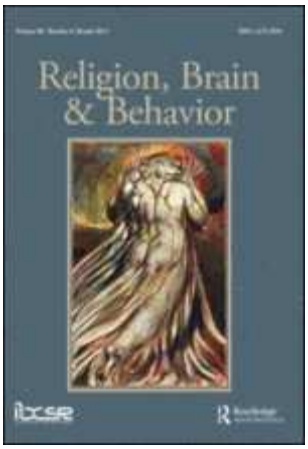


The need to believe: A neuroscience account of religion as a motivated process

Journal:	*Religion, Brain & Behavior*
Manuscript ID:	RRBB-2011-0013.R1
Manuscript Type:	Target article: with commentaries and response
Keywords:	religion, social neuroscience, meaning, uncertainty, motivation, error related negativity, anterior cingulate cortex

The need to believe: A neuroscience account of religion as a motivated process

Michael Inzlicht, Alexa M. Tullett, & Marie Good

University of Toronto

Word Count: 11,064

Correspondence should be addressed to:
Michael Inzlicht, Ph.D.,
Department of Psychology
University of Toronto Scarborough
1265 Military Trail
Toronto, Ontario M1C 1A4
Canada

Telephone: 416-208-4826
email: Michael.Inzlicht@utoronto.ca.

Abstract

Religious belief has been shown to offer substantial benefits to its vast numbers of adherents, including improved well-being and health. We suggest that these benefits might arise, at least in part, from the capacity for religion to confer meaning in people's lives. Specifically, we propose that religion satisfies people's need for meaning, and that it reduces anxiety as a result. We further propose that religion's palliative attributes can be measured at the level of the brain. In this paper we investigate four main predictions that arise from this model. First, (1) religion should be associated with error-related brain states and (2) religion should lower such brain states, (3) this association should be related to religion's impact on bodily states of distress, and (4) religion should have these effects because it provides meaning and thus buffers people from randomness and chaos. Using a social neuroscience paradigm, we investigate each of these predictions.

The Need to Believe: A Neuroscience Account of Religion as a Motivated Process

God is not great. At least that's what the patriarchs of the New Atheist movement would like us to believe. According to them, and their myriad adherents, organized religion is a virus that infects the modern world (Dawkins, 2006; Harris, 2004; Hitchens, 2007). They maintain that the "god hypothesis" has failed, that predictions derived from religion have been falsified, and that belief is, in fact, delusional. However, this focus on the truth-value of religion, on whether it is based on actual facts and verifiable claims, has perhaps distracted the New Atheists from another set of facts—that religion has undeniably positive effects, at least for individual believers.

A large body of research has suggests that, on average, religious people are happier and healthier than nonreligious people. For example, individuals with strong religious faith report higher levels of life satisfaction, greater personal happiness, and fewer negative psychological consequences of traumatic life events compared to those without faith (Diener, Suh, Lucas, & Smith, 1999; Ellison, 1991; Gartner, Larson, & Allen, 1991). Further, in several longitudinal studies, researchers have demonstrated that religiosity (in particular, religious service attendance), was strongly and consistently linked to a reduction in the risk of mortality and in the incidence of cardiovascular disease (Powell, Shahabi, & Thoresen, 2003). Some have even suggested that religious attendance can add 2 to 3 years to a person's life (Hall, 2006). One longitudinal study found that religious attendance stems the cognitive decline that is typical of the elderly, leading its authors to encourage religious practice as a form of therapy (Corsentino, Collins, Sachs-Ericsson, & Blazer, 2009). There is also reason to believe that religion may foster self-control – a trait that has been widely implicated in health, happiness, and success

(McCullough & Willoughby, 2009). Finally, many of the findings listed above hold even after statistically controlling for important "third-variables" such as gender, age, pre-existing physical health, etc. (e.g. Powell et al., 2003), implying that there may be something *unique* about religiosity that promotes mental and physical well-being.

Given these findings, a focus on whether religion is based on facts may be beside the point; other facts indicate that it may allow believers to live the good life. This is good news to many, as most people around the world have one form of belief or another. Some have suggested that about 85% of the world's population could be classified as religious (Zuckerman, 2005). Why is religion so widespread? And how does it confer such undeniable benefits to the individual? These are the central questions driving our paper. Our thesis is straightforward: we suggest that religion is prevalent and beneficial because it fulfils one of our most basic needs, which is the need to create and sustain meaning. Meaning can be conceptualized as the perceived coherence between one's beliefs, goals, and perceptions of the environment. When these things align, we are left with the sense that the world is ordered, controlled, and understandable. When this coherence is disrupted, however, meaning is threatened and we feel distressed and anxious as a result (e.g., Festinger, 1957). We view religion as a means through which the motivation for meaning is satisfied, and offer as evidence brain data relating religiosity to the reduction of distress and anxiety. In particular, we present data indicating that both religion and beliefs in an orderly universe predict muted distress responses in the human brain.

Toward a Cognitive Science of Religion

Our work, of course, is hardly the only research to address the question of religion's prevalence, roots, and function. Recent work in psychology, neuroscience, cultural anthropology, and archaeology has been addressing such questions in building a new cognitive science of

religion (e.g., Barrett, 2000; Bering, 2006; Boyer, 2001; McNamara, 2006; Norenzayan & Shariff, 2008; Sosis & Alcorta, 2003). One of the core themes of this research is that religious beliefs are a natural product of the way human minds and brains work. As such, there are a number of complimentary explanations to the questions about religion's prevalence and benefits. Comprehensive coverage of all of these accounts is beyond the scope of this paper, but we briefly discuss two of them, before going into greater detail on a third of these, the motivational account, which we think has been under-developed or at least under-appreciated by the new breed of scientists of religion.

Hyperactive agency detection. The first account suggests that belief in God is a by-product of the evolutionarily adaptive ability to detect agency in the external world (Atran, 2002; Barrett, 2000). Agency detection describes humans' tendency to perceive events as being caused by a purposeful actor, even in situations where it is clear that no agent is present. Although such a tendency can lead to errors, it also confers survival advantages. In situations where the presence of a potentially dangerous agent is uncertain, it makes sense to assume such a presence. It is safer to confuse a rock for a bear, in other words, than the other way around. The high cost of failing to detect agents has led researchers to propose that humans have a module for agency detection. Belief in God, according to this view, is a by-product, a non-adaptive spandrel that was passed down with agency detection.

Prosociality, costly signaling, and the evolution of large groups. The second account, rooted in evolutionary psychology, suggests that religion flourished because it promotes prosocial tendencies among humans (Norenzayan & Shariff, 2008). One prosociality account suggests that religion flourished, in part, as a by-product of other evolutionarily adaptive traits, namely, the human sensitivity to prosocial reputation. Some have suggested that such traits may

have contributed to the stability of reciprocal cooperation within groups (Fehr & Fischbacher, 2003; Henrich, 2006). When an all-knowing God observes and punishes misdeeds, this sensitivity will foster good behavior and prosociality even between complete strangers and within very large groups (Norenzayan & Shariff, 2008; Shariff & Norenzayan, 2007). Relatedly, the costly signaling perspective (e.g., Sosis & Bressler, 2003) holds that religion flourished and that religious groups became large and dominant because religious behaviors and rituals are often "costly" and difficult to fake (i.e., they involve doing things that are unpleasant such as fasting, abstaining from certain foods, and abstaining from sex, etc.). This effectively provides a signal of true commitment to the group and reduces the likelihood of the group attracting uncommitted freeloaders. Because costly rituals and behaviors deter such freeloaders from joining a group, trust among members increases, and intergroup cooperation and prosociality is maximized. The result is that religion allows for large, committed, and cooperative groups that, through the process of cultural group selection, are more likely to survive and flourish than smaller ones.

Religion as motivated meaning-making. While both of these ideas can, in many ways, account for why religion became so successful, they may not present the full story. Namely, these accounts claim that many of the traits that directly contributed to religious belief were originally selected to do other things. What is missing, we suggest, is the consideration of the role that motivation and emotion may play in the prevalence and salutary properties of religious belief. In contrast, we suggest that belief is prevalent because people need to believe; they are strongly motivated to create *meaning* within their world.

What is meaning? Although the meaning of "meaning" has been thoroughly discussed in the scientific literature, it is clear that a single, simple definition does not exist. Dilthey (1910/2002)

proposed that meaning arises when we consider the connectedness between life events. Proulx and Heine (2010) defined meaning as "mental representations of relationships between committed propositions" (p. 8). Finally, McGregor and Little (1998) conceptualized it as "consonance among the temporally extended and contextually distributed elements of the self" (p. 496). Following these lines of thought, we define meaning as the perceived coherence between beliefs, salient goals, and perceptions of the environment. When this coherence exists, we feel that the world is an orderly, controlled place that we can understand and explain (Frankl, 1946; Heine, Proulx, & Vohs, 2006; Peterson, 1999). Although people orient and react strongly to negativity (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001), they react even more strongly to uncertainty (Hirsh & Inzlicht, 2008; Tritt, Peterson, & Inzlicht, 2011). That is why when people's needs for order, control, and explanation are met, people feel calm; when, however, these needs are not met, people feel anxious, afraid, and inhibited, and they are highly motivated to reduce these states of distress (Gray & McNaughton, 2000; Proulx & Heine, 2008). We suggest that religion provides meaning, and reduces anxiety and distress as a result. This account explains why religion is correlated with, and in fact leads to, a reduction in a brain-based "distress signal" (Inzlicht, McGregor, Hirsh, & Nash, 2009; Inzlicht & Tullett, 2010; Tullett, Inzlicht, & Kay, 2011).

We should quickly note that we do not view any of these three accounts as mutually exclusive. Rather, these explanations likely overlap. For example, the hyperactive agency detection account is not incompatible with the idea that perceiving an external mind may allow people to create meaning out of random events and thus feel that they can understand and possibly control the events around them (Epley, Waytz, & Cacioppo, 2007; Kay et al., 2008). Similarly, the costly signaling perspective suggests that because co-religionists perform costly

rituals and behaviors, one develops a set of expectations for these in-group members that foster trust and reduce uncertainty with regard to their level of commitment. Our view that these accounts are not mutually exclusive can also allay some criticisms of a motivated meaning-making account (e.g. Boyer, 2001). If religious explanations are soothing, these critics charge, why are these explanations sometimes bizarre and why are they sometimes terrifying? While we suggest that even a frightening explanation is less unsettling than no explanation at all (Dickerson & Kemeny, 2004; Kagan, 1972; Tritt et al., 2011), we also admit that the other accounts above are perhaps better suited to explain the specific content and form of religious explanations (e.g. Atran, 2002; Barrett, 2000; Epley et al., 2007).

The account of religion as motivated meaning-making is by no means new. Scholars of religion, from James (1902/2002) to Durkheim (1912/1954), have noted that religion imbues life with meaning. Freud (1939/1955) commented that religion structures the outside world thus giving people a sense of control. Furthermore, this feeling may act as a kind of palliative against life's travails and may have contributed to Marx's view that religion is a kind of opiate of the masses. While the theory is not new, what is new is the evidence that we use to support the motivated meaning-making account—evidence from the human brain.

Social neuroscience

Research in human neuroscience has exploded in the past two decades, with more and more research relating social and cultural phenomena to basic information processing functions implemented by the brain. This new, social neuroscience approach (Cacioppo & Bernston, 2002; Harmon-Jones & Winkielman, 2007; Ochsner & Lieberman, 2001) allows for the integration of multiple levels of analysis and therefore refines and constrains psychological theories (Cacioppo & Bernston, 2002; Wilson, 1998; however, see Kihltstrom, 2006).

This social neuroscience approach captures implicit and non-conscious processes as they occur, produces results that are reducible to a core set of functions and mental modules, and, above all, is reliable. That's not to say that this approach is not without its problems (see Kang, Inzlicht, & Derks, 2010; Vul, Harris, Winkielman, Pashler, 2009). Because each brain area accomplishes many functions, there is no one-to-one mapping between area and function, meaning that when we discover that some psychological construct of interest is related to a specific brain area, we may not understand why without more information (Poldrack, 2006). For example, as will shortly see, the anterior cingulate cortex plays a role in, among other things, self-control, negative emotion, and psychological pain (Shackman et al., 2011). So, when we find that belief in God is related to less activity in this part of the brain is it because believers have less self-control, experience fewer negative emotions, or experience less pain? The challenge, then, is not to find a "God-spot" in the brain, but to correlate God with brain activity and then figure out why this association exists. And the only way to navigate through the mess of brain data is with good psychological theory (Kihlstrom, 2006), of which the motivated meaning-making account may be most apt.

Religion as Motivated Process

Epistemic motivation. As humans, we need to construct explanations about the way the world works (Kruglanski & Webster, 1996). We are especially attracted to answers that organize a diverse set of stimuli because they provide meaning (i.e., a sense of coherence among one's beliefs, goals, and perceptions of the environment), and attendant feelings of order, control, and explanation (Preston & Epley, 2005). This need is a motivated tendency and can result in feelings of threat when the need is not met, and feelings of serenity, when it is (Heine et al., 2006; McGregor, Zanna, Holmes, & Spencer, 2001). This is why we pay so much attention to

the things we cannot easily categorize or understand (Tritt et al., 2011); and why we find uncertainty and randomness especially aversive (Grupe & Nitschke, 2011; Hirsh & Inzlicht, 2008; McGregor, 2006).

There has been considerable research on the "negativity bias," the tendency to orient and react to negative over positive things. Recent research, however, suggests that although "bad is stronger than good" (Baumeister et al. 2001), uncertainty may be even stronger (Tritt et al., 2011). For example, in a recent meta-analysis of acute psychological stressors and their impact on cortisol response, Dickerson and Kemeny (2004) found that psychological stressors related to uncertain, uncontrollable threat increased cortisol levels more dramatically than any other stressor. We also attend, orient, and react to uncertain stimuli more than negative stimuli (Hirsh & Inzlicht, 2008; Tritt et al., 2011). In fact, not knowing whether a dreaded event will occur is frequently more anxiety-producing than knowing with certainty that it will (Grupe & Nitschke, 2011). Because people are motivated to see the world as an orderly, controlled, and understandable place, and to reject suggestions that events can happen randomly, people should be drawn to systems of belief that foster this worldview. From this perspective, religion might be a particularly adaptive way of understanding, or giving meaning to, a world which often seems disorderly, random, and uncertain.

Religion as a meaning system. Research consistently shows that one of the ways that people react to violations of meaning is to increase affirmations of religious beliefs. For instance, one way in which people try to insulate themselves against the anxiety associated with the unknown is by affirming the existence in a controlling God. In one study, respondents claimed higher belief in a controlling and benevolent God when they were exposed to randomness (Kay, Moscovitch, & Laurin, 2010). Critically, this study also indicated that it was the feeling of

aversive arousal, fostered by a sense of randomness (i.e., lack of order), which led to increased belief in God. This kind of uncertainty-God link has also been found in naturalistic settings, where political instability is often followed by increases in faith (Kay, Shepherd, Blatz, Chua, & Galinsky, 2010; Kay, Gaucher, Napier, Callan & Laurin, 2008).

Having faith in God may also be a way to increase feelings of (external) control, and thus provide another buffer from the uncomfortable reality that randomness can determine life outcomes (Kay, Whitson, Gaucher, & Galinsky, 2009). Indeed, the pursuit and maintenance of control has long been considered a key human motivation (Kelley, 1971), and the perception that one can predict and steer events is an important contributor to wellbeing (Langer & Rodin, 1976). People are thus sensitive to threats to control and will go to great lengths to avoid feeling anxious about such a loss, including imbuing the heavens with power. For example, studies that experimentally lower personal control result in increases in belief, specifically in an interventionist or controlling God (Kay et al., 2008). People, in other words, have a strong need for control, and violations of this need may motivate people to perceive the world as being controlled by an external agent.

In addition to the perception of a controlling God, religious belief facilitates meaning-making in an uncertain world because it offers a framework for understanding why things, particularly unexpected things, happen (Silberman, 2005). Take, for example, death. Our inevitable non-existence is notoriously difficult to comprehend and accept—pondering it is a particularly powerful way to threaten people's sense of meaning (Heine et al., 2006); it leads to feelings of distress that promote efforts to regain a sense of meaning (Greenberg, Pyszczynski, Solomon, Rosenblatt, Veeder, Kirkland et al., 1990; Rosenblatt, Greenberg, Solomon, Pyszczynski, & Lyon, 1989). As such, people may be comforted by ideas of afterlife or reincarnation, variations

of which are proposed by all of the world's major religions. Indeed, there is some evidence that believing in an afterlife is associated with reduced death anxiety (Cohen, Pierce, Chambers, Meade, Gorvine, & Koenig, 2005; Swanson & Byrd, 1998; cf. Thorson & Powell, 1989). Religious belief systems also commonly offer explanations for why some people are fortunate and other people are unfortunate (i.e., notions of karma and of godly rewards and punishments). They also provide accounts of how humans came into existence and why suffering occurs. In this way, religion suggests that there is an order to the universe, even when things appear inexplicable.

Religion may also have an advantage over other systems of belief in that the explanations it provides aren't necessarily testable (Dawkins, 2006). Take, for example, a person who believes that fairness is a law that governs events – that people generally get what they deserve, good or bad. This theory might work much of the time, especially if one is free to speculate about aspects of a person's past in order to make sense of the good or bad luck they might experience. Inevitably, however, this rule will be violated—whether it's by an infant who suffers a painful illness or a psychopath who wins the lottery—and thus the reliability of this belief system will be called into question. Religious belief, on the other hand, entails that there is an order to the universe that believers are not always able to comprehend, and for this reason even the most inexplicable events become explicable: God works in mysterious ways.

If religion is, in fact, an effective meaning system, it should protect us against anxiety and distress when we face conflict or uncertainty. Although findings reviewed above (e.g., Kay et al., 2008; 2010) suggest that making people uncertain can cause them to turn to religion as a palliative, we have yet to see whether religion actually has these palliative effects. In the next

section, we turn to neuroscientific evidence to assess whether religious belief can, as we predict, buffer against anxiety.

The Neuropsychology of Anxiety

Given our view of religion as a motivated process—that we need meaning, order, and control and that religion may help meet these needs and thus help buffer against uncertainty and the attendant feelings of anxiety—it follows that religious belief should not only be associated with low anxiety, but also prevent it. According to Gray and McNaughton's (2000) neuropsychological theory of anxiety, which is based on animal models, lesion studies, and pharmacological effects, anxiety is produced whenever an organism is uncertain about how to act. This can come about because the situation evokes two or more conflicting response options, for example when a dieter is presented with a delicious, albeit fattening, dessert (Gray & McNaughton, 2000; Corr, 2008). It can also arise when people's expectancies are violated or when they make errors, as these occurrences imply that our assumptions about the effects of our actions are flawed (Gentsch, Ullsperger, Ullsperger, 2009; Plaks & Stetcher, 2007; Oliveira, McDonald, & Goodman, 2007). It can also come about when facing explicit uncertainty, such as when people are deprived of diagnostic performance feedback (Hirsh & Inzlicht, 2008) or are unsure of when aversive feedback will be administered (Grupe & Nitschke, 2011).

So, conflict, expectancy-violation, error, and uncertainty are all states associated with anxiety. They are also states that activate the anterior cingulate cortex (ACC), a region of the medial prefrontal cortex that is important for cognition and emotion (Bush, Luu, & Posner, 2000; Shackman et al., 2011). The importance of the ACC in the experience of anxiety is confirmed by a number of sources. Lesions to the ACC reduce anxiety and autonomic reactivity, with patients

often described as apathetic and unconcerned when significant events occur, including the commission of errors (Critchley et al., 2003; Eslinger & Damasio, 1985; Laplane, Degos, Baulac, & Gray, 1981). Neuroimaging studies further reveal that patients who suffer from anxiety disorders and normal healthy volunteers chemically induced into an anxious state show elevated ACC activity (Rauch et al., 1997; Benkelfat, et al., 1995).

In EEG studies, activation of the ACC is associated with an event-related brain-potential called the error-related negativity (ERN), which emerges between 50 and 100 ms after people make errors (Dahaene, Posner, & Tucker, 1994; Gehring, Goss, Coles, Meyer, & Donchin, 1993). Although there is wide agreement that the ERN reflect aspects of performance-monitoring, a new consensus is emerging that suggests that the ERN also reflects aspects of motivation and emotion (Olvet & Hajcak, 2008). By demonstrating that the ERN is larger for patients suffering from various anxiety disorders (Hajcak, McDonald, & Simons, 2003b; Gehring, Himle, & Nisenson, 2000), is diminished by alcohol and other anxiolytic agents (Johannes, Wieringa, Nager, Dengler, & Munte, 2001; Ridderinkhof et al., 2002; Bartholow, Henry, Lust, Saults, Wood, in press), and is associated with heart-rate reactivity and galvanic skin response (Hajcak, McDonald, & Simons, 2003a), this work suggests that the ERN, at least in part, is a product of affective responses to one's performance (Bartholow et al., in press; Luu, Collins, & Tucker, 2000) or a neural ''distress signal'' indicating when attention, vigilance, and control are needed (Bartholow et al., 2005, p. 41).

The ACC and ERN, then, are connected to distress and negative affect more generally, including psychological pain (Shackman et al., 2011). And given the predictions of the motivated meaning-making account of religion—which sees religion serving a palliative, anxiolytic function and predicts that religious belief will not only be related to an alleviation of distress, but

also contribute to this alleviation—we wondered if religion's effects could be observed at the level of the ERN. If religion is a meaning system, a system that people are motivated to endorse because of the order, control, and explanation it creates, it should protect against distress in the face uncertainty and be manifest in the ACC and ERN.

Neural Marker of Religious Conviction

In a series of studies (Inzlicht et al., 2009; Inzlicht & Tullett, 2010; Tullett et al., 2011), we tested four hypotheses derived from the motivated meaning-making account of religion. First, we hypothesized that religious belief would be associated with less error-related ACC activity. Second, we hypothesized that experimentally activating religious thoughts in the minds of believers, either consciously or not, would lower this same type of ACC activity; in contrast, we hypothesized that similar religious activations would increase ACC activity in non-believers because of the distress such meaning-violations could cause them. Being mindful of the reverse-inference problem stemming from the lack of a one-to-one relationship between mind-states and brain-states (e.g., Poldrack, 2006), our third hypothesis is that the association between religiosity and low ERN activity is at least partially explained by religiosity's influence on distress, and not by the ERN's association with a lack of attention, motivation, or mental flexibility. Our final, and perhaps most critical, hypothesis is that religion's effects on distress-related ACC activity are similar and perhaps reducible to the effects of meaning on the same distress-related ACC activity. In sum, we hypothesize (1) that religion is associated with error-related brain states and (2) that religion lowers such brain states, (3) that this association is related to religion's impact on bodily states of distress, and (4) that religion acts as such because it provides meaning and thus buffers from randomness and chaos.

Place Figure 1 here

We tested these hypotheses in a series of studies that each used a similar set of methods (see Figure 1 for a schematic of the standard experimental procedures)[1]. Participants were all college students participating for extra course credit. These students came from a diverse set of ethnic and religious backgrounds; so while many were Christian, there were also sizable numbers of Muslims, Hindus, Buddhists, Sikhs, and Atheists. Participants were first fitted with electrode caps, each embedded with 32 tin electrodes located in standardized locations such that they would sit over strategic spots of the scalp. Once fitted, the caps were connected to EEG digital amplifiers and recording computers, which amplified and recorded the continuous EEG waves at all 32 electrode locations.

Participants then completed the main behavioral measure, the Stroop color-naming task (MacLeod, 1991). This task requires participants to name the color in which a sequential series of color words are presented. Sometimes the semantic meaning of the word is congruent with the display color (e.g. “red” presented in red), making it easy to name the color; other times, however, semantic meaning and display color are incongruent (e.g. “red” presented in green), making color-naming difficult. The Stroop is widely thought to index attentional control and inhibition because, on incongruent trials, naming colors requires overriding the prepotent word-reading response.

Although we were interested in response times and behavioral measures of control, the main reason we used the Stroop was because it involves cognitive conflict, generates a lot of errors, and thus allows us to assess our central index of ACC activity, the ERN. As discussed above, the

ERN occurs within about 50 ms of making an error, and, is thought to relate to the negative affect, distress, and autonomic response of having just made an error (see Olvet & Hajcak, 2008, for a review).

Religious conviction predicts the ERN. In our first study (Inzlicht et al., 2009; Study 1), we tested our first hypothesis, that religiosity would predict error-related ACC activity, by correlating the ERN with religious zeal (McGregor, Haji, Nash, & Teper, 2008). Religious zeal is an ardent, even fanatic form of belief, measured with items such as "In my heart I believe that my religious beliefs are more correct than others,'' ''My religious beliefs are grounded in objective truth,'' and ''I would support a war that defended my religious beliefs'' (McGregor et al., 2008). Participants completed this scale, and in the same session, they completed the Stroop task while their ERN was recorded. If religious conviction is associated with less distress, then we should find that the more people believe, the lower their ERN. And, as shown in Figure 2, this is precisely what we found. The more willing people were willing to endorse fervent statements about their religious belief, the lower their error-related response. Source localizations confirmed that the brain signal was generated by an area consistent with the ACC.

Place Figure 2 here

In our next study (Inzlicht et al., 2009; Study 2), we tried to replicate the association between religious conviction and the ERN, but this time with a less militant and ardent type of belief. In this second study, we simply asked about belief in God with a single-item belief in God question ranging from certain God does not exist to certain that God exists. As with our first study, we found a reliable association between religious conviction and the ERN. Also, replicating our first

study, we found that religious conviction predicted fewer errors on the Stroop task. So, in two studies we found that religious conviction predicted less error-related brain activity, consistent with the view that religion acts like a palliative.

Religious primes lower the ERN. In addition to the two studies discussed above, we have also tested for the association between belief and the ERN, using other forms of religiosity including religious service attendance, in papers that are published (e.g. Inzlicht & Tullett, 2010) and those that are still in progress (Teper & Inzlicht, 2011; Hirsh, Nash, McGregor, & Inzlicht, 2011). Across all studies, the results were the same: religious conviction predicts lower error-related ACC activity. We are thus confident that the association between religiosity and error-related ACC activity is robust; however, the causal direction of this relationship is unclear. The motivated-meaning-making account of religion casts religion as an anxiolytic and predicts that religion buffers this brain-implemented distress signal; however, given the heritability of the ERN (Anokhin, Golosheykin, & Heath, 2008), it is also possible that people born with a particularly low ERN will become attracted to religion. So, does religion cause a low ERN or does a low ERN lead to religion?

In a series of two studies (Inzlicht & Tullett, 2010), we examined this very question. In our first attempt (Inzlicht & Tullett, 2010, Study 1), we brought religious people from a broad spectrum of religious denominations into the lab to complete our now typical Stroop-EEG paradigm. However, we added a twist: Right before they started the Stroop task, we had them write a short paragraph for five minutes. Half of the religious participants wrote about what their religion meant to them personally and what it explained in their lives. The other half of the participants wrote about their favorite season and what it meant to them personally – something positive but not relevant to religion or belief. If religion is indeed a palliative, then when

religious people think about their religion, they should feel less distress about making a mistake and this should be reflected in lower ERNs compared to religious people who did not think about their religion. And this is precisely what we found. Religious affirmation, in other words, soothed error-related and brain-mediated distress.

In our second attempt (Inzlicht & Tullett, 2010, Study 2), we took this finding a step further. Our first study indicated that consciously reflecting on one's religion can alleviate distress, and in our second study we wanted to see if being non-consciously primed can do the same. We also wanted to see what would happen to non-believers when they were experimentally primed with religion. In this study, both believers and non-believers completed the Stroop task as their error-related brain activity was measured. Right before the Stroop, however, participants completed an ostensibly unrelated word-scramble task. In this task, participants saw a series of five words that had to be rearranged to form a grammatical four-word sentence. Importantly, for half of the participants some of the presented word-series contained one word related to religion (e.g. sacred, prophet, etc.); the other half of the participants (the control group) saw no such words. This type of scrambled-sentence task is commonly used to prime concepts nonconsciously (Bargh & Chartrand, 2000) and has been used successfully in the past to prime religion (Shariff & Norenzayan, 2007).

In line with our first study, when religious believers were primed with religion they showed muted error-related brain responses. Non-believers, in contrast, showed elevated levels of such brain activity. After being primed with religion, non-believers seemed to be more distressed about their errors, which is in line with the idea that the religious primes violated their own meaning-system. Taken together these two experiments indicate that religion is not only associated with lower error-related brain states, but that it has the potential to actually lower

these brain states. This is consistent with the idea that religion buffers against distress when people face error and uncertainty and supports our view of religion as the product of a motivated process to create and sustain meaning.

Interpretation of the religion/ERN link. We have thus far provided support for our first two hypotheses: that religious belief is related to error-related brain activity and that religion actually lowers said brain activity. But what does such brain activity, the ERN, actually signify? We have been suggesting that it reflects an association between religion and lower levels of negative affect, anxiety, and distress (Inzlicht et al., 2009). However, because each brain area, including the ACC (e.g. Shackman et al., 2011), accomplishes many things, it is also possible that the relationship between religion and the ERN could reflect something else. Given the association between the ERN and attention, motivation, flexible responding, and negative affect (see Olvet & Hajcak, 2008, for a review), we consider four broad explanations for the religion/ERN link: religious people are (1) less likely to attend to errors, (2) less motivated to perform the Stroop task, (3) less able to adapt to conflicting response tendencies, and (4) less distressed about their own errors.

While all of the above explanations are possible, it should come as no surprise that we think there is most support for the fourth explanation—that religious people are less anxious and defensive about the errors they make. We think the first two possibilities relating religion to lower attention and motivation are untenable. While past research has linked the ERN with both error-monitoring (e.g., Botvinick, Braver, Barch, Carter, & Cohen, 2001) and motivation (Hajcak, Moser, Yeung, & Simons, 2005), both of which contribute to better task performance, we do not think that a lower ERN among those who are highly religious reflects these aspects of the ERN. That is because in our studies religion tended to be associated with *improved*

performance on the Stroop task, consistent with other work on religion and self-control (McCullough & Willoughby, 2009). If our effects were produced by religious people paying less attention or being less motivated, we should find the opposite pattern of results.

We also do not think our data support the third explanation—that religious people are cognitively less flexible. Because religiosity is associated with a preference for certainty and a motivation to avoid uncertainty (e.g., Jost, Glaser, Kruglanski, & Sulloway, 2003) and because the ERN may index flexible attentional control (Yeung et al., 2004), it's possible that lower ERNs among the religious reflects inflexibility, closed-mindedness, or even low intelligence (e.g., Amodio, Jost, Master, & Yee, 2007; Lynn, Harvey, & Nyborg, 2009). We found, however, that the relationship between religion and the ERN—and between religion and performance—held after controlling for measures of close-mindedness and IQ (Inzlicht et al., 2009). This is inconsistent with the (lack of) cognitive flexibility explanation.

These results indicate that something other than attention, motivation, or cognitive flexibility are contributing to our findings. This something else, we suggest, is religion's palliative qualities. However, because of the reverse-inference problem (Poldrack, 2006), more direct evidence is needed to strengthen our claim. And we found such evidence in yet another study (Inzlicht & Tullett, 2010, discussion) where we once again measured religious belief and the ERN (during a Stroop task), but this time we also measured a well-validated index of bodily states of defensive activation, the startle blink response (Lang, Bradley, & Cuthbert, 1998). The startle blink response—which is measured by placing an electrode under the eye and measuring the electromyographic blink response when participants hear a loud noise—is an evolutionary old response promoting bodily defense and involving the central nucleus of the amygdala (Davis, Walker, & Meyers, 2003). Figure 3 illustrates that we found that the more participants believed

in God, the lower the amplitude of their ERNs, but also the lower the amplitude of their defensive startle response. So not only did we replicate our past work (Inzlicht et al., 2009), we also extended it by showing that religion (and the ERN) predicts lower states of distress using a well-validated measure of defensive motivation (Lang et al., 1998; see Hajcak & Foti, 2008). All told, our results are inconsistent with the view that the religion/ERN link is due to attention, motivation, and cognitive flexibility, but is consistent with our view that religion acts like a palliative, buffering against defensive arousal during times of error and uncertainty. So religion appears to reduce distress; but why?

Place Figure 3 here

Order, randomness, and the ERN. Our final study sought to understand the possible mechanism through which religion might reduce distress (Tullett et al., 2010). The motivated meaning-making account suggests that religion's palliative qualities come about because religion is a meaning system that offers explanation, order, and protection from chaos. In our final study, we explored whether exposure to the simple idea that the world is orderly, although not fully comprehensible to humans (i.e., an ideological framework akin to many religions, particularly those that emphasize that only God can know how the world truly operates) can offer the same kind of protection from error-related distress as religion. We asked, in other words, if religion's effects on the ERN were similar or even reducible to the effects of order. As a comparison, we also tested the effect on the ERN of exposure to an idea that the world is orderly, and fully comprehensible to humans (i.e., an alternative ideological framework that is *not* akin to religion,

since it proposes that humans can understand the order of the world; this may be more akin to the order provided by science)

Participants completed our standard EEG paradigm with a reaction-time task very similar to the Stroop. Critically, right before they started the Stroop, participants read one of three fabricated newspaper articles, all of which detailed a supposed conference where the world's top scientists discussed "an issue that has fascinated and frustrated the human species for centuries: Is there a meaning, a greater purpose or order, to the events that make up our lives?" Through the ideas conveyed in the article, participants were primed with one of three ideas: (1) that the world is random and chaotic, (2) that the world is ordered, although not comprehensible for humans, and (3) that the world is ordered and humans can fully comprehend this order. We hypothesized that the comprehensible order prime should give rise to a smaller ERN than the randomness prime, since understanding and order should reduce distress. We also predicted, perhaps less intuitively, that the incomprehensible order prime should reduce the ERN relative to the randomness prime, and perhaps even to the same level as the comprehensible order condition. In other words, we predicted that order in itself, even without comprehension, should buffer people against anxiety.

This pattern is precisely what we found: participants in the randomness prime showed higher ERNs than participants in either of the other conditions. Participants in the two ordered conditions, however, were not different from each other, even though one prime emphasized comprehension of the world's order while the other emphasized that comprehension is impossible. So primes of order resulted in reduced states of distress. Importantly, order was all that mattered; whether this order was personally scrutable or not did not affect subsequent states of error-related distress. In other words, our two order conditions capture two kinds of

epistemologies, one where order is personally known, and one where it is exclusively known to some external force (or agent). The fact that incomprehensible order also relieved states of distress suggests that what is important is the existence of a "master-plan," and that personal knowledge of this plan is almost superfluous. This is consistent with research indicating that people seek to increase feelings of control, even if that means it is someone (or something) else that is doing the controlling (Kay et al., 2008).

Taking Stock: Existential Neuroscience

The view of religion as a motivated process suggests that people have a need to believe in something transcendent because of the meaning and order this belief provides. The main claim of this model is that religion acts like a meaning system that offers order and control, protecting people against anxiety and distress when faced with uncertainty. People flock to religion, in other words, because religion provides confidence in the orderliness of one's environment, thereby acting as a bulwark against anxiety-producing uncertainty and minimizing the subjective pain of error.

Although there remain questions about the precise meaning of our effects, what is less questionable is that we have found a robust connection between religion and error-related brain activity. We have interpreted this connection as meaning that religion leads people to feel less anxious about their mistakes. But is this a good thing? There is no clear answer here, as there are both pros and cons to error-related distress. On the one hand, this type of affect is uncomfortable and sometimes paralyzing. High error-related brain activity is related to the personality dimension of neuroticism (Luu et al., 2000), which at its extremes contributes to a host of psychopathologies, including generalized anxiety disorder, obsessive-compulsive disorder, and depression (see Olvet & Hajcak, 2008). Low error-related brain activity is also related to

subjective well-being (Larson, Good, & Fair, 2010). On the other hand, being distressed about errors may be adaptive. Because anxiety and distress are uncomfortable emotions, they prompt us to avoid doing the things that make us feel that way—theoretically, they should help us to learn from our mistakes (Holroyd & Coles, 2002). This may be why error-related brain activity is related to better academic performance, and to task engagement and motivation more generally (Hajcak, et al., 2005; Hirsh & Inzlicht, 2010).

So, is it good to feel anxious about being wrong? Although the available evidence is equivocal, we suspect there exists an optimal level of distress, high enough to alert us that something is wrong and that we need to change course, but not so high that we become incapacitated with conflicting tendencies and paralyzed by indecision (e.g., Yerkes & Dodson, 1908). Given evidence that religious people not only show less error-related distress, but also make significantly fewer errors, we wonder if religion can buffer against the paralyzing forms of anxiety and leave people at that anxiety sweet spot.

Although we have found an association between religion and brain states that we have interpreted as indexing a form of anxiety and distress, we should also note that others have not always found a relation between religion and low anxiety. While research often suggests that religion predicts low anxiety (e.g. Amrai, Zalani, Arfai, Sharifian, 2011), it has not done so consistently (e.g., Frenz & Carey, 1989). In fact, a meta-analysis of the religion-anxiety link revealed that religion is sometimes related to increases in anxiety (Shreve-Neiger & Edelstein, 2004). The study of this link, then, has yielded mixed and often contradictory results likely attributed to a lack of reliable measures and limited assessments of anxiety (Shreve-Neiger & Edelstein, 2004). We suggest that our social neuroscience approach may be an improvement over past explorations because of our ability to not only rely on reliable measures of error-related

distress, but also to capture it online, precisely as it occurs. We also note that our account of religion as a motivated process suggests that religiosity may be related to both high and low anxiety, depending on when we measure it in a person's developmental trajectory. People who are dispositionally anxious and threatened may be attracted to religion's salutary promises, hence the occasional positive relationship between religion and anxiety; but once people are well entrenched in a religious community and become more committed believers, they may cash in on the promises and experience low anxiety. Furthermore, people may temporarily increase religious practices (e.g., prayer) during transitory states of anxiety (e.g., waiting for one's medical test results), which would be extremely difficult for researchers to capture outside of experience sampling methods. Future research using a longitudinal social neuroscience approach is needed to explore these possibilities.

Another potentially area for future research would be the consideration of whether the effect of religious primes on the ERN differs by religious group. It is possible that different religions may vary greatly in the extent to which they provide their adherents with frameworks of order, control, and explanation. While participants in our studies comprised a wide variety of religious backgrounds, meaningful between-group comparisons were not possible because of the small number of individuals in each of these different religious groups. Future research should explicitly test whether the effect of religious primes on the ERN is greater for religious groups whose beliefs are characterized by the provision of greater order, control, and explanation.

Religion, Brain, and Body

Our data indicate a robust connection between religion and brain activity in one region of medial prefrontal cortex, the ACC. However, because of the vast interconnections between brain areas and because of the connections between brain and body, it would be a gross simplification

to conclude that the ACC plays some privileged role in religious belief. To the contrary, the ACC is only one small node of a threat network that becomes dampened by religion. Although a detailed discussion of these other brain area and bodily systems is beyond the scope of the current paper, Figure 4 illustrates some other likely biological targets of religion's palliative effects. These include the amygdala, which is active during motivated states of arousal, threat, and fear (Ledoux, 1998; Ohman, 2005) and is less active among religious people after they are exposed to acoustic startles (Inzlicht & Tullett, 2010). It also likely includes the right dorsolateral prefrontal cortex, which is a node in the behavioral inhibition system (Shackman, McMenamin, Maxwell, Greschar, & Davidson, 2009) that is theoretically dampened by belief (Inzlicht et al., 2009). Religion is also associated with reduced stress reactivity in the hypothalamic-pituitary-adrenocortical (HPA) axis, as indexed by lower amounts of blood cortisol among religious adherents exposed to acute stress (Tartaro, Luecken, Gunn, 2005). A dampening of the HPA axis among believers is also associated with changes in heart rate, peripheral blood pressure, and cardiac output such that religious people tend to react with less physiological threat and more physiological challenge (Weisbuch-Remington, Mendes, Seery, & Blascovich, 2005). Given the casting of religion as a palliative, we expect that religion could have other, heretofore unexplored effects. For example, we suspect that religiosity could dampen parts of the sympathetic nervous system, for example the stress-induced sweating response, which can be measured by skin conductance. We also suspect that it could moderate the orienting reflex, which governs how an organism attends to unfamiliar stimuli, and so may have effects on the locus-coeruleus-norepinephrine system (Aston-Jones & Cohen, 2005). In short, religion's palliative effects are likely widespread in the brain and body and are certainly not limited to the kinds of error-related ACC activity that we have found.

Place Figure 4 here

Conclusion

Two simple, yet astonishing facts about religion have motivated our work: first, that it is widespread throughout the world and second, that it is usually positive for the individual believer. We join a growing rank of scientists of religion when we ask why it is so widespread and why it confers such benefit. In response, we suggest that religion is the product of a motivated meaning-making process; that religion is prevalent and beneficial because it fulfils the need to create and sustain a sense that the world is orderly and meaningful. When religion meets this need, it allows individual believers to cope with life's stresses, to feel secure in unfamiliar territory, and to feel calm under pressure. Religion provides a framework for understanding and acting, and reduces cognitive uncertainty as a result. Religion also espouses an order that is not transparent, often mysterious, and only knowable to an external agent. It therefore offers an advantage over other forms of belief or meaning—it is immune from falsification and thus adherents can be confident that it will stand the test of time. The evidence presented here makes it increasingly difficult to see religion as simply a curious, or even insidious, byproduct of our cognition. People refuse to believe that they're at the mercy of a chaotic and meaningless universe, and in many ways religion assures them that this is not the case.

Amodio, D. M., Jost, J. T., Master, S. L., & Yee, C. M. (2007). Neurocognitive correlates of liberalism and conservatism. *Nature Neuroscience, 10,* 1246-1247.

Amrai, K., Zalani, H. A., Arfai, F. S., & Sharifian, M. S. (2011). The relationship between the religious orientation and anxiety and depression of students. *Procedia Social and Behavioral Sciences, 15,* 613-616.

Anokhin, A. P., Golosheykin, S., & Heath, A. C. (2008). Heritability of frontal brain function related to action monitoring. *Psychophysiology*, *45*, 524–534.

Aston-Jones, G., & Cohen, J. D. (2005). An integrative theory of locus coeruleus-norepinephrine function: Adaptive gain and optimal performance. *Annual Review of Neuroscience, 28*, 403-450.

Atran, S. (2002). *In gods we trust: The evolutionary landscape of religion.* New York, NY: Oxford University Press.

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

Bargh, J. A., & Chartrand, T. L. (2000). The mind in the middle: A practical guide to priming and automaticity research. In H. T. Reis & C. M. Judd (Eds.), *Handbook of research methods in social and personality psychology* (pp. 253-285). New York, NY: Cambridge University Press.

Bartholow, B. D., Henry, E. A., Lust, S. A., Saults, J. S., & Wood, P. K. (in press). Alcohol effects on performance monitoring and adjustment: Affect modulation and impairment of evaluative cognitive control. *Journal of Abnormal Psychology*.

Bartholow, B. D., Pearson, M. A., Dickter, C., Sher, K. J., Fabiani, M., & Gratton, G. (2005). Strategic control and medial frontal negativity: Beyond errors and response conflict. *Psychophysiology, 42,* 33-42.

Baumeister, R. F., Bratslavsky, E., Finkenauer, C., & Vohs, K. D. (2001). Bad is stronger than good. *Review of General Psychology, 5,* 323-370.

Benkelfat, C., Bradwejn, J., Meyer, E., Ellenbogen, B. A., Milot, S., Gjedde, A., & Evans, A. (1995). Functional neuroanatomy of CCK4-induced anxiety in normal healthy volunteers. *American Journal of Psychiatry, 152,* 1180–1184.

Bering, J. M. (2006). The folk psychology of souls. *Behavioral and Brain Sciences, 29*(5), 453-498.

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

Botvinick, M., Braver, T., Barch, D. Carter, C. & Cohen, J. (2001). Conflict monitoring and cognitive control. *Psychological Review, 108*(3), 624-652.

Burle, B., Roger, C., Allain, S., Vidal, F., & Hasbroucq, T. (2008). Error negativity does not reflect conflict: A re-appraisal of conflict monitoring and anterior cingulate activity. *Journal of Cognitive Neuroscience, 20*(9), 1637-1655.

Bush, G., Luu, P., & Posner, M. I. (2000). Cognitive and emotional influences in anterior cingulate cortex. *Trends in Cognitive Science, 4*(6), 215-222.

Cacioppo, J. T., & Berntson, G. G. (2002). Social neuroscience. In J.T. Cacioppo et al. (Eds.), *Foundations in social neuroscience* (pp. 1-10). Cambridge, MA: MIT Press.

Cohen, A. B., Pierce, J. D., Chambers, J., Meade, R., Gorvine, B. J., & Koenig, H. G. (2005). Intrinsic and extrinsic religiosity, belief in the afterlife, death anxiety, and life satisfaction in young Catholics and Protestants. *Journal of Research in Personality, 39,* 307-327.

Corr, P. J. (2008). Reinforcement sensitivity theory (RST): Introduction. In P. J. Corr (Ed.), *The reinforcement sensitivity theory of personality* (pp. 1–43). Cambridge, England: Cambridge University Press.

Corsentino, E. A., Collins, N., Sachs-Ericsson, N., & Blazer, D. (2009). Religious attendance reduces cognitive decline among older women with high levels of depressive symptoms. *Journals of Gerontology: Biological Science and Medical Sciences, 64A*(12), 1283-1289.

Critchley H. D., Mathias, C. J., Josephs, O., O'Doherty, J., Zanini, S., Dewar, B. K., et al. (2003). Human cingulate cortex and autonomic control: Converging neuroimaging and clinical evidence. *Brain, 126,* 2139-2152.

Dahaene, S., Posner, M. I., & Tucker, D. M. (1994). Localization of a neural system for error detection and compensation. *Psychological Science, 5,* 303-305.

Davis, M., Walker, D. L., & Myers, K. M. (2003). Role of the amygdala in fear extinction measured with potentiated startle. *Annals of the New York Academy of Sciences, 985,* 218-232.

Dawkins, R. (2006). *The God Delusion.* London, England: Bantam Press.

Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: A theoretical integration and synthesis of laboratory research. *Psychological Bulletin 130*(3), 355-391.

Diener, E., Suh, E. M., Lucas, R. E., & Smith, H. L. (1999). Subjective well-being: Three decades of progress. *Psychological Bulletin, 125,* 276-302.

Dilthey, W. (1910/2002). The categories of life. In R. A. Makreel, & F. Rodi (Eds.) *The formation of the historical world in the human sciences* (pp. 248-265). Princeton, NJ: Princeton University Press.

Durkheim, E. (1954). *Elementary forms of religious life* (J.W. Swain, Trans.). Glencoe, IL: Free Press. (Original work published 1912)

Ellison, C. G. (1991). Religious involvement and subjective well-being. *Journal of Health and Social Behavior, 32*, 80-99.

Epley, N., Waytz, A., & Cacioppo, J. T. (2007). On Seeing Human: A Three- Factor Theory of Anthropomorphism. *Psychological Review, 114*(4), 864-886.

Eslinger, P. J., & Damasio, A. R. (1985). Severe disturbance of higher cognition after bilateral frontal lobe ablation: Patient EVR. *Neurology, 35,* 1731–1741.

Fabiani, M., Gratton, G., & Federmeier (2007). Event-related brain potentials: Methods, theory, and applications. In J. Caccioppo, L. G. Tassinary, & G. Bernston (Eds.). *Handbook of Psychophysiology, 3rd Edition* (pp. 85-119). Cambridge: Cambridge University Press.

Fehr, E., & Fischbacher, U. (2003). The nature of human altruism. *Nature, 425,* 785-791.

Festinger, L. (1957). *A theory of cognitive dissonance.* Stanford, CA: Stanford University Press.

Frankl, V. E. (1946). *Man's Search for Meaning.* London, England: Hodder and Stoughton.

Frenz, A. W., & Carey, M. P. (1989). Relationship between religiousness and trait anxiety: Fact or artifact? *Psychological Reports, 65,* 827–834.

Freud, S. (1939/1955). *Moses and monotheism.* New York, NY: Vintage Books.

Gartner, J., Larson, D. B., & Allen, G. D. (1991). Religious commitment and mental health: A review of the empirical literature. *Journal of Psychology and Theology, 19*, 6-25.

Gehring, W. J., Goss, B., Coles, M. G. H., Meyer, D. E., & Donchin, E. (1993). A neural system for error detection and compensation. *Psychological Science, 4*, 385-390.

Gehring, W. J., Himle, J., & Nisenson, L. G. (2000). Action monitoring dysfunction in obsessive-compulsive disorder. *Psychological Science, 11,* 1-6.

Gentsch, A., Ullsperger, P., & Ullsperger, M. (2009). Dissociable medial frontal negativities from a common monitoring system for self- and externally caused failure of goal achievement. *NeuroImage, 47*(4), 2023-2030.

Gray, J. A. (1976). The behavioural inhibition system: A possible substrate for anxiety. In M. P. Feldman & A. M. Broadhurst (Eds.), *Theoretical and experimental bases of behaviour modification* (pp. 3-41). London, England: Wiley.

Gray, J. A., & McNaughton, N. (2000). *The neuropsychology of anxiety: An enquiry into the functions of the septo-hippocampal system* (2nd ed.). Oxford, England: Oxford University Press.

Greenberg, J., Pyszczynski, T., Solomon, S., Rosenblatt, A., Veeder, M., Kirkland, S., & Lyon, D. (1990). Evidence for terror management theory: II. The effects of mortality salience on reactions to those who threaten or bolster the cultural worldview. *Journal of Personality and Social Psychology*, *58,* 308-318.

Grupe, D. W., & Nitschke, J. B. (2011). Uncertainty is associated with biased expectancies and heightened responses to aversion. *Emotion 11*(2), 413-424.

Hall, D. E. (2006). Religious attendance: More cost-effective than Lipitor? *The Journal of the American Board of Family Medicine, 19,* 103-109.

Hajcak, G. & Foti, D. (2008). Errors are aversive: Defensive motivation and the error-related negativity. *Psychological Science, 19*, 103-108.

Hajcak, G., McDonald, N., & Simons, R. F. (2003a). To err is autonomic: error-related brain potentials, ANS activity, and post-error compensatory behavior. *Psychophysiology, 40*, 895-903.

Hajcak, G., McDonald, N., & Simons, R. F. (2003b). Anxiety and error-related brain activity. *Biological Psychology, 64*, 77-90.

Hajcak, G., Moser, J. S., Yeung, N., & Simons, R. F. (2005). On the ERN and the significance of errors. *Psychophysiology, 42*, 151-160.

Harmon-Jones, E., & Winkielman, P. (2007). A brief overview of social neuroscience. In E. Harmon-Jones & P. Winkielman (Eds.), *Social neuroscience: Integrating biological and psychological explanations of social behavior* (pp. 3-11). New York, NY: Guilford Publications.

Harris, S. (2004). *The end of faith: Religion, terror, and the future of reason.* New York, NY: W. W. Norton & Company.

Heine, S. J., Proulx, T., & Vohs, K. D. (2006). The meaning maintenance model: On the coherence of human motivations. *Personality and Social Psychology Review, 10,* 88-110.

Henrich, J., McElreath, R., Barr, A., Ensminger, J., Barrett, C., Bolyanatz, A., et al (2006).Costly punishment across human societies. *Science, 312*, 1767-1770.

Hirsh, J. B., & Inzlicht, M. (2008). The devil you know: Neuroticism predicts neural response to uncertainty. *Psychological Science, 19,* 962–967.

Hirsh, J. B., & Inzlicht, M. (2010). Error-related negativity predicts academic performance. *Psychophysiology*, *47,* 192-196.

Hirsh, J. B., Nash, K., McGregor, I. D., & Inzlicht, M. (2011). Religion protects against threat-induced error-related distress. *University of Toronto: Unpublished Manuscript*

Hitchens, C. (2007). *God is not great: How religion poisons everything.* New York, NY: Twelve Books.

Holroyd, C. B., & Coles, M. G. H. (2002). The neural basis of human error processing: Reinforcement learning, dopamine, and the error-related negativity. *Psychological Review, 109*(4), 679-709.

Inzlicht, M., McGregor, I., Hirsh, J. B., & Nash, K. (2009). Neural markers of religious conviction. *Psychological Science, 20,* 385-392.

Inzlicht, M., & Tullett, A. M. (2010). Reflecting on God: Religious primes can reduce neurophysiological response to errors. *Psychological Science, 21,* 1184 – 1190.

James, W. (2002). *The varieties of religious experience.* New York, NY: The Modern Library. (Original work published 1902)

Johannes, S., Wieringa, B. M., Nager, W., Dengler, R., & Münte, T. F. (2001). Oxazepam alters action monitoring. *Psychopharmacology, 155,* 100-106.

Jost, J. T., Glaser, J., Kruglanski, A. W., & Sulloway, F. J. (2003). Political conservatism as motivated social cognition. *Psychological Bulletin, 129,* 339–375.

Kang, S. K., Inzlicht, M., & Derks, B. (2010). Social neuroscience and public policy on intergroup relations: A Hegelian analysis. *Journal of Social Issues, 66,* 585-601.

Kay, A. C., Gaucher, D., Napier, J. L., Callan, M. J., & Laurin, K. (2008). God and the government: Testing a compensatory control mechanism for the support of external systems. *Journal of Personality and Social Psychology, 95,* 18-35.

Kay, A. C., Moscovitch, D. M., & Laurin, K. (2010). Randomness, attributions of arousal, and belief in God. *Psychological Science, 21*, 216-218.

Kay, A. C., Shepherd, S., Blatz, C. W., Chua, S. N., & Galinsky, A. D. (2010). For God (or) country: The hydraulic relations between government instability and belief in religious sources of control. *Journal of Personality and Social Psychology, 99,* 725-739.

Kay, A. C., Whitson, J. A., Gaucher, D., & Galinsky, A. D. (2009). Compensatory control: Achieving order through the mind, our institutions, and the heavens. *Current Directions in Psychological Science, 18*, 264-268.

Kelley, H. H. (1971). *Attributions in social interaction.* Morristown, NJ: General Learning Press.

Kihlstrom, J.F. (2006). Does neuroscience constrain social-psychological theory? *SPSP Dialogue, 21*, 26-27.

Kruglanski, A. W., & Webster, D. M. (1996). Motivated closing of the mind: "Seizing and freezing." *Psychological Review, 103,* 263–283.

Langer, E. J., & Rodin, J. (1976). The effects of choice and enhanced personal responsibility for the aged: A field experiment in an institutional setting. *Journal of Personality and Social Psychology, 134,* 191-198.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1998). Emotion, motivation, and anxiety: Brain mechanisms and psychophysiology. *Biological Psychiatry, 44,* 1248–1263.

LaPlane, D., Degos, J. D., Baulac, M., & Gray, F. (1981). Bilateral infarction of the anterior cingulate gyri and of the fornices. *Journal of the Neurological Science, 51,* 289-300.

Larson, M. J., Good, D. A., & Fair, J. E. (2010). The relationship between performance monitoring, satisfaction with life, and positive personality traits. *Biological Psychology, 83*(3), 222-228.

LeDoux, J. E. (1998). The *emotional brain: The mysterious underpinnings of emotional life.* New York, NY: Weidenfeld & Nicolson.

Luck, S. (2005). *An introduction to the event-related potential technique*. Cambridge: MIT Press.

Luu, P., Collins, P., & Tucker, D. M. (2000). Mood, personality, and self-monitoring: Negative affect and emotionality in relation to frontal lobe mechanisms of error monitoring. *Journal of Experimental Psychology: General, 129*, 43–60.

Lynn, R., Harvey, J., & Nyborg, H. (2009). Average intelligence predicts atheism rates across 137 nations. *Intelligence, 37,* 11-15.

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin, 109,* 163-203.McCullough, M. E., & Willoughby, B. L. B. (2009). Religion, self-regulation, and self-control: Associations, explanations, and implications. *Psychological Bulletin, 135,* 69-93.

McGregor, I. (2006). Offensive defensiveness: Toward an integrative neuroscience of compensatory zeal after mortality salience, personal uncertainty, and other poignant self-threats. *Psychological Inquiry, 17,* 299-308.

McGregor, I., Haji, R., Nash, K., & Teper, R. (2008). Religious zeal and the uncertain self. *Basic and Applied Social Psychology, 30,* 183–188.

McGregor, I. & Little, B.R. (1998). Personal projects, happiness, and meaning: On doing well and being yourself. *Journal of Personality and Social Psychology, 74*, 494-512.

McGregor, I., Zanna, M. P., Holmes, J. G., & Spencer, S. J. (2001). Compensatory conviction in the face of personal uncertainty: Going to extremes and being oneself. *Journal of Personality and Social Psychology, 80*, 472–488.

McNamara, P. (Ed.). (2006). The frontal lobes, and the evolution of cooperation and religion. In *Where God and science meet: How brain and evolutionary studies alter our understanding of*

religion: Volume II: The neurology of religious experience (pp. 189-204). Westport, CT: Praeger Perspectives.

Norenzayan, A., & Shariff, A. F. (2008). The origin and evolution of religious prosociality. *Science, 322*, 58-62.

Ochsner, K. N., & Lieberman, M. D. (2001). The emergence of social cognitive neuroscience. *American Psychologist, 56*, 717-734.

Öhman, A. (2005). The role of the amygdala in human fear: Automatic detection of threat. *Psychoneuroendocrinology, 30,* 953–958.

Oliveira, F. T. P., McDonald, J. J., & Goodman, D. (2007). Performance monitoring in anterior cingulate is not all error related: Expectancy deviation and the representation of action-outcome associations. *Journal of Cognitive Neuroscience, 19*(12), 1994-2004.

Olvet, D. M., & Hajcak, G. (2008). The error-related negativity (ERN) and psychopathology: Toward an endophenotype. *Clinical Psychology Review, 28,* 1343-1354.

Peterson, J. B. (1999). *Maps of meaning: The architecture of belief.* New York, NY: Routledge.

Plaks, J. E., & Stecher, K. (2007). Unexpected improvement, decline, and stasis: A prediction confidence perspective on achievement success and failure. *Journal of Personality and Social Psychology, 93,* 667-684.

Poldrack, R.A. (2006). Can cognitive processes be inferred from neuroimaging data? *Trends in Cognitive Sciences*, *10*, 59–63.

Powell, L. H., Shahabi, L., & Thoresen, C. E. (2003). Religion and spirituality: Linkages to physical health. *American Psychologist, 58,* 36-52.

Preston, J., & Epley, N. (2005). Explanations versus applications: The explanatory power of valuable beliefs. *Psychological Science, 18,* 826-832.

Proulx, T., & Heine, S. J. (2008). The case of the transmogrifying experimenter: Reaffirmation of a moral schema following implicit change detection. *Psychological Science, 19,* 1294–1300.

Proulx, T., & Heine, S. J. (2010). The frog in Kierkegaard's beer: Finding meaning in the threat-compensation literature. *Social and Personality Psychology Compass*, *4*, 889-905.

Ridderinkhof, K. R., de Vlugt, Y., Bramlage, A., Spaan, M., Elton, M., Snel, J., & Band, G. P. H. (2002). Alcohol consumption impairs detection of performance errors in mediofrontal cortex. *Science, 298,* 2209-2211.

Rosenblatt, A., Greenberg, J., Solomon, S., Pyszczynski, T., & Lyon, D. (1989). Evidence for terror management theory: I. The effects of mortality salience on reactions to those who violate or uphold cultural values. *Journal of Personality and Social Psychology, 57,* 681-690.

Rauch, S. L., Savage, C. R., Alpert, N. M., Fischman, A. J. & Jenike, M. A. (1997). The functional neuroanatomy of anxiety: a study of three disorders using positron emission tomography and symptom provocation. Biological Psychiatry, 42, 446–452.

Shackman, A. J., McMenamin, B. W., Maxwell, J. S., Greischar, L. L., & Davidson, R. J. (2009). Right dorsolateral prefrontal cortical activity and behavioral inhibition. *Psychological Science, 20,* 1500-1506.

Shackman, A. J., Salomons, T. V., Slagter, H. A., Fox, A. S., Winter, J. J., & Davidson, R. J. (2011). The integration of negative affect, pain and cognitive control in the cingulate cortex. *Nature Reviews Neuroscience, 12,* 154–167.

Shariff, A. F., & Norenzayan, A. (2007). God is watching you: Priming God concepts increases prosocial behavior in an anonymous economic game. *Psychological Science, 18*, 803-809.

Shreve-Neiger, A. K., & Edelstein, B. A. (2004). Religion and anxiety: A critical review of the literature. *Clinical Psychology Review, 24,* 379-397.

Silberman, I. (2005). Religion as a meaning system: Implications for the new millennium. *Journal of Social Issues, 61*, 641–663.

Sosis, R., & Alcorta, C. (2003). Signaling, Solidarity, and the Sacred: The Evolution of Religious Behavior. *Evolutionary Anthropology 12,* 264-274.

Sosis, R., & Bressler, E.R. (2003). Cooperation and commune longevity: A test of the costly signaling theory of religion. *Cross-Cultural Research, 37,* 211-239.

Swanson, J. L., & Byrd, K. R. (1998). Death anxiety in young adults as a function of religious orientation, guilt, and separation-individuation conflict. *Death Studies, 22,* 257-268.

Tartaro, J., Luecken, L. J. Gunn, H. E. (2005). Exploring heart and soul: Effects of religiosity/spirituality and gender on blood pressure and cortisol stress responses. *Journal of Health Psychology, 10*, 753-766.

Teper, R., & Inzlicht, M. (2011). Active transgressions and moral elusions: Action framing influences moral behavior. *Social Psychological and Personality Science, 2,* 284-288.

Thorson, JA, & Powell, FC (1989). Death anxiety and religion in an older male sample. *Psychological Reports, 64*, 985-986.

Tritt, S. M., Peterson, J. B., & Inzlicht, M. (2011). The uncertainty bias: Brain evidence that ambiguity is more captivating than threat or reward. *University of Toronto: Manuscript under Review*.

Tullett, A. M., Inzlicht, M., & Kay, A. C. (2011). The comfort of predictability: Threats of randomness exacerbate anxious responding to errors. *University of Toronto: Unpublished Manuscript*.

Vul, E., Harris, C., Winkielman, P., & Pashler, H. (2009). Puzzlingly high correlations in fMRI studies of emotion, personality, and social cognition. *Perspectives on Psychological Science, 4*, 274-290.

Waytz, A., Morewedge, C., Epley, N., Monteleone, G., Gao, J., & Cacioppo, J. T. (2010). Making sense by making sentient: Effectance motivation increases anthropomorphism. *Journal of Personality and Social Psychology, 99,* 410-435.

Weisbuch-Remington, M., Mendes, W. B., Seery, M. D., & Blascovich, J. (2005). The non-conscious influence of religious symbols in motivated performance situations. *Personality and Social Psychology Bulletin, 31,* 1203-1216.

Wilson, E. O. (1998). *Consilience: The unity of knowledge.* New York, NY: Knopf.

Yeung, N. (2004). Relating cognitive and affective theories of the error-related negativity. In M. Ullsperger, & M. Falkenstein (Eds.), *Errors, conflicts, and the brain: Current opinions on performance monitoring* (pp. 63-70). Leipzig, Germany: Max Planck Institute of Cognitive Neuroscience.

Yerkes, R. M., & Dodson, J. D. (1908). The relation of strength of stimulus to rapidity of habit-formation. *Journal of Comparative Neurology and Psychology, 18,* 459–482.

Yeung, N., Botvinick, M. M., & Cohen, J. D. (2004). The neural basis of error detection: Conflict monitoring and the error-related negativity. *Psychological Review, 111,* 931–959.

Zuckerman, P. (2005). Atheism: Contemporary rates and patterns. In M. Martin (Ed.), *The Cambridge companion to atheism* (pp. 47–67). Cambridge, England: Cambridge University Press.

End Notes

1. A thorough discussion of our specific methods or the more general techniques of EEG are beyond the scope of the current paper. We direct readers who are interested in our specific methodology to the original papers (Inzlicht et al., 2009; Inzlicht & Tullett, 2010); and we direct readers interested in learning more about EEG and event-related potential methods and analyses to excellent treatments by Luck (2005) and Fabiani, Gratton, and Federmeier (2007).

Authors' Note

This research was supported by grants from the Canada Foundation for Innovation, the Ontario Ministry of Research and Innovation to Michael Inzlicht, and the Social Sciences and Humanities Research Council to Michael Inzlicht, Alexa Tullett, and Marie Good. We thank Ian McGregor, Steve Heine, Travis Proulx, Eddie Harmon-Jones, Jacob Hirsh, Kyle Nash, Lisa Legault, Jennifer Gutsell, Rimma Teper, Shona Tritt, Danielle Bader, and Naomi Sarah Ball for valuable insights.

Correspondence concerning this article should be addressed to Michael Inzlicht, University of Toronto, Department of Psychology, 1265 Military Trail, Toronto, Ontario, Canada M1C 1A4 (E-mail: Michael.inzlicht@utoronto.ca).

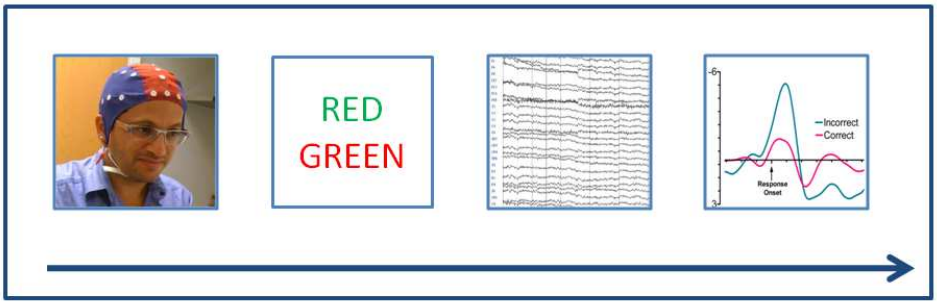
Figure Captions

Figure 1. Illustration of our standard experimental procedure: Participants are first fitted with an electrode cap connected to a digital EEG amplifier while they complete a standard color-naming Stroop task. The continuous EEG recording from all 32 channels is processed, cleaned, and averaged. The end of result is an ERN measured at fronto-central electrode sites, locked on participants' responses and showing a prominent negative deflection when participants make errors.

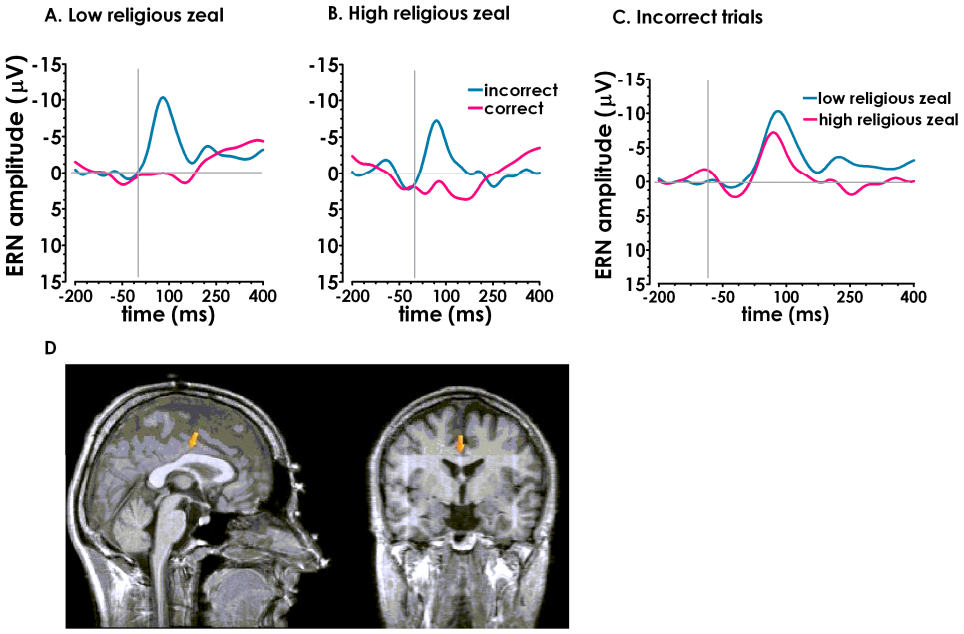
Figure 2. The relation between religious zeal and ACC activity: event-related potentials for (A) participants low in religious zeal and (B) participants high in religious zeal, (C) ERNs for people high and low in religious zeal, and (D) illustration of the neural generator for the ERN in the ACC, as determined by source localization. Image taken from Inzlicht et al. (2009).

Figure 3. Scatter plots illustrating association between trait religiosity, startle-blink response, and ERN. (A) Scatter plot indicates a negative correlation between religiosity and the magnitude of startle blink, (B) a positive correlation between religiosity and ERN amplitude, and (C) a negative correlation between religiosity and the magnitude of startle blink. Note that higher amplitude ERNs are more negative; so a positive correlation between religion and the ERN means that the more religious people get, the more positive (lower amplitude) they're ERN.

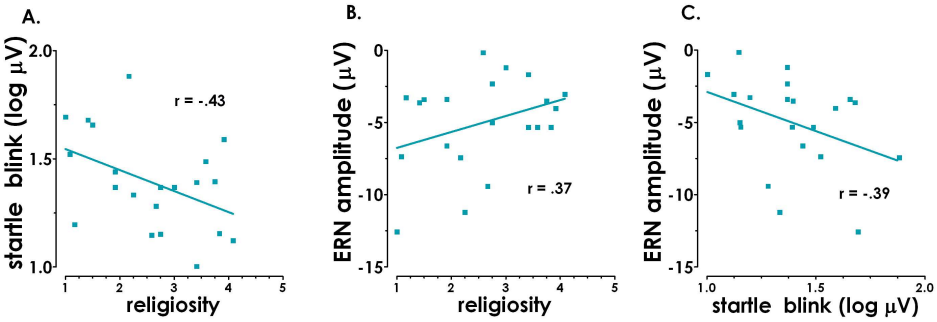
Figure 4. Biological targets of religion's palliative effects. In the brain, religion's palliative effects can be seen in the ACC, the right dorsolateral prefrontal cortex, the hypothalamus and pituitary (as part of the HPA axis), and (in theory) the locus-coeruleus norepinephrine system. In the body, these targets include the adrenal glands, which produce cortisol (also part of the HPA axis), the heart and peripheral vasculature, and (in theory) sweat glands in the skin. Illustration by Danielle Bader, MScBMC.



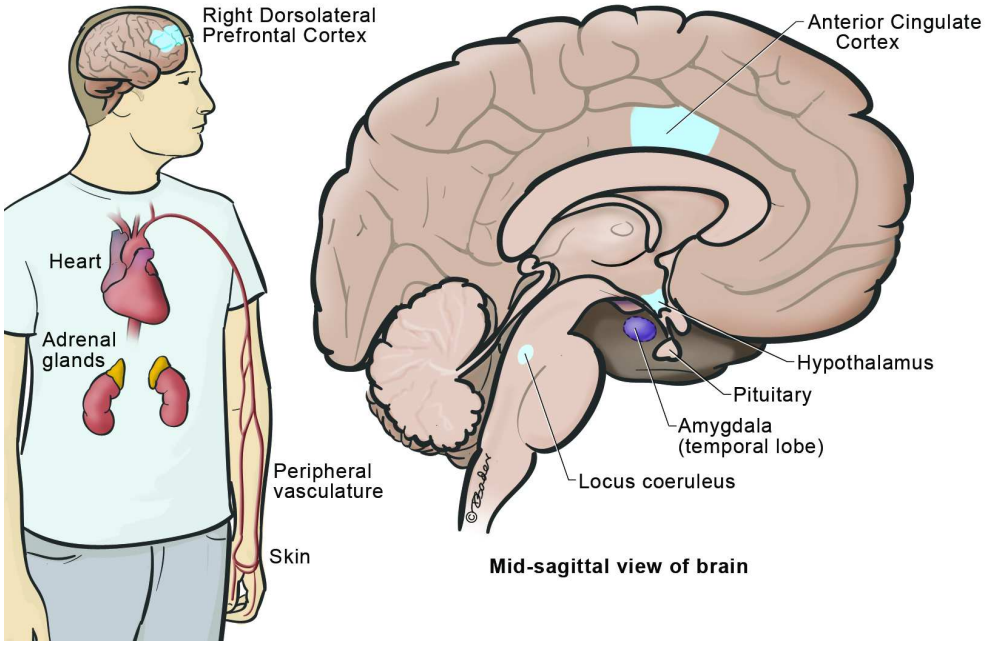
253x95mm (96 x 96 DPI)



266x174mm (300 x 300 DPI)



251x89mm (300 x 300 DPI)



139x96mm (300 x 300 DPI)