F	Apes are more closely related to monkeys than humans.	0.23	0.46	5490	4658
	F	T	Whales are more closely related to humans than fish.	0.69		3825	
Phylogeny	T	T	Humans are descended from tree-dwelling creatures.	0.22	0.59	3979	3525
	F	F	Humans are descended from plants.	0.96		3071	
	T	F	Humans are descended from chimpanzees.	0.77	0.54	2681	3057
	F	T	Humans are descended from sea-dwelling creatures.	0.31		3433	
Variation	T	T	Evolution requires differential survival.	0.88	0.85	4209	3993
	F	F	Evolution requires climate stability.	0.82		3776	
	T	F	Evolution requires long periods of time.	0.26	0.56	2081	2936
	F	T	Evolution requires within-species variation.	0.86		3791	
Selection	T	T	Most organisms are adapted to their environment.	0.93	0.65	3503	3438
	F	F	Most organisms live in temperate climates.	0.36		3373	
	T	F	Most organisms have plenty to eat.	0.39	0.30	3504	3955
	F	T	Most organisms die before leaving offspring.	0.22		4406	
Adaptation	T	T	Biological species evolve.	0.95	0.93	2748	2614
	F	F	Inanimate objects evolve.	0.90		2479	
	T	F	Individual organisms evolve.	0.27	0.31	3724	2987
	F	T	Computer viruses evolve.	0.35		2251	

Fractions

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Addition	T	T	1/3 plus 1/3 is 2/3.	0.95	0.97	2815	2973
	F	F	1/3 plus 1/3 is 1/3.	0.98		3131	
	T	F	2/3 plus 2/4 is 2/7.	0.91	0.86	7021	5846
	F	T	1/10 plus 1/10 is 1/5.	0.82		4671	
Division	T	T	4 divided by 2/1 is 2.	0.93	0.95	4199	4021
	F	F	8 divided by 2/1 is 3.	0.98		3842	
	T	F	8 divided by 1/2 is 4.	0.83	0.71	5243	4346
	F	T	4 divided by 1/2 is 8.	0.59		3449	
Conversion	T	T	All decimals are expressible as fractions.	0.89	0.66	3293	4151
	F	F	All fractions are expressible as integers.	0.43		5009	
	T	F	All fractions are expressible as decimals.	0.02	0.48	6058	5315
	F	T	All integers are expressible as fractions.	0.93		4571	
Ordering	T	T	12/13 is greater than 1/13.	0.93	0.88	3467	3653
	F	F	1/17 is greater than 16/17.	0.84		3839	
	T	F	1/17 is greater than 1/9.	0.89	0.92	3017	3252
	F	T	1/13 is greater than 1/30.	0.96		3486	
Infinite density	T	T	There are numbers between 1 and 3.	0.89	0.87	2161	2909
	F	F	There are numbers between 10 and 10.	0.86		3657	
	T	F	There are numbers between 1/10 and 10/100.	0.50	0.70	5940	4552
	F	T	There are numbers between 1/3 and 1/2.	0.91		3163	

Genetics

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Heritalibty	T	T	Hair color is heritable.	1.00	0.98	2257	2172
	F	F	Pierced ears are heritable.	0.95		2086	
	T	F	Immunity to chickenpox is heritable.	0.73	0.71	3120	2931
	F	T	Intelligence is heritable.	0.68		2742	
Chromosome	T	T	Humans have more chromosomes than mosquitoes.	0.70	0.79	3382	3198
	F	F	Men have more chromosomes than women.	0.89		3014	
	T	F	Adults have more chromosomes than children.	0.91	0.65	3032	3898
	F	T	Skin cells have more chromosomes than egg cells.	0.39		4765	
Dominance	T	T	Two brown-eyed parents could have a brown-eyed baby.	1.00	0.63	2871	2757
	F	F	Two blue-eyed parents could have a brown-eyed baby.	0.26		2644	
	T	F	A blue-eyed baby must have two blue-eyed parents.	0.84	0.83	3478	3346
	F	T	Two brown-eyed parents could have a blue-eyed baby.	0.81		3214	
Expression	T	T	Genes that code for eye color can be found in the eye.	0.69	0.67	3802	3683
	F	F	Genes that code for eye color can be found in hair.	0.64		3563	
	T	F	Genes that code for eye color can be found in tears.	0.87	0.67	3251	3450
	F	T	Genes that code for eye color can be found in the liver.	0.48		3650	
Mutation	T	T	Radiation can change one's genome.	0.68	0.80	3294	3006
	F	F	Sunscreen can change one's genome.	0.91		2718	
	T	F	Exercise can change one's genome	0.84	0.62	2508	3050
	F	T	Viruses can change one's genome.	0.41		3591	

Germs

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Contagion	T	T	Being sneezed on can make a person sick.	0.89	0.93	2621	2631
	F	F	Being happy can make a person sick.	0.98		2640	
	T	F	Being cold can make a person sick.	0.30	0.60	2474	2873
	F	T	Being depressed can make a person sick.	0.91		3273	
Contamination	T	T	Rotting meat contains germs.	0.86	0.90	2642	2529
	F	F	Sunshine contains germs.	0.93		2415	
	T	F	Urine contains germs.	0.23	0.56	2204	2415
	F	T	Dish sponges contain germs.	0.89		2627	
Infection	T	T	Germs enter the body through cuts.	0.91	0.91	2164	2418
	F	F	Germs enter the body through the hair.	0.91		2671	
	T	F	Germs enter the body through the skin.	0.32	0.47	2633	2662
	F	T	Germs enter the body through the eyes.	0.61		2692	
Sterilization	T	T	Alcohol kills germs.	0.86	0.93	1989	2010
	F	F	Kindness kills germs.	1.00		2031	
	T	F	Water kills germs.	0.91	0.90	1950	2102
	F	T	Heat kills germs.	0.89		2255	
Microbe	T	T	Germs have a shape.	0.82	0.88	2404	1969
	F	F	Germs have feelings.	0.95		1534	
	T	F	Germs have an odor.	0.73	0.74	2311	2619
	F	T	Germs have DNA.	0.75		2928	

Matter

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Mass	T	T	Rocks are composed of matter.	0.98	0.97	2302	2699
	F	F	Numbers are composed of matter.	0.95		3097	
	T	F	Fire is composed of matter.	0.38	0.65	2889	2745
	F	T	Air is composed of matter.	0.91		2602	
Weight	T	T	A liter of water weighs more than a liter of air.	0.68	0.83	4652	4925
	F	F	A pound of steal weighs more than a ton of steal.	0.98		5199	
	T	F	A pound of steal weighs more than a pound of feathers.	0.70	0.53	3399	4484
	F	T	A liter of water weighs more than a liter of ice.	0.35		5570	
Density	T	T	Steal is denser than foam.	0.93	0.93	3259	2964
	F	F	Foam is denser than brick.	0.93		2670	
	T	F	Ice is denser than water.	0.55	0.49	4313	4579
	F	T	A cold penny is denser than a hot penny.	0.43		4846	
Divisibility	T	T	A log can be cut in half.	0.98	0.94	2433	2543
	F	F	An idea can be cut in half.	0.91		2653	
	T	F	A shadow can be cut in half.	0.95	0.95	2095	2575
	F	T	A grain of sand can be cut in half.	0.95		3054	
Atom	T	T	Atoms are the constituents of matter.	0.96	0.94	3548	3229
	F	F	Atoms are visible to the naked eye.	0.93		2910	
	T	F	Atoms are weightless.	0.93	0.74	2653	2769
	F	T	Atoms are mostly empty space.	0.54		2886	

Mechanics

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Force	T	T	Forces can be strong or weak.	0.98	0.87	2001	2030
	F	F	Forces can be male or female.	0.76		2060	
	T	F	Forces can be straight or curved.	0.43	0.65	5298	3956
	F	T	Forces can be balanced or unbalanced.	0.86		2614	
Velocity	T	T	A moving bullet loses speed.	0.87	0.88	3153	3248
	F	F	A moving bullet loses weight.	0.89		3342	
	T	F	A moving bullet loses force.	0.22	0.44	2500	2856
	F	T	A moving bullet loses height.	0.66		3212	
Acceleration	T	T	Constant acceleration requires constant force.	0.91	0.80	3950	4920
	F	F	Constant speed requires constant acceleration.	0.69		5889	
	T	F	Constant motion requires constant force.	0.49	0.42	4721	4682
	F	T	Constant force can yield constant rest.	0.34		4642	
Momentum	T	T	Momentum can be transferred from one object to another.	0.89	0.78	3636	3856
	F	F	Color can be transferred from one object to another.	0.68		4075	
	T	F	Forces can be transferred from one object to another.	0.09	0.53	4116	3638
	F	T	Energy can be transferred from one object to another.	0.98		3161	
Gravity	T	T	Anvils fall through air faster than feathers.	0.69	0.84	3218	3502
	F	F	Bright objects fall through air faster than dark objects.	1.00		3787	
	T	F	Heavy balls fall through air faster than light balls.	0.52	0.56	9594	7635
	F	T	Pointy objects fall through air faster than flat objects.	0.59		5676	

Physiology

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Life	T	T	Fish are alive.	1.00	0.93	1357	1644
	F	F	Rocks are alive.	0.87		1931	
	T	F	The sun is alive.	0.84	0.85	2097	1788
	F	T	Coral is alive.	0.87		1479	
Death	T	T	Turtles can die.	0.98	0.99	1255	1520
	F	F	Screwdrivers can die.	1.00		1786	
	T	F	Clouds can die.	0.96	0.91	1573	1660
	F	T	Mushrooms can die.	0.86		1747	
Reproduction	T	T	Tigers can reproduce.	1.00	0.99	1551	1610
	F	F	Chairs can reproduce.	0.98		1669	
	T	F	Caterpillars can reproduce.	0.18	0.51	3216	2580
	F	T	Ferns can reproduce.	0.84		1943	
Metabolism	T	T	People turn food into energy.	0.86	0.92	2356	2454
	F	F	Rocks turn food into energy.	0.98		2552	
	T	F	Plants turn food into energy.	0.27	0.42	3778	4119
	F	T	Bacteria turn food into energy.	0.57		4461	
Kinship	T	T	A baby can be a niece or a nephew.	1.00	0.86	3309	3434
	F	F	A baby can be a mother or a father.	0.73		3559	
	T	F	A baby can be identical to an older sibling.	0.80	0.81	3539	3594
	F	T	A baby can be an uncle or an aunt.	0.82		3650	

Thermodynamics

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Heat	T	T	The sun has heat.	1.00	0.96	1767	1958
	F	F	Gravity has heat.	0.91		2148	
	T	F	Atoms have heat.	0.43	0.56	2787	2952
	F	T	Ice has heat.	0.68		3117	
Heat source	T	T	Ovens produce heat.	0.98	0.93	2686	2585
	F	F	Rain produces heat.	0.89		2484	
	T	F	Coats produce heat.	0.84	0.73	2971	3210
	F	T	Pressure produces heat.	0.61		3448	
Heat transfer	T	T	Water transfers heat to ice.	0.75	0.78	5085	4816
	F	F	Cold objects transfer heat to warm objects	0.82		4546	
	T	F	Water transfers heat to steam.	0.66	0.74	5423	5500
	F	T	Cold objects transfer heat to even colder objects.	0.82		5578	
Temperature	T	T	Ice has a lower temperature than water.	0.78	0.85	3660	3962
	F	F	Steam has a lower temperature than ice.	0.93		4263	
	T	F	Two cups of ice have a lower temperature than one.	0.87	0.61	6152	5791
	F	T	Boiling water has a lower temperature than steam.	0.36		5431	
Thermal expansion	T	T	Heat increases an object's temperature.	0.98	0.89	3302	3335
	F	F	Heat increases an object's color.	0.80		3367	
	T	F	Heat increases an object's weight.	0.82	0.66	3233	3375
	F	T	Heat increases an object's size.	0.50		3518	

Waves

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Light	T	T	Rainbows contain all colors of light.	0.73	0.77	3097	3359
	F	F	Shadows contain all colors of light.	0.82		3622	
	T	F	Black objects reflect all colors of light.	0.71	0.76	3727	3391
	F	T	White light contains all colors of light.	0.82		3056	
Color	T	T	Red objects reflect red light.	0.72	0.71	3644	3684
	F	F	Red objects reflect blue light.	0.70		3724	
	T	F	Red objects absorb red light.	0.70	0.62	2840	3066
	F	T	Red objects absorb blue light.	0.55		3292	
Sound	T	T	Sounds can be loud or quiet.	0.98	0.95	2699	2795
	F	F	Sounds can be dead or alive.	0.93		2891	
	T	F	Sounds can be near or far.	0.07	0.53	6595	5205
	F	T	Sounds can be direct or reflected.	1.00		3815	
Propagation	T	T	Sound travels through air.	0.95	0.70	1823	2193
	F	F	Sound travels through foam.	0.45		2564	
	T	F	Sound travels through a vacuum.	0.66	0.68	3225	3251
	F	T	Sound travels through metal.	0.71		3277	
Reflection	T	T	Mirrors reflect light.	0.98	0.80	1827	2063
	F	F	Foam reflects sound.	0.62		2298	
	T	F	Prisms reflect light.	0.18	0.24	4647	3880
	F	T	Mirrors reflect sound.	0.30		3113	

SUPPLEMENTARY MATERIALS FOR CHAPTER 3

Religion

Category	Intuition	Reflection	Statement	M Proportion Correct		M Response Time (ms)	
				Per statement	Per type	Per statement	Per type
T1	T	T	Many people around the world pray, and day after day God listens to their prayers toward Him.	0.98	0.99	6069	5941
	F	F	Many people around the world pray, and God doesn't listen to any of their prayers toward Him.	1.00		5813	
	T	F	Many people around the world pray, and in one day God listens to some of their prayers.	0.92	0.82	6105	6713
	F	T	Many people around the world pray, and in one day God listens to all of their prayers.	0.71		7321	
T2	T	T	When I say the Lord's Prayer quietly at my home, God hears it very well.	1.00	1.00	4285	4144
	F	F	When I say the Lord's Prayer quietly at my home, God has difficulty hearing it.	1.00		4003	
	T	F	When I say the Lord's Prayer on a busy street, God has difficulty hearing it.	0.98	0.96	4113	4119
	F	T	When I say the Lord's Prayer on a busy street, God hears it very well.	0.94		4124	
T3	T	T	God can be present at my church and at other churches as well.	1.00	1.00	3990	3788
	F	F	God is never present at my church, nor is He present anywhere else.	1.00		3585	
	T	F	Sometimes God is at my church, and sometimes He is at other churches.	0.97	0.87	4553	4514
	F	T	God is at all times both at my church and at other churches.	0.77		4474	
T4	T	T	God listens to people's prayers all the time.	0.98	0.99	6070	4870
	F	F	God doesn't listen to people's prayers at all.	1.00		3669	
	T	F	God listens to people's prayers one by one.	0.97	0.95	3112	3281
	F	T	God listens to people's prayers all at once.	0.93		3450	
T5	T	T	God can act on the world in various ways.	0.99	0.99	4396	4159
	F	F	God can't act on the world in any way.	1.00		3921	
	T	F	God needs a body to act on the world.	0.94	0.76	3243	3752
	F	T	God can act on the world without a body.	0.58		4260	
T6	T	T	God can see people's actions.	0.98	0.95	5963	4815
	F	F	God can't see people's actions.	0.93		3666	
	T	F	God needs eyes to see.	0.91	0.92	4378	4404
	F	T	God can see without eyes.	0.94		4430	
T7	T	T	God can see what it is I am doing.	1.00	0.99	4248	3507
	F	F	God can never see what it is I'm doing.	0.99		2766	
	T	F	God needs to look to see what I'm doing.	0.97	0.98	3266	3264
	F	T	God always sees what it is I am doing.	0.99		3262	

T8	T	T	God has beliefs that are true.	1.00	0.96	2580	3440
	F	F	All beliefs God has are false.	0.92		4299	
	T	F	God has beliefs that are false.	0.90	0.94	3910	4426
	F	T	All beliefs God has are true.	0.98		4942	
T9	T	T	God knows of various things that happened in the past.	1.00	0.98	3475	3634
	F	F	God doesn't know of things that happened in the past.	0.97		3793	
	T	F	God knows only some things that happened in the past.	1.00	0.99	3639	3582
	F	T	God knows of all things that happened in the past.	0.99		3524	
T10	T	T	God hears my prayers and the prayers of other people well.	0.97	0.98	4222	3965
	F	F	God hears my prayers worse than the prayers of other people.	1.00		3708	
	T	F	God hears my prayers better than the prayers of other people.	0.72	0.84	4654	5652
	F	T	God doesn't hear my prayers better than those of other people.	0.95		6649	
T11	T	T	God can hear what I say out loud.	0.99	0.98	4227	3840
	F	F	God can't hear what I say out loud.	0.98		3453	
	T	F	God can't hear what I say to myself.	0.97	0.98	4560	3819
	F	T	God can hear what I say to myself.	0.98		3077	
T12	T	T	God knows what I want and what I pray for.	0.97	0.98	3422	3910
	F	F	Even if I pray for it, God won't know what I want.	1.00		4397	
	T	F	God won't know what I want unless I pray for it.	0.94	0.94	3845	4242
	F	T	God will know what I want even if I don't pray for it.	0.94		4639	

Astronomy

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Planet	T	T	Planets are more massive than moons.	0.87	0.82	5428	5377
	F	F	Asteroids are more massive than planets.	0.76		5325	
	T	F	Planets are more massive than stars.	0.73	0.72	4706	4657
	F	T	Stars are more massive than planets.	0.71		4607	
Star	T	T	The sun produces light.	0.97	0.82	2764	3666
	F	F	The sun produces sound.	0.67		4568	
	T	F	The moon produces light.	0.69	0.61	3363	3766
	F	T	The sun produces gravity	0.52		4169	
Solar system	T	T	The moon revolves around the earth.	0.88	0.90	4759	4356
	F	F	The sun revolves around the moon.	0.92		3952	
	T	F	The sun revolves around the earth.	0.92	0.86	4400	4588
	F	T	The earth revolves around the sun.	0.80		4775	
Lunar phase	T	T	Phases of the moon are caused by changes in illumination.	0.50	0.73	6809	5396
	F	F	Phases of the moon are caused by clouds.	0.96		3983	
	T	F	Phases of the moon are caused by the earth's shadow.	0.29	0.54	7288	7068
	F	T	Phases of the moon are caused by the moon's orbit.	0.79		6847	
Season	T	T	A change in overall sunlight causes the seasons.	0.46	0.35	7359	7830
	F	F	The earth's rotation causes the seasons.	0.23		8300	
	T	F	The earth's distance from the sun causes the seasons.	0.45	0.61	5680	5425
	F	T	The earth's tilt causes the seasons.	0.76		5170	

Evolution

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Common Ancestry	T	T	Humans are more closely related to apes than monkeys.	0.73	0.85	5535	5823
	F	F	Whales are more closely related to plants than fish.	0.97		6110	
	T	F	Apes are more closely related to monkeys than humans.	0.48	0.55	8908	7305
	F	T	Whales are more closely related to humans than fish.	0.61		5702	
Phylogeny	T	T	Humans are descended from tree-dwelling creatures.	1.00	0.71	3832	4710
	F	F	Humans are descended from plants.	0.41		5588	
	T	F	Humans are descended from chimpanzees.	0.70	0.59	5055	5238
	F	T	Humans are descended from sea-dwelling creatures.	0.47		5420	
Variation	T	T	Evolution requires differential survival.	0.84	0.82	5460	5588
	F	F	Evolution requires climate stability.	0.79		5716	
	T	F	Evolution requires long periods of time.	0.11	0.50	4692	6194
	F	T	Evolution requires within-species variation.	0.89		7696	
Selection	T	T	Most organisms are adapted to their environment.	0.95	0.70	5330	5842
	F	F	Most organisms live in temperate climates.	0.45		6353	
	T	F	Most organisms have plenty to eat.	0.21	0.35	8068	7022
	F	T	Most organisms die before leaving offspring.	0.49		5976	
Adaptation	T	T	Biological species evolve.	0.10	0.53	3753	4008
	F	F	Inanimate objects evolve.	0.95		4263	
	T	F	Individual organisms evolve.	0.45	0.36	5015	5891
	F	T	Computer viruses evolve.	0.26		6766	

Fractions

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Addition	T	T	1/3 plus 1/3 is 2/3.	0.97	0.96	4001	3822
	F	F	1/3 plus 1/3 is 1/3.	0.94		3643	
	T	F	2/3 plus 2/4 is 2/7.	0.73	0.81	5683	7707
	F	T	1/10 plus 1/10 is 1/5.	0.89		9730	
Division	T	T	4 divided by 2/1 is 2.	0.80	0.89	7483	6737
	F	F	8 divided by 2/1 is 3.	0.98		5991	
	T	F	8 divided by 1/2 is 4.	0.58	0.54	6486	6324
	F	T	4 divided by 1/2 is 8.	0.49		6162	
Conversion	T	T	All decimals are expressible as fractions.	0.84	0.69	5654	5877
	F	F	All fractions are expressible as integers.	0.53		6099	
	T	F	All fractions are expressible as decimals.	0.02	0.42	10807	8189
	F	T	All integers are expressible as fractions.	0.81		5570	
Ordering	T	T	12/13 is greater than 1/13.	0.84	0.85	5064	5205
	F	F	1/17 is greater than 16/17.	0.85		5346	
	T	F	1/17 is greater than 1/9.	0.95	0.97	5199	5496
	F	T	1/13 is greater than 1/30.	0.98		5792	
Infinite density	T	T	There are numbers between 1 and 3.	1.00	0.87	3511	4637
	F	F	There are numbers between 10 and 10.	0.73		5762	
	T	F	There are numbers between 1/10 and 10/100.	0.48	0.71	8098	7132
	F	T	There are numbers between 1/3 and 1/2.	0.93		6166	

Genetics

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Heritalibty	T	T	Hair color is heritable.	0.97	0.98	2866	3100
	F	F	Pierced ears are heritable.	0.98		3333	
	T	F	Immunity to chickenpox is heritable.	0.61	0.71	6620	5433
	F	T	Intelligence is heritable.	0.80		4245	
Chromosome	T	T	Humans have more chromosomes than mosquitoes.	0.75	0.79	5417	4902
	F	F	Men have more chromosomes than women.	0.83		4386	
	T	F	Adults have more chromosomes than children.	0.94	0.64	4125	6274
	F	T	Skin cells have more chromosomes than egg cells.	0.33		8423	
Dominance	T	T	Two brown-eyed parents could have a brown-eyed baby.	1.00	0.58	4461	4859
	F	F	Two blue-eyed parents could have a brown-eyed baby.	0.16		5256	
	T	F	A blue-eyed baby must have two blue-eyed parents.	0.94	0.93	4995	4653
	F	T	Two brown-eyed parents could have a blue-eyed baby.	0.91		4310	
Expression	T	T	Genes that code for eye color can be found in the eye.	0.72	0.54	5204	6239
	F	F	Genes that code for eye color can be found in hair.	0.35		7273	
	T	F	Genes that code for eye color can be found in tears.	0.78	0.62	6660	6249
	F	T	Genes that code for eye color can be found in the liver.	0.45		5837	
Mutation	T	T	Radiation can change one's genome.	0.78	0.83	4257	3973
	F	F	Sunscreen can change one's genome.	0.87		3688	
	T	F	Exercise can change one's genome	0.76	0.67	4031	4618
	F	T	Viruses can change one's genome.	0.57		5205	

Germs

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Contagion	T	T	Being sneezed on can make a person sick.	0.89	0.94	4895	4408
	F	F	Being happy can make a person sick.	0.98		3920	
	T	F	Being cold can make a person sick.	0.30	0.65	4083	3879
	F	T	Being depressed can make a person sick.	0.99		3674	
Contamination	T	T	Rotting meat contains germs.	0.97	0.94	3196	3569
	F	F	Sunshine contains germs.	0.91		3942	
	T	F	Urine contains germs.	1.00	0.66	2958	4764
	F	T	Dish sponges contain germs.	0.31		6570	
Infection	T	T	Germs enter the body through cuts.	0.96	0.91	3227	3971
	F	F	Germs enter the body through the hair.	0.85		4714	
	T	F	Germs enter the body through the skin.	0.77	0.54	4175	5305
	F	T	Germs enter the body through the eyes.	0.31		6434	
Sterilization	T	T	Alcohol kills germs.	0.94	0.95	2627	2977
	F	F	Kindness kills germs.	0.95		3327	
	T	F	Water kills germs.	0.90	0.91	3432	3858
	F	T	Heat kills germs.	0.91		4283	
Microbe	T	T	Germs have a shape.	0.86	0.88	2975	3126
	F	F	Germs have feelings.	0.89		3277	
	T	F	Germs have an odor.	0.71	0.74	5015	4529
	F	T	Germs have DNA.	0.76		4043	

Matter

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Mass	T	T	Rocks are composed of matter.	0.99	0.97	2681	3321
	F	F	Numbers are composed of matter.	0.94		3960	
	T	F	Fire is composed of matter.	0.17	0.51	10441	7241
	F	T	Air is composed of matter.	0.84		4041	
Weight	T	T	A liter of water weighs more than a liter of air.	0.59	0.77	7548	7612
	F	F	A pound of steal weighs more than a ton of steal.	0.95		7676	
	T	F	A pound of steal weighs more than a pound of feathers.	0.72	0.53	5816	8238
	F	T	A liter of water weighs more than a liter of ice.	0.34		10660	
Density	T	T	Steal is denser than foam.	0.97	0.96	3786	4047
	F	F	Foam is denser than brick.	0.94		4307	
	T	F	Ice is denser than water.	0.41	0.40	6583	7400
	F	T	A cold penny is denser than a hot penny.	0.38		8216	
Divisibility	T	T	A log can be cut in half.	1.00	0.92	3099	3866
	F	F	An idea can be cut in half.	0.83		4632	
	T	F	A shadow can be cut in half.	0.85	0.90	4999	4901
	F	T	A grain of sand can be cut in half.	0.95		4802	
Atom	T	T	Atoms are the constituents of matter.	0.98	0.94	5202	4267
	F	F	Atoms are visible to the naked eye.	0.90		3331	
	T	F	Atoms are weightless.	0.76	0.60	4118	4128
	F	T	Atoms are mostly empty space.	0.43		4137	

Mechanics

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Force	T	T	Forces can be strong or weak.	0.96	0.87	2742	3840
	F	F	Forces can be male or female.	0.78		4937	
	T	F	Forces can be straight or curved.	0.41	0.64	6756	5610
	F	T	Forces can be balanced or unbalanced.	0.86		4464	
Velocity	T	T	A moving bullet loses speed.	0.85	0.88	3904	4135
	F	F	A moving bullet loses weight.	0.91		4365	
	T	F	A moving bullet loses force.	0.25	0.47	7409	6835
	F	T	A moving bullet loses height.	0.69		6261	
Acceleration	T	T	Constant acceleration requires constant force.	0.89	0.61	5549	6604
	F	F	Constant speed requires constant acceleration.	0.32		7659	
	T	F	Constant motion requires constant force.	0.29	0.34	7607	8111
	F	T	Constant force can yield constant rest.	0.39		8614	
Momentum	T	T	Momentum can be transferred from one object to another.	0.91	0.78	4474	5364
	F	F	Color can be transferred from one object to another.	0.65		6254	
	T	F	Forces can be transferred from one object to another.	0.06	0.51	6596	5508
	F	T	Energy can be transferred from one object to another.	0.95		4419	
Gravity	T	T	Anvils fall through air faster than feathers.	0.85	0.89	6910	5977
	F	F	Bright objects fall through air faster than dark objects.	0.92		5044	
	T	F	Heavy balls fall through air faster than light balls.	0.41	0.54	6512	6828
	F	T	Pointy objects fall through air faster than flat objects.	0.66		7143	

Physiology

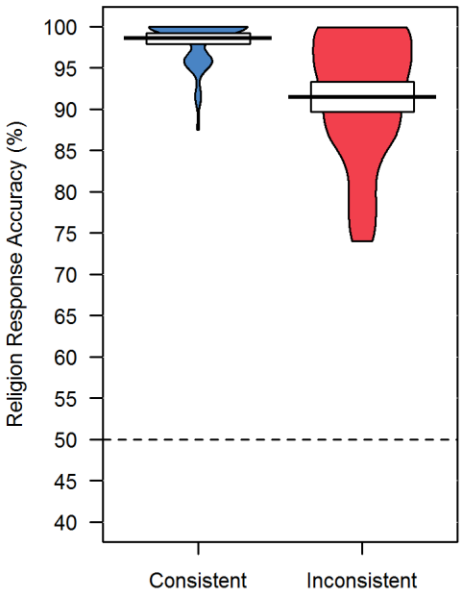
				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Life	T	T	Fish are alive.	0.97	0.97	2243	2432
	F	F	Rocks are alive.	0.96		2620	
	T	F	The sun is alive.	0.67	0.83	4729	3412
	F	T	Coral is alive.	0.98		2094	
Death	T	T	Turtles can die.	0.99	0.94	1913	2870
	F	F	Screwdrivers can die.	0.88		3827	
	T	F	Clouds can die.	0.99	0.98	1913	2440
	F	T	Mushrooms can die.	0.97		2967	
Reproduction	T	T	Tigers can reproduce.	0.99	0.98	2755	2460
	F	F	Chairs can reproduce.	0.97		2165	
	T	F	Caterpillars can reproduce.	0.28	0.60	10467	7257
	F	T	Ferns can reproduce.	0.91		4046	
Metabolism	T	T	People turn food into energy.	0.95	0.97	3059	3996
	F	F	Rocks turn food into energy.	0.98		4933	
	T	F	Plants turn food into energy.	0.19	0.41	6047	5560
	F	T	Bacteria turn food into energy.	0.63		5072	
Kinship	T	T	A baby can be a niece or a nephew.	0.97	0.81	4130	4739
	F	F	A baby can be a mother or a father.	0.65		5348	
	T	F	A baby can be identical to an older sibling.	0.69	0.79	6845	6093
	F	T	A baby can be an uncle or an aunt.	0.89		5341	

Thermodynamics

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Heat	T	T	The sun has heat.	0.97	0.88	2718	2993
	F	F	Gravity has heat.	0.78		3268	
	T	F	Atoms have heat.	0.23	0.38	4649	5024
	F	T	Ice has heat.	0.52		5399	
Heat source	T	T	Ovens produce heat.	0.97	0.88	2903	4077
	F	F	Rain produces heat.	0.78		5250	
	T	F	Coats produce heat.	0.74	0.82	5054	4999
	F	T	Pressure produces heat.	0.89		4943	
Heat transfer	T	T	Water transfers heat to ice.	0.59	0.70	7146	7440
	F	F	Cold objects transfer heat to warm objects	0.81		7733	
	T	F	Water transfers heat to steam.	0.55	0.60	7098	7180
	F	T	Cold objects transfer heat to even colder objects.	0.65		7261	
Temperature	T	T	Ice has a lower temperature than water.	0.85	0.88	5758	5577
	F	F	Steam has a lower temperature than ice.	0.91		5396	
	T	F	Two cups of ice have a lower temperature than one.	0.91	0.76	8036	7194
	F	T	Boiling water has a lower temperature than steam.	0.61		6351	
Thermal expansion	T	T	Heat increases an object's temperature.	0.95	0.73	4873	4777
	F	F	Heat increases an object's color.	0.51		4681	
	T	F	Heat increases an object's weight.	0.81	0.76	6120	6208
	F	T	Heat increases an object's size.	0.70		6296	

Waves

				M Proportion Correct		M Response Time (ms)	
Category	**Naive theory**	**Scientific theory**	**Statement**	**Per statement**	**Per type**	**Per statement**	**Per type**
Light	T	T	Rainbows contain all colors of light.	0.83	0.78	4722	5099
	F	F	Shadows contain all colors of light.	0.73		5475	
	T	F	Black objects reflect all colors of light.	0.69	0.73	6622	6203
	F	T	White light contains all colors of light.	0.77		5784	
Color	T	T	Red objects reflect red light.	0.83	0.77	4151	4535
	F	F	Red objects reflect blue light.	0.70		4918	
	T	F	Red objects absorb red light.	0.66	0.68	5288	5103
	F	T	Red objects absorb blue light.	0.70		4918	
Sound	T	T	Sounds can be loud or quiet.	0.99	0.90	3006	3650
	F	F	Sounds can be dead or alive.	0.81		4294	
	T	F	Sounds can be near or far.	0.06	0.53	12940	8554
	F	T	Sounds can be direct or reflected.	0.99		4168	
Propagation	T	T	Sound travels through air.	0.98	0.61	3115	3915
	F	F	Sound travels through foam.	0.24		4714	
	T	F	Sound travels through a vacuum.	0.66	0.76	6114	5120
	F	T	Sound travels through metal.	0.85		4126	
Reflection	T	T	Mirrors reflect light.	1.00	0.84	2725	4222
	F	F	Foam reflects sound.	0.68		5718	
	T	F	Prisms reflect light.	0.18	0.28	5624	6066
	F	T	Mirrors reflect sound.	0.38		6508	


Religion Response Accuracy (%)
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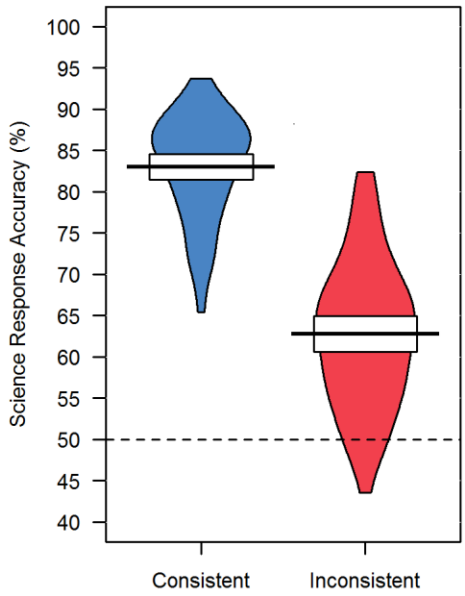
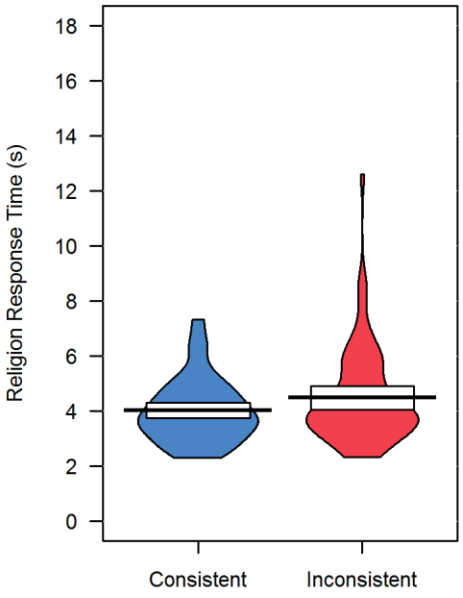
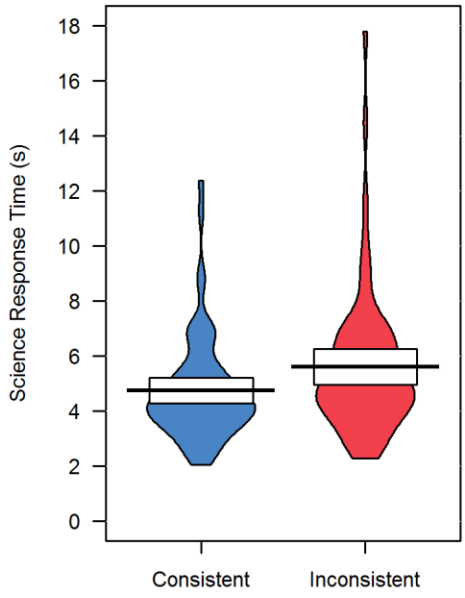
95
90
85
80
75
70
65
60
55
50
45
40
Consistent
Inconsistent


Science Response Accuracy (%)
100
95
90
85
80
75
70
65
60
55
50
45
40
Consistent
Inconsistent


Religion Response Time (s)
18
16
14
12
10
8
6
4
2
0
Consistent
Inconsistent


Science Response Time (s)
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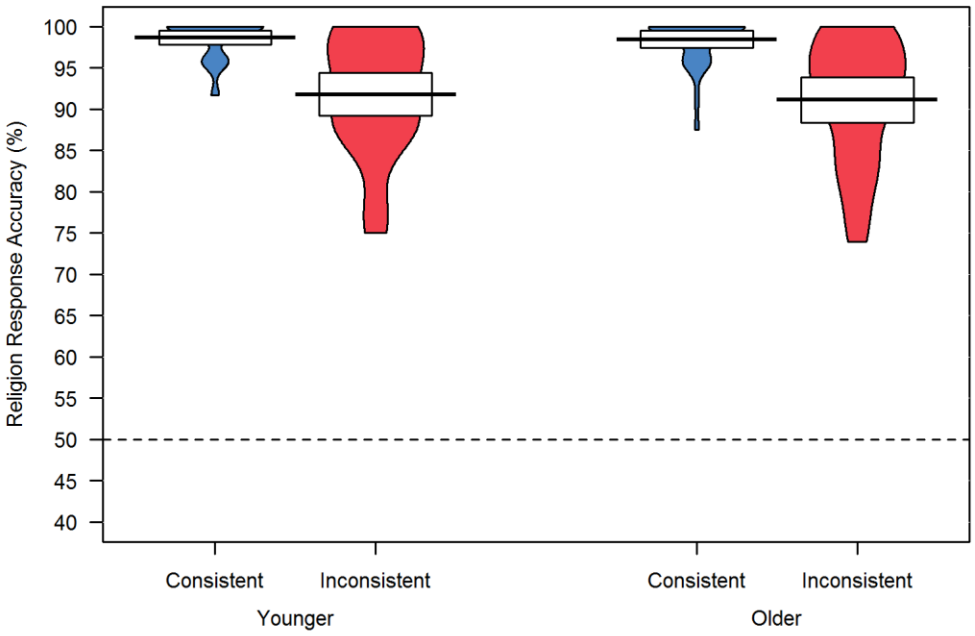
Religion Response Accuracy (%)
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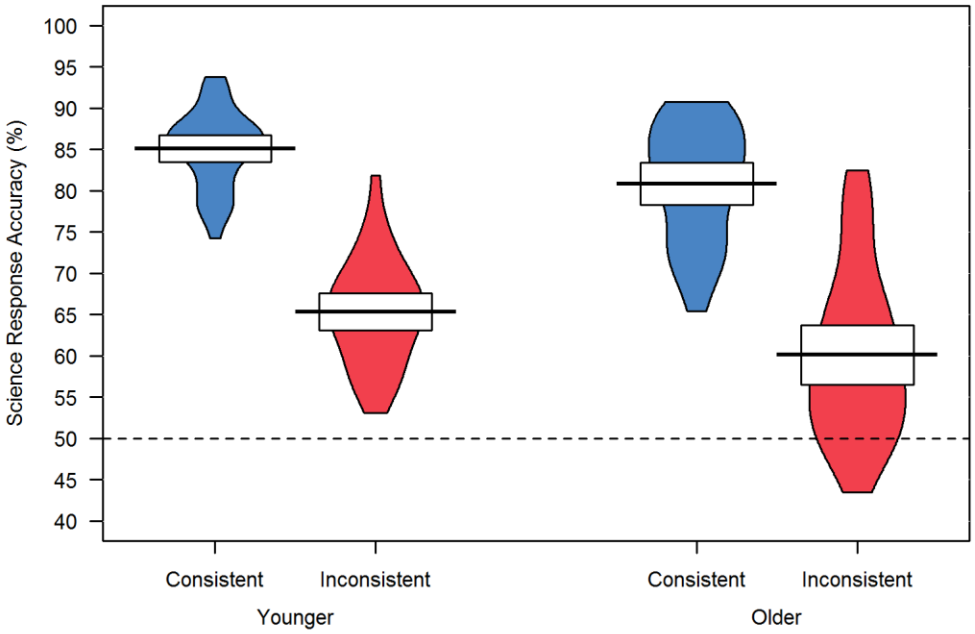
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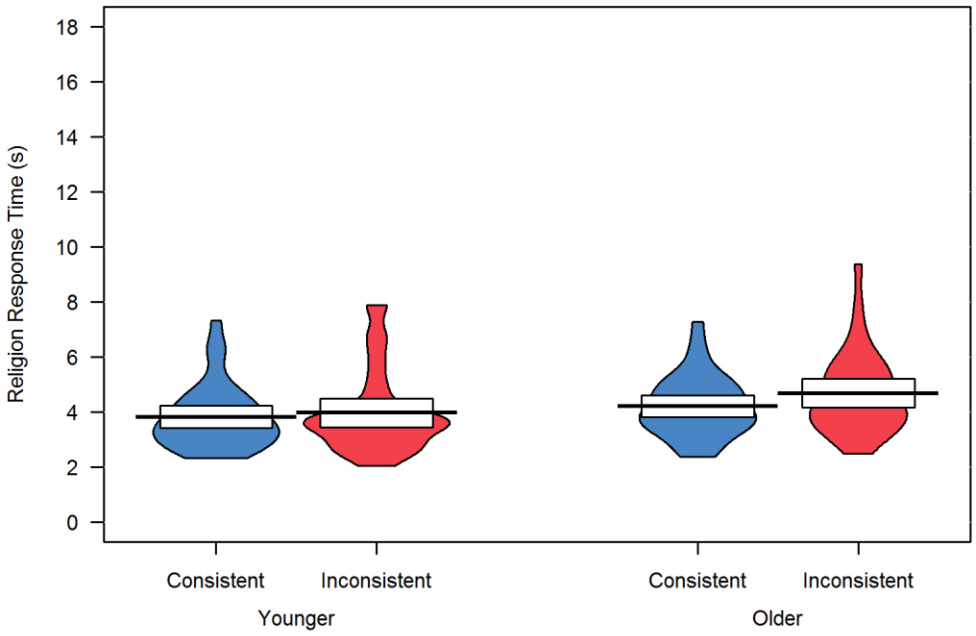
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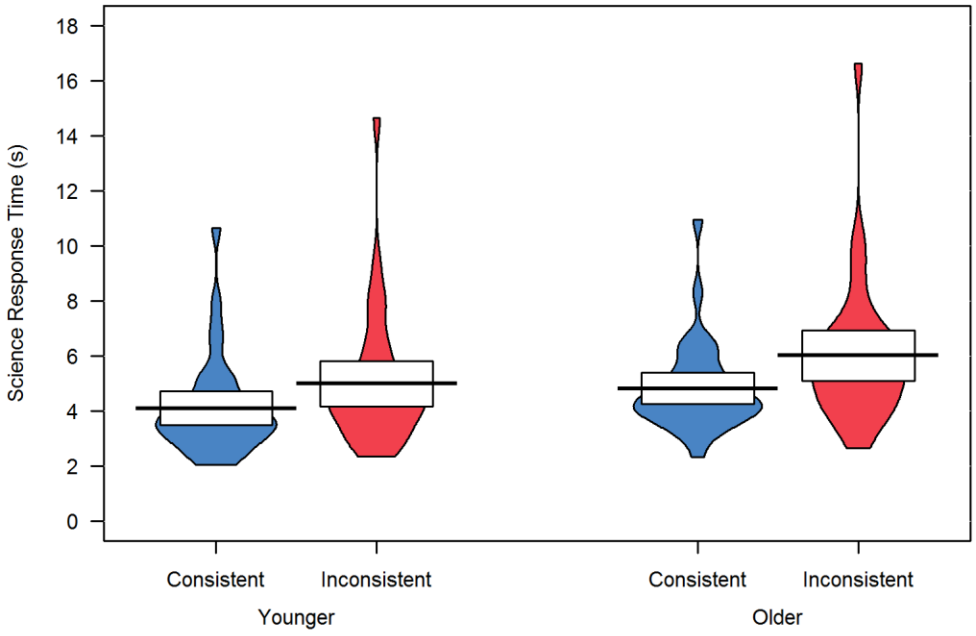
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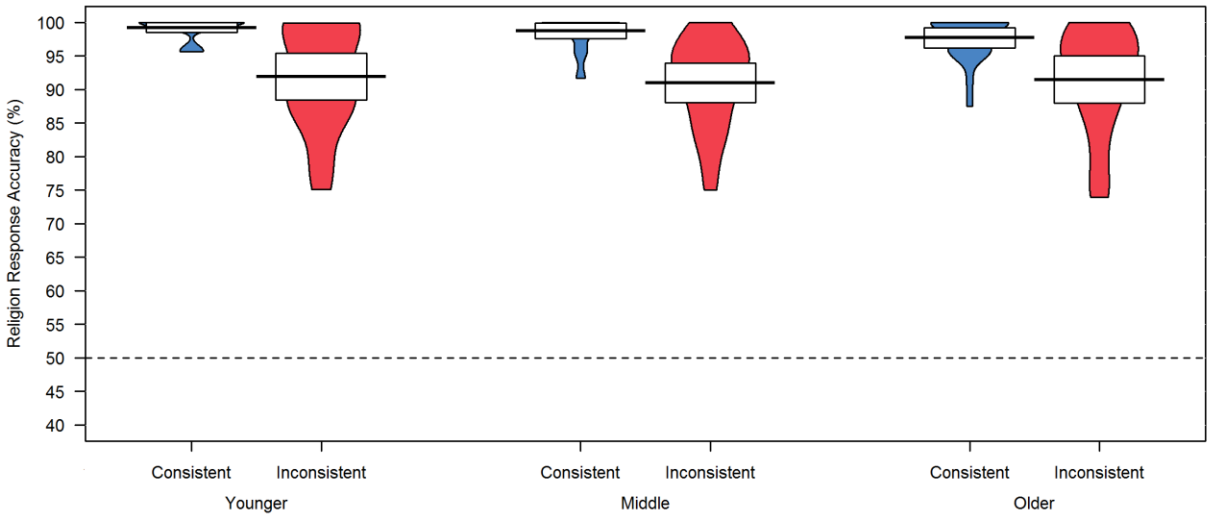
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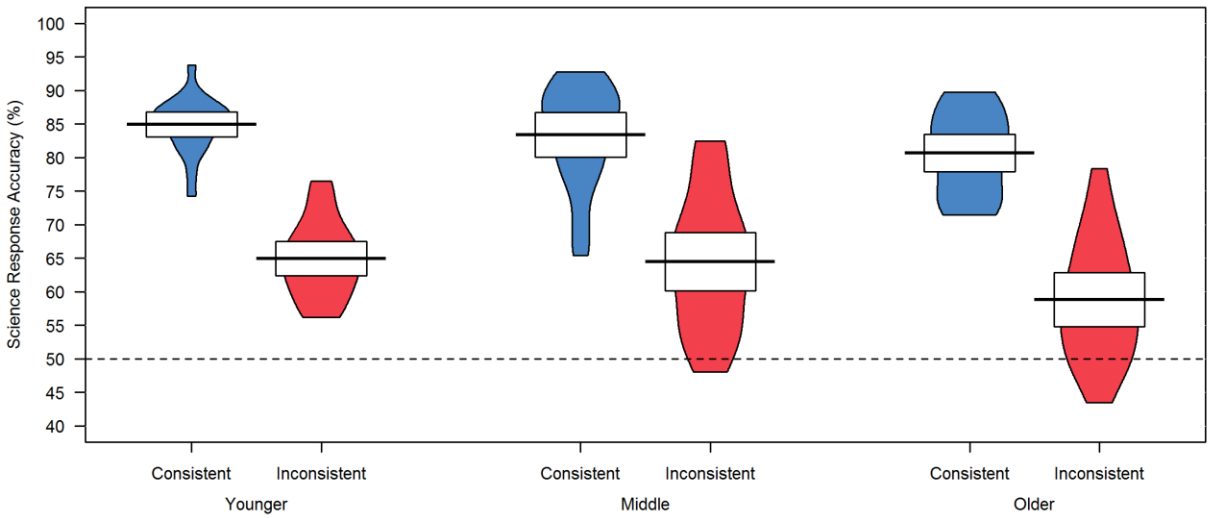
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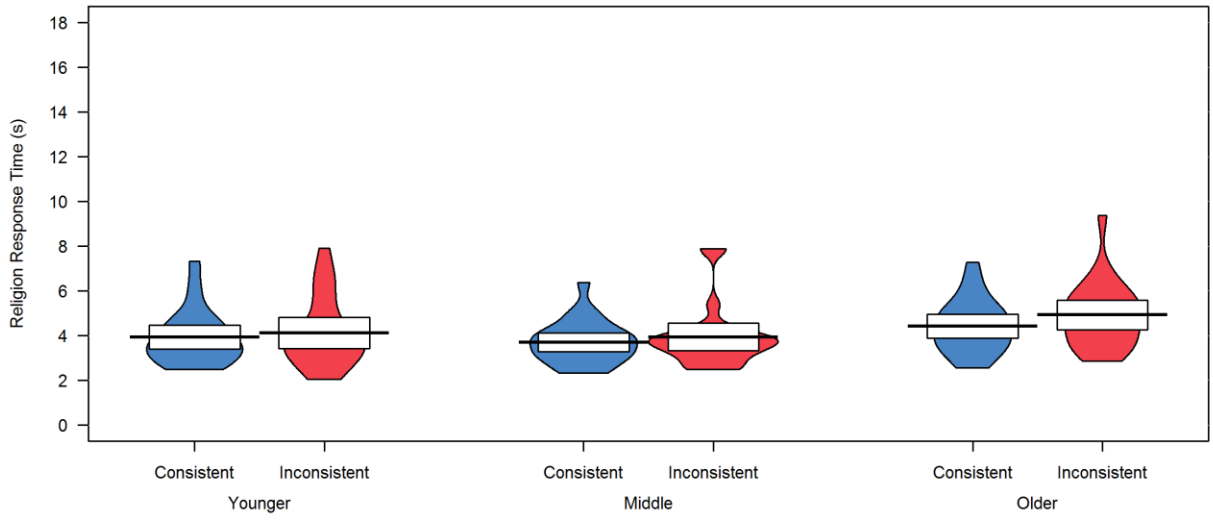
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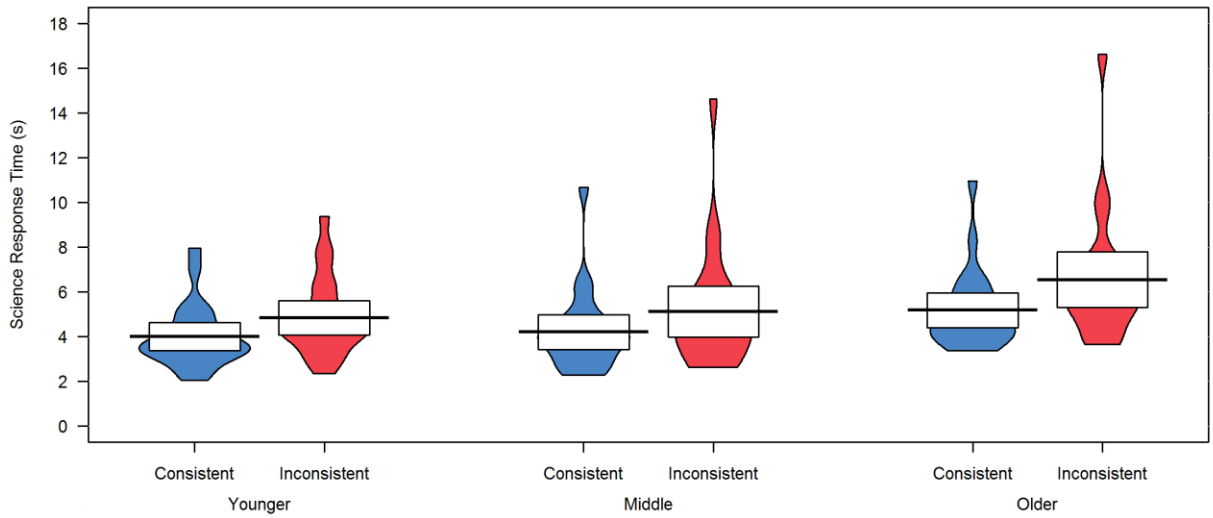
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REFERENCES

Baillargeon, R. (2004). Infants' physical world. *Current Directions in Psychological Science, 13* (3), 89–95.

Baillargeon, R., Scott, R. M., & Bian, L. (2016). Psychological reasoning in infancy. *Annual Review of Psychology, 67,* 159–186. doi:10.1146/annurev-psych-010213-115033.

Barlev, M., Mermelstein, S., & German, T. C. (2017). Core intuitions about persons coexist and interfere with acquired Christian beliefs about God. *Cognitive Science, 41*(S3), 425-454. http://doi.org/10.1111/cogs.12435

Barlev, M., Mermelstein, S., & German, T. C. (Accepted). Representational co-existence in the God concept: Core knowledge intuitions of God as a person are not revised by Christian theology despite lifelong experience. *Psychonomic Bulletin & Review*.

Barlev, M., Mermelstein, S., & German, T. C. (In Prep). Christian religious adherents represent God as an embodied person, not a disembodied mind.

Baron-Cohen, S. (1997). *Mindblindness: An essay on autism and theory of mind*. MIT Press.

Baron-Cohen, S., Leslie, a M., & Frith, U. (1985). Does the autistic child have a "theory of mind"? *Cognition, 21*(1), 37–46

Barrett, J. L. (1998). Cognitive constraints on Hindu concepts of the divine. *Journal for the Scientific Study of Religion, 37* (4), 608–619.

Barrett, J. L. (1999). Theological correctness: Cognitive constraint and the study of religion. *Method & Theory in the Study of Religion, 11*, 325–339.

Barrett, J. L. (2000). Exploring the natural foundations of religion. *Trends in Cognitive Sciences, 4* (1), 29–34.

Barrett, J. L., & Keil, F. C. (1996). Conceptualizing a nonnatural entity: Anthropomorphism in god concepts. *Cognitive Psychology*, *31*, 219–247.

Baumard, N., & Boyer, P. (2013). Religious beliefs as reflective elaborations on intuitions : A modified dual-process model. *Current Directions in Psychological Science*, *22* (4), 295–300. doi:10.1177/0963721413478610.

Berry, D., Misovich, S., Kean, K., & Baron, R. (1992). Effects of disruption of structure and motion on perceptions of social causality. *Personality and Social Psychology Bulletin*, 18 (2), 237-244.

Berry, D. & Springer, K. (1993). Structure, motion, and preschoolers' perceptions of social causality. *Ecological Psychology*, 5 (4), 273-283.

Bloom, P. (2005). *Descartes' Baby: How the science of child development explains what makes us human*. New York: Basic Books.

Bloom, P. (2007). Religion is natural. *Developmental Science*, *10*(1), 147–51. http://doi.org/10.1111/j.1467-7687.2007.00577.x

Bourguignon, Erika. 1968. *A cross-cultural study of dissociational states*. Columbus: Research Foundation, Ohio State University.

Boyer, P. (1994a). Cognitive constraints on cultural representations: Natural ontologies and religious ideas. In L. A. Hirschfeld & S. A. Gelman (Eds.), *Mapping the mind: Domain-specificity in culture and cognition* (pp. 391–411). New York: Cambridge University Press.

Boyer, P. (1994b). *The naturalness of religious ideas: A cognitive theory of religion*. Berkeley: University of California Press.

Boyer, P. (2001). *Religion explained: The evolutionary origins of religious thought*. New

York: Basic Books.

Boyer, P., & Ramble, C. (2001). Cognitive templates for religious concepts: Cross-cultural evidence for recall of counter-intuitive representations. *Cognitive Science, 25*, 535–564.

Broadway, J., & Engle, R. (2010). Validating running memory span: Measurement of working memory capacity and links with fluid intelligence. *Behavior Research Methods, 42* (2), 563-570.

Carey, S. (1985). *Conceptual change in childhood*. Cambridge, MA: MIT Press.

Carey, S. (2009). *The origin of concepts*. New York: Oxford University Press.

Carey, S., and Spelke, E. (1994) Domain-specific knowledge and conceptual change. In L. A. Hirschfeld & S. A. Gelman (Eds.), *Mapping the mind: Domain-specificity in culture and cognition* (pp. 391–411). New York: Cambridge University Press.

Chudek, M., McNamara, R. A., Birch, S., Bloom, P., & Henrich, J. (2017). Do minds switch bodies? Dualist interpretations across ages and societies. *Religion, Brain & Behavior, 0*(0), 1–15. http://doi.org/10.1080/2153599X.2017.1377757

Cohen, E. (2007). *The mind possessed: The cognition of spirit possession in an Afro-Brazilian religious tradition*. New York: Oxford University Press.

Cohen, E. (2008). What is spirit possession? Defining, comparing, and explaining two possession forms. *Ethnos, 73* (1), 101-126.

Cohen, E., & Barrett, J. (2008). When minds migrate: Conceptualizing spirit possession. *Journal of Cognition and Culture, 8*, 23–48.

Cohen, E., & Barrett, J. L. (2008). Conceptualizing Spirit Possession : Ethnographic and Experimental Evidence. *Ethnos*, *36*(2), 246–267.

Cohen, E., Burdett, E., Knight, N., & Barrett, J. (2011). Cross-cultural similarities and differences in person-body reasoning : Experimental evidence from the United Kingdom and Brazilian Amazon. *Cognitive Science,* 1–23. http://doi.org/10.1111/j.1551-6709.2011.01172.x

Csibra, G., Gergely, G., Bíró, S., Koós, O., & Brockbank, M. (1999). Goal attribution without agency cues: the perception of "pure reason" in infancy. *Cognition, 72*, 237–67.

Davis, W. (2010). *The serpent and the rainbow*. New York: Dover Publications.

Dawkins, R. (2006). *The God delusion*. New York: Random House.

Epley, N., Converse, B. A., Delbosc, A., Monteleone, G. A., & Cacioppo, J. T. (2009). Believers' estimates of God's beliefs are more egocentric than estimates of other people's beliefs. *Proceedings of the National Academy of Sciences, 106* (51), 21533–21538. doi:10.1073/pnas.0908374106.

Evans, J. S. B. T. (2003). In two minds: Dual-process accounts of reasoning. *Trends in Cognitive Sciences, 7* (10), 454–459. doi:10.1016/j.tics.2003.08.012.

Evans, J. S. B. T. (2008). Dual-processing accounts of reasoning, judgment, and social cognition. *Annual Review of Psychology, 59,* 255–278. doi:10.1146/annurev.psych.59.103006.093629.

Evans, J. S. B. T., & Stanovich, K. E. (2013). Dual-process theories of higher cognition: Advancing the debate. *Perspectives on Psychological Science, 8* (3), 223–241. doi:10.1177/1745691612460685.

Forstmann, M., & Burgmer, P. (2015). Adults are intuitive mind-body dualists. *Journal of Experimental Psychology: General*, *144*(1), 222–235.

Forstmann, M., Burgmer, P., & Mussweiler, T. (2012). "The mind is willing, but the flesh is weak": the effects of mind-body dualism on health behavior. *Psychological Science, 23*(10), 1239–45. http://doi.org/10.1177/0956797612442392

Fullerton, T. J., & Hunsberger, B. (1982). A unidimensional measure of Christian orthodoxy. *Journal for the Scientific Study of Religion, 21*(4), 317–326.

Gazzaniga, M. (2005). *The ethical brain: The science of our moral dilemmas.* New York: Dana Press.

Goldberg, R. F., & Thompson-Schill, S. L. (2009). Developmental "roots" in mature biological knowledge. *Psychological Science, 20* (4), 480–487. doi:10.1111/j.1467-9280.2009.02320.x.

Granqvist, P., & Kirkpatrick, L. A. (2008). Attachment and religious representations and behavior. In J. Cassidy & P. R. Shaver (Eds.), *Handbook of attachment: Theory, research, and clinical applications* (2nd ed., pp. 906-933). New York: Guilford Press.

Gray, H. M., Gray, K., & Wegner, D. M. (2007). Dimensions of mind perception. *Science, 315* (5812), 619. doi:10.1126/science.1134475.

Heider, F., & Simmel, M. (1944). An experimental study of apparent behavior. *American Journal of Psychology*, 57, 243–259.

Heiphetz, L., Lane, J. D., Waytz, A., & Young, L. L. (2016). How children and adults represent God's mind. *Cognitive Science, 40*, 121–144. doi:10.1111/cogs.12232.

Hodge, K. M. (2008). Descartes' mistake: How afterlife beliefs challenge the assumption that humans are intuitive cartesian substance dualists. *Journal of Cognition and Culture, 8*, 387–415. doi:10.1163/156853708X358236.

Hodge, K. M. (In Revision). Theory of mind, mind-body dualism, and their (mis) application

in the cognitive science of religion.

Hood, B., Gjersoe, N. L., & Bloom, P. (2012). Do children think that duplicating the body also duplicates the mind? *Cognition*, *125*(3), 466–74. http://doi.org/10.1016/j.cognition.2012.07.005

Hyde, K. E. (1990). *Religion in childhood and adolescence: A comprehensive review of the research*. Birmingham, AL: Religious Education Press.

Inagaki, K., & Hatano, G. (2002).*Young children's naıve thinking about the biological world*. New York, NY: Psychology Press.

Inagaki, K., & Hatano, G. (2006). Young children's conception of the biological world. *Current Directions in Psychological Science*, *15*, 177–181. doi:10.1111/j.1467-8721.2006.00431.x.

Ioannidis, J. P. A. (2005). Why most published research findings are false. *PLOS Medicine*, *2* (8), 696-701. doi:10.1371/journal.pmed.0020124.

JASP Team (2017). JASP (Version 0.8.1.2)[Computer software].

Johnson, S., Slaughter, V., & Carey, S. (1998). Whose gaze will infants follow? The elicitation of gaze-following in 12-month-olds. *Developmental Science*, 1, 233–238.

Kelemen, D., & Rosset, E. (2009). The human function compunction: Teleological explanation in adults. *Cognition, 111* (1), 138–143. doi:10.1016/j.cognition.2009.01.001.

Kelemen, D., Rottman, J., & Seston, R. (2012). Professional physical scientists display tenacious teleological tendencies: Purpose-based reasoning as a cognitive default. *Journal of Experimental Psychology: General*, *142* (4), 1074–1083. doi:10.1037/a0030399.

Kinsella, M. (2017). Near-Death Experiences and Networked Spirituality: The Emergence of an Afterlife Movement. *Journal of the American Academy of Religion*, *85*(1), 168–198. http://doi.org/10.1093/jaarel/lfw037

Kirkpatrick, L. A. (2005). *Attachment, evolution, and the psychology of religion*. New York: Guilford.

Klein, E., & Klein, C. (2012). Did the Chinese have a change of heart? *Cognitive Science*, *36*(2), 179–182. http://doi.org/10.1111/j.1551-6709.2011.01231.x

Klin, A. (2000). Attributing social meaning to ambiguous visual stimuli in higher-functioning Autism and Asperger Syndrome: The social attribution task. *Journal of Child Psychology and Psychiatry*, *41*(7), 831–846. http://doi.org/10.1111/1469-7610.00671

Kovács, Á. M., Téglás, E., & Endress, A. D. (2010). The social Sense: Susceptibility to others' beliefs in human infants and adults. *Science*, *330*, 1830–1834. http://doi.org/10.1126/science.1190792

Kuhlmeier, V., Bloom, P., & Wynn, K. (2004). Do 5-month-old infants see humans as material objects? *Cognition*, 94, 95–103.

Kuhlmeier, V., Wynn, K., & Bloom, P. (2003). Attribution of dispositional states by 12-month-olds. *Psychological Science*, 14 (5), 402-408.

Kuhlmeier, V. A., Wynn, K., & Bloom, P. (2004). People v. objects: a reply to Rakison and Cicchino. *Cognition*, *94*, 109–112. http://doi.org/10.1016/j.cognition.2004.03.006

Lane, J. D., Wellman, H. M., & Evans, E. M. (2010). Children's understanding of ordinary and extraordinary minds. *Child Development*, *81* (5), 1475–1489. doi:10.1111/j.1467-8624.2010.01486.x.

Lane, J. D., Wellman, H. M., & Evans, E. M. (2012). Sociocultural input facilitates

children's developing understanding of extraordinary minds. *Child Development*, *83* (3), 1007–1021. doi:10.1111/j.1467-8624.2012.01741.x.

Lane, J. D., Wellman, H. M., & Evans, E. M. (2014). Approaching an understanding of omniscience from the preschool years to early adulthood. *Developmental Psychology*, *50* (10), 2380–2392.

Lane, J. D., Evans, E. M., Brink, K. A., & Wellman, H. M. (2016). Developing concepts of ordinary and extraordinary communication. *Developmental Psychology*, *52* (1), 19–30. doi:10.1037/dev0000061.

Leslie, A. (1994). ToMM, ToBY, and Agency: Core architecture and domain specificity. In L. A. Hirschfeld & S. A. Gelman (Eds.), *Mapping the mind: Domain-specificity in culture and cognition* (pp. 391–411). New York: Cambridge University Press.

Leslie, A. M., Friedman, O., & German, T. P. (2004). Core mechanisms in "theory of mind". *Trends in Cognitive Sciences*, *8*(12), 528–33. http://doi.org/10.1016/j.tics.2004.10.001

Leslie, a M., & Keeble, S. (1987). Do six-month-old infants perceive causality? *Cognition*, *25*(3), 265–88.

Lindeman, M., & Aarnio, K. (2007). Superstitious, magical, and paranormal beliefs: An integrative model. *Journal of Research in Personality*, *41* (4), 731–744. doi:10.1016/j.jrp.2006.06.009.

Luhrmann, T. M. (2012). *When God talks back: Understanding the American Evangelical relationship with God*. New York: Alfred A. Knopf. doi:http://dx.doi.org/10.14318/hau3.3.021.

Luo, Y., Kaufman, L., & Baillargeon, R. (2009). Young infants' reasoning about physical

events involving inert and self-propelled objects. *Cognitive Psychology*, *58*(4), 441–86. http://doi.org/10.1016/j.cogpsych.2008.11.001.

Meltzoff, A. N. (1995). Understanding the intentions of others: Re-enactment of intended acts by 18-month-old children. *Developmental Psychology*, *31*(5), 838–850. doi:10.1037/0012-1649.31.5.838.

Mercier, H., & Sperber, D. (2009). Intuitive and reflective inferences. In J. S. B. T. Evans & K. Frankish (Eds.), *In two minds: Dual processes and beyond* (pp. 147–170). New York: Oxford University Press. doi: 10.1093/acprof:oso/9780199230167.001.0001.

Michotte, A.E. (1963). *The perception of causality* (trans. T.R. Miles & E. Miles). London: Methuen.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*, 49–100. doi:10.1006/cogp.1999.0734.

Norenzayan, A. (2013). *Big gods: How religion transformed cooperation and conflcit*. Princeton, NJ: Princeton University Press.

Nagel, T. (1974). What is it like to be a bat? *The Philosophical Review*, *84*(4), 435–450. http://doi.org/10.2307/2176743

Nosek, B. A., & Lakens, D. (2014). Registered reports: A method to increase the credibility of published results. *Social Psychology*, *45* (3), 137–141. doi:10.1027/1864-9335/a000192.

Purzycki, B. G., & Willard, A. K. (2015). MCI theory: a critical discussion. *Religion, Brain & Behavior*, 1–42. doi:10.1080/2153599X.2015.1024915.

Onishi, K. H., & Baillargeon, R. (2005). Do 15-Month-Old Infants Understand False Beliefs? *Science, 308,* 255–258. http://doi.org/10.1126/science.1107621

Parfit, D. (1984). *Reasons and persons*. Oxford: Oxford University Press.

Piaget, J. (1954). *The construction of reality in the child*. New York, NY: Routlege.

Pinker, S. (1994). *The language instinct: How the mind creates langue*. New York: William Morrow and Company.

Rakison, D. & Cicchino, J. (2004). Is an infant a people person? *Cognition*, 94, 105-107.

Redick, T. S., Broadway, J. M., Meier, M. E., Kuriakose, P. S., Unsworth, N., Kane, M. J., & Engle, R. W. (2012). Measuring working memory capacity with automated complex span tasks. *European Journal of Psychological Assessment, 28* (3), 164–171. doi:10.1027/1015-5759/a000123.

Riekki, T., Lindeman, M., & Hood, B. M. (2011). Is weaker inhibition associated with supernatural beliefs? *Journal of Cognition and Culture, 11*, 231–239. doi:10.1163/156853711X570038.

Saxe, R., Tzelnic, T., & Carey, S. (2006). Five-month-old infants know humans are solid, like inanimate objects. *Cognition, 101*(1), B1-8. http://doi.org/10.1016/j.cognition.2005.10.005

Schlottman, A. & Ray, E. (2010). Goal attribution to schematic animals: Do 6-month-olds perceive biological motion as animate? *Developmental Science*, 13 (1), 1-10.

Schlottmann, A., & Surian, L. (1999). Do 9-month-olds perceive causation-at-a-distance? *Perception*, 28, 1105–1113.

Schlottmann, A., Surian, L.,& Ray, E. (2009). Causal perception of action-and-reaction

sequences in 8- to 10-months-old infants. *Journal of Experimental Child Psychology*, 103 (1), 87–107.

Schulz, K. (2017, November 6). Fantastic beasts and how to rank them. The New Yorker. Retrieved from https://www.newyorker.com/magazine/2017/11/06/is-bigfoot-likelier-than-the-loch-ness-monster

Senju, A., Southgate, V., White, S., & Frith, U. (2009). Mindblind eyes: An absence of spontaneous theory of mind in Asperger Syndrome. *Science*, *325*, 883–885. http://doi.org/10.1126/science.1176170.

Shtulman, A. (2006). Qualitative differences between naïve and scientific theories of evolution. *Cognitive Psychology*, *52* (2), 170–94. doi:10.1016/j.cogpsych.2005.10.001.

Shtulman, A. (2017). *Scienceblind: Why our intuitive theories about the world are so often wrong*. New York: Basic Books.

Shtulman, A. (2008). Variation in the anthropomorphization of supernatural beings and its implications for cognitive theories of religion. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *34* (5), 1123–38. doi:10.1037/0278-7393.34.5.1123.

Shtulman, A., & Harrington, K. (2016). Tensions between science and intuition across the lifespan. *Topics in Cognitive Science*, *8* (1), 118-137.

Shtulman, A., & Lindeman, M. (2016). Attributes of God: Conceptual foundations of a foundational belief. *Cognitive Science*, *40* (3), 635–670. doi:10.1111/cogs.12253.

Shtulman, A., & Valcarcel, J. (2012). Scientific knowledge suppresses but does not supplant earlier intuitions. *Cognition*, *124*, 209–215. doi:10.1016/j.cognition.2012.04.005.

Slingerland, E., & Chudek, M. (2011). The prevalence of mind-body dualism in early China. *Cognitive Science, 35*(5), 997–1007. http://doi.org/10.1111/j.1551-6709.2011.01186.x.

Slone, D. J. (2004). *Theological incorrectness: Why religious people believe what they shouldn't*. New York: Oxford University Press.

Spelke, E. S. (1990). Principles of object perception. *Cognitive Science, 14*, 29–56. doi:10.1016/0364-0213(90)90025-R.

Spelke, E. S., Breinlinger, K., Macomber, J., & Jacobson, K. (1992). Knowledge of material objects. *Psychological Review*, *99*(4), 605–632.

Spelke, E. S., Kestenbaum, R., Simons, D. J., & Wein, D. (1995). Spatiotemporal continuity, smoothness of motion and object identity in infancy. *British Journal of Developmental Psychology*, *13*, 113–142.

Spelke, E., & Kinzler, K. (2007). Core knowledge. Developmental Science, 10 (1), 89-96.

Spelke, E., Phillips, A. & Woodward, A. (1995). Infants' knowledge of object motion and human action. *Causal Cognition: A Multidisciplinary Debate*. Clarendon Press/Oxford University Press, Oxford, pp. 44–78.

Spelke, E., & Van de Walle, G. (1993). Perceiving and reasoning about objects: Insights from infants. In N. Eilan, R. McCarthy, & W. Brewer (Eds.), *Spatial Representation*. Oxford: Basil Blackwell.

Sperber, D. (1985). *On anthropological knowledge: Three essays*. Cambridge University Press.

Sperber, D. (1996). *Explaining culture: A naturalistic approach*. Oxford: Blackwell Publishers Ltd.

Sperber, D. (1997). Intuitive and reflective beliefs. *Mind and Language, 12* (1), 67–83.

Sperber, D. (Ed.). (2000). *Metarepresentations: A multidisciplinary perspective*. New York: Oxford University Press.

Sperber, D., & Hirschfeld, L. A. (2004). The cognitive foundations of cultural stability and diversity. *Trends in Cognitive Sciences*, *8*(1), 40–46. http://doi.org/10.1016/j.tics.2003.11.002

Starns, J. J., & Ratcliff, R. (2010). The effects of aging on the speed-accuracy compromise: Boundary optimality in the diffusion mode. *Psychological Aging*, *25*(2), 377–390. http://doi.org/10.1037/a0018022

Streri, A., & Spelke, E. S. (1988). Haptic perception of objects in infancy. *Cognitive Psychology, 20*, 1–23.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, *18*, 643–662.

Surian, L., Caldi, S., & Sperber, D. (2007). Attribution of Beliefs by 13-Month-Old Infants. *Psychological Science*, *18*(7). http://doi.org/10.1111/j.1467-9280.2007.01943.x

Svedholm, A. M., & Lindeman, M. (2013). The separate roles of the reflective mind and involuntary inhibitory control in gatekeeping paranormal beliefs and the underlying intuitive confusions. *British Journal of Psychology, 104*, 303–319. doi:10.1111/j.2044-8295.2012.02118.x.

Taves, A. (1999). *Fits, trances, & visions: Experiencing religion and explaining experience from Wesley to James*. Princeton, NJ: Princeton University Press.

Taves, A. (2009). *Religious experience reconsidered: A building-block approach to the study of religion and other special things*. Princeton, NJ: Princeton University Press.

Taves, A. (2016). *Revelatory Events: Three Case Studies of the Emergence of New Spiritual Paths*. Princeton, NJ: Princeton University Press.

Tooby, J., Cosmides, L., & Barrett, C. H. (2005). Resolving the debate on innate ideas: Learnability constraints and the evolved interpenetration of motivational and conceptual functions. In P. Carruthers, S. Laurence, & S. Stich (Eds.), *The Innate Mind: Structure and Content* (pp. 305–337). New York: Oxford University Press.

Vosniadou, S., & Brewer, W. F. (1992). Mental models of the earth: A study of conceptual change in childhood. *Cognitive Psychology*, *24*, 535–585. doi:10.1016/0010-0285(92)90018-W.

Wason, P. C. (1959). The processing of positive and negative information. *Quarterly Journal of Experimental Psychology*, *11* (2), 92–107.

Wertz, A. E., & German, T. C. (2007). Belief-desire reasoning in the explanation of behavior: do actions speak louder than words? *Cognition*, *105*(1), 184–94. http://doi.org/10.1016/j.cognition.2006.08.002.

Wertz, A. E., & German, T. C. (2013). Theory of mind in the wild: toward tackling the challenges of everyday mental state reasoning. *PloS One*, *8*(9), e72835. http://doi.org/10.1371/journal.pone.0072835.

Woodward, A.L. (1998). Infants selectively encode the goal object of an actor's reach. *Cognition*, 69, 1–34.

Woodward, A. L. (1999). Infants' ability to distinguish between purposeful and non purposeful behaviors. *Infant Behavior & Development*, 22 (2), 145-160.

Wynn, K. (1992). Addition and subtraction by human infants. *Nature*, *358*(6389), 749–750.